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Enhancing Students' Learning Skills by Enriching the Lecture "Mechanics 1 / Statics" in Various Interactive Ways

Michael Canz[1], Evgenia Sikorski[2]
[1]Offenburg University, Information Center, [2]Department Mechanical and Process Engineering[2] (Germany)
michael.canz@hs-offenburg.de, evgenia.sikorski@hs-offenburg.de

Abstract

Skills, abilities and capability of our freshmen are increasingly heterogeneous, regarding age, attained levels of education and motivational aspects. Additionally, students tend to recoil from subjects dealing with mathematical backgrounds. As a result high, drop-out numbers are a huge problem in technical degree programs.
Since mechanics is based on physics and mathematics our students face enormous difficulties. To deal with them, a form of teaching and learning has been developed that is composed of the following arrangements:

1. *Problems and tasks of different levels are solved during lessons. The access to theoretical issues is being developed by or rather as a result of solving these problems. By doing so, especially students with yet insufficient skills are enabled to develop their methodological skills.*
2. *Challenging students to independently transfer these skills on other problems is helpful. At the end of each lecture two students are selected randomly. Each of them is faced with an exercise they have to solve and present at the beginning of the next lecture. Because of small student numbers, chances are high that every student participates at least once by the end of semester. Surveys show that particularly weaker students benefit from that kind of model learning.*
3. *We are surrounded by mechanical issues. Given that, students are presented with "every-day-life" problems which students can apply their theoretical knowledge on. The problems are analyzed by groups of students, which leads to an enhanced and reflective perception of each and every one. Some examples are: "A broomstick in equilibrium", "Sensitive cups", "Transforming a roman basilica into a gothic cathedral".*
4. *All lectures have been filmed by the staff of the Information Center of the Offenburg University during the previous term. Additionally to the notes taken by the students individually during the lectures, these recordings are helpful in the process of preparation and post-processing of the material. The recordings are accessible via the university's learning management system "Moodle".*

Surveys show that students benefit from the great variety of the provided, interactive learning arrangements. It is interesting to discover that students not only take positive advantages in the lecture "mechanics 1/statics" but tend to transfer these positive experiences on other subjects.

1. What do we try to achieve?

Teaching mechanics has a long tradition as a part of engineering education. At the Offenburg University there are all together three courses of mechanics, taught in the first three semesters. Another, well established, at least theoretically, tradition in pedagogy is to arouse learners' auturgy [1]. If one tries to understand one has to deal with a subject regularly in many different ways. With education being understood this way, the teachers' function is to provide a didactical well prepared learning environment, in which learning is going to take place. Besides preparation, the second function is to moderate, accompany and supervise these triggered learning processes. Didactical competence means hereby "die Distanz zwischen Thematik und Adressat zu überbrücken, zwischen Lerngegenstand und Lernenden zu vermitteln" (to bridge the gap between subject and adressee, between learning object and learner (translated by the authors)) [2].
Teachers' actions and learners' (re)actions are always necessarily happening in time-based sequences. Concurrently learning processes are affected and determined by chronology. Therefore in a classroom you can observe a lot of individual time-based sequences and dependent (learning and teaching) processes, such as perceiving, assimilating, structuring, etc. that are very different for each involved individual. The challenge for teachers is to notice individual moments that are sensitive to

learning and to refer to those processes when continuing teaching [3]. It is a constant process of drawing decisions whether it is more suitable to accompany and foster learners by influencing and manipulating or fading. Teachers need to have a lot of experience and the will to reflect on those to synchronize these processes [4]. The development of these subjects and competences is topic of a great amount of programs of continuing education for teaching staff. By creating enriched learning environments like the one in “mechanics 1/ statics” the involved persons become aware of the described aspects and perceive them as opportunities to deal with them actively.
As the beginning of a degree program is a phase of transition in which a lot of requirements are needed to be coped with, both for the freshmen and professors, our approach is intended to be a reaction with regards to content and methodology to help changing individual and institutional preconditions.
An approach that offers a space in which different experiences are possible: to develop individual learning styles, to learn from each other, to cope with requirements and to experience a culture of feedback that needs to be established by giving feedback and developing forms of helpful one by dealing with a specific subject that is traditionally a part of engineering education.

2. What are the elements of the approach?

2.1 Task- and problem-based learning

Often, the situation in lectures is described like that: The professor is playing an active part by imparting knowledge, the students are sitting in rows, listening or making notes. That often leads to inert knowledge [5] that can’t be adopted or transferred on other issues or problems, learners are being faced with. To avoid these situations teaching and learning in the lecture “mechanics1/ statics” is task- and problem-based in the first place [6]. For most of the freshmen mechanics is a brand-new subject. The first step in dealing with something new is to observe someone who is an expert in that specific topic. The professor can be recognized as a role-model. She knows theoretical backgrounds and is able to apply those on given problems or tasks. The next step is to enable the students to try to solve tasks and problems in groups and individually. By doing so, students are developing both knowledge and problem-solving abilities they can transfer and adapt to other (similar) tasks. They are developing abilities, skills and knowledge in form and content. These success opportunities have a high impact to develop an intrinsic motivated attitude rather than constantly being motivated by external influences. Surveys (n=66) and interviews (n=7) with a selected group of students show, that they highly appreciate that kind of methodological training. Two thirds of the students surveyed are doing their best and giving a go on the problems given for homework.
Six weeks before the exam period, a mock exam is offered (there are no intermediate testings during the semester in Germany). Almost 90 per cent of the students strongly agree to the statement “Due to the mock exam I’m feeling better about what I am going to face in the main exam at the end of semester.”

2.2 Challenging students to take part actively in the process of teaching

Challenging students to independently transfer these acquired skills to other mechanical problems and tasks is helpful. Particularly at the beginning of the semester a lot of students hesitate to take part actively. In most of the other lectures it is not expected that students play an active role in the process of teaching. So, most of them are not used to it. Therefore the professor has to activate the students when necessary, the beginning of the semester is in most cases such a situation. The professor is randomly selecting one or two students who each have to solve a given task or problem until next lecture. Then they have to present their solution at the beginning of the lecture. The professor is urging the students to think out loud while solving the tasks, so the other students get a glimpse of the cognitive processing. The students presenting are getting a valuable feedback of their individual process of understanding and appliance. It is interesting to observe students who are good in explaining right from the beginning and others who are developing these abilities step by step by benefiting from others’ example. Furthermore these experiences can encourage them to form groups in which they learn self-dependently after lecture. About 60 per cent of the surveyed students form groups in which they prepare themselves up to several times per week. It is worth mentioning that in the course of the lecture the number of students, coming voluntarily to the blackboard or interactive whiteboard to take actively part in the lesson is increasing. Students who weren’t very successful in school subjects like math and physics benefit from that kind of activating and model-type learning to a great extent.

2.3 Mechanics and everyday life

When perceiving everyday life through mechanics we will be getting aware in no time that we are literally surrounded by mechanical issues. In almost each lecture students are presented with an open-ended structured "every-day-life" problem to train their perception and approach.
Students are divided into small groups which have to pose their own questions. Posing questions is very difficult for the students but regarded necessary in the process of developing an active attitude towards the subject and applying theoretical knowledge. Because these requests are ambitious, it is helpful for many students to be a part of a group. In a situation of uncertainty it can be inspiring to draw back on others' knowledge and skills. Free riding is a usual problem but lecturers can contain it by monitoring activities within the groups and by encouraging group members to establish strong relations and rules.
Two examples shall illustrate the intended goals:

1. A broomstick is hold by a string and brought in equilibrium. What questions may arouse here? When cut in two at the equilibrium point, will the two parts be of the same weight? Which forces can be determined at the equilibrium point? Only these few questions illustrate the potential. Mathematical and mechanical concepts have to be linked together by the students. As the professor is monitoring the teamwork, she can give hints and tips whenever necessary.
2. This example has a historical background: A roman basilica has to be transformed into a gothic cathedral. The students shall imagine being gothic master-builders. How can they transform a small church into a gothic cathedral, regarding terms like forces, bearings, bearing reactions and free body diagrams.

Selected teams are going to present their conclusions, so the other teams can compare their own results with. Important steps in learning processes are moments of reflections. What is understood so far, what can be applied and transferred to other problems? The engagement with these questions is leading towards deeper processing of knowledge and developing of skills. More than 90 per cent of the surveyed students agree to the statement "These everyday life examples helped me to develop a better understanding of the theory taught".

2.4 Lecture recording

All lectures have been recorded by the staff of University's Information Center during the previous semester. Besides the offered active learning opportunities within class it can be helpful for students to draw upon a conserved form of the lectures. As students of the previous year were almost enthusiastic about these recordings and their possibilities we decided to record the subsequent lecture "mechanics 2" as well. Reported advantages are: "You can rewind crucial moments as often as you like.", "If you miss a lecture you don't really miss, because it was recorded." A reported disadvantage or danger was: "If you don't attend the lecture anymore, because you want to listen only to the recordings, you get a problem with the available time and you miss a lot, because important stuff is happening in the classroom and you have to be really there."
Our original plan was to implement a form of flipped classroom. By the help of sequences of the recordings the students could prepare themselves independently for the lectures held in presence afterwards. That idea was boycotted by the students so far. They favored a traditional form of imparting knowledge.

3. Conclusion and perspective

It is our goal to transfer and adapt the positive experiences made with the described learning approach to other (similar) lectures that more students can benefit from it. It is encouraging to see that more than half of the surveyed students are preparing themselves for other lectures within the learning team they formed during the lecture "mechanics 1/ statics". You have to keep in mind though, that teaching is strongly influenced by individual experiences and beliefs. What works well with one professor in one lecture doesn't have to work well with another. Previous experiences in learning environments that aim to engage students to participate actively has shown, that active learning is demanding compared to just "listening" to a lecture. Though having made good experiences caused by active approaches a lot of students tend to fall back to forms of consuming attitudes when active learning is not challenged and "controlled" externally. It seems that changes of behavior and dispositions happen slowly. We are therefore at the beginning to establish more active and foster hereby self-regulated forms of teaching and learning. The described teaching approach has shown that it is worth trying.

References

[1] Flitner, W. (1982): Warum mehr Arbeitsgemeinschaften? (1920) In: Gesammelte Schriften. 17-19
[2] Faulstich, P. (2001): Deprofessionalisierung des Personals der Erwachsenenbildung und Neoregulierung. In: Bolder, A. u. a. (Hrsg.): Deregulierung der Arbeit – Pluralisierung der Bildung? Opladen, 278-293
[3] Berdelmann, K. (2009): Die (A-)Synchronisation von Zeitstrukturen in Lehr- Lerninteraktionen. In: Berdelmann, K., Fuhr, T. (Ed.): Operative Paedagogik. Grundlegung, Anschluesse, Diskussion. Paderborn. 69-92
[4] Schoen, D. A. (1983): The reflective practitioner. How professionals think in action. New York
[5] Whitehead, A. N. (1929): The aims of education and other essays. New York
[6] Zumbach, J. (2003): Problembasiertes Lernen. Muenster