

THE USE OF SPREADSHEETS IN BUSINESS EDUCATION

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This article is about the usefulness of spreadsheets in business education. These computer programs can force students to analyze the relationships between the data and the unknown, while the program takes care of the required calculations.

It was found that an instructional method, using explicit diagrams of the business models behind the computations, resulted in better problem solving capacities than an instructional method using the traditional examples of computations.

Introduction

Some years ago a research program was started to investigate the usefulness of spreadsheets in business education. Spreadsheets are computer programs facilitating arithmetic processes. In the program 15 year old students from a secondary school in Holland were studied. It was part of a larger program aimed at developing a systematic approach to solving problems in business administration (Vernooij, 1993a and 1993b).

Literature on cognitive psychology (Anderson, 1985; De Jong, 1986; Schoenfeld, 1985; Ferguson-Hessler, 1989) suggests that problems should be solved in stages and teachers should give instructions to students on how to go through these stages. The stages recognized are (1) orientation on the problem situation, (2) analysis of the problem structure, (3) planning of the solution, and (4) calculation of the answer.

The emphasis in solving problems usually rests on the calculation of the answer. The expectation is that the use of spreadsheets forces students to concentrate on the other stages in solving problems as computers are able to perform the calculations. An example of a case study on spreadsheets is given in appendix 1.

First the essential features of case studies in business education are described. Next the design of the research program and its main results are stated. A short discussion of the results follows. In a second article, a more detailed analysis will be given of the way students perceive problems in business administration. A close examination of some solutions students presented, will lead to information about the mental processes students go through while solving problems.

Case studies in business administration

Many case studies in business administration have the same structure: some data are provided and students are required 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 characterize the kind of problems involved.

A commercial company has gathered the following information for April:

| | | |
|----|------------------------------|-------------|
| a. | sales revenues ^{*/} | = £ 123,753 |
| b. | product costs of goods sold | = £ 84,000 |
| c. | purchasing costs | = £ 3,150 |
| d. | overhead costs | = £ 30,000 |

Required:

1. compute the gross margin in April,
2. compute the operating income in April.

^{*/} The names of the concepts are taken from Horngren & Foster (1991) and are slightly adapted to Dutch terminology.

Figure 1: A case study in business administration

In this problem the functional relationship between the data and the unknowns is missing. To solve the problem, students will have to make a choice: either try to make the best guess in combining the given quantities or try to remember some rules about how to relate the economic quantities to one another.

As a matter of fact, there are two ways to perceive this problem: a mathematical approach and an economic approach. In the *mathematical approach* the figures are important and students abstract from the names of the concepts. This results in the problem structure as presented in Figure 2.

A commercial company has gathered the following information:

- a = £ 123,753
- b = £ 84,000
- c = £ 3,150
- d = £ 30,000

Required:

1. compute x,
 2. compute y.
-

Figure 2: Mathematical perception of the case study

There are no directions given on how to solve the problem as represented in Figure 2. Still the students might find an answer, because some general rules about solving problems in business administration are available.

1. Doing nothing will not result in a good mark while making the *best guess* might lead to a successful answer.
2. One can use the *data-clause*: all required data are available and all available data must be used in computing the answer.
3. Data should be used in the sequence they are introduced.
4. If two quantities must be computed, the first unknown is often required for the computation of the second unknown.
5. Pounds can be added and subtracted, but not multiplied. Sometimes it is possible to divide two financial quantities, but that is only done with specific topics.
6. If one knows a little bit about business administration, then one knows subtraction is probably required in this kind of case studies.

The best guess has a reasonable chance of being successful. The implication of this is that a good result does not prove anything about the economic insight a student has acquired. In one of the think-aloud protocols a student once formulated her strategy of solving problems:

"I always start by writing all the data at the top of my sheet. Then I make some feasible computations. After that I will take a look at the requirements and usually part of the answer is already there."

How successful this strategy may sometimes be, it is not the way teachers want their students to behave. To solve the problem based on economic insight, students should start their orientation by ignoring the figures and concentrating on the names of the variables (see Figure 3).

A commercial company has gathered the following information:

- a. sales revenues
- b. product costs of goods sold
- c. purchasing costs
- d. overhead costs

Required:

1. compute the gross margin,
 2. compute the operating income.
-

Figure 3: Economic perception of the case study

To solve this problem based on an *economic approach*, 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. However, economists are inconsistent in the way they define their concepts. The generally accepted accounting principles for financial accounting in Holland prescribe a conceptual model as presented in Figure 4. This Figure is a frame of reference for actions diagrams required to solve specific case studies about operating income.

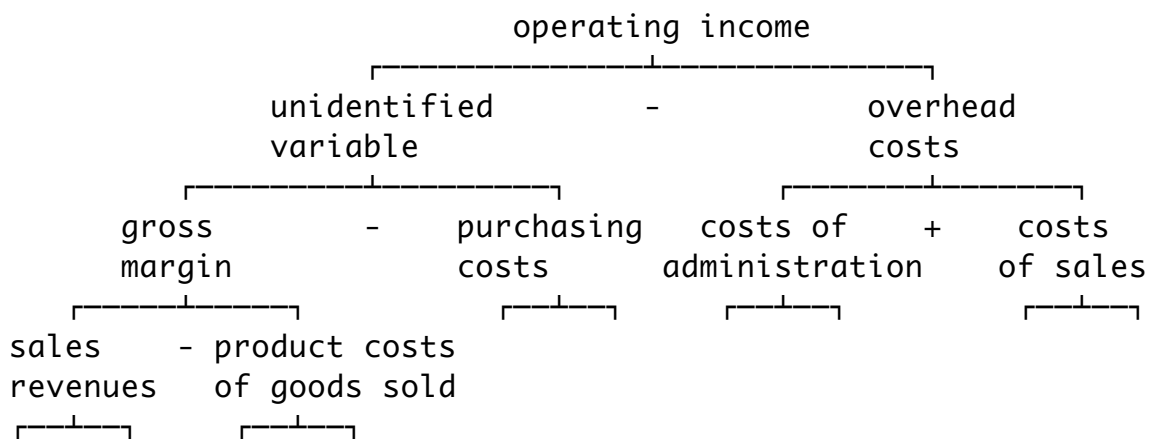


Figure 4: Conceptual model of computing operating income in a certain period in a commercial company

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).

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.

Achtenhagen et al (1993) even distinguish eight different kinds of knowledge, but confirm the essential difference mentioned by Norman.

In business administration little educational research has been done on the relationships between conceptual models and mental models. A lot can be learned from education in physics. 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.

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. Williams, Hollan & Stevens (1983) gave some examples of mental models students develop while solving a problem in physics.

The research program reported here, was aimed at helping students to understand that case studies are related to hidden conceptual models and to create mental models suitable for solving those problems. The use of conceptual models in financial accounting, however, is not consistent with managerial accounting. In managerial accounting some relationships are stated differently.

The same concepts (like *product costs*) are used, but in another way. In a second article this point will be elaborated on. This article focuses on the technical performance of the students in applying a spreadsheet program, which is considered to be an indication of their capacity to analyze and plan the solution of a case study.

The role of spreadsheets in business education

Spreadsheets can be used to force students to conceptualize their mental models (Visch, 1991; Vernooij, 1991). For the computer to calculate the correct answer, the relationships between the economic quantities must be defined explicitly in a *template*. A template is a

worksheet within a spreadsheet program (see appendix 1). It is a process of modeling as the students have to formulate all the relationships explicitly.

The writing of a well-organized template requires a clear distinction between the data to be used and the calculations to be performed. Therefore students must conceptualize their mental model by specifying the path from the data to the unknown while implementing their solution in a template.

To help students to find these relationships, explicit attention was paid to a systematic problem approach (Mettes & Pilot, 1980; Mettes, 1985; De Jong, 1986; Ferguson Hessler, 1989). To formulate the computations it is presumed that students must first *orientate* themselves on the problem by wondering if they understand which data are available and what the requirements are.

Then they must *analyze* the problem and think about the relationships between the data and the unknown. After that, they can *plan* a solution by formulating which computations to perform in what sequence. These computations must be translated in the language of the spreadsheet program.

The aim of the research program

The research program aimed to find out whether the use of spreadsheets actually contributed to solving problems based on economic insight. The expectation was that students would discover the importance of the connections between cells in a template and would realize the unimportance of the values of a particular set of data.

A change in the data-set does change the results but it leaves the computations unchanged. To support this understanding a strong separation was made between a data field and a field for computations in the template (see again appendix 1).

The usual way of introducing new procedures is by presenting an example before inviting the students to do similar exercises. The conceptual model, hidden in the example, remains implicit. An alternative method of instruction was developed, offering conceptual models in an explicit way.

The hypothesis is that instruction with explicit conceptual models will lead to better results, both on the technical performance and on the economic performance. To test the hypothesis two groups were formed. The students of one group, the experimental group, received instruction with explicit conceptual models. The students of the other group, the control group, were treated the usual way.

Design of the research program

The research was focused on a chapter from a regular Dutch textbook (Hoogheid & Fuchs, 1987). This chapter introduced the principles of management accounting. In preceding chapters the students were made familiar with the principles of financial accounting (see Figure 4). The chapter under consideration, consists of two sections.

The research is devised as a so-called *pre-test post-test design*. The same test is given to the students of the two groups before and after the instruction. This makes it possible to measure differences between the pre- and post-test as well as the differences between the groups.

If the groups had significant difference at the start, and if there were a significant difference in favour of the experimental group at the end, then the research hypothesis is accepted. One confirmation would have been obtained for the statement, that instruction with explicit conceptual models is better than instruction with demonstrations of calculations. Still, one confirmation is not enough to generalize the hypothesis. More confirmations would have to be obtained to do so.

However, introducing spreadsheet programs in business education results in two types of intervention: learning to use actions diagrams and learning to use a spreadsheet program. This approach contains the problem of two dependent variables: instruction strategy and instruction medium (Clark; 1983, Hagler & Knowlton, 1987).

Thus, two stages were created with two series of tests. The first section was used to introduce the use of actions diagrams to the experimental group. The second section was used to teach both groups to use a spreadsheet program.

The test described in this article, registered the 'Knowledge of Procedures' and consisted of regular case studies. The same case studies were offered in the pre-test and the post-test with different values for the same quantities. The test of the first section was presented a third time after the second section was finished. The post-test at the end was taken at the computer with the spreadsheet program (see Figure 5).

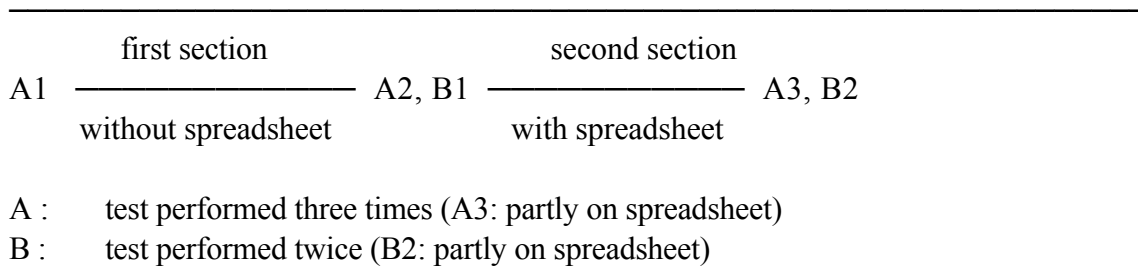


Figure 5: Design of the research program in two stages

The research took place at the Cals College in Nieuwegein, a school in Holland participating in an experimental computer program. Two existing classes were compared, each consisting ultimately of 14 students.

The students of these two groups had a score on the Differential Aptitude Test (Evers & Lucassen, 1984) which was not significantly different. However, the groups were not homogeneous as they differed in their choice of mathematics as part of their personal examination program. For that reason, the results must be interpreted with care.

Materials and procedure

In the first stage, the control group used their own textbook containing the usual method of introducing procedures by presenting a demonstration of a calculation. The experimental group received a rewritten version of the first section. All the demonstrations of calculations were replaced by actions diagrams inviting the students to calculate the results themselves.

In the second stage, the spreadsheet program Quattro was used. This program is very much like Lotus 1-2-3. A major point in using a spreadsheet is a surveyable user-interface. Most spreadsheet programs have a great number of functions and possibilities. Many of these are not required, but take time to learn. The program we used, Quattro, has the facility to create a drop down menu at student level, that offers only a limited number of options.

To prepare the use of this program, a textbook was developed for each group with case studies modified to the use of spreadsheets in business education. Before implementing the computation in a template, the experimental group was asked to make an actions diagram first. The control group was asked to calculate the answer of the case study before implementing the computation.

Scoring the technical performance

This article focuses on the technical results of two case studies, measuring the differences students register in separating the data from the formulae. The economic results will be presented in a second article.

To count the differences in separating data and formulae, four categories were distinguished: correct data, incorrect data, correct formulae and incorrect formulae. Correct data are data taken from the presented case study. Incorrect data are data resulting from computations the students have made outside the template.

Correct formulae contain references to data mentioned somewhere else in the template. Incorrect formulae contain one or more data instead of references to cells containing the data. The counting was done by two independent judges. They counted the presence of the four categories in the data field and in the field reserved for computations.

To test reliability between the two judges Cohen's kappa was counted. This statistical method results in a score between 1.0 (complete agreement) and 0.0 (no agreement at all). Every score higher than 0.8 is considered to be a good score. Cohen's kappa was 0.87 for problem A3 and 0.85 for problem B2.

Results

The results for the experimental group (e.g.) and the control group (c.g.) for problem A3 are presented in Table 1. The results for problem B2 are presented in Table 2.

| | data field | | computations field | | total score | |
|--------------------|------------|------|--------------------|------|-------------|------|
| | e.g. | c.g. | e.g. | c.g. | e.g. | c.g. |
| correct data | 82 | 64 | 0 | 0 | 82 | 64 |
| incorrect data | 6 | 14 | 0 | 1 | 6 | 15 |
| correct formulae | 3 | 27 | 95 | 62 | 98 | 89 |
| incorrect formulae | 6 | 10 | 21 | 11 | 27 | 21 |

Table 1: Results of the technical performance in case study A3

| | data field | | computations field | | total score | |
|--------------------|------------|------|--------------------|------|-------------|------|
| | e.g. | c.g. | e.g. | c.g. | e.g. | c.g. |
| correct data | 77 | 55 | 0 | 0 | 77 | 55 |
| incorrect data | 20 | 38 | 1 | 0 | 21 | 38 |
| correct formulae | 6 | 20 | 86 | 57 | 92 | 77 |
| incorrect formulae | 5 | 5 | 7 | 4 | 12 | 9 |

Table 2: Results of the technical performance in case study B2

To find out whether there are significant differences between the control group and the experimental group, the chi-square test was performed on the technical results of cases A3 and B2. The students who made no mistake at all in a certain field were counted (see Table 3).

In A3, a significant difference is found at a level where the chance of a mistake is less than twice the standard deviation (95%). In B2, the difference is nearly significant (94%).

| | | e.g. | c.g. | chi ² | P < |
|-----|-------------------|------|------|------------------|--------|
| A3: | data field | 9 | 2 | 5.4 | 0.020* |
| | computation field | 4 | 8 | 1.3 | 0.252 |
| B2: | data field | 5 | 0 | 3.5 | 0.060 |
| | computation field | 10 | 11 | 0.0 | 1.000 |

* significant difference at a level of $P < 0.050$.

Table 3: Results on the chi-square test: number of students which made no mistake

Discussion

The interpretation of the results has a qualitative character, as only small groups have participated in this study and they were not selected at random. Still, some remarks can be made about the actual value of spreadsheets in the curriculum of business education.

As both groups consisted of 14 students, the same results might be expected. This, however, is not the case. As Table 3 indicates, the experimental group performed significantly better in separating the data from the procedures. The experimental group used more correct and less incorrect data than the control group. The experimental group used less formulae in the data field than the control group.

As far as the technical performance is concerned, the hypothesis is confirmed. This is an indication, that the experimental group performed better on analyzing and planning the case study.

It seems that students can learn to distinguish between the procedure hidden in a specific case study and the actual values of the economic quantities involved in it. Students in the experimental group were forced to think about the actions diagram as a representation of the insight required to solve the problem.

For subjects with clear conceptual models, spreadsheets are very helpful in focusing attention on the relationships between the economic quantities. Instead of accepting business administration as a form of arithmetic it could quite well develop into a study of relationships between concepts.

As far as the economic discipline is concerned, some specific arithmetic methods deserve special attention. In this study, all lessons about the second section were held in a computer-room where all exercises were done on the computer. For some case studies,

though, the difficulty was not to find the actions diagram, but to use some uncommon way of calculating percentages. The experimental group in particular had difficulties in applying these techniques. Time and attention was taken away from what the study was really about.

There is also an awkward characteristic of spreadsheets. They cannot achieve completely the separation of data and formulae. It is not possible to build a model first and then introduce the values of the quantities involved. The program generates error messages if cells are left empty, for instance if a formula divides one value by another. The default value of an empty cell is zero, so the division is impossible. For that reason, one has to start with a particular set of data.

To be effective, lessons with a spreadsheet should be prepared carefully. The power of a spreadsheet is found in its capacity to revolve around the same model. This 'playing with models' can be realized by presenting variations on the same model, like data manipulation and goal-seeking.

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Appendix 1: knowledge of procedures: case study A

A trader wants to have a template which offers him the selling price, the gross margin, and the operating income of his product Flora after filling in the required data. To construct the template he has gathered some information about his business in the month of April. The lay-out of the template must be such that all the data can be changed without having to change the formulae.

In April 2800 units of Flora are bought and 2100 units are sold. The purchase price of Flora is £ 48.00 a unit including 20% VAT. The actual overhead this month was £ 30,000 excl. VAT. The purchasing costs were £ 4,200 excl. VAT. The markup for overhead was 30% on the purchase price including purchasing costs. The markup for operating income was 40% on the product costs per unit.

Required:

Formulate a template and save it under PROBLEMA.WKQ. Put the word 'data' on line 3 and the word 'computations' on line 13. Compute on this template:

1. the selling price of FLORA;
2. the gross margin per month;
3. the operating income per month;

Answers to case study A:

| A | B | C | D |
|---|---------------|--------------------|-------------------|
| 1 Problem A | Name: Student | | |
| 2 | | | |
| 3 DATA: | | | |
| 4 volume bought | | 2800 | units |
| 5 volume sold | | 2100 | units |
| 6 purchase price | | £ 48.00 | per unit |
| 7 overhead costs | | £ 30000 | this month (t.m.) |
| 8 purchasing costs (PC) | | £ 4200 | this month (t.m.) |
| 9 markup% overhead costs | | 30 | % |
| 10 markup% operating income | | 40 | % |
| 11 VAT% | | 20 | % |
| 12 | | | |
| 13 COMPUTATIONS: | | INSERTIONS: | IN DIGITS: |
| ON SCREEN: | | | |
| 14 purchase price ex VAT (100+20) £ 40.00 p.u. | | C6x100 / (100+C11) | £ 48x100/ |
| 15 purchasing costs (PC) 2,800 £ 1.50 p.u. | | C8 / C4 | £ 4,200 / £ |
| 16 purchase price inc PC £ 41.50 p.u. | | C14 + C15 | £ 40 + £ 1.50 |

| | | |
|-----------------------------|-------------------|-------------------------------|
| 17 markup overhead costs | $C9 / 100 * C16$ | $30\% \times \text{£ } 41.50$ |
| £ 12.45 p.u. | | |
| 18 product cost per unit | $C16 + C17$ | $\text{£ } 41.50 + \text{£}$ |
| 12.45 £ 53.95 p.u. | | |
| 19 markup operating income | $C10 / 100 * C18$ | $40\% \times \text{£ } 53.95$ |
| £ 21.58 p.u. | | |
| 20 selling price excl VAT | $C18 + C19$ | $\text{£ } 53.95 + \text{£}$ |
| 21.58 £ 75.53 p.u. | | |
| 21 VAT | $C11 / 100 * C20$ | $20\% \times \text{£ } 75.53$ |
| £ 15.11 p.u. | | |
| 22 selling price incl VAT | $C20 + C21$ | $\text{£ } 75.53 + \text{£}$ |
| 15.11 £ 90.64 p.u. | | |
| 23 | | |
| 24 sales revenues | $C5 * C20$ | $2100 \times \text{£}$ |
| 75.53 £ 158,613 t.m. | | |
| 25 product costs goods sold | $C5 * C16$ | $2100 \times \text{£}$ |
| 41.50 £ 87,150 t.m. | | |
| 26 gross margin | $C24 - C25$ | $\text{£ } 158,613 -$ |
| 87,150 £ 71,463 t.m. | | |
| 27 operating income | $C26 - C7$ | $\text{£ } 71,463 -$ |
| 30,000 £ 41,463 t.m. | | |

