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The Value of Example Solutions in Pharmacy Education: The role of seniority and gender.

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Abstract

Background: Example solutions to problem sets and exams are provided in the majority of pharmacy courses at the University of Copenhagen.

Aims: Since the impact and usage of examples solutions are unknown, we wanted to evaluate the positive and negative aspects of the usage of example solutions as an educational tool-.

Method: 164 Danish pharmacy program students answered a questionnaire and answers were analyzed using non-parametric tests.

Results: We found that example solutions encourage deep learning strategies among students. Furthermore, the study identified significant differences in the students' self-assessment of preparation level prior to classes depending on gender. Male students feel as well prepared as female students despite spending significantly less time in preparation.

Conclusion: This study shows that example solutions are mostly used by students to follow a deep learning strategy, but that it is essential to properly introduce the students to the intended usage of the example solutions.

Keywords: *Example solution, deep learning, gender*

Introduction

Teacher-controlled problem solving sessions (TCS) for small groups of students are a substantial part of the Danish pharmacy education program at Copenhagen University. Typically, TCSs are one-hour or two-hour sessions, where students solve theoretical problems either alone or in collaboration with their fellow students under the supervision of a teacher. This teaching form has the purpose of helping the students learn the curriculum and to provide them with the necessary tools to solve complex theoretical problems independently. Typically, the students are required to solve a problem set in advance of a TCS. A generic TCS has the following format: in the beginning of a session, the students discuss, modify and finalize their problem solutions with their fellow students before the solutions are discussed *in plenum,* controlled by the teacher, with emphasis on the students' input to the solutions.

In most courses at the Faculty of Pharmaceutical Sciences in Copenhagen, the students are also supplied with *example solutions* (ESs) to the problem sets in advance of these sessions. Typically, an ES contains a detailed step-by-step procedure, which goes from problem to solution. While this concept is widely used in pharmacy education, it is also

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commonly applied in other disciplines, for instance in chemistry and physics bachelor education in Denmark and elsewhere.

As the goal of our study is to investigate the usage of ESs by students in terms of study strategy, it is necessary to review the surface and deep approaches to learning, a distinction often made in the phenomenographic research tradition (Ramsden, 1992a, Biggs and Tang, 2007, Marton and Booth, 1997). Students adopting deep approaches to learning are characterized by focusing on the intrinsic meaning of the task, seeking understanding and coherence, whereas students adopting surface approaches to learning roughly focus on passing the exam rather than understanding the subject matter. Surface approaches are characterized by memorization rather than understanding. Several studies have shown that students' approaches to learning are closely related to their learning outcomes (Ramsden, 1992b). It is important to note that the approach to learning should not be seen as personality trait, but rather as an expression of different strategies that individuals may adopt when faced with different educational contexts. However, as noted by Ramsden (Ramsden, 1992c), a general preference for adopting one learning strategy may develop over time. Thus, for instance, one might expect students to gradually adopt deeper approaches of learning as they progress through their education and the cognitive demands are increased.

In this context, the usage of ESs appear intuitively to be a double-edged sword from the teacher's perspective, since they can enhance deep approaches to learning (for instance: students using the ES as a means of improving their own solutions), but conversely can be used for surface learning (i.e. by memorizing the algorithm used to solve one type of problem without reflecting over the content, or using the solution before attacking the problem). The availability of ES in the learning environment may even encourage the adoption of surface approaches to learning, by making it an "easy choice", particularly if the exam allows the ESs to be brought to the exam. ES do not necessarily help the students to independently identify a problem-solving strategy to reach the solution, which is one of the main goals of education. However, to our knowledge, no empirical studies have been presented to investigate the value of ESs and if the positive aspects of this method overshadow the negative ones, or vice versa. Here, we use a large group of pharmacy students as a study group to investigate these questions. We also investigate if attitudes towards ES change during educational progress, and if gender differences in attitudes towards the usage and role of ES for learning exist.

Methods

Data collection

We designed an extensive questionnaire, which was provided to students from the 2nd, 3rd and 4th year of the pharmacy education in the M.Sc. study; in all, we received filled questionnaires from 164 students (Table I). The questionnaire is available as Supplementary material; note that we only focus on the analysis of answers to selected questions in this report. The original questionnaire was formulated in Danish, whereas we here use a translation to English.

Table I shows the number of students grouped by year of study; the goal was to obtain similar numbers of answers from each group.

Data availability

The collected data is freely available at http:// people.binf.ku.dk/albin/supplementary_data/pedagogy, for further data mining by interested readers.

Statistical methodology

All statistical analysis and visualization was made using the R statistical environment (Ihaka and Gentleman, 1996) except the pre-processing and data collection. Some plots were made using the gplots and lattice (Serker 2008) packages.

Pre-processing: The answers from the questionnaire were coded so that the first option (from left to right) was set to 1, the second 2, etc. Importantly, questions have a theoretical answer range that is either 1-2, 1-3, or 1-5. This coding of the answers was chosen in order to later be able to handle categories numerically.

Pair-wise tests: The most interesting results obtainable from data of this questionnaire are whether two questions are correlated in the sense that the answer of one of them will affect the outcome of the other. For instance, does the gender of the students affect the usage of ES? This was investigated in two ways, depending on the number of categories in each question, i.e. in the example above only two categories exist, male and female. If the question had only two categories, a two-sided Wilcoxon test was used. Answers are broken up in two groups depending on the two categories and it is tested if the center points of the groups are significantly different. In case both questions had only two variables and could be summarized as a 2x2 contingency table, Fisher exact test was used. In cases where the tested question had more than two categories, a Kruskal-Willis test was used (this is essentially a non-parametric variant of the Anova test, which tests if the means in a set of samples are significantly different). Thus, the answers are broken up depending on the categories and the test reveals if any of the groups has a significantly different center point compared to the others.

Table I. Participants in the survey.

Year of study	*Number of collected answers*	*Class*
2	54	Laboratory exercise in Physical Chemistry
3	57	Laboratory exercise in Pharmaceutical Technology
4	53	Pharmacotherapy lecture
Total	164	

Table II. Usage of example solutions in the preparation to TCSs.

Item in original q'naire	***Item***	***Do not agree***				***Totally agree***
9	I check the SE after I have solved the task	1 □	2 □	3 □	4 □	5 □
11	I start up my task solving by consulting SE	1 □	2 □	3 □	4 □	5 □
10	When I have a problem with the task(s), I use SE to help me to proceed	1 □	2 □	3 □	4 □	5 □
13	SE helps me to see how to improve my own solutions	1 □	2 □	3 □	4 □	5 □
16	Do you use the SE to reduce the time used for the task solving?	yes □			no □	

Results and Discussion

General use of the Example Solutions

We first focused on a set of questions intended to investigate the general usage and attitude towards the ESs. Specifically, we wanted to see if the students used the ES in a manner that promotes shallow learning (for instance by memorizing procedures, without gaining deeper understanding), or, in contrast, if students used the ES as a component of a deep learning approach.

The questions 9, 10, 11, 13, and 16 from the original questionnaire were designed to assess how and why students use the ESs in the preparation for TCSs, with emphasis on assessing if students indeed use ESs as an 'easy route' to problem-solving. In these questions, 1 indicates total disagreement, while 5 indicates total agreement (Table II).

Figure 1 shows histograms summarizing the answers to these questions. Questions 9 (Fig. 1A) and 11 (Fig. 1B) test if the students use the ES before or after trying to solve the given problem. There is a clear trend that the students use the ES after first trying to solve the problem, which can be seen as an indication of a deep learning approach. Similarly, many students use the ES as a tool when getting stuck in a problem (Question 10 – Fig. 1C), which is correlated to the previous two questions. A majority of students also uses the ESs to improve their own solutions (Question 13, Fig. 1D). About 67% of the students (105 out of 157) do not use the ES to save time (Question 16, Fig. 1E).

These descriptive statistics indicates that the potential positive aspects of ESs (a tool which helps deep learning) outweigh the negative aspects (a means to save time or a help for shallow learning by memorization). Below, we continued to see if the attitudes towards ESs change during the course of the education, and/or with gender.

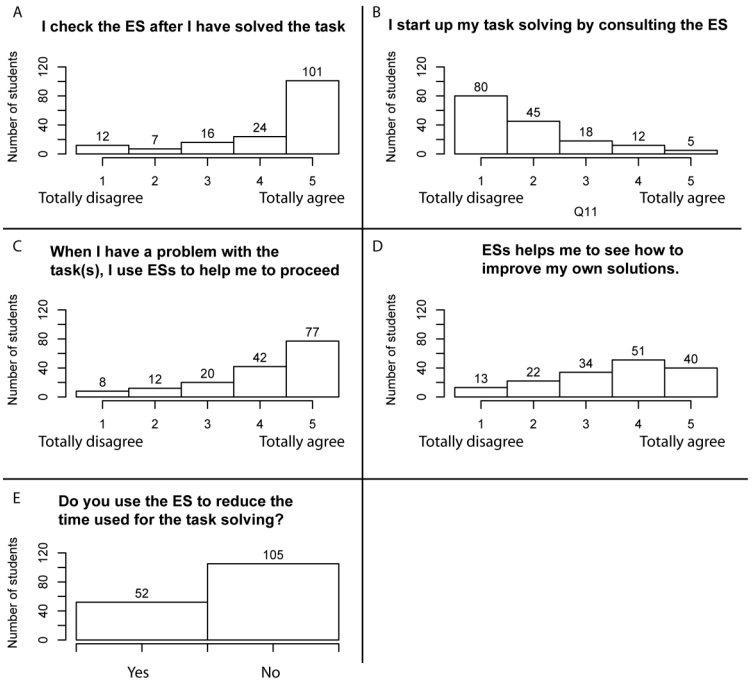

Figure 1: General usage of the ESs

Histograms showing the distribution of student answers corresponding to the questions in Table II.

Deep learning approach usage increases with student seniority

First year university students often tend to continue to follow study patterns developed during high school attendance, hereby using study strategies that have proven useful before (Bang Jakobsen and Johannsen, 2009). In high school education it is important to appear well prepared to all lessons, as students are constantly graded on the basis of daily performance. At university, where learning is dependent on self-motivation to a higher extent, students are not credited for their continuous efforts during the TCSs where the problem sets are discussed; instead the result of their study efforts is examined in the final assessment at the end of the course. The usage of ESs might reinforce the students to continue with their high-school studying behavior and delay their adaption to university studying because ESs allow the students to appear well-prepared in a TCS without having practiced at finding solutions to a problem set independently and without being forced to think deeply about the origin of the problem solution. Hence, the availability and usage of ESs may conceal a lack of understanding the core of the subject. Furthermore, one of the potential dangers of ESs is that students might think that there is only one specific solution to each problem, which should be memorized. Hence, we attempt to study if the ESs reinforce or hinder the students to study actively and independently.

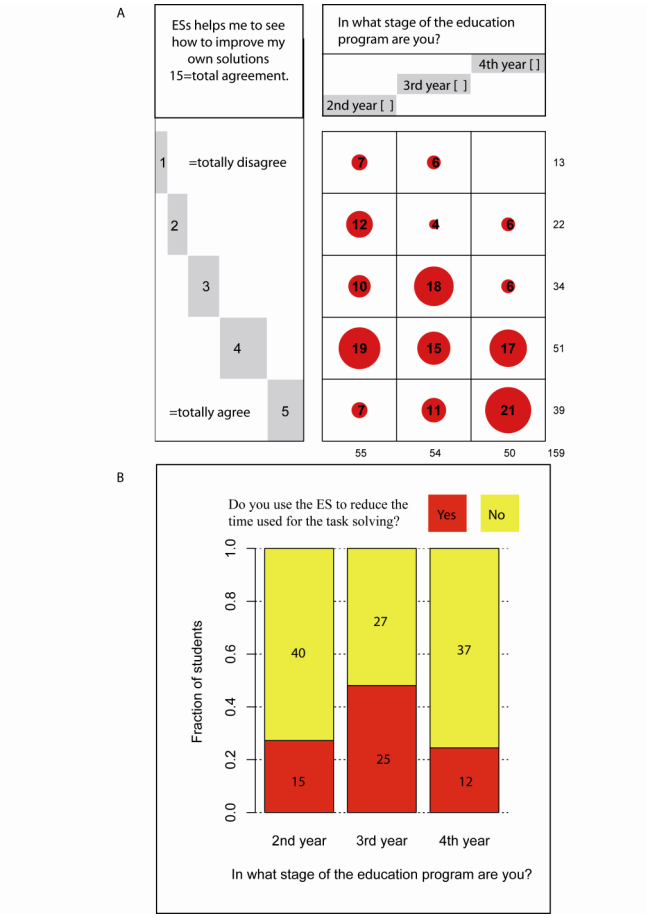

Figure 2 : Attitudes towards ES over the course of the education

A) Balloonplot showing the distribution of answers to the question "ESs helps me to see how to improve my own solutions", broken up by year of study. The area of each red circle is proportional to the number of student in each bin. There is a trend to agree more with the statement with student seniority.

B) Bar plot showing the distribution of answers to the question "Do you use the ES to reduce the time used for the task solving?", broken up by year of study. Actual number of students are shown as numbers on top of the graphs.

In this context, we focused on examining if certain patterns in ES usage could be correlated to student seniority (i.e. the year of study). In Fig. 2, the answers of the questions asked in Fig. 1D and 1E are shown as a function of student seniority. High values in figure 2A imply that students regard ESs as a way to improve their own solutions, which can be regarded as an indication of a deep learning approach. We observe that this behavior is strongly correlated with student seniority ($P<0.001$, Kruskal-Wallis test); fewer students choose the surface approach with each year of study. Therefore the usage of the ESs for self-improvement increases with time, which might indicate that the students' approaches to learning undergo a transition from an explicitly goal-oriented teaching in high school to the more independent learning in university education (figure. 2A).

The student seniority also has an impact on the tendency to use ESs to save time (Figure 2B, $P=0.022$, Kruskal-Wallis test), although the trend is not so clear. It seems that it is most common by students from the third year to use ESs in order to save time, which indicates that this result in fact might not be due to the seniority but rather other (non-measured) effects, such as that students in year 3 might be busier than students in year 2 and 4.

We also observe that the usage of the ESs self-improvement increases with time, which might indicate that the students' approaches to learning undergo a transition from an explicitly goal-oriented teaching in high school to the more independent learning in university education (Figure 2A).

Male students tend to use the surface or strategic approach in conjunction with ESs

Based on in-depth interviews with lecturers on the pharmacy education program, we suspected that some aspects of ES usage discussed above would differ depending on gender. There was a consensus opinion among most lecturers that female students tend to be more meticulous and hard working than male students, and hence would use the ESs as intended more often, that is, in conjunction with a deep learning strategy. It is important to note that the majority of the students are female (71% (112 out of 158)), which means that the overall results presented above might be biased towards the preference of females, if there is a difference between genders for a particular question.

To investigate this further, we focused on question 13, which asks the students whether they use the ESs as a way to improve their own solutions. High values indicate in-depth learning strategies. We split up the answers according to gender, and see that there is indeed a significant difference; female students have higher values on average ($P<0.001$, Wilcoxon two sided test) (Fig. 3). This indicates an increased male student preference for surface approaches to learning. In order to investigate if males use less time to prepare for TCSs

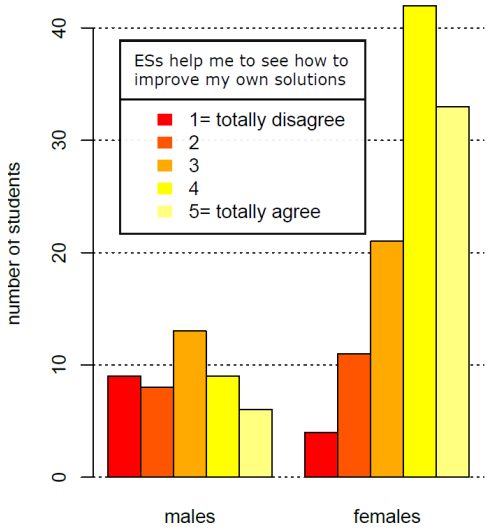

Figure 3: Attitudes towards ES differs by gender. Answers to the question "ESs helps me to see how to improve my own solutions", broken up by gender.

we asked two questions (question 6 and 17 in Table III), focused on how much time students prepare, and how well-prepared they felt prior to TCSs.
Figure 4A shows that there is a significant difference in the number of hours spent on preparation between genders; female students use much more time (P=0.003, Wilcoxon two sided test). Surprisingly, the perceived level of preparation is not different between the genders (P =0.442, Wilkoxon two-sided test) (Figure 4B). This means that male students spend less time for preparations and yet feel equally well-prepared as the female students.

At the same time, there seems to be a greater fraction of female students that use the ESs to reduce the time for task solving, however, the signal is not large enough to reach statistical significance (question 16 broken up by gender: P = 0.09, Fisher exact test) (Figure 4C). A related question is question 12, which asks if the students feel that ESs are good to have as there are too many exercises that they do not have time to finish. Here, there is a significant difference between genders, which corroborate the difference found in question 16: male students are generally not agreeing to this statement, while female students do. (Fig. 4D).

There are two possible explanations for these results: i) either male students in general employ more time-efficient study techniques than female students, e.g. they actively seek the most time-efficient strategy, ii) or, male students are more indifferent and/or much more self-confident than female students. While the second hypothesis agrees with views expressed by teachers on the pharmacy program during interviews, this questionnaire cannot with certainty resolve this issue; one way would be to compare the grades of the student group. Unfortunately, we could not access this information due to university regulations. An interesting follow-up study would be to investigate whether the difference in study techniques between males and females holds also in other study programs.

Conclusion

In this work we have studied if the positive aspects of using ESs outweigh their potential risks of misuse. In our test set, it is clear that the majority of students use ESs in a positive way – as a help for self improvement and rarely as a time-saving device. This tendency is strengthened over the time of study.

However, these general results are biased towards female students since few of the participating students (29%) are male. If comparing these two groups we see that male and female students use the ESs in different ways and that males seem to regard the ESs as a tool for following a surface approach more than females do. Interestingly, we also see that while there is no difference in the perception of how well prepared the students in both groups are before lessons, whereas the actual time spent in preparation is significantly smaller in the male group.

In summary, our study indicates that the positive aspects of using ESs outweigh the negative ones, although this is affected both by gender and student seniority. This suggests that the usage of ESs should be accompanied by teaching strategies that encourage their usage in deep learning approaches.

Table III. Gender aspects of example solutions.

Item in q'nnaire	***Item***	***Not prepared Well-prepared***
6	When you attend, how well are you prepared, in your own opinion, for the TCS?	1 □ 2 □ 3□ 4 □ 5 □
17	How much time do you use for TCS preparations?	<½ hour □ ½-2 hours □ >2 hours□
12	It is good to have the ES, as otherwise I would not get to solve many of the tasks	1 □ 2 □ 3 □ 4 □ 5 □
16	Do you use the ES to reduce the time used for the task solving?	yes □ no □

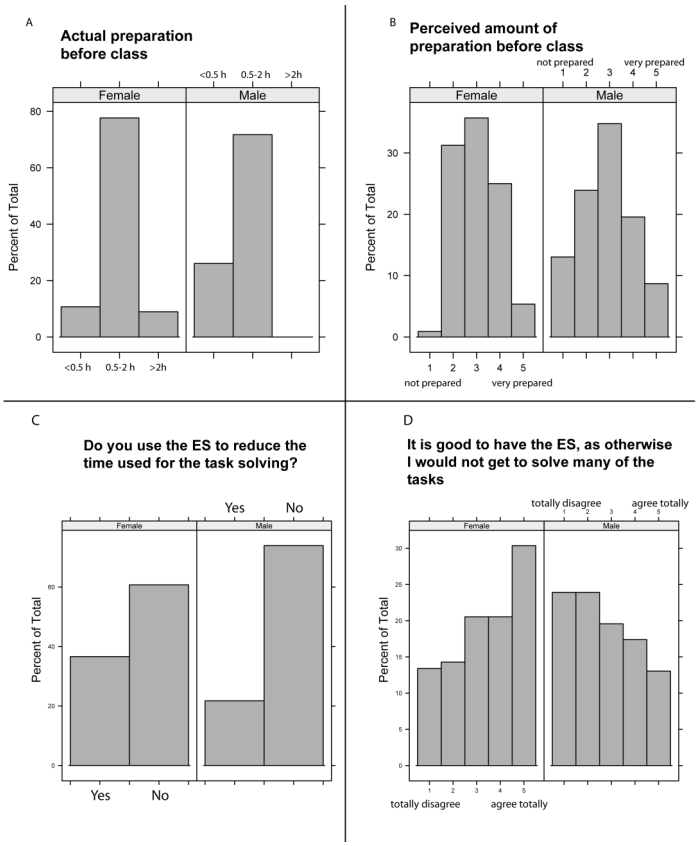

Figure 4: Preparation and time saving, broken up by gender. Histograms showing the fraction of students answering

References

Ramsden, P. (1992a). Learning to Teach in Higher Education. London: Routledge.

Biggs, J. and Tang, C. (2007). Teaching for Quality Learning at University. Berkshire: Open University Press.

Marton, F. and Booth, S. (1997). Learning and Awareness. NewJersey: Lawrence Erlbaum Associates.

Ramsden, P. (1992b). Learning to Teach in Higher Education. London: Routledge. pp. 53-60.

Ramsden, P. (1992c). Learning to Teach in Higher Education. London: Routledge. pp. 51.

Ihaka, R. and Gentleman, R. (1996). R: A Language for Data Analysis and Graphics. Journal of Computational and Graphical Statistics 5:299-314.

Bang Jakobsen, L. and Johannsen, B. F. (2009). Didactical Contract: An Analytical Concept to facilitate Successful Implementation of Alternative Physics Labs. ESERA conference, Istanbul, Turkey.

Serker, D. (2008) . Lattice: Multivariate Data Visualization with R. New York: Springer.