Approaches to learning mathematics in engineering study program

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Abstract. The students' approaches to learning have been significantly researched in the last few decades, particularly since Marton and Säljö in 1979. elaborated about a deep/surface approach dichotomy. The above dichotomy appears to be very useful in the assessing of teaching, based on which one can obtain parameters according to which teaching can be improved. Precisely for these purposes the term approach to learning is more suitable than the term learning style. Learning style addresses ability-like dimensions while the term approach means that person can choose to learn in different ways depending on his/her motivation, the nature of the course taken and subject-matter, as well as the host of other variables. We use The Approaches and Study Skills Inventory for Students (ASSIST), developed by N.J. Entwistle, to investigate learning approaches of the first-year undergraduate engineering students in compulsory mathematics course. We emphasize that this inventory considers an additional type of approach, the strategic one. Inventory explored which of three approaches to learning (deep, strategic or surface) was chosen the most to cope with demands of the specific mathematics course, and how the chosen approach relates to the students' grades obtained in the course. The results showed that majority choose strategic approach, what might indicate that it was the nature of the mathematics course that resulted in this approach. Also, in this paper we discuss the potential main factors that could result in such a selection.

Keywords: approaches to learning, deep, surface, strategic

Introduction

One of the main goals of education is to build effective learners. There are several variables that affect students' learning. Many research point out that the approach to learning and study skills significantly influence on the quality of student's learning (e.g. Marton & Saljo, 1976; Entwistle & Ramsden, 1983; Biggs,

1993; Entwistle, 2000; Smith& Miller, 2005; Byrne, et al., 2009). According to Biggs (2001) a term *approach to learning* is more fitted than learning style because learning style addresses ability-like dimensions while approach means that students can choose to learn in different ways depending on their motivation, the nature of the course and subject-matter, and a host of other variables.

Approach to learning is a method or a way of dealing with learning material to facilitate understanding. Approaches have a relational nature and can vary according to learning context (Trigwell & Prosser, 1991, Entwistle et al., 2002; Leung et al., 2008). Biggs (2001) pointed out that students usually choose their approach after making a "cost/benefit analysis" for the course they are enrolled into. In the field of student learning in higher education, large number of empirical research has been conducted and as well as many theories have been developed in the last two decades (e.g. Biggs, 1999; Diseth, 2003).

Theoretical background

Approaches to learning emerged from work of Marton and Säljo (1976) and Ramsden (1979). Marton and Säljo identified deep and surface approaches to learning, whereas Ramsden identified a strategic one. *A deep approach* to learning implies that students have intention to understand the material, and to be actively engaged in their studies. Students use arguments and critically relate to new material using prior knowledge and other resources. According to Entwistle (2000) they also monitor the development of their own understanding and learning which presents an internal process to them. In mathematics, this means that learner is making connections between mathematical topics, concepts and procedures, and is aware of relationships between them. In contrast, students who adopt *a surface approach* tend to memorize the material without understanding. They rely on reproduction of the learning material and use different forms of rote learning. Mainly, they are limited by the specific learning task and do not go beyond it. In this approach, fear of failure and concern with the completion of a course is main guide through the learning process. Unlike surface approach, where usually a low level of understanding is achieved and learning is ineffective in a long run, deep approach is more likely to result in a high level of understanding and effective learning (Entwistle & Ramsden, 1983). Students who use the third approach, called a *strategic approach*, have no distinct learning strategy. In this approach, students use both deep and surface approaches (but not at the same time) when they found it appropriate and have a competitive motivation. The major intention is to achieve the highest grades managing study methods and time effectively. Strategic approach also involves monitoring one's study effectiveness and alertness (Entwistle et al., 2003).

Approaches to learning can be related to the assessment of student learning (e.g. grade), and this relation has been well established (Betoret & Artiga, 2011; Biggs et al., 2001; Byrne et al., 2004; Trigwell & Prosser, 1991). A deep approach is related to high quality of student learning, whereas surface learning is related to the poor learning outcomes (Biggs et. al., 2001; Trigwell & Prosser, 1991). Other findings are related to students' perceptions of the teaching–learning environment.

In a well-planned teaching–learning environment with clear goals, good quality teaching, appropriate assessment and workload, students tend to choose a deep approach to learning. In the teaching–learning environment with a poor quality of teaching together with assessment focused on memorizing and very high workload, students tend to choose a surface learning approach (e.g. Trigwell & Prosser, 1991)

When it comes to mathematics as a subject discipline, investigating how students view a nature of mathematics (fragmented vs. cohesive), Crawford et al. (1998) discovered that fragmented conceptions of mathematics were associated with surface learning approaches. Perceptions of workload and assessment were seen as inappropriate where the workload was too high and the assessment was focused on memorizing. On the other hand, the cohesive conceptions of mathematics, as well as perceptions of clear goals and good teaching were associated with deep learning approaches.

Methodology

The Approaches and Study Skills Inventory for Students (ASSIST) (Tait, et al., 1998) was used for collecting quantitative data relating to students' approaches to learning mathematics. The questionnaire contains 67 statements, where respondents indicate their agreement with each statement, using a five point Likert scale. ASSIST consists of four sections. The first section is a six-item measurement of the student's own conception of what the term "learning" means to them. The second section consists of 52 statements related to mainly three dimensions – deep, strategic, and surface. As mentioned above, every dimension has a subscale. Every approach has four or five subscales comprised of four items. The third section of ASSIST is an eight-item questionnaire measuring preferences for different types of teaching – lectures, courses, exams and books. In the fourth section, the students are asked what they think regarding their overall performance.

Participants were the first year engineering students enrolled in the compulsory course Mathematics 1. The sample comprised $2/3$ of the cohort (69) and students were reached through direct contact in exercise lessons of Mathematics 1 where they were given paper copies of the questionnaire. Course Mathematics 1 is a one-semester course and students were surveyed almost at the end of the semester, before final colloquiums and exams. Participating in the survey was voluntary so no penalties were given for those who refused to take a part. Besides filling the questionnaire, the students were asked to leave the personal data to be able to track their scores in colloquiums and their final grades. All students who were present at the exercise lessons took part in questionnaire. The students who were not present at the time usually did not attend lessons so we were not in position to reach them.

Reliability and validity

ASSIST was translated into Croatian language with the great care, but we adapted some statements to fit better to mathematics environment. We performed confirmatory factor analysis to ensure that this translation of the instrument into

Croatian was successful and to examine the factor structure of the original inventory based on data obtained from the Croatian students. The goodness of fit of the confirmatory factor structure was assessed by the following fit indices: RMSEA (Root Mean Square Error of Approximation) GFI, and AGFI.

In Croatian version of the ASSIST, Cronbach's Alpha values ranged from 0.81 to 0.87 (whole questionnaire and deep, surface, strategic subscales) which could be considered as a high internal consistency. In the case of deep subscale, indices indicated very god fit of the data (RMSEA = 0.04, GFI = 0.98, AGFI = 0.97), and acceptable fit in the cases of the whole questionnaire (RMSEA = 0.08, GFI = 0.93, AGFI = 0.90), strategic subscale (RMSEA = 0.08, GFI = 0.88, AGFI = 0.86) and surface subscale (RMSEA = 0.11, GFI = 0.86, AGFI = 0.82).

Results

Analysis of the ASSIST revealed that a strategic approach to learning was the most commonly adopted by the participants, with 58% scoring most highly on this scale. This was followed by 29% scoring highest on the deep scale and 13% on surface. Average scores on each scale were 61.15 (SD = 14.59) on strategic, 56.39 (SD = 10.74) on deep and 49.55 (SD = 11.07) on surface approach to learning.

At the level of $\alpha = 0.05$ there were no statistically significant differences between mean scores of students using deep approach and strategic approach, while there were statistically significant differences between deep approach and surface approach, and between strategic approach and surface approach.

Grades obtained in the course range between 1 and 5, with 2 as minimum passing grade while 1 means that student did not pass the course. Looking at the correlations between grades and approaches to learning (Table 1), a significant negative correlations were found between surface approach and grades, positive correlations were found for strategic approach and negative or no correlation were found for deep approach.

Approach	**Grades in lecture colloquiums (theory)**	**Grades in exercise colloquiums (tasks)**	**Final grade**
Deep	−0.249	−0.065	−0.046
Surface	−0.485	−0.448	−0.437
Strategic	0.142	0.197	0.275

Table 1. Correlation between grades and approaches to learning.

Learning, conceptualised as a reproducing knowledge, is represented by three items in the questionnaire (see Table 2, bold). Surface approach to learning was negatively correlated to all of these items. Further, strategic and deep approach scores had positive correlations to some of these items. Learning, conceptualised as transformational, is represented by three items in the questionnaire (see Table 2, normal). Surface approach to learning had either no correlation or was negatively

correlated to all of these items. Strategic and deep approach scores correlated significantly with the conceptualisation of learning as a transformational process that facilitates development as a person. Also, deep approach scores correlated significantly with the last item that describes learning as a new way of seeing things.

Items	Deep	Surface	Strategic
Making sure you remember things well	0.237	−0.074	0.228
Developing as a person	0.389*	0.065	0.611*
Building up knowledge by acquiring facts and information	0.238	−0.170	0.206
Being able to use information you've acquired	0.050	−0.118	−0.135
Understanding new material for yourself	0.059	−0.246	0.085
Seeing things in a different and meaningful way	0.366*	−0.033	0.001

*significant at 0.05

Table 2. Correlation between conceptions of learning and approaches to learning.

Third part of the questionnaire examined preferences for different types of course and teaching. There are four items that are related to a deep approach and support understanding (see Table 3, normal) and four items that are related to a surface approach and promote transmitting information (see Table 3, bold).

Items	Deep approach	Surface approach	Strategic approach
Lecturers who tell me exactly what to put down in our notes.	−0.042	0.144	0.101
Lecturers who encourage me to think for myself and show us how they themselves think.	0.367*	−0.179	0.103
Exams that allow me to show what I've thought about the course material for myself.	0.019	−0.365*	0.210
Exams or tests that need only the material provided in the lecture notes transmitting info.	−0.062	0.099	−0.007
Courses in which it's made very clear just what books we have to read.	−0.192	0.263	0.295
Courses where we are encouraged to read around the subject for ourselves.	0.364*	−0.016	0.516*
Books that challenge me and provide explanations that go beyond the lecture.	0.028	−0.097	0.135
Books that give me definitive facts and explanations that can easily be learned.	−0.199	0.536*	0.277

*significant at 0.05

Table 3. Correlation between preferences for different types of courses and teaching and approaches to learning.

Looking at the total number of students, results showed that 92% of them have preference for the surface approach and only 8% for the deep approach. We have found positive correlation with students' surface approach to learning scores and courses and teaching strategies based on the transmission of information, and moreover, a significant positive correlation with item "Books that give me definitive facts and explanations that can easily be learned." In the case of strategic approach scores, correlation was mostly positive but not significant. Students' deep approach to learning scores correlated negatively with those items.

Teaching and course types that support understanding correlated positively to deep and strategic approaches to learning, and in some cases are correlated significantly (Table 3). Furthermore, a significant negative correlation was found between the surface approach and item "Exams that allow me to show what I've thought about the course material for myself."

Discussion and conclusion

Students who enroll into a technical study programs at university usually have mathematics courses as compulsory ones. According to SEFI, these courses present a necessary requirement for the education of qualified engineering graduates and most of these courses are taken in the first years of studying. The role of these courses should be a service one, but in many cases such courses appear to be the eliminating ones, differentiating successful from non-successful students.

Students surveyed in this study were the first year engineering students, who were given a questionnaire almost at the end of the first semester. We believe that the questionnaire was given in a good time because students participated in colloquiums from other courses more related to their study program, and had opportunity to adapt to a new concept of mathematics that is different from the high school mathematics, and where mathematics theory was highly emphasized. Small number of studies has used the ASSIST to investigate approaches to learning in mathematics. Since students can employ different approaches for learning for different courses, depending on whether the course is more related to their future profession or not, our study enriches the corpus of research in mathematics education. Majority of students have chosen the strategic approach to learning. Similar results for mathematics can be found in Darlington (2011), who investigated first year mathematics students. Many studies (e.g. Speth et al., 2007) reported similar results for other subject disciplines.

Significant negative correlations that we have found between surface approach and grades (exercise and lecture colloquiums, and, consequently, final grade), have also been discovered in other studies (e.g. Entwistle & Ramsden, 1983). Similar holds for positive correlations between strategic approach and grades (Entwistle & Ramsden, 1983; Byrne et al., 2002), even though we have found positive correlation, but not the significant one. Absence of correlation with deep approach and grades is a concern, and this has also been reported by other researchers (Byrne, et al., 2004). The possible explanation for these results could lie in the examination style that does not asses what the examiner believes it should asses. It is possible

that examination of knowledge is structured in a way where strategic approach is encouraged, meaning that students using lecturers and teaching assistants hints and remarks can improve their performance, but not their understanding. This is also in line with Entwistle's comment that in fact many study programs in higher education are promoting a strategic approach when they are using summative assessments. That means that students are combining deep and surface approach in order to achieve the best possible grades, organizing their learning time in the effective way.

Combining these results with the first and the third part of the questionnaire gives better overview of students' approaches to learning. The results concerning conceptions of learning and approaches to learning might suggest that engineering students who choose surface approach do not consider learning of mathematics as a transformational process nor as a pure reproduction of learned facts. Also, findings suggest that some students who adopt deep or strategic approach for learning mathematics might conceptualize learning as a reproduction of facts, at least in some parts. This may be connected with the rote-learning of a definition in order to be able to understand the meaning or application of a theorem or procedure.

It is interesting to discover that many students have preference for courses that promote surface approach to learning. This can be related to the structure of the mathematics course but also with other courses that students were taking in the first semester. Such preference can indicate overloaded mathematics course syllabi and overburden students who are coping with many different courses at the same time.

Given these results, it seems that in our case engineering students estimated that deep approach is unrewarded, but also that surface approach is not the best way to achieve the success in mathematics course. Biggs (1991) and many others report similar findings in other subject disciplines. Although we would prefer that engineering students choose the deep approach toward learning mathematics, we believe that good strategic approach should be developed, that has a potential to later outgrow into the deep approach. This seems more realistic and usable in the context of such study program, where mathematics is service course but is highly important as a base for further studying.

Cano & Berben (2009) discovered a pattern between achievement goals and approaches to learning in mathematics what suggests that they can be intertwined. In order to fully understand engineering students' motives for choosing certain approach to learning in mathematics courses, we should certainly broaden our research in this direction.

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Pristupi učenju matematike na tehničkom studiju

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Sažetak. Pristupi učenju značajno su istraživani u posljednjih nekoliko desetljeća, osobito nakon što su 1976. Marton i Säljö razradili dihotomiju pristupa učenju podijelivši ga na dubinski i površinski pristup. Navedena dihotomija se pokazuje vrlo korisnom pri procjenjivanju nastave, na osnovu čega se dobivaju parametri prema kojima se nastava može unaprijediti. Upravo za te potrebe je pojam pristupa učenju pogodniji od pojma stila učenja. Stil učenja se odnosi na nečije sposobnosti, dok pristup učenju označava da studenti mogu izabrati različite načine učenja, ovisno o njihovoj motivaciji, sadržaju i prirodi upisanog kolegija te mnogim drugim varijablama. Pri istraživanju pristupa učenja studenata prve godine jednog tehničkog studija na obaveznom kolegiju iz matematike, koristili smo Upitnik o pristupu i vještinama učenja (ASSIST), koji koristi još jednu dodatnu vrstu pristupa (strateški pristup) te kojeg je izradio N. J. Entwistle. Navedenim upitnikom smo istražili koji je od tri pristupa učenju (dubinski, površinski ili strateški) najviše odabiran kako bi se studenti nosili sa zahtjevima kolegija, te su proučeni odnos pristupa učenju i ocjene postignute na kraju kolegija. Rezultati su pokazali da je većina studenata odabrala strateški pristup, što bi moglo ukazivati da je i priroda proučavanog kolegija rezultirala ovim odabirom. Također, u radu diskutiramo i potencijalne glavne čimbenike koji su mogli za rezultat imati takav odabir.

Ključne riječi: pristup učenju, dubinski, površinski, strateški