Making Engineering students think about their study approaches

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ABSTRACT

At the University of Twente a longitudinal project was conducted about the mindset of engineering students on learning and their study behaviour. In the previous phases of this project the study approaches of first year students has been visualized. This showed a difference in study approaches between Mechanical Engineering (ME), Industrial Design (ID) and Civil Engineering (CE) students. The CE students applied surface approaches most frequently while studying, compared to the ME and ID students. During the second phase of this project an intervention was carried out with 47 CE students, focussing on deep study approaches and mindsets about learning. The rest of the CE students acted as a control group, which consisted of 22 students. The intervention was connected to the course of Structural Mechanics. Directly after the intervention students wrote a reflection, and a validated questionnaire was filled in by the students (mindsets and ASSIST) half a year after the intervention. In the short

term the students experienced a positive effect, they indicated that they adopted deep study strategy approach and several students mentioned that the deep study strategies helped them really understanding the content. Unfortunately there were no significant differences on the long term. For future research it would be interesting to investigate the effect of the teaching style on the study behaviour of the students.

1 INTRODUCTION

1.1 Deep and surface learning approaches

Over the years a gap has become visible between university and industry. Students know a lot about the content, but the lack of skills is a common reason for unemployment amongst new graduates [1]. This highlights the importance for students not to only learn disciplinary content but also the soft skills, which are a combination of academic and professional skills such as presenting, writing, teamwork, study skills, and time/project management [2].

In general engineering students love their own disciplinary content, so the problem does not lie with learning in general, but specifically soft skills [2]. However these soft skills remain important during their whole careers. Because when graduates find a job, it is likely they will not keep that same job for their entire career. Nowadays both senior and junior employees switch jobs more regularly then 20 year ago [1], so they have to be flexible and adaptive to learn the new skills and content necessary for their new jobs. Which makes the learning how to learn an important soft skill to have.

How to teach skills education is a highly researched topic, and it is widely accepted that it is an important aspect of a study programme. This does not automatically mean that the importance is also acknowledged by the students. For engineering students, it is shown that they dislike learning the soft skills [2].

When visualising the current study behaviour of engineering students, it shows that attention on the topic is important [3]. The learning approach can be categorised into three categories 1. a deep approach, 2. a strategic approach, and 3. a surface approach. A deep approach focusses on real understanding of the content, and gives meaning to the content. A strategic approach focusses the organisation of learning, the structure of the textbooks, management of time, and a focus on the expectations of the teacher. A surface approach focusses on passing the exam, memorizing the content with no or limited understanding of the content [4].

First year engineering students mostly apply a surface approach of learning, a strategic approach is applied second and lastly a deep approach. When looking at how they want to be taught a different image appears, they prefer to be taught by teachers using deep approaches [3]. The mismatch between their applied approaches and the way they want to be taught could indicate that students would like to apply deep approaches themselves as well, but don’t know how or don’t want to put the effort in themselves.

1.2 Mindsets

When linking effort to learning, a theory that comes to mind is the mindsets theory, by Carol Dweck. A meta-analysis published in 2012 found 113 studies conducted by many authors concluded that mindsets are a significant factor in people's self-regulation toward goals [5]. A person with a fixed mindset beliefs that intelligence is a fixed trait, a growth mindset is the understanding that abilities and intelligence can be developed. When students understand that they can get smarter they put more effort in their studies. Students can change their mindsets from fixed to growth, for example with proper guidance. But how can this mindset be influenced? The Dutch Brain Centred Learning (BCL) institute studied the mindset theory of Carol Dweck [6] and came to the following approach to influence the mindset [7].

1. Give concrete feedback on approach, effort and perseverance (development-oriented feedback), students that were praised for their effort outperformed students that were told they were smart.
2. Show appreciation and stimulate pride on progress and development.
3. Make students aware and proud of mistakes made and that they are part of learning.
4. Stimulate the use of own examples (learning, mistakes, perseverance).
5. Explain the plasticity of the brain; if you believe your brain can grow, you behave differently.

1.3 Study strategies

The aspects listed above are aspects that teachers can take into account when designing their course and communicating with students. But in the end it comes down to the behaviour of the students themselves. Even if students have a growth mindset, they need to know which study strategies work and how to apply them. A surface approach requires less effort than deep approach, but the long term effect is lower [7]. For short term the effect might be more positive result as in passing the exam, but it is questionable if the students would really learn the content. Whether deep- or surface learning occurs also has to do with how they think about learning and their actual behaviour, so the study strategies applied by the students. Therefore it is important to make students aware of the effectiveness of their study strategies.

There are a lot of misconceptions and myths concerning study strategies [9]. Students think they are studying well but often use strategies with little effect, such as rereading. Study strategies that showed a positive result are spaced practice, elaboration, self-explaining, and practice testing [9]. Weinstein and Sumeracki [10] added two more strategies, and wrote about six effective study strategies: 1. Spaced practice, 2. Interleaved practice, 3. Elaboration, 4. Concrete examples, 5. Dual coding, 6. Retrieval practice.

1.4 Intervene

At the University of Twente first year engineering students mostly apply a surface learning approach [3]. Of the three engineering programmes within the faculty of

Engineering Technology, the students of Civil Engineering (CE) apply the most surface approaches. What is seen is that a lot of these students have difficulties with the more fundamental engineering focused courses, such as structural mechanics. Could an academic skills course with a focus on learning, mindsets and study strategies help the students in applying more deep approaches to learning, to facilitate a short term and long term effect?

2 METHODOLOGY

2.1 Setting

This paper describes the second phase of a longitudinal study. During the first phase the starting situation has been visualized, in which 378 students filled in a combination of two validated questionnaires. The result showed that the CE students applied the most surface approaches during studying (in comparison with the ME students and ID students [3]). In the fourth quartile the CE students could choose between 4 different academic skills activities: improving writing skills, research skills, time management or study skills. Each topic was shortly explained during an introduction lecture, after which the students could notify their decision. 47 students chose to participate in the study skills activities.

2.2 Intervention

At the end of their first year, 47 students joined the intervention, consisting of 8 (weekly) workshops related to study skills and strategy. The workshops consisted of a combination of theory to create more awareness of study skills and strategy, and exercises to practise these techniques. Subjects addressed during these workshops are i) study strategy per individual, ii) how do people learn, iii) motivation iv) efficiency, v) concentration & focus, vi) dealing with set-backs, vii) time management and viii) exam preparation. All with a relation to the course of Structural Mechanics, realizing that the student could simultaneously apply the knowledge and exercises in a real course. When discussing relevant study strategies, the six strategies of Weinstein and Sumeracki [10] were given.

2.3 Instruments

To collect data, two different types of instruments have been used: questionnaires and reflections written by the students.

Validated questionnaires

For data about the long term effect two validated questionnaires have been combined into one, namely the mindset questionnaire and the ASSIST questionnaire. The mindset questionnaire is based on the theory from Carol Dweck [6]. The questionnaire consist of 16 multiple choice questions, about views on intelligence and talent. Students had to answer the questions on a 6 point Likert scale. The ASSIST questionnaire [8] consists of 60 multiple choice questions. Students had to answer the questions on a 5 point Likert scale. 52 questions were about the study approached applied by the students and 8 questions about the preferred teaching style.

Reflections

At the end of the quartile the students finished an assignment in which they reflected on whether their knowledge on the theory behind the subjects has increased, they became more aware of their own study strategy and skills (strengths and weaknesses) and whether they experienced and increase in their capability of applying this in their studying.

2.4 Analysis

The pre- and post-questionnaire were the same questionnaire, which made it possible to do a good comparison. The results of the pre- and post-tests have been statistically analysed. For this analysis the averages, standard deviations and/or correlations have been visualised for the following questions:

- Is there a change in the mindsets and study approached applied?
- Is there a correlation between the applied study approaches and the preferred teaching style?

These results are then linked to the reflections written by the students were possible. In the analysis of the reflection the focus was on their mindset, applied study strategies, and the experienced effect of their study behaviour.

3 RESULTS

At the moment of the pre-test survey, 80 students were in the Civil Engineering programme. Those 80 students received the pre-test survey of which 56 completely filled in the survey. This is a response rate of 70%, which is quite high and suggests the sample (56 out of 80) is representative. Quite some of them dropped out after the first year. For students who filled in the survey, 29% (16 out of 56) dropped out. From the remaining 40 students, 50% (20 out of 40) also completely filled in the post-test survey. This response rate is still significant, although somewhat lower than expected. Of the 20 students that filled in the pre- and post-test 14 participated in the intervention and 6 students were in the control group.

3.1 Changes in study approach

To indicate changes in study approaches we looked at the paired scores of the post and pre-test. As expected, the paired scores show a positive correlation (between 0.5 and 0.8, except for the deep preference for which the correlation is less strong). The variation in the differences of the scores are generally smaller than in the scores themselves. The distribution of the differences basically peak around the average difference with a few large negative and positive differences. In any case, due to the limited range of possible outcomes, the distribution of sample means quickly converges to a normal distribution when the sample size increases. In Figure 1, the variation of the differences between the pre-and post-test are visualised for the whole sample, where light grey represents the differences of the deep study approach, dark grey of the strategic study approach and black of the surface study approach. It can be seen that the differences between the pre-and post-test are small, mostly between

-1,99 and 2 points. As a result, sample means and standard deviations (of the mean) are good indicators to represent the distributions. There was no significant difference between the group who participated in the intervention and the group who did not. The control group of 6 students is simply too small for any meaningful comparison.

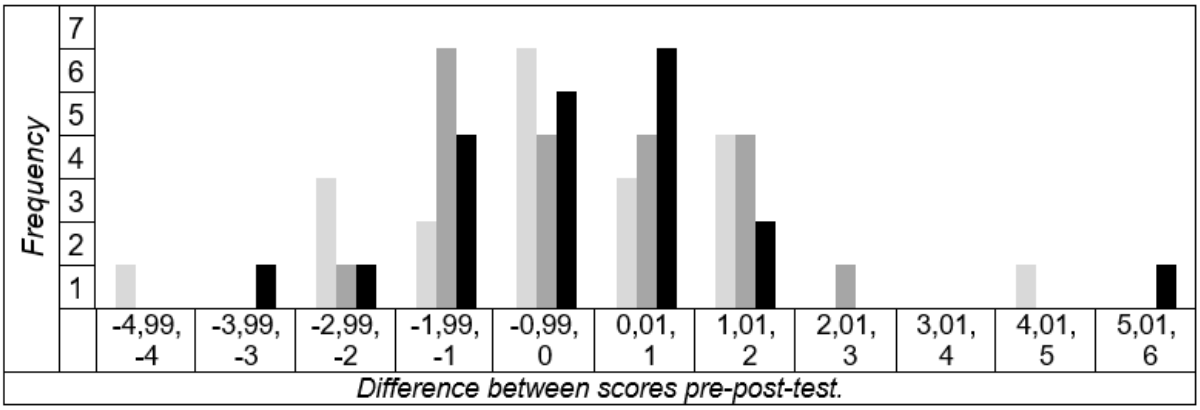

Figure 1. The variation of the difference between the pre- and -post test for the study approaches.

Table 1. shows the results of the paired differences. The first two rows (without and with intervention) shows the sample means and standard deviations of the mean. The lower two rows show the respective standard deviations of the differences. On average the result appear to show the opposite effect of what was strived for, students started applying less of the deep approach and more of the surface approach. However, the results are not statistically significant. In short, we cannot conclude that there is any difference between intervention and non-intervention. Moreover, there is no statistical evidence that students changed their preference or strategy over time.

Table 1. Averages and standard deviation of the differences (pre-post)

	Study approach			Preference	
	Surface	Strategic	Deep	Surface	Deep
Average no intervention	-0,71±0.44	0,67±0.46	0,71±0.48	-0,50±0.34	-1,00±0.63
Average intervention	0,32±0.52	-0,37±0.37	-0,50±0.57	0,64±0.86	0,21±1.18

The correlation between the study approach applied and the preference to be taught using a deep approach appears to have become stronger, see Table 2. For the group who did the intervention the correlation went from 0,45 to 0,86. The correlation for applying a surface approach and preferring a surface approach of teaching became less, it went from -0,64 to -0,30. Although results from Table 2 suggest that approach and preference for deep learning are better aligned after the intervention, the sample size is too small to conclude this with enough confidence. The only conclusion we can draw, is that after the intervention the correlation is significant for deep learning (i.e., significantly different from 0 with a significance level of 0.05), while this is not the case for the pre-test situation.

Table 2. Correlations between preference and study approach

	Deep approach – deep preference		Surface approach – surface preference	
	Pre-test	Post-test	Pre-test	Post-test
Total	0,37	0,61	0,03	0,11
No intervention	0,49	0,57	0,36	0,32
With intervention	0,45	0,86	-0,64	-0,30

3.2 Mindsets

No correlations was found between the scores of the pre- and post-test of the mindset with the approaches they applied. When solely comparing the averages of the group that participated in the intervention with the control group, it is shown that before the intervention both groups were almost equal (with intervention 4,7, without 4,6). After the intervention the group that participated in the intervention moved one category up towards a growth mindset (see Table 3). Category 1 is a completely growth mindset and category 8 is a completely fixed mindset.

Figure 2. shows the scores in the pre-test (in grey) and the scores of the post-test (in black) of the group that participated in the intervention. The distribution over the categories grew, and on average they scored a bit more towards the growth mindset. However, again this result is not statistically significant. In the reflections, all but one student indicated that they had a growth mindset. The one student said that he was in the mix of both a growth and fixed mindset. The mismatch between the scores of the post-test and the reflections could mean that they can't categorize themselves properly, or not all students could not retain their growth mindset over time.

Table 3. Averages of mindset categories

	Pre	Post
Whole group	4,6	4,4
Did not participate in intervention	4,7	5,0
Did participate in intervention	4,6	4,1

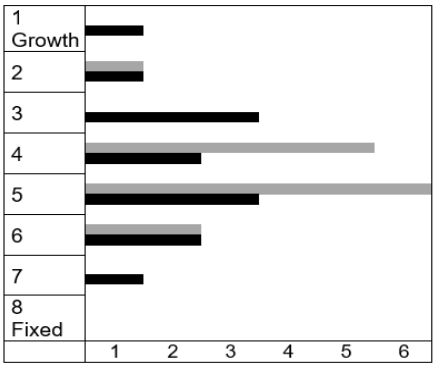

Figure 2. distribution of scores on growth and fixed mindset.

3.3 Study strategies

Of the fourteen students who participated in the intervention and filled in both the pre- and post-test, thirteen wrote a reflection. In this section the results of those thirteen reflections are presented. In these reflections most students indicated that they applied mostly a strategic approach (see Figure 3). Three students indicated that they combined two approached. In the reflections three students wrote that they

did not change their study strategies while participating in the intervention. The other students did change something in their studying. During the intervention six study strategies were discussed. Figure 4 shows how many students used these strategies. Five students commented that applying these study strategies helped them in really understanding what they were doing. One student explicitly added that it gave him more confidence. There was a big variation in which strategy they found most useful. Eight students experienced a positive effect of changing their study strategies, three were neutral and one student experienced a negative effect. The student who experienced a negative effect indicated that he did not put in as much effort as he normally would put in, because he did not need to pass the course before summer to continue with his studies.

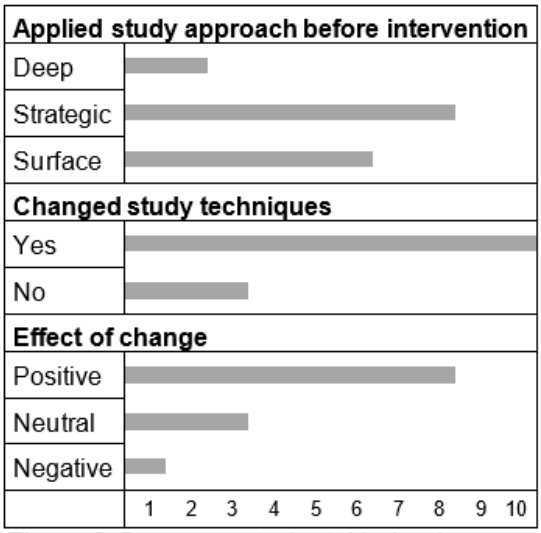

Figure 3. Summary students' behaviour

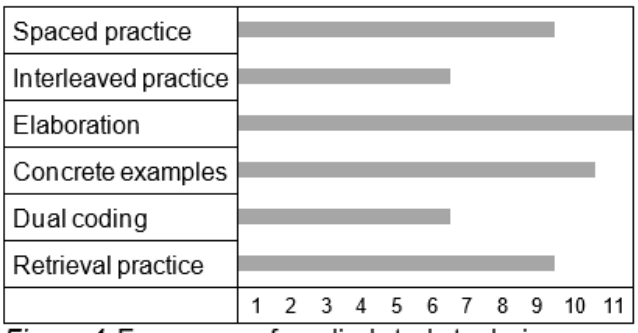

Figure 4. Frequency of applied study techniques

4 CONCLUSION AND DISCUSSION

4.1 Conclusion

The question that was asked was: could an academic skills course with a focus on learning, mindsets and study strategies help the students in applying more deep approaches to learning, to facilitate a short term and long term effect? The answer to this question is not one sided.

When looking at the short term effect, visualised in the reflections the intervention can be seen as a success. The intervention was intensive, eight meetings in a period of ten weeks. Most students said they experienced a positive effect, and that they changed their study approach towards a deep study approach. They wrote that they saw the relevance of the learning strategies. A comment written often was that the change in applied study strategies helped them to really understand the content instead of just applying the tricks, which was exactly the goal of the study. When asking the students about their mindsets, they all said that they had more of a growth mindset then before the intervention.

Half a year after the intervention, the questionnaires were distributed to test the long term effect of the intervention. Unfortunately no significant changes were visible on the long term, so no hard conclusions can be drawn about the long term effects. The intervention did not succeed in letting students apply more deep learning approaches and fewer surface approaches in the long run.

When looking at the mindsets, a small long term effect is visible. The students who participated in the intervention on average moved one category towards a growth mindset. Whereas students in the control group remained the same as in their first year, but these changes are not significant.

The effect that was seen and experienced by the students on the short term did not stay for the long term, which is a pity. Providing a onetime course is not the solution for the problems students (and teachers) experience about the study behaviour of the students. If the topic of study strategies is integrated into the curriculum in a more prominent manner, and repeated several times maybe this could have a positive effect on long term effect. So a recommendation would be to make study strategies a permeant topic in Engineering curricula.

4.2 Discussion

When interpreting the results, some aspects have to be taken into consideration. One of the things that limits the generalization of the results is the small amount of respondents that filled in both the pre- and the post-test. It was proven difficult to let students fill in the questionnaire, even when reminding them during lectures. For stronger conclusions, a larger sample size would be necessary.

Another discussion point that the focus was on the students, but as indicated in the introduction the way of teaching has an effect as well [7]. The variable of how is being taught has not been taken into account. It would be interesting for future research to investigate the effect of the teaching style on the study behaviour of the students.

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