Students' perception about mechanical stress and what is most important for learning, during a practical task, using digital interactive lab description.

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ABSTRACT

This study investigated student's knowledge about mechanical stress using material created by the authors of this text. The material was an interactive lab description which can be used as an aid for teachers when teaching solid mechanics. During the studies in upper secondary school in Sweden, students at the technology programme take a general introductory course in mechanics. The participants consisted of four classes from one school in Sweden. They answered a questionnaire before and after the solid mechanics task, 85 out of 107 students answered both questionnaires. A thematic analysis was applied on the material, resulting in 6 groups based on the students' previous knowledge and how much they have learned. To find correlations between the different groups a Oneway Anova analysis with multiple comparison post hoc test was performed. No significant differences were found between groups and how the students rated importance of their preparation, lab description, interactive links, formula book, course book, the teacher or execution of the lab. Significant differences between groups and class, and between the class and the importance of the teacher were found. The teachers' role was most important of all the categories in all classes while the lowest was the course book and the digital links. This study showed that the teacher was important for the students' perception of solid mechanics during this lab and that the interactive lab description played less roll.

Key Words: technology, solid mechanics, practical task, interactive links, learning

1. INTRODUCTION

The technology course is mandatory in Sweden and is studied in all nine years of compulsory school. It has a broad curriculum where students are introduced to both the engineering aspect as well as to the importance of technology in daily life. The course also highlights, among other things, different technological advances done in the past as well as the importance of stable constructions (Skolverket, 2019a). At the end of the compulsory school, students apply for an upper secondary school programme and about 8.4% choose technology (Skolverket, 2023b). In

the program all students study a compulsory introductory course that includes ethical perspectives on technology, and the technical properties of materials among other things.

Solid mechanics has played an important role in the technology course plan and even though its role may have lessened it is still widely used when teaching material calculations. Materials is a big aspect and still play a big part of the technology course criteria's (Skolverket, 2022). Teaching is an activity of great complexity and the role of the teacher for student learning is well established (eg. Darling-Hammond, 1996). This role may concern, for example, relational aspects where a good teacher-student relationship support student learning (Hirsch, 2021). Furthermore, the teacher's attitude towards the subject is also of importance, previous studies have shown that teachers usually do not teach subjects they have no or less confidence in (Holroyd and Harlen, 1996)

A didactical model may be used to explain and reason about the different teaching approaches that a teacher may conduct. The teaching approach depends on the context that is to be taught (Wickman, Hamza & Lundegård, 2018). This is also discussed by Hattie (2003). The didactical model should not only be used when planning and conducting a lesson but also in its evaluation (Jank & Meyer, 2003).

Many studies have investigated how digital aids can help students performing practical tasks (Barrow & Rouse, 2009; Karlsudd, 2014; Usulu & Usulu, 2021). An international study reported that the better adapted a digital aid is for the students, the less stress they feel during practical tasks. (Inquimbert, 2019). Thus, an interactive digital material was constructed specifically for a lab experiment involving strain and stress. Additionally, earlier research conducted by the main author (2019a) showed that the attitude the teachers have when approaching solid mechanics during lessons was important for the students learning. In the study some challenges regarding teaching solid mechanics were identified. The present study focused on one of these challenges, namely the learning of new terms and concepts like stress and strain. It was designed to evaluate the impact of digital support on students learning also considering the role of the teacher.

2. AIM

The aim of this study was to evaluate a material designed to support student learning. More specifically:

- What do students know about mechanical stress before and after doing the experiment?
- What do the students perceive as helpful in the material in their learning about mechanical stress?

3. METHOD

3.1. Participants

The participants consisted of 107 students, in four different classes all studying at one school in Sweden, and all classes had different teachers. None of the participants had any previous knowledge of solid mechanics. All the students got two forms with identical questions to answer, one before the experiment and one after, 85 students answered both forms. Before the lesson the students were informed that the participation in the study was voluntary and that the answer to the questionnaires were anonymous. The ethical advice and rules for the Swedish research council where followed (Vetenskapsrådet, 2017).

3.2. Experiment

An interactive lab description of a tensile test was designed and implemented. The questions to the students shortly described the term so that the students would remember from earlier studies in grade school. The questions were as follows:

(i) Mechanical stress occurs in a material when you try to pull out the material so that it becomes longer. Mechanical stress is force pushing on a surface that is perpendicular to the force. What do you know about mechanical stress?

(ii) Strain occurs when pulling a material. Strain is how much you extend a material relative its original length. There is a relation between strain and elongation. What do you know about this relation?

(iii) Stress and strain relate to each other. When you draw a graph (curve, as a mathematical function with appearance f(x)= x) that describes the relationship between mechanical stress and elongation, you get a certain appearance that is unique for the material being studied. What do you know about the graph? What does it describe?

The students were also asked to rate the importance of different learning aspects on a scale where six was the most important and one was the least. The options they had were; their own preparation, the lab description, the interactive links, formula booklet, course book, the teacher, and the execution of the lab.

3.3. Thematic analysis

A thematic l analysis (Braun and Clarke, 2006) was used to find groups among the students depending on how they experienced mechanical stress. Significant statements phrases and sentences where extracted. Different themes where generated where statements with similar meaning were put together to form themes. Themes where then summarized and described. Six groups of students (Perception group1-6) with different themes were identified during the analyses. The different groups had different perceptions of mechanical stress before and/or after the performed task.

3.4. Statistical analysis

A Oneway Anova with multiple comparison post hoc test (Ostertagova et al., 2013) was used to find associations and relations between the different groups generated in the thematic analysis. The mean and standard deviation for the students' ratings were also calculated. The statistically significant relations between classes, the perception groups with the same theme, and what the student rated of importance was investigated.

4. RESULT

In table 1 the results from the thematic analysis are described; student answers are used for exemplifying the perception group descriptions. In three of the four classes most students were found in perception group one. Most of the students (perception group 1) learned less than we hoped and even though the provided material was some help it was not the most important thing compared to many other factors.

Table 1.
Groups of students with different perception on mechanical stress.

Perception group	Example of an answer before the task	Example of an answer after the performed task
Group 1 **Before the task: Students know nothing, or very little, about mechanical stress, strain, or about the relationship between the two. They expressed this by writing things that were wrong or by not writing anything at all.** **After the task: Students express some understanding of the concept mechanical stress but no or very little understanding of what how affects material or the relationship to strain. They could also have expressed some understanding of the relationship but nothing about the concept of strain.**	"No idea, no clue, do not know"	"It's the power divided by the area in mm^2." "nothing, doesn't understand what I should have realized with the graph"
Group 2 **Before: Same as group 1** **After: Express some understanding of mechanical stress, strain and the relationship between them.**	"Nothing, nothing special"	"It depends on epsilon and the stress." "It is the mechanical stress. Elasticity".
Group 3	"Looked a little at it. I know F/A = some stress. Beyond	"I know now that F/A = stress. Thus, when

Before: Express some understanding of the concept mechanical stress. **After: Express some understanding of strain and the relationship between strain and mechanical stress. The student also expresses an understanding of the concept mechanical stress.**	that I do not know more." "I know there is a relation between them. I do not know how you use it or what equation I should use." "I know that the graph probably gets a bigger y value the more stress you have and enough stress result in that the material will break." "It depends a lot on different material."	you pull a material the stress will increase depending on how big area you have." "I know now that strain is depending on the elongation and the original length of the material you had." "I know that the graph descries the correlation between stress and strain."
Group 4 **Before: Express an understanding of the concepts mechanical stress and strain and the relation between them.** **After: They do not express any difference in understanding before the task as compared to after the task.**	"A force on object that you pull." "A Rubber band." "But I do not know more about this." "Do not know anything but my guess is that there is a relation between the length of the material and the force you pull with. There is also a relationship with what material it is. Rubber can stretch more than stone." "Have absolutely no idea."	"An object is stretched when a certain stress occurs on the object. The more stress, the more strain." "It describes the relationship between the strain and stress."
Group 5 **Before: Express no understanding of the concepts stress and strain or the relation between them** **After: Express no understanding on the concepts stress and strain or the relationship between them.**	"Nothing". "The stress increases when you stretch something. " "High stress means that the object you are pulling stretches a lot." "Proportional increase in the graph."	"Mechanical stress in a material occurs when you try to pull out the material so that it becomes longer." "Stress is a force that is applied on a surface that is perpendicular to the force." "Proportional relation. It should be equally constant."
Group 6 **Before: Express some understanding of the concept mechanical stress** **After: No difference in understanding after the task than before.**	"Mechanical stress in a material occurs when you pull a material, so it gets longer."	"You calculate stress by F/A = the force divided by the area."

Table 3 presents the results from the One-way Anova analysis. There was not much difference in importance between for example teacher and digital links. However, there were significant differences between groups of students with different perceptions and different classes they

belonged to ($p<0.01$) and, for the group versus teacher and the digital links, see table 4. For two groups, one and six, the teacher seemed to be of greater importance than for example the digital links ($p<0.05$). There was no significant difference between groups in the rating of the links but in the rating of the teacher ($p<0.05$).

Table 2.
Number of students in the four classes divided in the different perception groups.

		Groups						Total
		1	2	3	4	5	6	
Classes	1	11	4	5	0	6	2	28
	2	11	2	2	0	2	1	18
	3	16	1	0	0	3	5	25
	4	2	0	3	2	3	4	14
Total		40	7	10	2	14	12	85

Table 3.
The importance of different aids during the lab for the different perception groups, rating 1-6 where 6 was most important.

Groups	Own preparation	Description of lab	Interactive links	Formula book	Course book	The teacher	Execution of the lab
Total	2.76	2.51	2.96	2.78	3.25	2.79	3.24
Mean Std	0.56	0.76	0.47	0.45	1.16	0.74	1.16

Table 4.
The importance of a) The digital links for the different groups b) The teacher for the different groups. Rated 1-6 where 6 was the most important.

Groups versus digital links	Mean	Std.
1	2.60	1.73
2	2.26	1.97
3	2.91	1.92
4	3.71	2.56
5	3.33	2.58
6	2.92	2.07
Groups versus teacher	Mean	Std.
1	4.25	2.12
2	2.00	1.83
3	2.83	1.70
4	2.25	2.32
5	2.39	1.98
6	3.00	1.99

5. DISCUSSION AND CONCLUSION

The present study found a correlation between the importance of the teacher and which class the student belonged to when learning something new. However, there was no significant correlations between the student perception groups and the importance of the digital links nor the class they belonged to and the digital links.

The result implies that the teacher was very important for the outcome of the task and depending on which specific teacher the student had the teacher was more or less important.

This might have been due to that teaching is a very complicated task (Darling-Hammond, 1996) and that the relationship between the teacher and student is important for learning (Hirsh, 2021). Thus, we think the importance of the teachers dominated in our study and thus other significant differences might not have been not seen. Maybe with less help from the teachers we could have investigated how much help the digital aids gave to understand the concepts stress and strain. It might also be that the teachers facilitated the use of the digital aids and the students rated this as teachers' importance (Collison and Cook, 2013). The importance of using the digital links and exactly how it is used thus needs to be further investigated.

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