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E-LEARNING IN PROCESS AND CHEMICAL ENGINEERING EDUCATION: STUDENTS AND FACULTY MEMBER POINT OF VIEW

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ABSTRACT. The aim of this work is to discuss the results of two surveys on e-learning carried out at eight chemical engineering faculties from seven European countries. The first survey was conducted with students, the second with faculty members. The focus of the survey was on aspects such as computer and network facilities, on-line use, personal skills in several computer applications, and use of computer-based learning materials. Similarities and contrasts regarding e-learning were analysed within the group of students as well as between students and faculty members. For the students, differences considering gender, faculty, and region were studied using both, descriptive and multivariate statistical techniques. Results show that the differences in computer use were stronger between different faculties than between women and men. The use of information and communication technologies is still evolving and all stakeholders (organisation, students and staff) are still exploring the best procedure to reach the maximum potential of these tools. Students' attitudes towards e-learning are rather conservative and the driving force depends mainly on the faculty members, who have a slightly more positive attitude to distance-learning initiatives. This positive attitude promotes a large number of e-learning activities. Efforts range from single personal initiatives to cooperative projects on regional, national or international level. The *EuPaCe.net* consortium (www.eupace.net) challenge consists in building a community that bundles some of these efforts, providing a platform to create an international online community.

Keywords: e-learning, chemical engineering, comparative study.

1. INTRODUCTION

This work presents the results of a study on e-learning in higher education in Europe that was conducted within the European Network for E-Learning in Process and Chemical Engineering (*EuPaCE.net*). Most analyses about the e-learning situation show that, independently of the domain, most initiatives, after a time of pioneering and expansion, lead to insufficient transfer of know-how and lack of sustainability of the applications developed. Still, e-learning initiatives in higher education are often "*lone ranger*" approaches (Bates, 2000) with high development costs and low pedagogic (not to mention economic) benefit. Harmonization, standards and communication about best practices is needed to achieve synergies. The central issue of the study consisted in the identification of trends, challenges, and open questions about e-learning in process and chemical engineering. Therefore, the study comprised two surveys that addressed the two most important groups in chemical engineering higher education: the first survey was conducted with students, the second with faculty members. This allows to draw conclusions about the e-learning market in European higher education for chemical engineering, comparing "*vendors*" (faculty members) and "*customers*" (students).

Both surveys were carried out with different questionnaires. While the student questionnaire consisted of rating questions, the faculty members questionnaire focused more on open questions for qualitative analysis. In addition, the questionnaires of students and faculty members contained some identical or comparable rating items on attitudes towards the use of new information and communication technologies, so that similarities and contrasts of students' and faculty members' opinions and preconceptions about e-learning could be analysed.

Moreover, to get a more detailed picture of the students' situation, classical statistical methods and multivariate statistical techniques (cluster analysis, linear principal component analysis and linear discriminant analysis; Montgomery and Runger, 1998; Ross, 1999) were applied to study similarities, differences and relationships among student variables like gender, faculty affiliation, and region. The advantages of these techniques is that results are shown in easily interpretable graphical plots. In particular, facing the high importance that is currently being put on the issue of gender mainstreaming by national and European authorities, the analysis of gender differences in the population of chemical engineering students was of interest.

The results of the study provide the empirical basis for guidelines for e-learning in process and chemical engineering, that are being developed by the EuPaCE.net consortium. At the open internet platform (available at www.eupace.net), a cooperative work space is provided for the discussion of the guidelines among the chemical engineering community.

This paper is organised as follows: in section 2, methodology and results of the students survey are presented. Section 3 is dedicated to the faculty members survey. In section 4, both surveys are compared to discuss similarities and contrasts of students' and faculty members' preconceptions. Section 5 provides the conclusions.

2. STUDENTS SURVEY

The student survey was carried out with a questionnaire comprising 54 items, divided into four aspects: (1) personal data, (2) computer experience, (3) attitudes towards computer based learning, and (4) motivation for studying. The following questions were addressed:

- What is the current state of private access, computer use, and computer experience of the students?
- How do students judge the use of computers at their faculty?
- To what extend are students knowing and using computer-based applications for learning that are offered by their faculty?

491 students at Bachelor and Master level participated in the study (Table 1). The sample sizes differed considerably at the different faculties, and therefore comparison between the different faculties can only be made in an explorative manner and conclusions have to be drawn with caution. In view of the historical and general economic situation, we distinguish for the analysis of regional differences between *EU-15* (represented by Barcelona, Berlin, Lappeenranta, Manchester, Oxford and St-Etienne) and *East-EU*, (represented by Bucharest and Cracow). In average, participants were 23 years old. 45% of the total sample were women, but only 27% of the *EU-15* sample. 80% of the subjects stated to have advanced English language skills (90% in *EU-15* vs. 65% in *East-EU*).

Table 1

Description of the sample.

University	Faculty/Department	n
Ecole Nat. Supérieure des Mines de St-Etienne (EMSE, France)	Sciences, Information et Tech. pour l'Environnement	101
Jagiellonian University of Cracow (JUC, Poland)	Chemistry	7
Lappeenranta University of Technology (LUT, Finland)	Chemical Technology	53
Technische Universitaet Berlin (TUB, Germany)	Process Dynamics and Operation	42
Univ. of Barcelona (UB, Spain)	Chem. Eng. and Metallurgy	22
University of Manchester (UMIST, England)	Process Integration	21
Univ. of Oxford (UOX, England)	Engineering Science	25
University Politehnica of Bucharest (UPB, Romania)	Chemical Engineering	220

2.1. PRIVATE ACCESS TO COMPUTERS AND THE INTERNET

At home, 87% of the total sample had access to a computer (96% in *EU-15* vs. 77% in *East-EU*), 75% had access to the internet (91% in *EU-15* vs. 56% in *East-EU*). Table 2 shows the distribution of Internet connection speed. While almost half of the connections in *EU-15* are high-speed, this is the case for only about one third in the *East-EU* sample.

In the total sample, there are gender differences concerning computer access at home (81% of women vs. 91% of men), internet access at home (66% of women vs. 82% of men), and speed of internet connection (37% of women vs. 50% of men have high speed connection). These results are caused by the situation in the *East-EU* sample.

Table 2

Speed of private internet connections (% of total).

		Slow < 56k	Medium	Fast > 768k	Total
EU-15	Men	17 %	28 %	46 %	91 %
	Women	17 %	22 %	58 %	97 %
East-EU	Men	20 %	17 %	33 %	70 %
	Women	18 %	28 %	10 %	56 %

2.2. COMPUTER USE

In average, the students use a computer for 25 hours per week (range 0 to 170, standard deviation, SD = 21), thereof 15 hrs/week online (range 0 to 104, SD = 16). For studying, they use computers for 12 hrs/week (range 0 to 105, SD = 12), thereof 6 hrs/week for studying online (range 0 to 80, SD = 8). There is a considerable variation in the intensity of computer use between subjects. Most students use computers to a relatively low extent, while a minority seem to spend most of their daytime with computers. There is a substantial difference in the average time between the different faculties: for total computer time ranging from an average of 19 hrs/week (TUB) to 43 hrs/week (UMIST), or for online time for studying ranging from an average of 2 hours (TUB, UB) to 11 hours (UMIST). Computer use time is strongly related to computer and internet access at home (Figure 1).

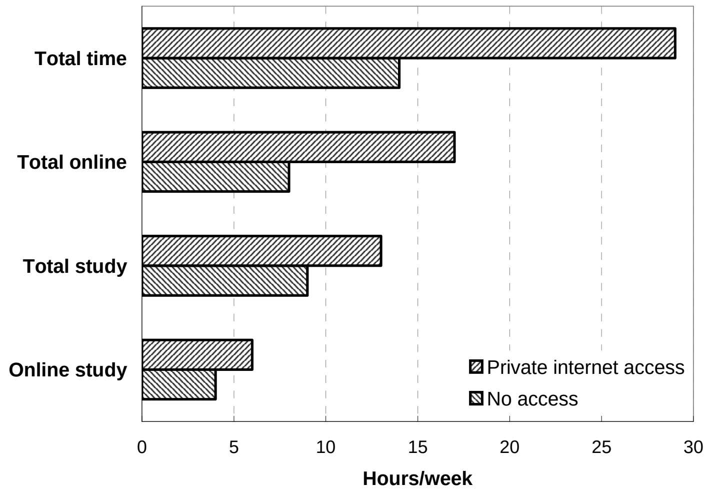

Figure 1. Computer use time for students: influence of private internet connection.

Students without private internet access only spent about half of the time than their fellows with private internet access. For computer use time related to their study, this difference is smaller. Despite the gap in computer and internet access at home, differences in computer use time between *EU-15* and *East-EU* are rather small.

The analysis of gender differences show a considerable difference in total time (women 19 vs. men 30 hrs/week). However, gender differences in computer use for studying were much smaller (women 11 vs. men 14 hrs/week). Concerning the effect of gender on computer use, a notable difference between *EU-15* and *East-EU* was found. In the *East-EU* sample, gender difference in total computer time is stronger (*East-EU*: women 16 vs. men 33 hrs/week; *EU-15*: women 24 vs. men 29 hrs/week). In the *EU-15* sample, women spend more time for studying with the computer than men (15 vs. 14 hrs/week), while in the *East-EU* sample the situation is reverse (9 vs. 14 hrs/week).

2.3. COMPUTER SKILLS

Students were asked to rate their skills from 0 (no skills) to 3 (expert). According to their answers, they can be grouped into:

(1) Basic skills (word processing, internet use, e-mail, spread sheet): average = 2.0, "*no skills*" < 10%.

(2) Domain specific skills (simulators, graphics software, programming languages): average = 1.0, "*no skills*" < 50%.

(3) Extra skills (web design, database systems): average = 0, "*no skills*" > 50%.

There are considerable differences in the self-ratings of computer skills in relation to internet access at home. In all categories of skills, students without private internet access rate their skills lower than students with private access. Also, regional and gender differences in the self ratings could be identified (Figure 2). In all categories, women from the *East-EU* sample gave the lowest self-rating.

2.4. ATTITUDES TOWARD LEARNING WITH COMPUTERS

Table 3 shows the ratings for six statements about learning with computers (0 = "*completely disagree*", 3 = "*completely agree*"). Most students agree that computers should play a bigger role in their studies, that the quality of materials should be improved, and would like to have a wider choice of learning materials. However, they mostly also agree that the current extent of computer use is adequate, and they do not want traditional lectures to be replaced by learning with computers. From the students' point of view, higher quality, better integration, and variety of computer applications are rather needed than higher quantity of computer use. Overall, the students' attitudes toward learning with computers can be characterised as moderate to slightly positive, but not enthusiastic.

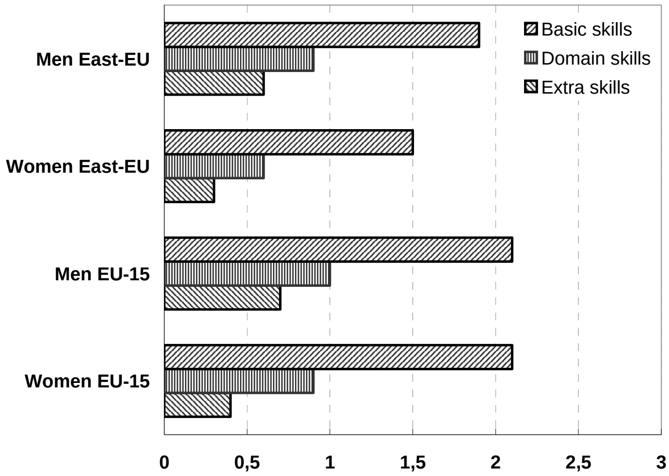

Figure 2. Regional and gender differences in self rating of computer skills.

Table 3

General attitudes toward learning with computers.

	Mean	SD
"I prefer learning with computer based learning software to attending a lecture"	1.4	0.9
"Learning with computers should play a bigger role in my studies"	1.9	0.9
"I would like to have a wider choice of computer based learning materials for my studies"	2.0	0.8
"Currently, the extent of computer use in my studies is adequate"	1.8	0.8
"The quality of computer based learning materials for my studies should be improved"	2.0	0.8
"We are already using computers too often in my studies"	1.2	0.9

2.5. PERCEPTION OF OFFERS AND USE OF APPLICATIONS

In the total sample, download of course materials is the best-known application (63% of the students perceive that downloads are offered by their faculty), followed by electronic communication (49%), online learning modules (33%), and virtual courses (14%). There are substantial differences in the perception of offers related to internet access at home.

The perception of offers is also related to the speed of the internet connection: students with a faster internet connection perceive more offers, while students without private access tend to ignore some of the e-learning applications offered. Also, the region is related to the perception of offers. *East-EU* faculties seem to offer less e-learning applications to their students than *EU-15* faculties. The patterns of the offers is reflected in the percentage of actual use of the different applications (Figure 3).

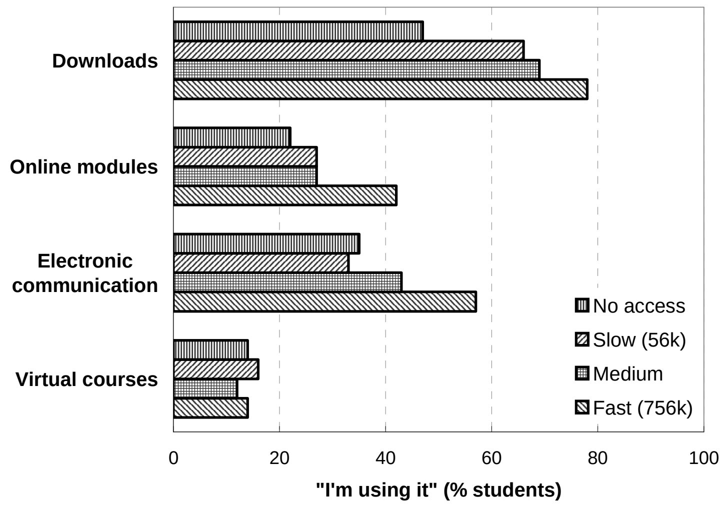

Figure 3. Relations between internet connection at home and use of applications.

2.6. MULTIVARIATE ANALYSIS

All variables group in a very predictable way. Just four linear principal components explain 75% of the variability of the original data: the key aspect is the use of computer (it is not very important if it is online or offline, at the university or at home). Also, the differences of gender behaviour can be neglected.

The linear discriminant analysis performed to find differences among students coming from different locations just includes five variables (a variable is not included because their behaviour is random or because their variability is already considered in another variable already included): use of computer at the university, gender, cost of the internet connection, e-mails related to study and time devoted to online study at home. Using this 5 variables, we can predict with a probability of 44 % to which University the student attends, while random probability is 16 % (Figure 4):

- Ecole Nationale Supérieure des Mines St-Etienne (EMSE): 41 %.
- Lappeenranta University of Technology (LUT): 25 %.
- University of Manchester (UMIST): 70 %.
- Technische Universitaet Berlin (TUB): 78 %.
- University of Barcelona (UB): 72 %.
- University of Oxford (UOX): 48 %.

3. FACULTY MEMBER SURVEY

The faculty member survey was conducted in two rounds. In the first round, a questionnaire was applied, containing 13 questions. About half of the questions were ratings, while the rest had open answers with free text (e. g., "What are the major advantages of e-learning in your opinion?"). In the second round, the results of the questionnaires were subject to a group discussion during a meeting of the EuPaCE.net project. On average, the 18 participating faculty members were 41 years old and had a teaching experience of 13 years. Faculty members were from the same departments than the students, and members of the EuPaCE.net consortium (Table 1).

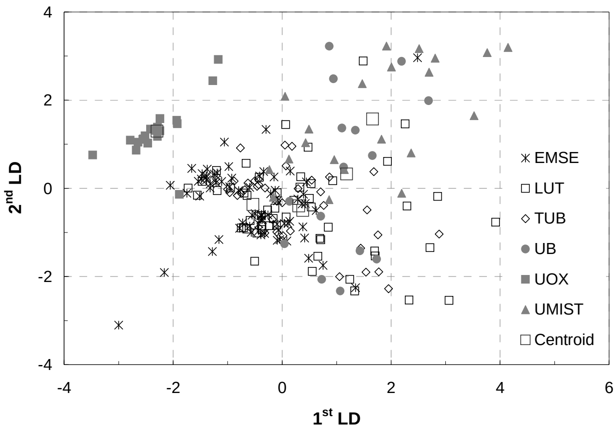

Figure 4. Linear discriminant analysis of the *EU-15* students.

The most important results of the faculty members survey are summarised in the following. The general observation of "*continuity and diversity*" for the introduction of e-learning into academic education (Lepori *et al.*, 2003) also applies to the present chemical engineering sample. Instead of provoking revolutionary changes, the integration of e-learning applications into the curricula is a slow, incremental process. At the moment, only one of the partners offers complete online courses, the others are still traditional campus universities. The most widely used information and communication technology (ICT) application is offering learning materials for download, and commu-nication via e-mail. Web-based interactive learning modules and virtual courses are still rare. Accordingly, the rationale behind the introduction of e-learning is in most cases the enrichment of face-to-face learning scenarios to improve the quality of learning. The survey revealed a considerable diversity in the use of e-learning within and between different chemical engineering faculties. For a staff member's engagement in e-learning, individual preferences are more important than organisational (not to mention national) culture. Table 4 summarizes some of the positive and negative comments and feedback received. As major challenges for e-learning in chemical engineering, the following issues were identified through qualitative content analysis of open questions and the group discussion:

- How can we integrate technology and pedagogical requirements?
- We need reliable tools for rapid development of e-learning materials.
- How can we keep our e-learning materials constantly updated?
- How can we develop and implement interactive process simulators, close to real industrial processes.

- How can we produce modules to achieve deep understanding and avoid superficial playing with e-learning applications?
- How can we integrate theory with online modelling, simulation and experiments?
- What about licence problems, authentication and intellectual property rights?

Table 4

Advantages and disadvantages of computer-based learning.

Advantages	Disadvantages
Visualization/Illustration/Animation: relations of input-output variables	Students' loss of motivation: no clear objectives and no evaluation criteria
Available anytime, anyplace	Lack of personal contact → abstraction
Enhance motivation	Superficial learning
Fast access to new releases	Which is the cost/benefit ratio?
To archive and provide course material	Never do with technology what could be done better without it
To prepare fast/interactive questions and answers tests Student motivation	Initiative valuable for a few percentage of students that are deeply interested in learning ("They will learn anyway")

4. COMPARISON OF SURVEYS

Overall, the results of both surveys match quite well, and there seems to be a "*mainstream*" of experiences, opinions, and preconceptions about e-learning that is shared by students and faculty members. Nonetheless, there are also some notable differences between the two groups of the surveys. Comparison of attitudes towards e-learning shows that the relations between the different items are similar in both groups, e.g. students as well as faculty members tend to agree that the quality of e-learning applications should be improved, and tend to disagree that computers are already being used too often for learning. But for all items, the tendency of the ratings of the faculty members can be interpreted as somewhat more in favour of e-learning than the students' ratings (Figure 5). The average staff members' attitude score on a scale from 0 (very negative) to 3 (very positive) was slightly more positive than the students' attitude score (2.0 vs. 1.6).

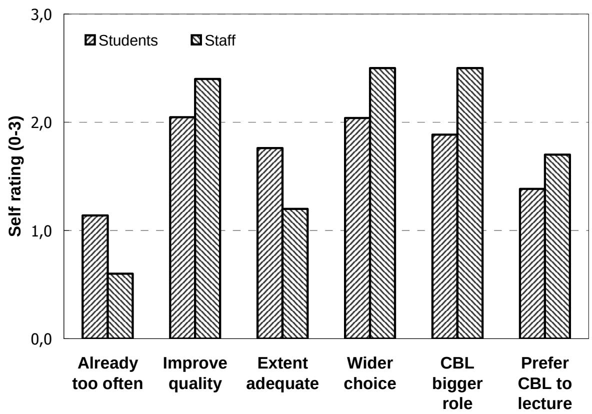

Figure 5. Attitudes towards computer base-learning (CBL).

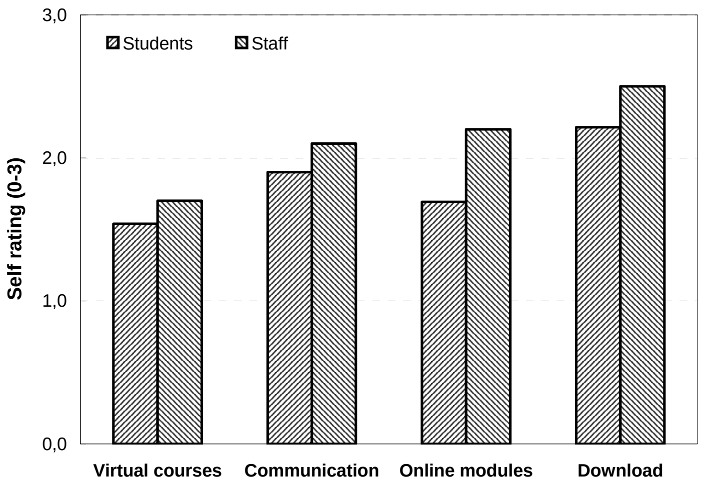

Figure 6. Attitudes towards different e-learning applications.

Today's most prevalent e-learning application is download of course materials, followed by electronic communication and online learning modules. Virtual courses are still rare. For both groups, prevalence is reflected by the judgment of the importance of different applications (Figure 6). Once more, faculty members show a general tendency to rate e-learning applications as more important than the students do, regardless of the type of application.

5. CONCLUSIONS

Summing up, the results of the study show that the use of information and communication technologies in chemical engineering education is still evolving. The vast majority of the students are already using computers in their daily life and for their studies. Students' attitudes towards e-learning are rather moderate, and there seems to be no urgent demand for new applications from their part. So, the driving force for innovations are the faculty members, who have a slightly more positive attitude towards e-learning and often act as "lone rangers" in experimenting with novel e-learning solutions. The situation on the higher education market for e-learning is characterised by "*customers*" that are generally open for new solutions, but have to be convinced by high quality offers. At least campus-based students are not very much interested in becoming completely virtual, nor are the faculty members planning tovirtualise chemical engineering higher education completely. Blended learning is the future.

Analysis shows that there is no substantial gender effect in computer use for chemical engineering students, i.e. the differences were stronger between different faculties than between women and men. Therefore, in *EU-15*, gender mainstreaming actions for chemical engineering higher education should primarily focus on attracting more women to increase their presence in engineering, instead of developing computer literacy programs for women that are already dedicated to chemical engineering. The most important precondition for perception and use of e-learning offers, as well as for developing advanced computer skill, seems to be private computer and internet access. While in *EU-15*, women (at least if they are studying chemical engineering) have equal private access than men, women in *East-EU* have considerably less private access than their male fellows. Here, gender mainstreaming could consist in financing private computer access for women. On the other hand, in *EU-15*, the vast majority of chemical engineering faculty members are men, and the support of academic careers for women in engineering could be an appropriate measure.

Above gender issues, the great challenge on the European level consists in building a community that bundles the efforts and makes sure that the "lone rangers" of e-learning do not get annihilated in the academic wilderness. The *EuPaCE.net* project is an attempt to integrate and harmonize the currently existing activities in the field of e-learning in process and chemical engineering through an international dialogue, and the development of guidelines. We aim to achieve an international cooperative network with participants from various backgrounds. All interested actors in the field of process and chemical engineering education are welcome to register at the open internet portal www.eupace.net and become part of the *EuPaCE.net* online community.

ACKNOWLEDGMENTS

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REFERENCES

1. W. Bates, *"Managing technological change",* Jossey-Bass, San Francisco, USA, 2000.
2. Lepori, L. Cantoni, C. Succi, C. *The introduction of eLearning in European universities: models and strategies*, GMW 2003, accessed March 2005: http://www.newmine.org/newmine_edum_lepori_alii_article_gmw03.pdf (2003).
3. D. Montgomery, G. Runger, "*Applied Statistics and Probability for Engineers",* John Wiley and Sons, New York, USA, 1998.
4. S. M. Ross, "*Introduction to Probability and Statistics for Engineers and Scientists"*, John Wiley and Sons, New York, USA, 1999.
5. www.eupace.net (accessed March 2005).