Exercise Problems that Facilitate Deep Approaches to Learning

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Abstract— **In this paper we consider the problem of constructing exercises and problems that encourage and enable students to take on a deep approach to learning. Well known concepts such as motivation, transfer of learning and constructive alignment are discussed in the context of problem solving. Several ideas and guidelines for constructing good problems are presented and even though learning styles are very individual, it is argued that these ideas can help constructing better problems.**

I. Introduction

University courses use several teaching and learning activities. The most common is probably the lecture, but it is often complemented, at least in the faculty of engineering, by problem solving classes, laboratory practicals, projects and sometimes also other activities, such as home assignments or essays. Here we focus on exercises and problem solving classes and how they can be improved to facilitate a deep approach to learning. We will look at well known concepts and beliefs that are results from research in teaching and learning. We look at the following concepts:

- Motivation - High motivation influences and stimulates learning.
- Transfer of Learning - Previous knowledge is used when acquiring new knowledge.
- Constructive Alignment - There should be a clear link between course goals, teaching activities and examination.

With this as background we aim to formulate a few ideas that can be kept in mind when designing new problems.

II. Concepts

We start by looking at surface and deep approaches to learning, as facilitating the latter is the main goal of this paper.

A. Surface and Deep Approaches to Learning

A student's approach to learning a particular subject can be divided into two categories, deep and surface approach. Basically, students that focus on just memorizing as much as possible are said to having a surface approach to learning. Putting the different parts together is not seen as important. Learning how to solve a problem does not imply that other, similar, problems can be solved. At the other end of the scale are the students that are trying to *understand* the concepts and the message in the material. They relate the knowledge to previously gained knowledge and put everything together in a bigger picture. Learning how to solve a problem will allow these students also to solve other problems since they can use the knowledge in other situations.

It is important to remember that the choice between a deep and a surface approach to learning is not a constant defining characteristic of a student. One student can take a surface approach in one situation or course and a deep approach in another. Also, this may not be an active choice, but can be a subconscious choice. In this case, teaching activities can play an important part in this choice. Thus, teachers should actively develop problems and exercises that motivate the students to take on a deep approach.

B. Motivational Aspects

There are several factors that influence and stimulate learning. One important factor is *motivation*. Motivation is usually divided into *external* and *internal* motivation. Externally motivated students are motivated by outer factors, e.g., getting a degree or getting a good job. Internally motivated students are driven by interest in the subject, curiosity, or that they believe that the knowledge is actually useful for them. Students that are internally motivated learn better than students that have only external motivation [1]. It is possible to influence the internal motivation. If teaching activities can be formed such that they show that what the students learn is actually useful for them, then by definition the internal motivation is increased, and learning will benefit. Relating this to problem solving, the problems should be stated such that they support this. This could e.g., mean that problems should be taken from real situations that students can identify with. We base this on a belief that knowledge is easier to find useful if it relates to real situations. Thus, we conclude that a real life scenario is much better than a made up ad hoc scenario. The problem has to emphasize that what is learned is really relevant. Other ways to stimulate motivation is to give students challenges that are neither too hard nor too easy [2]. This is of course difficult when there are many students with different background and initial knowledge. More motivational factors can be found in [2], but most are difficult to apply in our context.

C. The Transfer of Learning

One important goal of teaching is that students should be able to use knowledge from one course in a later course. This often means that they must be able to transfer what they have learned in one context into another context. In our treatment,

we restrict ourselves to four key characteristics of learning and transfers given in [4].

- Initial learning is important. The transfer of knowledge to a new context will not work unless the student has good knowledge in the first context.
- Knowledge should not be too contextualized, but should be learned in a more abstract setting in order to promote transfer.
- Transfer is an active and dynamic process. A transfer from a first context to a second may not require the same strategies and activities as a transfer from a second to a third context.
- All learning is transfer. When we learn something new this builds upon something that we know since before. Thus transfer is present in all types of learning. In teaching this can be taken advantage of by relating new knowledge to something students already know.

At first glance, the second bullet seems to contradict the conclusion that problems should be based on real life scenarios from the section on motivational aspects. However, we believe that using real life scenarios instead of made up ad hoc scenarios in problems based on actual situations does not contradict the fact that abstract problems should also be used, since these are a different type of problems. Moreover, real life problems can include and encourage abstract reasoning.

D. Constructive Alignment

There should be a clear link between course goals, teaching activities and examination. This is the concept of constructive alignment [3]. Consider a course which consists of lectures, problem solving classes, and a few labs or projects. Lectures will provide necessary information and hopefully help the students structure the information [5]. The problem solving will allow the students to practice just that, solving problems related to the course content. The laboratory practicals or projects will give the students the opportunity to apply the knowledge in practice.

Often, problems are taken from the course book, where they are located at the end of each chapter. These problems test the material covered in the corresponding chapter. However, the exam may include problems that connect the material in different chapters and require the students to combine information from several parts of the course. This would not be in agreement with the constructive alignment as students do not get the opportunity to practice on these types of problems, which might show up on the exam. Thus, it seems favorable to include in the list of problems, also problems that combine the material from several parts of the course if these types of problems will be used on the exam. Often, this is solved by giving the students a set of previous exams. Then they can practice also on these problems. Still, in the view of constructive alignment we consider this solution to be suboptimal. These problems will be considered by students as typical exam problems, while problems solved during the course will be considered to be another type of problems. Hence, the problem with constructive alignment remains in this case.

III. Applying Theory to Problems and Exercises

Considering the previous section, we summarize the aspects of problems and exercises that should be considered. It must be noted that this is not a definitive and exhaustive list, but it can be used as starting point when constructing new problems aimed at helping students take on a deep approach to learning.

- Problems based on real life situations or facts can help the students to increase the motivation.
- Be careful not to make too easy or too difficult questions.
- Problems based on finding connections between different contexts can help transferring the learning.
- Relating problems to something that the students already know, e.g., previous courses or earlier parts of the same course can also help transfer.
- Give students problems that are comparable to the problems given on the exam. It should not be completely different types of problems on exam and during the course.

IV. Conclusion

In this report we propose ideas on how to construct problems that should facilitate a deep approach to learning. Our discussions are based on motivational aspects, the transfer of learning, and constructive alignment.

Since the main goal is to facilitate better learning, it could be interesting to let the student give input to how problems should be constructed, or even let them construct problems by themselves. Some teachers have taken this even further by letting the student construct problems on their own, and then include the best problems on the exam. The respective student will obviously benefit from this since the solutions should be clear to him or her.

References

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