



Relationships among Civil Engineering Students' Approaches to Learning, Perceptions of the Teaching–Learning Environment, and Study Success

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Abstract: This study examines the relationship among civil engineering students' approaches to learning, their perceptions of the teaching–learning environment, and their study success. The aim was to identify civil engineering students' approaches to learning and how their approaches to learning are related to their perceptions of the learning–teaching environment and their study success. The data of the study consist of the students' answers to a questionnaire ($n = 215$) and their study success data ($n = 204$), which were gathered from their university's study register. The study success data consist of the cumulative study credits and weighted averages of their course grades. The students were classified into four clusters according to their approaches to learning. Differences in their perceptions of the teaching–learning environment and study success between the clusters were statistically significant. Students who belonged to clusters that emphasized the deep approach to learning experienced their teaching–learning environment more positively than did other students. Students who belonged to clusters emphasizing organized studying earned more credits and higher marks in their studies than did other students. DOI: [10.1061/\(ASCE\)EI.1943-5541.0000343](https://doi.org/10.1061/(ASCE)EI.1943-5541.0000343). © 2017 American Society of Civil Engineers.

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Introduction

Since the 1970s, students' approaches to learning have been one of the main topics in research on learning in higher education after Marton and Säljö (1976) identified the deep and surface-level learning processes (Baeten et al. 2010). Later, Entwistle and Ramsden (1983) embraced a wider concept called an “approach to learning,” which includes not only the learning process, but also the intention to learn. Students' approaches to learning are usually divided into deep and surface approaches (Biggs 1979; Entwistle and Ramsden 1983; Marton and Säljö 1976, 1997). Previous studies (Entwistle 2009; Entwistle and McCune 2004) have also identified a third approach, called “organized studying.” This research tradition, known as students' approaches to learning (SAL tradition), examines differences in how and why students' engage in learning.

This study focuses on civil engineering students' approaches to learning at a University of Technology in Finland. The purpose of the study is to uncover new knowledge about the relationships among civil engineering students' approaches to learning, their perceptions of the teaching–learning environment, and factors that affect students' study success in higher engineering education. Exploring these relationships is important because previous studies have shown that approaches to learning are related to students'

perceptions of the teaching–learning environment (Kreber 2010; Parpala et al. 2010; Richardson 2005) and study success (Asikainen et al. 2013; Erkkilä 2009; Lizzio et al. 2002; Rytönen et al. 2012). Studies on students' approaches to learning has covered a broad range of disciplines, but to the authors' knowledge, few researchers have studied approaches to learning among engineering students. This study aims to fill this gap in the research on the SAL tradition. SAL tradition studies in the context of engineering education have mainly focused on students' approaches to learning at an individual course level (e.g., Richardson and Newby 2006; Salmisto and Nokelainen 2014). This study focuses on civil engineering students' approaches to learning at a degree level and takes into account study success during a longer period than one course. In this research, the used students' study success data consist of the cumulative study credits and weighted grade-point averages (GPA). The objectives of the study are to investigate civil engineering students' approaches to learning at a University of Technology and the relationship among the approaches, students' perceptions of the teaching–learning environment, and their study success.

Based on previous studies, the research hypothesis is that higher engineering education leads students to the strategic execution of their courses and encourages them to adopt the surface approach to learning. Some researchers have found that teachers in the hard sciences, such as engineering, tend to adopt a more teacher-centered approach to teaching than teachers in the soft sciences (e.g., Nevgi et al. 2009; Lindblom-Ylänne et al. 2006; Lueddeke 2003). Teachers' approaches to teaching and students' approaches to learning are related. If the teacher is teacher-centered, this method of teaching promotes students' surface leaning. If the teacher adopts a student-centered approach to teaching and the learning promotes conceptual change, the teaching will more likely support the adoption of the deep approach to learning (Prosser and Trigwell 1999; Trigwell et al. 1999). The aim of teaching in the hard sciences could be only to disseminate the content, which may promote the surface learning process. According to Erkkilä (2009), students' organized

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studying correlates positively with their study progress at Finnish universities of technology.

The research questions of the study are as follows:

- What kind of approaches to learning do civil engineering students at a Finnish University of Technology adopt?
- How do civil engineering students perceive their teaching–learning environment and how are their approaches to learning related to their perceptions of the teaching–learning environment at a Finnish University of Technology? and
- How are civil engineering students’ approaches to learning related to their study success at a Finnish University of Technology?

In Finland, the engineering education system is different than that in United States and many other countries. Two kinds of schools are recognized, Universities of Technology and universities of applied sciences. Universities of applied sciences award 4-year Bachelor of Engineering degrees, which aim to develop professional competency with less emphasis on scientific content. Universities of technology, on the other hand, award Bachelor of Science in Technology and Master of Science in Technology degrees. These degrees emphasize content that is more scientific. Completion of the Bachelor of Science degree takes 3 years of full-time studying, whereas the Master’s degree can be completed in 5 years. This research focuses on engineering education in a Finnish University of Technology. In the present study, these more scientific engineering studies are referred to as a higher engineering education.

Theoretical Framework

Students’ Approaches to Learning

Research on students’ approaches to learning (SAL tradition) is usually based on students’ own perceptions in a specific learning environment or learning situation (Baeten et al. 2010; Biggs 1987, 2001; Entwistle et al. 2006). Marton and Säljö (1976) emphasized the importance of not only student-centered teaching, but also the students’ approach to learning in a high-quality learning process. Marton and Säljö (1976) investigated differences in how students approached a specific learning task. Some students used a deep-level learning process, which was related to their intention to understand the learning task. Other students used a surface-level learning process to reproduce the learning material. In the deep-level learning process, the learner analyzes the learning tasks and tries to understand them as a whole. In the surface-level learning process, the learner focuses on the content of the learning task with the intention to remember the content in order to reproduce the learning material as it was presented.

The combination of intention to learn and level of the learning process is referred to as an approach to learning (Baeten et al. 2010). The deep approach to learning is related to understanding the subject and consists of the intention to understand as well as an active and critical approach to learning (Entwistle et al. 1979; Entwistle and Ramsden 1983). Students’ strong self-regulation skills are also related to the deep approach (Nieminen et al. 2004). The surface approach to learning is related to memorizing and reproducing the content of the study materials without understanding. A lack of regulation (Nieminen et al. 2004) and students’ inability to see relations between ideas (Meyer 1991) are related to the surface approach. The third approach, organized studying, describes how students organize their studying and manage time (Entwistle 2009). Students who adopt organized studying complete their courses (systematic and organized) on time and are well aware of the demands for completing them. Organized studying is also related to students’ motivation and learning skills

(Entwistle 2009; Entwistle and McCune 2004; Entwistle et al. 2001). The deep and surface approaches to learning describe students’ ways of handling the learning tasks, whereas organized studying refers to the ways in which students plan and organize their learning (Biggs 2001; Lonka et al. 2004).

Some researchers have explored various combinations and weightings of these approaches (Lindblom-Ylänne 2003; Lindblom-Ylänne and Lonka 1998; Meyer 1991, 2000; Parpala et al. 2010). The combination of the approaches may be coherent, as in combinations of the deep approach and organized studying (Lindblom-Ylänne and Lonka 1998; Meyer 2000). On the other hand, some researchers have found combinations that are theoretically conflicting. Such combinations contain elements from both the deep and surface approaches (Lindblom-Ylänne 2003; Lindblom-Ylänne and Lonka 1998; Meyer 1991, 2000; Parpala et al. 2010).

Relationships among Approach to Learning, Learning Environment, and Study Success

Several studies have identified a relationship between students’ approaches to learning and their perceptions of the teaching–learning environment. Students’ positive perceptions of the teaching–learning environment are related to the deep approach, and more negative perceptions to the surface approach (Kreber 2010; Lawless and Richardson 2002; Parpala et al. 2010; Richardson 2005; Sadlo and Richardson 2010). According to Parpala et al. (2010), students who apply a higher level of the deep approach perceive their teaching–learning environment most positively from the perspectives of constructive feedback, interest and relevance of their courses, support from other students, teaching for understanding, staff enthusiasm and support, and alignment of teaching. Students applying a surface approach, on the other hand, perceive these factors negatively. In addition, Kyndt et al. (2011) found that the surface approach relates positively to perceived workload and task complexity, whereas the deep approach relates negatively to these factors.

There are different views on how students’ approaches to learning vary in different contexts, e.g., when student is carrying out a specific learning task or when student is immersed in a specific learning environment. According to Fransson (1977), context affects students’ approaches to learning. On the other hand, according to Entwistle and Ramsden (1983), approaches to learning are quite stable, because students develop the habit of learning a certain task in a certain way. Moreover, researchers in later studies have also found conflicting results. Some of these studies suggested that approaches to learning are context-specific and can vary across learning environments (Baeten et al. 2010; Nieminen et al. 2004; Postareff et al. 2015; Vermunt 2005, 1998), whereas other studies argued that approaches to learning can be quite stable and consistent across contexts (Lietz and Matthews 2010; Zeegers 2001). Lietz and Matthews (2010) found that the deep and surface approaches are quite stable, but that the organized approach changes over time and across contexts. Lindblom-Ylänne et al. (2013) recently suggested that approaches show individual differences in stability. Some students seem to adopt the same approach in different contexts, whereas other students seem more vulnerable to the effects and demands of the teaching–learning environment and therefore change their approaches to suit the context.

Students’ approaches to learning also differ across disciplines (Lonka and Lindblom-Ylänne 1996; Parpala et al. 2010; Smith and Miller 2005; Vermunt 2005). Students in the natural sciences adopt a surface approach more often than students in the humanities or social sciences, who more often adopt a deep approach to learning (Entwistle and Ramsden 1983; Lonka and Lindblom-Ylänne 1996; Parpala et al. 2010; Smith and Miller 2005).

In addition, research has identified a relationship between approaches to learning and learning outcomes, namely that compared to the surface approach to learning, the deep approach leads to higher-quality learning outcomes (Marton and Säljö 1997; van Rossum and Schenk 1984; Trigwell and Prosser 1991; Ramsden 1992; Prosser and Millar 1989). On the other hand, Asikainen et al. (2013) suggested that study success in university studies and high-quality learning outcomes do not necessarily correlate positively because assessment does not always measure deep learning, but might focus instead on measuring only factual knowledge. For example, Lizzio et al. (2002) found that the surface approach related positively to study success, and Rytönen et al. (2012) found that organized studying proved more important to success in university studies than a deep approach.

To summarize the theoretical section, previous studies have presented different views regarding how students' approaches to learning are related to the students' perceptions of the teaching–learning environment and study success. There is a need for the further studies. Especially in the field of engineering education, only a few studies have focused on students' approaches to learning. This study fills this gap in SAL tradition research. In the current study, three aspects were taken into account: students' approaches to learning, students' perceptions of the teaching–learning environment, and study success.

Method

The study was conducted at a University of Technology in Finland. The research data were collected in 2012 and 2013 with a HowULearn questionnaire developed for the Finnish context at the Helsinki University Centre for Research and Development of Higher Education (Parpala and Lindblom-Ylänne 2012). The HowULearn questionnaire was developed based on the Experiences of Teaching and Learning questionnaire (ETLQ) (Entwistle 2001) and the approaches to learning and studying inventory (ALSI) (Entwistle and McCune 2004). Many studies in Finnish university contexts have shown the HowULearn questionnaire's reliability (Parpala and Lindblom-Ylänne 2012); the questionnaire assesses students' approaches to learning and their experiences of the teaching–learning environment as well as provides information for the development of teaching quality (Parpala et al. 2010). The HowULearn questionnaire consists of 22 items on students' perceptions of their teaching–learning environment and 12 items on students' approaches to learning. Study participants responded to the questions using a five-point Likert scale ranging from “agree” to “disagree.”

Participants

Altogether, 215 students responded to the questionnaire: 53 (24.7%) women and 162 (75.3%) men. The ratio of female to male respondents corresponds to the ratio of female and male students at the university. Of the 215 students, 169 (78.6%) respondents were studying civil engineering and 46 (21.4%) respondents were studying in other disciplines (architecture, materials engineering, industrial engineering and management, automation engineering, information management, or mechanical engineering). The students completed the questionnaires during learning events in the three civil engineering mass courses. The respondents covered second-year to sixth-year civil engineering students ranging in age from 19 to 50 (average age of 22.9).

The research data also consist of information on the students' study success, namely their cumulative study credits and GPA for every semester from August 2005 to January 2014. The study

success data were gathered from the university's study register in January 2014. Because students in Finnish universities have a life-long permission to study, some students' studies are prolonged. For this reason, the studying success data used in this study consist of information on the students' study success already from the year 2005. Study success data were available for 208 students who answered the HowULearn questionnaire. However, four students had completed no courses during that period, so data on these students were excluded from the analyses. Thus, answers and data from 204 students were analyzed.

Statistical Analyses

First, cross tabulation and the chi-square test were used to analyze the similarities between civil engineering students and students from other disciplines. The analyses revealed no statistically significant differences between the groups in terms of their approaches to learning or perceptions of the teaching–learning environment. Therefore, the entire data set was analyzed as a single sample.

Exploratory factor analyses (maximum likelihood with oblimin rotation) served to test how the HowULearn questionnaire functioned with the data collected from engineering students, and Cronbach's alphas were calculated to estimate the internal consistency of the factor solutions. The factor analyses were applied to two parts of the questionnaire: students' experiences of their teaching–learning environment and students' approaches to learning sections.

After the factor analyses, students' approaches to learning were analyzed with *k*-mean cluster analyses using factor scores for each factor, and the clusters were compared in terms of students' perceptions of the teaching–learning environment and study success with univariate ANOVA. First, the relationship between clusters and explanatory variables (gender, age, discipline, and study year) was analyzed with cross-tabulation analyses. The analyses revealed no statistically significant differences between the clusters and explanatory variables. Univariate ANOVA served to explore any differences in the students' perceptions of the teaching–learning environment resulting from the different approach clusters. ANOVA also served to analyze any differences between the clusters in terms of the study success variables (earned credits and GPA).

The sample size of the study ($n = 215$) is sufficient for the used multivariate methods.

Sample size (N) to simultaneously analyzed variables (p) ratio should be close to $20N:1p$ (Hair et al. 1995). In this study, the maximum number of simultaneously analyzed variables was five, so technical minimum sample size requirement is $20 \times 5 = 100$, which is smaller than the sample size of current study ($n = 215$). Although this technical requirement is fulfilled, the generalization effect should also be considered, that is, the power of the analyses. Murphy and Myors (1998) suggested application of the following formula to estimate sample size needed to allow generalizable results: $n = N/1 + N(e)^2$ (where N = population size and e = sampling error, usually set at 5%). Because the population of students to whom the results of this study are intended to be generalized is 420, application of the formula yields i of 205, i.e., $420/[1 + 420 \times (0.05)^2]$, which is below the sample size of this study. In addition, all reliability tests showed that used data is acceptable for the analyses.

Results

Students' Approaches to Learning

The results of the exploratory factor analyses (maximum likelihood with the oblimin rotation and Kaiser normalization) suggested a

Table 1. Rotated Factor Matrix of the Section on Students' Approaches to Learning

Item	Factor		
	1	2	3
1. I have often have trouble making sense of the things I have to learn.	—	0.681	—
2. I put a lot of effort into my studying.	0.611	—	—
3. Much of what I've learned seems no more than unrelated bits and pieces.	—	0.387	—
4. On the whole, I've been systematic and organized in my studying.	0.797	—	—
5. Ideas and perspectives I've come across while I'm studying make me contemplate them from all sides.	—	—	0.663
6. I look at the evidence carefully to reach my own conclusions about what I am studying.	—	—	0.596
7. I am unable to understand the topics I need to learn because they are so complicated.	—	0.820	—
8. I organize my study time carefully to make the best use of it.	0.595	—	—
9. Often I have to repeat things in order to learn them.	—	0.690	—
10. I scheduled my studying so that I can complete all the tasks of the course according to a planned schedule.	0.489	—	—
11. In reading a new text, I try to think what I already know about the subject.	—	—	0.605
12. I try to relate what I have learned in one course to what I learn in other courses.	—	—	0.563

three-factor solution for the students' approaches to learning (Table 1). The Kaiser-Meyer-Olkin-test (KMO) (0.772) and Bartlett's test ($p = 0.000$) showed strong interitem dependencies in the correlation matrix and that the matrix was suitable for the factor analyses. The factor structure was as expected on the basis of previous studies. The factors were labeled (1) deep approach (Items 5, 6, 11, and 12), (2) surface approach (Items 1, 3, 7, and 9), and (3) organized studying (Items 2, 4, 8, and 10). The labeling is based on that used in previous studies (Parpala et al. 2010).

Students' Perceptions of Their Teaching–Learning Environment

The five-factor solution fit the students' experiences of their teaching–learning environment section best (Table 2). According to KMO (0.804) and Bartlett's test ($p < 0.001$), the factor matrix showed strong interitem dependencies and proved suitable for the factor analyses. The factors were labeled (1) interest and relevance (Items 4, 9, 10, and 13), (2) alignment (Items 1, 3, 18, and 19),

(3) support from other students (Items 8, 11, and 15), (4) constructive feedback (Items 2, 17, 20, 21, and 22), and (5) teaching for understanding (Items 5, 6, 7, 12, 14, and 16). The factor structure differs slightly from that in previous studies (Parpala et al. 2010). The items measuring staff enthusiasm and support were spread over factors such as constructive feedback (Item 2), interest and relevance (Item 10), and teaching for understanding (Items 12 and 16).

The factors of both sections and their reliabilities appear in Table 3, which shows that the reliabilities of all the scales are satisfactory ($\alpha > 0.60$) and similar to those in previous studies. However, Cronbach's alpha of the surface approach scale is higher than in several previous studies (Parpala et al. 2010; Postareff et al. 2015).

Student Clusters Based on Approaches to Learning

The first aim of the study was to investigate what kind of approaches to learning civil engineering students adopt at the

Table 2. Rotated Factor Matrix of the Section on Students' Perceptions of the Teaching–Learning Environment

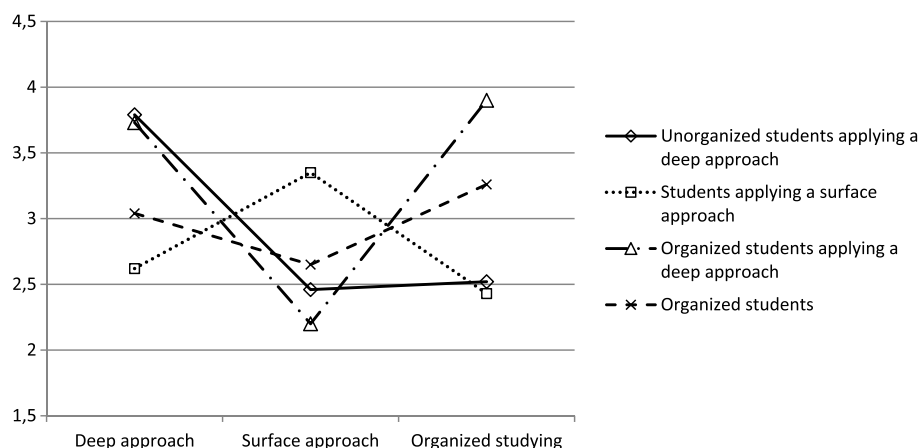
Item	Factor				
	1	2	3	4	5
1. It is clear to me what I am expected to learn in the courses.	—	0.441	—	—	—
2. Students can influence the content of the courses.	—	—	—	−0.254	—
3. What we are taught seems to match what we are supposed to learn.	—	0.566	—	—	—
4. The things we are taught are meaningful.	0.612	—	—	—	—
5. The courses give me a sense of the newest research and development of the discipline.	—	—	—	—	0.598
6. The teaching helps me to find the evidence underpinning different views.	—	—	—	—	0.445
7. I am encouraged to relate what I have learned to issues in a broader context.	—	—	—	—	0.339
8. Students support each other and try to provide help when it is needed.	—	—	−0.593	—	—
9. Most of the course contents are really interesting.	0.990	—	—	—	—
10. Teachers share their enthusiasm for the subject with the students.	0.401	—	—	—	—
11. Talking with other students helps me to develop my understanding.	—	—	−0.590	—	—
12. Teachers patiently explain things that seem difficult to understand.	—	0.237	—	—	0.259
13. I enjoy studying in the courses.	0.456	—	−0.266	—	—
14. Teachers help students to see how to think and reach conclusions in this discipline.	—	—	—	—	0.539
15. I find I can generally work comfortably with other students in the courses.	—	—	−0.813	—	—
16. The courses offer plenty of opportunities for me to discuss important ideas and subjects.	—	—	—	—	0.235
17. I get enough feedback on my learning.	—	—	—	−0.439	—
18. It is clear to me what is expected in the assessed coursework (exams, tasks, and assignments).	—	0.594	—	—	—
19. It is easy to see how the coursework fits in with what I am supposed to learn.	—	0.644	—	—	—
20. The feedback I receive on my work helps me to improve my learning and studying habits.	—	—	—	−0.574	—
21. The course tasks, assignments, and exams help me to make connections to my existing knowledge and experience.	—	—	—	−0.217	—
22. The feedback I receive on my coursework helps to clarify things I hadn't fully understood.	—	—	—	−0.639	−0.210

Table 3. Cronbach's Alphas of the Factors Measuring Students' Approaches to Learning and Perceptions of the Teaching–Learning Environment ($n = 204$)

Factor	α
Approaches to learning	
Deep approach	0.718
Surface approach	0.750
Organized studying	0.708
Perceptions of the teaching–learning environment	
Interest and relevance	0.739
Alignment	0.721
Support from other students	0.698
Constructive feedback	0.620
Teaching for understanding	0.642

University of Technology. First, the mean values for each approach were calculated: (1) deep approach ($M = 3.32$ and $SD = 0.639$), (2) surface approach ($M = 2.62$ and $SD = 0.651$), and (3) organized studying ($M = 3.11$ and $SD = 0.718$). Cluster analysis served to examine the respondents' placement on four clusters based on the deep approach, surface approach and organized studying (Fig. 1). Three-cluster, four-cluster, and five-cluster solutions were tested, all of which proved acceptable. Then the four-cluster solutions were selected for the analyses, because the clusters were almost of equal size ($n_{\text{cluster}1} = 45$, $n_{\text{cluster}2} = 41$, $n_{\text{cluster}3} = 57$, and $n_{\text{cluster}4} = 64$) and the cluster profiles were clear and theoretically logical. The respondents differed from each other statistically significantly in terms of the deep approach [$F(203) = 81.807$ and $p < 0.001$], surface approach [$F(203) = 41.940$ and $p < 0.001$], and organized studying [$F(203) = 140.350$ and $p < 0.001$].

Cluster 1 consisted of students who adopted the deep approach to learning. These students scored low on items measuring the surface approach and organized studying. Cluster 1 was labeled *Unorganized students applying a deep approach*. Cluster 2 contained students who scored high on the surface approach to learning. They scored low on items measuring the deep approach and organized studying. Therefore, Cluster 2 was labeled *Students applying a surface approach*. Cluster 3 consisted of students who scored high on the deep approach and organized studying. Cluster 3 featured low scores on the surface approach. This cluster was labeled *Organized students applying a deep approach*. Cluster 4 contained students who emphasized the organized studying approach. Their scores on the surface approach were low, and

**Fig. 1.** Cluster profiles based on final cluster centers of the cluster analyses**Table 4.** Mean Values of Each Cluster for Each Approach to Learning and Statistically Significant Differences among Clusters

Approach to learning	Cluster	M	SD	p			
				Cluster 1	Cluster 2	Cluster 3	Cluster 4
Deep approach	Cluster 1	3.79	0.52	—	—	—	—
	Cluster 2	2.62	0.49	0.000 ^a	—	—	—
	Cluster 3	3.73	0.36	0.886	0.000 ^a	—	—
	Cluster 4	3.04	0.36	0.000 ^a	0.000 ^a	0.000 ^a	—
Surface approach	Cluster 1	2.46	0.65	—	—	—	—
	Cluster 2	3.35	0.52	0.000 ^a	—	—	—
	Cluster 3	2.20	0.45	0.058	0.000 ^a	—	—
	Cluster 4	2.65	0.45	0.226	0.000 ^a	0.000 ^a	—
Organized studying	Cluster 1	2.52	0.46	—	—	—	—
	Cluster 2	2.43	0.44	0.708	—	—	—
	Cluster 3	3.90	0.42	0.000 ^a	0.000 ^a	—	—
	Cluster 4	3.26	0.35	0.000 ^a	0.000 ^a	0.000 ^a	—

^a $p < 0.050$.

on the deep approach, average. Cluster 4 was labeled *Organized students*. After the cluster analyses, differences between the clusters were analyzed with ANOVA and Tukey's post hoc test. Table 4 provides the mean values of each cluster for each approach to learning as well as which clusters showed statistically significant differences ($p < 0.050$) from each other on each scale.

Differences among Clusters

Univariate analysis of variance showed that perceptions of the teaching–learning environment, and study success variables, differed significantly across the four clusters (Table 5). Each individual scale differed significantly across the clusters (all $p < 0.005$). The test of homogeneity of variances showed that all other scales ($p > 0.500$) except credits earned per academic year ($p = 0.034$) proved suitable for univariate analysis of variance. That is why the Kruskal-Wallis test served to analyze any differences between the clusters and the earned credits variable. The analysis revealed a statistically significant difference in the earned credits variable across the clusters ($p < 0.001$).

In addition, the eta squared (η^2), which illustrates the effect size of the clusters, was calculated for each scale. The Interest and Relevance scale showed a large effect ($\eta^2 > 0.14$), whereas

Table 5. Results of the Univariate Analysis of Variance and Kruskal-Wallis Test

Variable	Clusters				F	p	η^2
	Unorganized students applying a deep approach (n = 44)	Students applying a surface approach (n = 41)	Organized students applying a deep approach (n = 57)	Organized students (n = 64)			
Perceptions of the teaching–learning environment							
Interest and relevance	3.26	3.04	3.66	3.27	10.991	0.000	0.142
Alignment	3.60	3.49	3.94	3.70	7.377	0.000	0.098
Support from other students	4.36	4.05	4.42	4.15	4.640	0.004	0.064
Constructive feedback	3.02	2.80	3.22	2.86	7.752	0.000	0.103
Teaching for understanding	3.40	3.07	3.49	3.25	7.874	0.000	0.105
Study success							
Credits earned per academic year (Kruskal-Wallis, mean rank value)	76.38	79.45	127.18	113.17	—	0.000	—
GPA	2.89	2.75	3.38	3.10	10.433	0.000	0.136

Note: F = Fisher-test.

other scales showed a medium effect ($\eta^2 > 0.06$) (Cohen 1988). The differences among the clusters were analyzed more closely with Tukey's post hoc test and the Kruskal-Wallis test (Earned Credits variable). The analysis revealed that clusters differed statistically significantly ($p < 0.050$) from each other on each scale (Table 6). All scales showed statistically significant differences across the clusters *Students applying a surface approach* and *Organized students applying a deep approach* ($p = 0.000$ – 0.008).

Table 6. Statistically Significant Differences between Clusters (Tukey's Post Hoc Test and Kruskal-Wallis Test)

Variable	Cluster	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Interest and relevance	Cluster 1	—	—	—	—
	Cluster 2	0.281	—	—	—
	Cluster 3	0.002 ^a	0.000 ^a	—	—
	Cluster 4	0.998	0.156	0.001 ^a	—
Alignment	Cluster 1	—	—	—	—
	Cluster 2	0.727	—	—	—
	Cluster 3	0.005 ^a	0.000 ^a	—	—
	Cluster 4	0.715	0.141	0.051	—
Support from other students	Cluster 1	—	—	—	—
	Cluster 2	0.061	—	—	—
	Cluster 3	0.938	0.008 ^a	—	—
	Cluster 4	0.250	0.803	0.046 ^a	—
Constructive feedback	Cluster 1	—	—	—	—
	Cluster 2	0.177	—	—	—
	Cluster 3	0.175	0.000 ^a	—	—
	Cluster 4	0.346	0.936	0.000 ^a	—
Teaching for understanding	Cluster 1	—	—	—	—
	Cluster 2	0.005 ^a	—	—	—
	Cluster 3	0.754	0.000 ^a	—	—
	Cluster 4	0.307	0.208	0.019 ^a	—
GPA	Cluster 1	—	—	—	—
	Cluster 2	0.701	—	—	—
	Cluster 3	0.000 ^a	0.000 ^a	—	—
	Cluster 4	0.290	0.022 ^a	0.047 ^a	—
Credits earned per academic year (Kruskal-Wallis test)	Cluster 1	—	—	—	—
	Cluster 2	0.808	—	—	—
	Cluster 3	0.000 ^a	0.000 ^a	—	—
	Cluster 4	0.001 ^a	0.004 ^a	0.198	—

^a $p < 0.050$.

The second aim of the study was to analyze how the students perceived their teaching–learning environment and how their different approaches to learning related to their perceptions of their teaching–learning environment. Table 5 indicates that students belonging to the *Organized students applying a deep approach* cluster scored highest on all five scales measuring students' perceptions of their teaching–learning environment. Students belonging to the *Students applying a surface approach* cluster scored lowest on all five scales. Students in every cluster scored highest on the Support from Other Students scale (Fig. 2). Students also scored high on the alignment scale, especially in the *Organized students applying a deep approach* and *Organized students* clusters. The constructive feedback factor saw the lowest scores in all clusters. The most significant difference between the clusters was on the Interest and Relevance scale. The cluster *Organized students applying a deep approach* showed a statistically significant difference ($p = 0.000$ – 0.002) from all the other clusters on the Interest and Relevance scale.

The third aim of the study was to determine how the students' different approaches to learning related to their study success. The Kruskal-Wallis test and ANOVA showed a statistically significant difference between earned credits and GPA variables across four clusters. Students belonging to the cluster *Organized students applying a deep approach* scored highest on both earned credits and GPA scales. Students belonging to the cluster *Unorganized students applying a deep approach* scored lowest on the earned credits scale, and students belonging to the cluster *Students applying a surface approach* scored lowest on the GPA scale. Organized studying showed a statistically significant relationship with study success. Students belonging to the clusters that emphasized organized studying scored higher than other students did on both scales.

Summary of Results

The exploratory factor analyses were used to test how the HowULearn questionnaire functioned with the data collected from engineering students. After the factor analyses, four student clusters were formed with cluster analysis. The students of each cluster applied a different approach to learning. Then, ANOVA was used to analyze any differences among clusters in terms of students' perceptions of their learning environment and in their study success. The results of the study can be summarized as follows:

1. Unorganized students applying a deep approach: The first cluster included 45 (21.7%) students who applied a deep approach to learning. These students scored low on organized studying

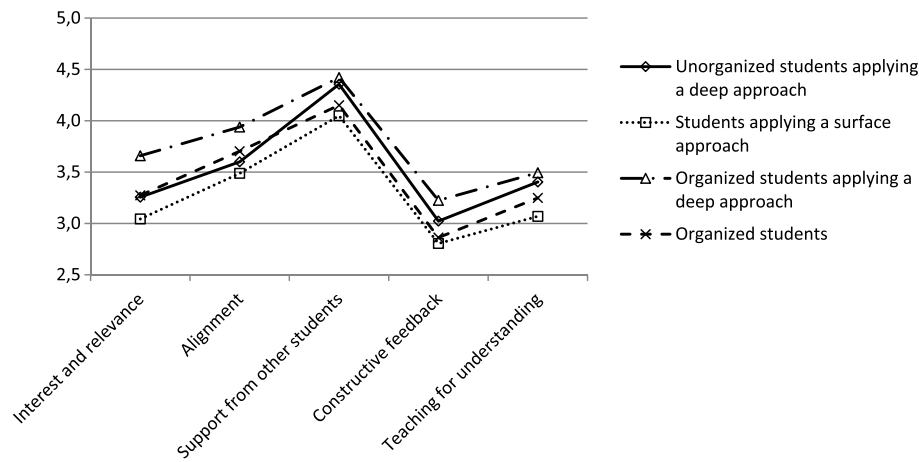


Fig. 2. Five factors measuring students' perceptions of the teaching-learning environment in four clusters

and on the surface approach. These students scored rather high on scales measuring perceptions of their teaching-learning environment, earned quite low grades in their courses, and earned fewer credits than did students in other clusters;

2. Students applying a surface approach: The second cluster included 41 (19.8%) students who applied a surface approach to learning. These students scored low on organized studying and did not apply a deep approach to learning. These students also scored low on scales measuring perceptions of their teaching-learning environment, earned low grades in their courses, and earned few credits;
3. Organized students applying a deep approach: The third cluster included 57 (27.5%) organized students who applied a deep approach to learning. These students scored low on the scale measuring the surface approach. These students scored high on scales measuring perceptions of their teaching-learning environment, earned high grades in their courses, and earned several credits; and
4. Organized students: The fourth cluster included 64 (30.9%) organized students. These students scored average on the scale measuring the deep approach to learning and low on the scale measuring the surface approach. These students scored average on the scales measuring perceptions of their teaching-learning environment, earned quite high grades in their courses, and earned several credits.

Conclusions and Discussion

The aim of the present study was to explore civil engineering students' approaches to learning and the relationships among these approaches and students' perceptions of their learning environment as well as the relationships among students' approaches to learning and their study success. The HowULearn questionnaire served to identify different student clusters showing how civil engineering students approach their learning. Because few previous studies have examined engineering students' approaches to learning, this study also aimed to fill this gap in research on students' approaches to learning.

The first aim of the study was to investigate what kind of approaches to learning civil engineering students adopt at a University of Technology. Cluster analyses revealed four student clusters whose cluster profiles closely resembled the profiles of a previous study by Parpala et al. (2010). The students in each cluster applied a different approach to learning. The research hypothesis of the study

predicted that higher education encourages engineering students to adopt a surface approach to learning. Previous studies have shown that students who study the hard sciences tend to score higher on a surface approach than do students who study the soft sciences (Entwistle and Ramsden 1983; Parpala et al. 2010). Because the participants in this study were all engineering students, the results of previous studies could not be entirely confirmed, because this study lacked a control group from other disciplines. On the other hand, our results are in line with those of a study by Parpala et al. (2010). The cluster sizes of this study that compared to those in Parpala et al. (2010) were *Unorganized students applying a deep approach* 21.7% (Parpala et al. value: 21.7%), *Students applying a surface approach* 19.8% (15.5%), *Organized students applying a deep approach* 27.5% (26.9%), and *Organized students* 30.9% (35.8%). Parpala et al. (2010) explored students' approaches to learning in different disciplines. In their study, the cluster *Students applying a surface approach* contained fewer respondents of the whole sample than did the same cluster in this study, unlike between the hard sciences, where the difference in cluster size between the present study (19.8%) and Parpala et al. [Faculties of Science (21.8%) and Pharmacy (21.3%)] was minor. The present study showed that higher civil engineering education encourages students to apply a deep approach slightly more often than higher education in the hard sciences usually does. In the present study, the clusters emphasizing a deep approach to learning contained 49.2% of the students, whereas in Parpala et al. (2010), these clusters encompassed approximately 45% of the students in the hard sciences.

The second aim of the study was to analyze students' experiences of their learning environment and how their different approaches to learning related to their perceptions of their teaching-learning environment. The results of the analyses of clusters of the students' approaches to learning and factors influencing their perceptions of their teaching-learning environment showed that students who applied a deep approach to learning (Clusters 1 and 3) perceived their learning environment more positively than did other students. These results further confirm the results of previous studies (Parpala et al. 2010; Richardson 2005; Richardson and Price 2003), which found the same relationship between a deep approach to learning and students' perceptions of the teaching-learning environment. To specify, the results showed that students in the cluster *Organized students applying a deep approach* scored the highest on all scales, and the clusters *Unorganized students applying deep approach* and *Organized students applying a deep*

approach showed a statistically significant difference in the factors (1) interest and relevance and (2) alignment. Evidence that student interest relates to high-quality learning indicates that combining a deep approach with organized studying, as well as interest and relevance, is important. When students become interested in a subject, they are willing to work harder and to dedicate more time to studying, which positively influences learning results (Lonka and Ketonen 2012). In addition, motivated students set personal goals, which leads to a deep approach to learning (Entwistle 1998).

The third objective was to determine how the students' approaches to learning relate to their study success. The results of the analyses of the relationships among clusters of the students' approaches to learning and study success variables showed that the students belonging to the clusters *Organized students applying a deep approach* and *Organized students* were the most successful in their studies. According to previous studies, students who are organized and apply a deep approach to learning achieve the highest learning outcomes (Entwistle and Ramsden 1983; Lindblom-Ylänne and Lonka 1998; Heikkilä et al. 2012). In this respect, the results of this study are partly in line with those of previous studies. According to this study, however, in higher civil engineering education, organized studying relates more to study success than does a deep approach. Indeed organizing studying and study success showed a statistically significant correlation. In terms of both earned credits and GPA, the organized students were more successful than the other students. This result is in line with the results of a study by Rytönen et al. (2012), which found that organized studying is the most important factor in succeeding in university studies.

The present study also found a weaker correlation between a deep approach to learning and study success than between organized studying and study success. The clusters *Unorganized students applying a deep approach* and *Students applying a surface approach* showed only minor differences in study success. Moreover, the difference between the clusters *Organized students applying a deep approach* and *Organized students* was minor. The organized studying approach relates especially to students' progress in their studies. A study by Erkkilä (2009) showed quite similar results. According to her study, the strategic executors were the most successful student group at Finnish universities of technology. On the other hand, previous studies (Asikainen et al. 2013) have also shown that high course grades do not necessarily correlate positively with high-quality learning outcomes. Consequently, the results of the present study do not confirm that organized studying leads to better learning outcomes in civil engineering studies than other approaches do without identifying what type of knowledge the exams and other assessment methods actually measured.

Previous studies have identified a relationship between students' approaches to learning and teachers' ways of teaching (Prosser and Trigwell 1999; Trigwell et al. 1999). Teaching in higher engineering education in the context of this study therefore appears to encourage students to be organized in their studies, because a majority of the participants belonged to clusters that emphasized organized studying. Education also encourages students to adopt a deep approach to learning slightly more often than usual in the hard sciences. The results of the present study suggest that encouraging students to adopt a deep approach to learning, and especially to adopt organized studying, seems to be extremely important in supporting their study pace and study success.

Students' approaches to learning have been studied extensively in Western cultures, and the understanding about the students' approaches to learning is similar across Western countries. Hence, the results of the present study could be generalized to other Western countries. Instead, for example, the Chinese students' approaches

to learning differ from Western students' approaches. In the Chinese context, the learners, who were seen as rote learners, used memorizing as a means to develop their own understandings of the content, which indicated the deep learning approach. On the contrary, in Western cultures, memorizing has been linked to the surface approach (Watkins and Biggs 1996).

The results of the present study could serve in the development of civil engineering higher education. To quicken students' study pace and to support their study success, higher civil engineering education should encourage students to be organized. On the other hand, the development of teaching and assessment methods as well as learning environments should seek to encourage students to adopt a deep approach to learning, which currently shows a weaker relationship to study success than does organized studying. Future studies should attempt to identify the teaching and assessment methods to use to provide more support for the deep approach to learning and organized studying. The development of teaching and learning methods is important, because results of the many reviews show that active and inductive methods are at least equal to, and in general more effective than, traditional deductive methods (Prince and Felder 2006), which may materialize as improved examination scores and lower failure rates (Freeman et al. 2014).

Besides academic achievement scores, active learning methods promote other skills needed in working life. Cooperative learning has a positive effect on academic achievement and attitudes (Prince 2004; Smith et al. 2005) and on interpersonal skills (Prince 2004). It can also promote higher self-esteem than competitive or individualistic activities (Smith et al. 2005). Usually the inductive methods also encourage students to adopt a deep approach to learning. Therefore, more studies are needed to explore engineering students' approaches to learning in order to confirm these results in different contexts.

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