Revitalising plenary finance lectures by students working on spreadsheet examples

ABSTRACT

Knowledge cannot necessarily be easily transferred from a lecturer to students. It needs to be constructed by the learners themselves. If a learner is active and allowed to directly apply abstract knowledge to concrete cases in a lecture, the learning process will improve. In aiming to improve learning outcomes for plenary lectures, we present new topics through examples from a Bachelor's degree course in finance. An example involves a problem and the procedure for solving it. The lecturer and the students develop the examples simultaneously on separate PCs. While the teacher demonstrates the examples on a spreadsheet on a large screen, the students model the examples in separate spreadsheets on PCs they have brought along. When the example requires, the lecturer introduces new concepts and principles. We can encode the general principles behind the problem solution when the example is complete. An evaluation reveals that students perceive it as instructive to work on examples in spreadsheets in plenary finance lectures.

Keywords: student activity, worked examples, plenary lecture, spreadsheet as blackboard

INTRODUCTION

Lecturing has a long tradition in higher education (Nordkvelle 2007), and is still prevalent. A review of descriptions of first year courses at institutions of higher business education in Norway reveal that all are implemented using plenary lectures (Gjønnes and Tangenes 2009). On some courses, lecturing is the only teaching method.

Theoretical educators believe, however, that lecturing provides a limited learning outcome (Bligh 2000). Delivering monologues to inactive students is hardly a recipe for good learning. The knowledge of a lecturer cannot be easily transferred to listening students. This didactic is based on a simplified mechanistic view of learning (Säljö 2001, Østerud 2009).

The Norwegian Quality Reform (St. meld. nr. 27 2001) expresses a desire for quality learning. Nevertheless, we continue to lecture. However, lecturers have replaced the blackboard and chalk with presentation technology (PowerPoint) in order to structure their monologues better and fill them with content. The slides also release students from making notes on lectures. The learners may, however, be cheating themselves if they think that fully completed slides can substitute for their own notes and reflections (Raaheim 2008).

Research shows that learners who actively transform the curriculum achieve the best learning outcomes (Prince 2004). However, to create student activity in plenary lectures is a challenge. Nevertheless, through running a Bachelor's course in finance with approximately 130 students, we have eight years experience at our college doing this.

In student-active lectures, the teacher and the students develop financial examples simultaneously on separate PCs in the auditorium. An example consists of a problem and the procedure for solving it. While the teacher demonstrates points using a spreadsheet on a large screen in the auditorium, the students model the examples in spreadsheets on their own PCs that they have brought along. New students can learn a lot by applying abstract knowledge to concrete examples (Sweller & Cooper 1985).

Using spreadsheets in lectures, however, requires learners to be both actively cognitive and motoric. They can learn finance while using a spreadsheet. When attention is split into several sources, an additional burden is put on working memory. This can obstruct learning (Tarmizi & Sweller 1988). For students with poor spreadsheet skills, it is conceivable that using a spreadsheet will distracts so much that they can fail to learn financial theory.

Against this backdrop, we will first discuss examples of literature which supports learning by examples in this article. Next, we will describe how a worked example can be designed as a financial lecture. Finally, we will, on the basis of a survey, try to answer the following research questions:

1 Will students achieve a good learning outcome by developing worked examples in their own worksheets in plenary finance lectures?
2 Is learning financial theory obstructed by spreadsheet use in plenary lectures, since this requires learners to be cognitive as well as motorically active?
3 Do students prefer a lecturer to use a blackboard or slides instead of a spreadsheet in basic finance plenary lectures?

THEORY

Learners should first gain an understanding of abstract principles and their application in problem solving before trying to solve problems on their own. Otherwise they will not experience deep learning, but will only learn on the surface (Renkl, 2010). For learners to be able to use abstract concepts and theories to solve complex problems, they should first train by using them on examples (Renkl, Mandl & Gruber, 1996). Later on, for cognitive skill acquisition, the learners should solve problems on their own in order to achieve proficiency (Kalyuga, Ayres, Chandler, & Sweller 2003, Renkl, 2009, Renkl & Atkinson, 2003).

The learning effect of worked examples is best when students are in the initial stages of their knowledge production; that is, when they can learn from analogies and establish abstract rules (Anderson & al. 1997). When a learner is more acquainted with his subject, training in worked examples is superfluous.

Exercises are preferable in the later stages when the goal is to automate and apply the knowledge gained to complex problem solving (Kalyuga et al. 2001). A worked example typically consists of a problem and the procedure (steps) needed to solve it (Clark, Nguyen, Sweller 2006).

In the auditorium, the lecturer introduces new concepts and principles as the example requires. When students are actively working on their PCs, they start processing the material immediately (Bligh 2000).

The fact that scientific concepts and theories are connected directly to an example modelled in the spreadsheet allows the learner to see the relevance of learning theory more easily because he can apply it. Concepts and principles become building blocks and tools used to analyse financial decisions. Students' motivation to learn theory can increase when they see it can being applied immediately and directly to a practical problem (Pintrich 1999).

When the example is complete, students are asked to think them through on their own and explain it to themselves (self-explanation). The aim is to abstract the concrete example and encode the general rules or principles behind the problem solution. When learners self-explain the principles addressed in the example, the learning effect is enhanced (Atkinson et al. 2003, Renkl 1997). This is necessary to retrieve the full learning outcome of example-based instruction.

In the auditorium, students therefore reflect on their own when the example is completed to see if it can be generalized. This can also be discussed together. The aim is that students conduct an interchange between a concrete and an abstract understanding of the problem illustrated by the example (Lave & Wenger 1991). Once learners understand the example and the procedure on an abstract level, they will be able to apply their abstract knowledge to solve corresponding specific instances of the problem on their own (Akinson & al, 2000).

We will reduce students' cognitive load when introducing new material through worked examples (Crissmann, 2006). Thus, the learners can concentrate more on the process leading to a correct answer than the answer itself. Students will gain an impression of how a successful solution can be created and how it will ultimately look.

Worked examples are particularly relevant to develop skills, such as ICT. But experiences are also good when it comes to software programming and basic math (Atkinson & al. 2000).

A financial subject in a Bachelor's programme can briefly be described as a basic course in mathematics, statistics and economic theory applied to financial problems. When combined with skill development in a spreadsheet, the conditions are well suited for producing learning based on worked examples. In a meta-analysis of the worked example in the research, Hattie identified a good learning effect (2009:172, d = 0.57).

In the next section, we will demonstrate how a worked example can be integrated into a finance lecture. The objective is that students will not only learn finance theory, but be allowed to apply the theory to concrete examples in their spreadsheets. The examples are discussed in the textbook, and are supported by practical interactive exercises later on. The learners exercise on their own outside class. Also, in two compulsory assignments in the course and in the final exam, students solve financial problems in their spreadsheets. The course design is constructively aligned (Biggs 1996, Bertheussen 2013).

A WORKED EXAMPLE USED ON A LECTURE

In this section, we will describe a typical worked example as we can present it in a lecture. The example was developed simultaneously by the teacher and the students on their own PCs. While the teacher explains and demonstrates on a large screen in the auditorium, the students carry out each step in the example on their own laptops. By activating the learners and allowing them to apply abstract knowledge to concrete cases the objective is to improve the students learning outcome.

Advanced spreadsheet skills are not required to take advantage of example-based lectures, though a learner must be able to create formulas based on cell addresses and he/she must manage to copy these in his/her spreadsheet. Additionally, the learner should be able to use some of the built-in spreadsheet's financial and statistical functions.

A worked example template

There is no precise definition of what a worked example is, but some features are common (Wittgenstein 1953). As a minimum, they contain a problem and a step by step procedure explaining how the problem can be solved.

Figure 1 below illustrates a worked example template used in a finance lecture. The elements of the template are explained in Table 1 below. The values in cells B8 and B9 are calculated by spreadsheet formulas. According to the example, we can use the same procedure, involving three steps (see labels in A7, A8 and A9), to perform similar calculations for years 2-5 in the range C7:F9 in Figure 1. The worked example in Figure 1 has not yet been processed by a student or a lecturer.

FIGURE 1

A template for a worked example

B8 | fx | =B2*$B$3

	A	B	C	D	E	F
5	**Example: how much will the amount grow when adding interests at the end of the year?**					
6		*1*	*2*	*3*	*4*	*5*
7	*Step 1: amount 1.1.*	100,00				
8	*Step 2: + interests*	5,00				
9	*Step 3: = amount 31.12.*	105,00				
10	*Future Value-formula*	105,00				
11	*Future Value-function*	105,00				

TABLE 1

Explaining the template in Figure 1

The procedure to be carried out in order to develop the worked example

The labels in A7:A9 in Figure 1 describes the three steps we must undertake in order to calculate the future value of an amount. Each step represents an intermediate learning objective on the way to a complete solution. Such intermediate targets can make it easier for a student to see the deeper structure or principles underlying the solution of a problem (Catrambone 1998).

Using dynamic spreadsheet formulas

In Figure 1 the formulas contain cell addresses and operators. The formula =B2*$B$3, which is in cell B8 (see the formula bar at the top of Figure 1), represents this year's interest on the amount in B2. Formulas based on cell addresses are more abstract than formulas based on specific values, and are more general. Using dynamic formulas, the spreadsheet becomes a simulation tool (Bertheussen 2012).

The range within which the example will be further developed

In the example, formulas calculating the future value for year 1 have already been entered. The teacher can discuss and explore these formulas before the students create their own formulas. To further develop the example for years 2-5, the learners must enter formulas in the range C7:F9 in their worksheets.

Example data and simulations

The input data to be used in the example is in cell B2 and B3 in Figure 1 (*Amount* and *Interest*). When the example is fully developed with spreadsheet formulas based on cell addresses, students can enter new input data and watch the effect of the changes instantly on their worksheets (simulation).

Figure 2 illustrates the complete solution to the worked example in Figure 1. In Figure 2 there are calculations in all cells in the range C7:F9. Behind each calculation there is a dynamic spreadsheet formula. The formulas for year 2 (C7:C9) are copied to years 2-5 (D7:F9). Students insert and copy formulas in their worksheets while the teacher explains and demonstrates how this can be done on a large screen in the auditorium.

FIGURE 2

The worked example after it is prepared into a complete solution
by the teacher and his/her students

F7 f_x =E9

	A	B	C	D	E	F
5	**Example: how much will the amount grow when adding interests at the end of the year?**					
6		*1*	*2*	*3*	*4*	*5*
7	*Step 1: amount 1.1.*	100,00	105,00	110,25	115,76	121,55
8	*Step 2: + interests*	5,00	5,25	5,51	5,79	6,08
9	*Step 3: = amount 31.12.*	105,00	110,25	115,76	121,55	127,63

Visualizing the mathematical logic of the example

In Figure 3 below, there are relational arrows between the formulas. These are created by the Trace Dependent feature of the worksheet. The arrows indicate how the formulas in the model are interconnected. They draw a clear pattern illustrating the mathematical logic of the computations.

We can calculate the future value for year 1 in B9 by adding B7 and B8. Next we replicate this calculation for year 2 in cell C7. We can also calculate the future value in year 2 using the same procedure as for year 1. In this way we create a recurring pattern for every year which is included in the example.

FIGURE 3

Visualizing the mathematical logic of the worked example

	A	B	C	D	E	F
5	**Example: how much will the amount grow when adding interests at the end of the year?**					
6		*1*	*2*	*3*	*4*	*5*
7	*Step 1: amount 1.1.*	100,00	105,00	110,25	115,76	121,55
8	*Step 2: + interests*	5,00	5,25	5,51	5,79	6,08
9	*Step 3: = amount 31.12.*	105,00	110,25	115,76	121,55	127,63

While experts may have a tendency to focus on the deeper structural aspects of a problem, beginners can focus more easily on more superficial attributes (Chi & al. 1982). Figure 3 illustrates the underlying structure of the calculation procedure we have implemented to compute future values. Illustrations can improve professional understanding, particularly for students who have a visual learning preference (Riding 2001).

Deducing the general future value formula

Based on the calculations and the patterns that are shown in Figure 3 above, we can deduce the general formula for calculating future value. In Figure 4 below, such derivations are inserted for years 1 and 2. Here we encode the general rules of the the problem solution.

FIGURE 4

Derivation of the general future value formula

	A	B	C	D	E	F
13	**Example: derivation of the general formula to calculate the future value of an amount**					
14		*1*	*2*	*3*	*4*	*5*
15	*Step 1*	=100*1,05	=100*1,05*1,05			
16	*Step 2*	=100*1,05^1	=100*1,05^2			
17	*Step 3*	=100*(1+0,05)^1	=100*(1+0,05)^2			
18	*Step 4:* ***Future Value (FV) =***	***PV*(1+i)^n***				

Students insert similar formulas for years 3-5 in the shaded range of the worksheet. In cell A18 in Figure 4, the formula is written in a general format where n is the year we want to return the value for: *Future value = Present value*(1+Interest rate)^n*

Applying the future value formula and comparing results

When we have derived the general future value formula, we can apply it. This is done in row 10 in Figure 5 below. There, the result also is compared with the less abstract but more labour-intensive procedure which students first became familiar with (see rows 7:9). According to the figure, we perform three separate arithmetical operations in one single general future value formula.

FIGURE 5

Application of the future value formula (row 10), and comparing the result with the original procedure used to calculate a future value (row 9)

B10 fx =$B$2*(1+$B$3)^B6

	A	B	C	D	E	F
1	**Data**					
2	Amount today	100,00				
3	Interest per year	5 %	in back payments			
4						
5	**Example: how much will the amount grow when adding interests at the end of the year?**					
6		*1*	*2*	*3*	*4*	*5*
7	*Step 1: amount 1.1.*	100,00	105,00	110,25	115,76	121,55
8	*Step 2: + interests*	5,00	5,25	5,51	5,79	6,08
9	*Step 3: = amount 31.12.*	105,00	110,25	115,76	121,55	127,63
10	*Future Value-formula*	105,00	110,25	115,76	121,55	127,63

Using the built-in FV function

The spreadsheet has a built-in function, FV (short for Future Value), which also calculates future value. The function automatically calculates a future value by only requiring the user to supply it with the required input. The FV function is applied in row 11 in Figure 6 below. Of course, it returns the same calculation results as the other FV-procedures discussed so far.

FIGURE 6

Application of the FV function (row 11), and comparing the result with the future value formula (row 10) and the original procedure to calculate a future value (row 9)

B11 =FV($B$3;B6;;-$B$2)

	A	B	C	D	E	F
1	**Data**					
2	Amount today	100,00				
3	Interest per year	5 %	in back payments			
4						
5	**Example: how much will the amount grow when adding interests at the end of the year?**					
6		*1*	*2*	*3*	*4*	*5*
7	*Step 1: amount 1.1.*	100,00	105,00	110,25	115,76	121,55
8	*Step 2: + interests*	5,00	5,25	5,51	5,79	6,08
9	*Step 3: = amount 31.12.*	105,00	110,25	115,76	121,55	127,63
10	*Future Value-formula*	105,00	110,25	115,76	121,55	127,63
11	*Future Value-function*	105,00	110,25	115,76	121,55	127,63

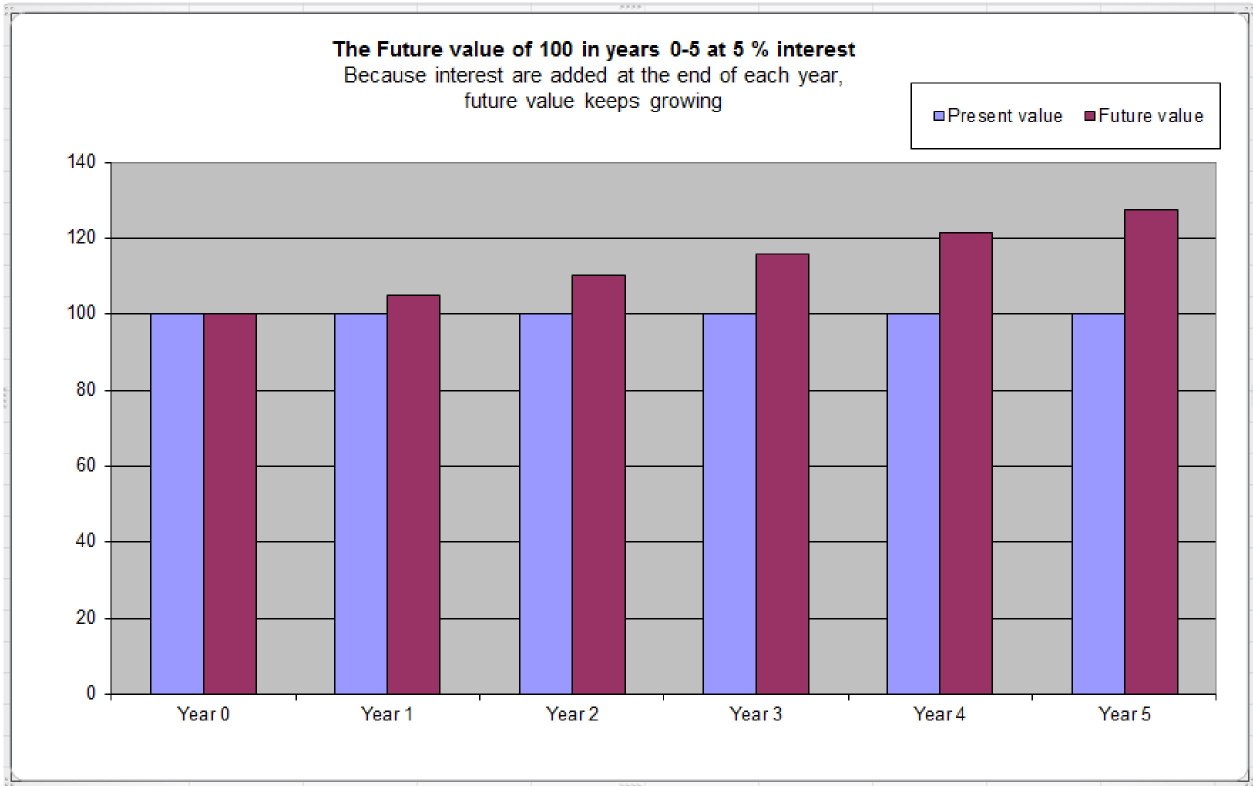
A student just memorizing the FV function and applying it mechanically without understanding what it calculates or how it calculates is experiencing only a surface approach to learning (Marton & Söljö 1984). This is the opposite of depth or quality learning (Pettersen 2005).

Such a learner can perform a future value calculation on request when all the required input is available. But if it is not obvious that a future value calculation is being looked for, the learner may not understand that he/she can solve the problem by using this kind of calculation. However, a learner with a deeper understanding of the future value concept will be able to structure and analyse the problem and assess its relevance to the specific context.

Visualizing theoretical concepts

A worked example can contain charts and drawings (Atkinsen & al. 2000). The chart in Figure 7 illustrates how the original amount (a present value), increases when interest and compound interest is added every year. The purpose of the illustration is to make it easier for students, especially those with a visual learning preference (Riding 2001), to comprehend the concepts being discussed in the worked example.

Figure 7
Visualizing concepts applied in the worked example



It is possible to create the graph from the spreadsheet after the example is completed. In other words, it is not a part of the procedure needed to calculate a future value. In this way, we avoid the problem of split attention that can occur when a student has to deal with both a text and a diagram in order to solve a problem (Ward & Sweller 1990).

In the following sections we will attempt to answer the research questions posed in the introduction to the article: (1) do students achieve a good learning outcome by developing worked examples in separate worksheets in finance lectures? (2) will learning of financial theory be obstructed by the spreadsheet use in lectures since this requires the learners to be both cognitive and motoric active? and (3) do students prefer the lecturer to use a blackboard or slides instead of a spreadsheet in basic financial lectures?

METHOD

Sample and questionnaire

The study includes 131 students who sat the exam for Investment and Finance in autumn 2011 at our business school. All the students received a written request by email to participate in the project, and were informed about the purpose of the study and how it would be implemented.

The participants received a questionnaire midway through the course (Quest Back), and we received 83 responses to this (63%). Only active students had a basis for answering the questions. Circa 90% of those who responded had participated in all or nearly all the lectures. For each research question, several claims were formulated which the students were asked to review. The claims were designed to capture the content of the questions in a valid and reliable manner.

The response was reported on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). In the results section the content of the claims and the students answers are described.

Research Ethical reflection

As the author of the article, I had multiple roles in the project. I developed the course design, and together with a colleague, I wrote the textbook for the course. With the same colleague I developed interactive exercises in the subject. Finally, I worked with the aforementioned colleague to lecture on the subject in my role as course coordinator.

My key roles may have put constraints on the student's answers. However, it was stressed that participation was voluntary and that it would have no impact on the student's relationship with the college, the author or others if he/she would not attend. Moreover, participants were able to withdraw at any time without giving any reason. I have tried to be conscious that the research results should not be influenced by my mixture of roles.

RESULTS

In this section we will attempt to answer the research questions which were initially posed.

Research Question 1: *Will students achieve a good learning outcome by developing worked examples in their own worksheets on plenary finance lectures?*

Using the two claims in Table 2 below, we attempted to measure if finance lectures with worked spreadsheet examples contributed to a good learning outcome for the learners.

TABLE 2
Learning outcome of using spreadsheets in finance lectures (n = 83)

	Average (SD)	**t-value (p)***
I learn a lot by working on examples in the finance lectures.	4,3 (1,0)	11,5 (,00)
I think it is a good idea to work with spreadsheet examples in lectures in other business subjects too.	4,1 (1,0)	9,9 (,00)

* Significantly different from the middle value 3.

The claim that students learn a lot by working on examples in the finance lectures provided a significant mean score of 4.3. The learners were so pleased about using spreadsheets in the finance lectures that they also recommended this for other business subjects (significant score of 4.1). An overall assessment of the results in Table 2 indicates that students achieve a good learning outcome by working on spreadsheet examples in the finance lectures.

Research Question 2: *Is learning finance theory obstructed by spreadsheet use in lectures since this requires students to be cognitive as well as motorically active?*

If spreadsheet usage is so distracting that students fail to learn financial theory in the lectures, we try to measure this against the claims made in Table 3 below.

Table 3
Is learning finance theory being obstructed by spreadsheet use in lectures? (n = 83)

	Average (SD)	**t-value (p)***
I cannot keep up building worked examples in the auditorium because my spreadsheet skills are too limited.	2,0 (1,1)	-8,3 (,00)
Using a spreadsheet in the lectures distracts me so much that I am obstructed from learning financial theory.	2,1 (1,0)	-7,0 (,00)
I think I would have learned more by taking paper notes instead of using a spreadsheet in the lectures.	1,8 (1,0)	-10,2 (,00)
I think the lecturer progresses too fast when developing worksheet examples in lectures.	2,9 (1,4)	-0,8 (,30)

* Significantly different from the middle value 3.

The students did not realise that they had such poor spreadsheet skills that they were having problems following the progress in the auditorium (significant score of 2.0). Neither did they realise that using a spreadsheet in lectures distracted them so much that they were being obstructed from learning financial theory (significant score of 2.1). The vast majority of the students preferred to use a spreadsheet in the lectures instead of taking notes on paper (significant score of 1.8).

The learners were indifferent to the claim that the lecturer progressed too fast when developing worksheet examples in the spreadsheet (score of 2.9). An overall assessment of the results in Table 3 suggested that spreadsheet use in the lectures inhibits students from learning finance theory to a small extent.

Research Question 3: *Do students prefer the lecturer to use a blackboard or slides instead of a spreadsheet in basic finance plenary lectures?*

If learners prefer the lecturer to use a blackboard or slides instead of a spreadsheet in basic finance lectures, we try to measure this with the two claims in Table 4 below.

TABLE 4
Do you think learning outcomes get better with a blackboard or slides instead of a spreadsheet in financial lectures? (n = 83)

	Average (SD)	*t-value (p)**
I think I would have learned more if the lecturer used slides and not a spreadsheet in the auditorium.	1,7 (0,9)	-13,3 (,00)
I think I would have learned more if the lecturer used a blackboard and not a spreadsheet in the auditorium.	1,4 (0,8)	-17,1 (,00)

* Significantly different from the middle value 3.

The claim that the students would learn more if the lecturer used slides and not a spreadsheet had a significant score of 1.7. The students did not experience using slides as an attractive alternative to spreadsheets in basic finance lectures. But replacing a spreadsheet with a blackboard appeared to be even less appealing. This claim had a significant score of 1.4. It differed most from the middle value 3 in this study.

DISCUSSION AND CONCLUSION

The purpose of this article is to discuss how we at our businss school have handled the challenge of creating student activity in plenary finance lectures. In a basic finance course, students are actively working on finance examples on their own PCs in the auditorium simultaneously with the teacher. While the teacher explains and demonstrates in a spreadsheet displayed on a large screen in the auditorium, the students develop the example in separate spreadsheets on PCs brought along.

New students in a subject can learn a lot from examples (Sweller & Cooper 1985, Anderson & al. 1998). For learners to be able to use abstract concepts and theories to solve complex problems, they should first be trained using them with specific examples (Renkl, Mandl & Gruber, 1996). Later on in cognitive skill acquisition, the learners should solve problems on their own in order to achieve proficiency (Kalyuga, Ayres, Chandler, & Sweller 2003, Renkl, 2009, Renkl & Atkinson, 2003).

In the introduction, we raised three research questions. Firstly, we asked if students would achieve a good learning outcome by developing worked examples in their own worksheets on plenary finance lectures.

The results of a survey answered by 83 students showed that it is reasonable to answer this question in the affirmative (Table 2). Students were so satisfied by using spreadsheets in lectures that they also recommended this for other business subjects.

In the next research question, we asked if learning finance theory was obstructed by spreadsheet use in lectures, since this also requires learners to be motoric active. When attention is split into several sources, this adds an extra burden to working memory and may hinder learning (Termini & Seller 1988). We must, however, also split our attention when taking lecture notes by hand. The results showed that the students did not experience split attention as a problem in spreadsheet lectures (Table 3). A significant majority did not wish to replace spreadsheets with traditional paper notes (Table 3).

In our third and last research question, we asked if students preferred lecturers to use a blackboard or slides instead of a spreadsheet on basic finance lectures. The results revealed that learners often do not perceive slides as an attractive alternative to spreadsheets in lectures (Table 4). However, replacing spreadsheets with a traditional blackboard appears to be even less appealing to students.

A theoretical implication of this study is that we can create student activity in plenary lectures by the innovative use of technology. Finance lectures based on worked examples that students develop themselves on their own brought with PCs, is a clear indication of this.

A practical implication of the study is that it may be fruitful to use spreadsheets and worked examples when lecturing also in other management disciplines such as accounting and financial management. However, this would require spreadsheet use to be woven into all practical learning and assessment activities and thus to become a part of the subject's user culture (Bertheussen, 2013).

In this study, there have been no attempts to differentiate learning outcomes of using spreadsheets in lectures from other educational approaches (Mayes 2009). Neither have we used a control group. These are methodological matters that future studies should address.

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