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# ANALYSIS OF STUDENTS' ICT USAGE IN THE FUNCTION OF CROATIAN HIGHER EDUCATION DEVELOPMENT MANAGEMENT

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Original scientific paper

The paper presents the results of the research aimed at establishing the purpose and frequency of using information and communication technologies (ICT) among Croatian polytechnic students in learning and education processes. The research was conducted on a sample of 818 students enrolled in six polytechnics. Within data analysis the descriptive statistics indicators were calculated. Discriminant analysis was conducted to determine the ways of ICT usage according to which the defined student groups differ the most. Research results indicate that certain student groups, especially those enrolled in technical studies, use ICT more intensively. Furthermore, the research revealed that some aspects of ICT usage among Croatian polytechnic students have been neglected. The significance of this paper arises from the fact that the issues analyzed therein, although crucial for current situation assessment and for formulating the Croatian higher education development strategy, have not been adequately investigated. The results presented here can therefore be viewed as management support to the development of this system, but also as a basis for future analyses.

***Keywords:*** *Croatian higher education, development management, discriminant analysis, ICT, polytechnic students*

## Analiza korištenja ICT od strane studenata u funkciji upravljanja razvojem hrvatskog visokog obrazovanja

Izvorni znanstveni članak

U ovom su radu dani rezultati istraživanja čiji je cilj bio utvrditi s kojom svrhom i koliko učestalo hrvatski veleučilišni studenti koriste informacijske i komunikacijske tehnologije (ICT) u procesu učenja i obrazovanja. Istraživanje je provedeno na uzorku od 818 studenata upisanih na šest veleučilišta. U okviru analize podataka izračunati su pokazatelji deskriptivne statistike. S namjerom određivanja načina korištenja ICT, prema kojima se definirane skupine studenata najviše razlikuju, provedena je diskriminativna analiza. Rezultati istraživanja pokazali su da pojedine skupine studenata, a poglavito oni upisani na tehničke studije, intenzivnije koriste ICT. Istraživanje je također pokazalo da su neki aspekti upotrebe ICT među hrvatskim veleučilišnim studentima zanemareni. Značaj ovog rada proizlazi iz činjenice da u njemu analizirana pitanja, iako ključna za ocjenu postojećeg stanja i formuliranje strategije razvoja hrvatskog visokog obrazovanja, još uvijek nisu na odgovarajući način istražena. Stoga se dani rezultati mogu shvatiti kao podrška upravljanju razvojem tog sustava, ali također i kao temelj za buduće analize.

***Ključne riječi:*** *diskriminativna analiza, hrvatsko visoko obrazovanje, ICT, upravljanje razvojem, veleučilišni studenti*

## 1 Introduction

The times that we live in can truly be called the information age. Owing to intensive technological advances information has, especially over the two past decades, become a fundamental resource. In the developed countries of the world a significant proportion of the population is engaged in work related to gathering, organization, storing and distribution of information, with a growing tendency persisting in this sector.

Information and the resulting knowledge are the key factors of development. They are the dynamo on which social and economic advancement depends directly. The continuous ICT evolution and implementation are forcing universities and colleges to respond to trends that are well on the way to transform our society into a so-called 'knowledge economy'. Globalization and ICT have put new demands on higher education institutions, with far-reaching implications for their teaching and research functions [1]. The publications of scientific papers and the number of patent applications are on the increase, which bears evidence that new technologies have changed the speed of production and distribution of knowledge. Technological advances impel higher education institutions around the world to redefine their attitudes towards their students, partners, and competitors, as well as to adapt their research infrastructure and teaching practices [2].

Technology is obviously a key factor in the development and growth of organizations, as it allows them to reduce costs, increase productivity, improve efficiency, develop new products, and reach new customers. The long term success of any organization depends on its ability to continually embrace and implement new technologies. Higher education is obviously no exception in this. Future success will belong to those higher education organizations that are better or faster than others in planning, utilizing and managing technology [3].

Starting from the concept of innovation, Dodds [4] emphasizes three broad areas where ICT contribute to university innovation: building communities of innovation, radical changes in institutional processes and practices, and providing infrastructure and tools that enable people to excel.

Cárdenas [5] argues that although educational technology has been given much attention recently, some major issues have been ignored. It is easy to speak of technology as "the wave of the future" and applaud its every manifestation in the education process. It is more difficult to determine the true value of technology, as well as its limitations. Another question is how fast higher education institutions can be in adopting new technologies, especially in comparison to the business sector. According to Castells [6] schools and universities seem to be least affected by the virtual logic embedded in information technology. In the case of universities, this is because the quality of education will probably remain associated with the intensity of face-to-face interaction for the foreseeable future. Experiences so far indicate that distance learning might play a significant role in the future; however, it could hardly replace current higher education institutions. Accordingly, good-quality universities tend to combine on-line teaching, distance learning and on-site education.

Higher education has two basic functions. It is a place of knowledge creation and the provider of educated people. To be able to meet the challenges of the era dominated by ICT, students need to acquire skills and competencies related to ICT usage. This paper aims to establish how

frequently, and to what purpose, Croatian polytechnic students use ICT in the learning and education process. Although these questions are crucial for assessing the current situation and formulating the development strategy of higher education, so far they have not been properly investigated in the Republic of Croatia.

## 2
## A brief overview of previous research

In the following text the most important results of available research on ICT usage by students will be presented. These publications, which will be discussed chronologically, have mostly been published over the past few years.

Lim [7] presented the results of a survey in which Australian first-year chemistry students self-assessed their ICT skills. The author concluded that the general level of ICT skill continued to improve, although minor deficiencies were noticeable in the use of word processors, e-mail attachments, the Internet, and in metacognitive skills. Significant deficiencies were observed in the use of spreadsheets, library databases, presentation software and computer conferencing, with major deficiencies in the use of relational databases.

The study by Strayhorn [8] aimed to estimate the relationship between the use of technology and educational gains on a sample of American students. Results suggested a modest, but statistically significant relationship between students' use of technology and closely related learning outcomes. Four computer-based activities were noted as strongest predictors of gains from higher education: Internet searches for course material, computer usage to analyze data, use of indexes or databases to find material, and retrieving off-campus library materials.

In the study conducted by Hisham et al. [9] it was established that students' sense of IT efficacy significantly affected their usage of such technology. In addition, the results showed that that students' sense of IT efficacy had a substantial indirect effect on their satisfaction. The study was carried out on a sample of undergraduate students from Malaysia.

Herrera-Batista and González-Martínez [10] surveyed a group of Mexican first-year undergraduate students to determine their habits, abilities and preferences in the use of ICT. The results clearly indicate that ICT are a part of their social-communicative environment. In all academic and socialization activities, the students frequently use mobile phones, Internet navigation, text messaging, e-mail, discussion boards and social networks. In addition, for many students it is important to belong to some Internet social community.

Mahmood [11] presents the findings of a survey conducted to determine the gender, subject and degree differences in access, use and attitudes toward ICT among Pakistani university students. For the most part, the results of the study correspond to those carried out elsewhere in the world. Affordable ICT equipment and Internet connectivity has enabled middle and lower middle class students to take full advantage of technological advances. Students are generally quite enthusiastic about technology, the Internet and e-mail being the most commonly used facilities. An encouraging finding is that ICT is used also for educational purposes. Female students still use ICT less than their male counterparts. The lowest awareness of ICT benefits is noted among students from arts & humanities. Similarly, ICT usage is lower among undergraduate students.

The study conducted by Littlejohn, Margaryan and Vojt [12] aimed to establish the changing patterns in Scottish students' use of electronic tools over a four-year period. The results showed no correlation between the extent of ICT usage by students and their expectations of how they will learn. Although ICT use among students increased dramatically over a four-year period, their expectations of how they might learn at university remained relatively static over the same timeframe.

Ramanau, Hosein and Jones [13] presented the results of a longitudinal study on first-year students' expectations and actual reported use of ICT at a British university. The authors found that the Net Generation students (aged 25 and younger) spend more time per day using ICT than the non-Net Generation students. The research further revealed that younger generation students used ICT predominantly for social life and leisure, whereas older students were more likely to use it for study.

The research by Ruiz and Romero [14] investigated the level of students' use of ICT at a Mexican university, and the factors affecting it. Although the surveyed students reported a high level of ICT related knowledge, they obtained a low score on the level of strategic awareness of ICT and their uses as problem-solving devices or as a means to achieve specific academic goals. The authors conclude that the problem lies in the fact that students are not being taught how to use ICT effectively for academic purposes. Since the institution has invested heavily in equipment and training, the consequence is waste of resources, both material and human.

Shyti [15] studied the ICT usage by Albanian students. The data were gathered during two periods: December 2004 – June 2005 and during the year 2010. The results indicate that ICT have become a normal part of life for students and their families. However, while some technologies, such as mobile phones, are widely used by students, the Internet usage is lagging behind.

Bazer, Pardillo and Ruales [16] looked into Filipino students' perceptions and their self-efficacy in relation to the use of ICT. The results of the study showed that over 50 % of students have their own computer, whereas slightly more than a third of them have Internet connection at home. Almost 70 % of students reported daily use of computer lasting 1÷3 hours. Word processors, web browsers, search engines and e-mails were the most commonly used ICT tools. The authors found a negative correlation between the frequency of ICT use and age, whereas there was a strong positive relationship between perception towards ICT and self-efficacy in the use of ICT.

The study by Porshnev and Giest [17] investigated the ICT usage by Russian students. Their results indicate that students' favourites are social networks and general information resources (e.g. Wikipedia). Young male students use ICT more frequently than female students for learning and leisure activities. Although ICT are used for educational purposes, this is far less popular than computer games, entertainment and social networks.

Finally, let us mention two studies that looked into ICT usage by Croatian students. Penny, Dukić and Dukić [18] examined the differences in ICT usage between Scottish and Croatian university students. The results of the analysis showed that a vast majority of students in both countries have their own computer device and Internet access. Still, Scottish students more frequently have broadband connection. They also stated more often that they use ICT for educational purposes, whereas Croatian students use them more for non-study related activities.

Vrana [19] investigated computer use by students at a Croatian faculty. Based on the results the author concluded that students use computers and the Internet for education, but also for unrelated activities, such as communication with family and friends, watching videos, and listening to music. Another finding was that students have learned about ICT mostly by themselves.

The papers presented here indicate that there is a worldwide interest in studying different aspects of ICT usage by students, regardless of the relevant country's level of development. Given the importance of such insights for effective management of higher education system, the interest in students' level of equipment and skills is more than understandable.

## 3
## Sample and methods

The data were the outcome of a survey conducted at six Croatian polytechnics. The sample consisted of 818 students – 453 of them female (55,4 %) and 365 male (44,6 %). The average age of students was 22,53 years, with standard deviation of 5,8 years. For the purpose of our analysis the students were divided into two age groups. Students aged between 18 and 24 were put in the first group, which comprised 655 respondents (80,1 %). The second group consisted of 163 students (19,9 %), aged between 25 and 51 years.

With regard to their professional field of study, the respondents were put into four groups: technical studies, biomedicine and health care, biotechnical studies and social studies. There were 273 (33,4 %) students enrolled in technical studies, 116 (14,2 %) of them were in the area of biomedicine and health care, biotechnical studies accounted for 89 students (10,9 %), whereas the group of social studies had 340 students (41,6 %).

Apart from descriptive statistics, the research also included discriminant analysis. According to Everitt and Skrondal [20], discriminant analysis is a term that covers a large number of techniques for the analysis of multivariate data that have in common the aim to assess whether or not a set of variables distinguish or discriminate between two (or more) groups of individuals. In this paper discriminant analysis was used to identify the variables, related to ICT usage, which do distinguish between the defined groups of students.

Finally, statistical data processing was carried out by means of statistical packages SPSS and Statistica.

## 4
## Results of the analysis

Out of 818 surveyed students, only seven stated they did not own a computer. Thus, 99,1 % of respondents had their own computer. The equipment was on average 19,15 months old, with standard deviation of 19,24 months. Among the surveyed students laptop computers were slightly prevalent. Out of 811 students with their own computer, 414 (51 %) had a laptop, whereas 397 (49 %) owned a desktop PC.

A high proportion of students had Internet access. Out of 818 students, 797 (97,4 %) stated they can access the Internet from their homes. Among those, only 14 (1,8 %) used a Dial-up connection, while 783 (98,2 %) had broadband access at their disposal. Given that broadband Internet access is a precondition for the development of information society, and consequently for participation in technologically advanced forms of teaching, our results indicate that ICT prerequisites are satisfactory among Croatian polytechnic students.

The surveyed students stated that they generally used ICT for 4,1 hours a day (standard deviation = 3 hours), of which 1,77 hours were for education purposes (standard deviation = 1,48 hours). Thus, our respondents use ICT most of the time to fulfil the needs that are not directly connected to their studies.

To determine for which purpose and how frequently polytechnic students use ICT in the learning and education process, the following items were defined in the research:

- Word processing (writing seminar papers and/or other texts);
- Creating presentations;
- Reading, i.e. studying educational content in digital form;
- Using spreadsheets;
- Drawing, i.e. designing;
- Solving problems that require the use of statistical or mathematical packages;
- Work with multi-media;
- Correspondence with teachers;
- Correspondence with fellow students;
- Browsing the web-site of their polytechnic;
- Downloading course materials from teacher's web-site;
- Using the Internet as an additional source of teaching content and information;
- Submitting homework and seminar papers in digital form;
- Participating in forum discussions on issues related to their studies.

Student responses were measured on a five-point Likert scale (1 = never, 2 = rarely, 3 = occasionally, 4 = frequently, 5 = regularly).

Tab. 1 shows the basic descriptive statistics (mean, median, mode, standard deviation and coefficient of variation) for all the research variables stated above.

The most frequent use of ICT by the surveyed students was to access the web-site of the polytechnic they were enrolled in. This was the only variable with the mean higher than 4. A relatively high average grade was also given to the frequency of downloading course materials from teacher's web-site, using computers for writing seminar papers and/or other texts, as well as for preparing presentations. On average, the lowest usage of computers by students was for solving problems that require the use of statistical or mathematical packages. Other relatively rare purposes in using computers were drawing / designing, and solving problems that require the use of spreadsheets. In the analyzed cases the median showed significant overlapping with the mean.

Tab. 2 contains the basic descriptive statistics and results of testing the equality of means of male and female students' responses. Lower values of Wilks' lambda and higher values of $F$-level, provided that $p < 0,05$, are characteristic of independent variables that reveal a more significant difference between male and female students.

Responses by male students indicate that on average they use ICT more than their female counterparts for the following purposes: reading or browsing different educational content in digital form, solving problems that require the use of spreadsheets, drawing/designing, solving problems that require the use of statistical or mathematical

**Table 1** Descriptive statistics relating to frequency of ICT usage for a certain purpose during studies

| Purpose of ICT usage | Mean | Median | Mode | Standard deviation | Coefficient of variation |
|---|---|---|---|---|---|
| Word processing | 3,96 | 4,00 | 5,00 | 1,07 | 27,14 |
| Presentations | 3,91 | 4,00 | 5,00 | 1,15 | 29,48 |
| Reading digital content | 3,51 | 4,00 | 3,00 | 1,16 | 32,99 |
| Spreadsheets | 2,41 | 2,00 | 2,00 | 1,21 | 50,29 |
| Drawing/designing | 2,35 | 2,00 | 1,00 | 1,32 | 56,20 |
| Statistical or mathematical packages | 2,04 | 2,00 | 1,00 | 1,08 | 53,06 |
| Multi-media | 3,00 | 3,00 | 3,00 | 1,34 | 44,76 |
| Correspondence with teachers | 2,66 | 3,00 | 3,00 | 1,23 | 46,07 |
| Correspondence with students | 3,55 | 4,00 | 5,00 | 1,33 | 37,51 |
| Browsing the web | 4,14 | 4,00 | 5,00 | 1,03 | 24,82 |
| Downloading course materials | 3,99 | 4,00 | 5,00 | 1,16 | 29,01 |
| Internet as an additional source | 3,85 | 4,00 | 5,00 | 1,12 | 29,14 |
| Submitting homework | 3,67 | 4,00 | 5,00 | 1,23 | 33,40 |
| Forums | 2,44 | 2,00 | 1,00 | 1,31 | 53,73 |

**Table 2** Basic descriptive statistics and results of testing the equality of means of male and female students' responses

| Purpose of ICT usage | Gender | | | | Tests of equality of groups' means | | |
|---|---|---|---|---|---|---|---|
| | Male | | Female | | | | |
| | Mean | Standard deviation | Mean | Standard deviation | Wilks' lambda | *F* | *p* |
| Word processing | 3,73 | 1,13 | 4,16 | 0,98 | 0,960 | 32,131 | 0,000 |
| Presentations | 3,73 | 1,23 | 4,09 | 1,03 | 0,974 | 20,495 | 0,000 |
| Reading digital content | 3,54 | 1,15 | 3,51 | 1,15 | 1,000 | 0,146 | 0,702 |
| Spreadsheets | 2,45 | 1,23 | 2,39 | 1,22 | 0,999 | 0,405 | 0,525 |
| Drawing/designing | 2,73 | 1,39 | 2,05 | 1,19 | 0,935 | 53,883 | 0,000 |
| Statistical or mathematical packages | 2,21 | 1,09 | 1,91 | 1,07 | 0,981 | 14,767 | 0,000 |
| Multi-media | 3,09 | 1,36 | 2,97 | 1,33 | 0,998 | 1,484 | 0,224 |
| Correspondence with teachers | 2,59 | 1,16 | 2,75 | 1,28 | 0,996 | 3,351 | 0,068 |
| Correspondence with students | 3,52 | 1,33 | 3,62 | 1,34 | 0,999 | 0,985 | 0,321 |
| Browsing the web | 3,96 | 1,08 | 4,29 | 0,95 | 0,975 | 19,812 | 0,000 |
| Downloading course materials | 3,80 | 1,16 | 4,14 | 1,11 | 0,978 | 17,244 | 0,000 |
| Internet as an additional source | 3,71 | 1,17 | 3,98 | 1,06 | 0,986 | 10,848 | 0,001 |
| Submitting homework | 3,49 | 1,25 | 3,87 | 1,17 | 0,975 | 19,587 | 0,000 |
| Forums | 2,52 | 1,34 | 2,40 | 1,30 | 0,998 | 1,521 | 0,218 |

packages, work with multi-media, and participating in forum discussions on issues related to their studies. According to the test results, the following differences in the ICT usage intensity between male and female polytechnic students were statistically significant: word processing (writing seminar papers and/or other texts), making presentations, drawing/designing, use of statistical or mathematical packages, browsing the web-site of their polytechnic, downloading course materials from teacher's web-site, using the Internet as an additional source of teaching content and information, and submitting homework and seminar papers in digital form. In most of these cases female students stated a higher level of ICT usage.

The results of testing indicate that the determined discriminant function is statistically significant ($\chi^2$ = 137,484, $p < 0,001$). The next table outlines the structure matrix.

The structure matrix contains the coefficients of correlations between each independent variable and the discriminant function. It lists independent variables according to absolute value of structural coefficients calculated for each discriminant function. On the basis of

**Table 3** Structure matrix

| Purpose of ICT usage | Discriminant function |
|---|---|
| | 1 |
| Drawing/designing | –0,596 |
| Word processing | 0,460 |
| Presentations | 0,367 |
| Browsing the web | 0,361 |
| Submitting homework | 0,359 |
| Downloading course materials | 0,337 |
| Statistical or mathematical packages | –0,312 |
| Internet as an additional source | 0,267 |
| Correspondence with teachers | 0,149 |
| Forums | –0,100 |
| Multi-media | –0,099 |
| Correspondence with students | 0,081 |
| Spreadsheets | –0,052 |
| Reading digital content | –0,031 |

the obtained results it can be concluded that the variable most strongly correlated with the determined discriminant function is the one defined as the frequency of computer usage for the purposes of drawing, i.e. designing. Most variables show a lower correlation with the discriminant function.

Tab. 4 contains canonical variable means by group. The obtained results indicate that male students are better discriminated by the determined discriminant function than female students.

**Table 4** Means of canonical variables

| Gender | Discriminant function |
|---|---|
| | 1 |
| Male | –0,494 |
| Female | 0,395 |

Tab. 5 shows the basic descriptive statistics and results of testing the hypothesis on equality of means of younger and older students' responses. Students from the younger age group stated that on average they used ICT more than their older colleagues for the purposes of drawing / designing, working with multi-media, correspondence with fellow students, participating in forum discussions on issues related to their studies, and the only statistically significant difference is the one in using computers for work on photographs or videos, i.e. with multi-media. Statistical significance was also confirmed in the following cases, which were rated higher by older students: reading or browsing different educational content in digital form, using spreadsheets, correspondence with teachers, browsing the web-site of their polytechnic and using the Internet as an additional source of teaching content and information. On the basis of these results it can be concluded that the age of students has an impact on the intensity of ICT usage for study purposes, i.e. that older students more frequently use computers and the Internet as support and a tool in their education.

In this case as well the results of testing showed that the determined discriminant function is statistically significant ($\chi^2$ = 112,689, $p$ < 0,001). Tab. 6 lists the correlation coefficients between each independent variable and the discriminant function. The variable most strongly correlated with the determined discriminant function is the one defined as the frequency of using spreadsheets. In addition, there is a moderately strong correlation between the discriminant function and the variable defined as ICT usage for the purpose of reading or browsing different educational content in digital form. Other variables show only a weak correlation with discriminant function.

Tab. 7 lists the canonical variable means by group.

Older students are better discriminated by the determined discriminant function.

Tab. 8 lists the basic descriptive statistics and results of testing the hypothesis on equality of means of students' responses with regard to their field of study. The results of analysis of ICT usage frequency with regard to the field of study were partly as expected. Thus, for example, students of technical studies use computers more than students in other fields for the purposes of drawing/designing, solving problems that require the use of statistical or mathematical packages, and working with multi-media. It is, however,

**Table 5** Basic descriptive statistics and results of testing the equality of means of younger and older students' responses

| Purpose of ICT usage | Age group (years) | | | | Tests of equality of groups' means | | |
|---|---|---|---|---|---|---|---|
| | 18 - 24 | | 25 - 51 | | | | |
| | Mean | Standard deviation | Mean | Standard deviation | Wilks' lambda | $F$ | $p$ |
| Word processing | 3,93 | 1,06 | 4,11 | 1,08 | 0,996 | 3,393 | 0,066 |
| Presentations | 3,91 | 1,12 | 4,01 | 1,18 | 0,999 | 0,805 | 0,370 |
| Reading digital content | 3,43 | 1,14 | 3,93 | 1,10 | 0,971 | 23,227 | 0,000 |
| Spreadsheets | 2,30 | 1,14 | 2,89 | 1,43 | 0,963 | 29,596 | 0,000 |
| Drawing/designing | 2,40 | 1,33 | 2,17 | 1,27 | 0,995 | 3,769 | 0,053 |
| Statistical or mathematical packages | 2,02 | 1,06 | 2,15 | 1,20 | 0,998 | 1,846 | 0,175 |
| Multi-media | 3,12 | 1,30 | 2,62 | 1,45 | 0,978 | 17,440 | 0,000 |
| Correspondence with teachers | 2,61 | 1,20 | 2,98 | 1,29 | 0,986 | 11,019 | 0,001 |
| Correspondence with students | 3,61 | 1,33 | 3,44 | 1,33 | 0,998 | 1,857 | 0,173 |
| Browsing the web | 4,10 | 1,02 | 4,33 | 1,02 | 0,992 | 6,050 | 0,014 |
| Downloading course materials | 3,96 | 1,13 | 4,13 | 1,23 | 0,997 | 2,556 | 0,110 |
| Internet as an additional source | 3,81 | 1,11 | 4,08 | 1,11 | 0,991 | 7,317 | 0,007 |
| Submitting homework | 3,68 | 1,20 | 3,80 | 1,30 | 0,998 | 1,269 | 0,260 |
| Forums | 2,46 | 1,30 | 2,45 | 1,41 | 1,000 | 0,007 | 0,931 |

**Table 6** Structure matrix

| Purpose of ICT usage | Discriminant function |
|---|---|
| | 1 |
| Spreadsheets | 0,492 |
| Reading digital content | 0,435 |
| Multi-media | –0,377 |
| Correspondence with teachers | 0,300 |
| Internet as an additional source | 0,244 |
| Browsing the web | 0,222 |
| Drawing/designing | –0,175 |
| Word processing | 0,166 |
| Downloading course materials | 0,144 |
| Correspondence with students | –0,123 |
| Statistical or mathematical packages | 0,123 |
| Submitting homework | 0,102 |
| Presentations | 0,081 |
| Forums | –0,008 |

**Table 7** Means of canonical variables

| Age group (years) | Discriminant function |
|---|---|
| | 1 |
| 18 ÷ 24 | –0,194 |
| 25 ÷ 51 | 0,812 |

**Table 8** Basic descriptive statistics and results of testing the equality of means of students' responses with regard to their field of study

| Purpose of ICT usage | Field of study | | | | | | | | Tests of equality of groups' means | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Technical studies | | Biomedicine and health care studies | | Biotechnical studies | | Social studies | | | | |
| | Mean | Standard deviation | Mean | Standard deviation | Mean | Standard deviation | Mean | Standard deviation | Wilks' lambda | *F* | *p* |
| Word processing | 3,81 | 1,08 | 4,19 | 0,91 | 3,71 | 1,10 | 4,09 | 1,07 | 0,976 | 6,446 | 0,000 |
| Presentations | 3,77 | 1,20 | 4,13 | 0,93 | 3,69 | 1,19 | 4,06 | 1,10 | 0,978 | 5,861 | 0,001 |
| Reading digital content | 3,66 | 1,09 | 3,83 | 1,04 | 3,31 | 1,22 | 3,37 | 1,18 | 0,974 | 6,770 | 0,000 |
| Spreadsheets | 2,42 | 1,19 | 2,05 | 1,12 | 2,07 | 1,03 | 2,61 | 1,29 | 0,968 | 8,512 | 0,000 |
| Drawing/designing | 3,19 | 1,35 | 1,90 | 1,08 | 1,89 | 1,09 | 1,95 | 1,09 | 0,797 | 65,739 | 0,000 |
| Statistical or mathematical packages | 2,29 | 1,02 | 1,75 | 1,11 | 1,78 | 1,01 | 2,01 | 1,11 | 0,966 | 9,191 | 0,000 |
| Multi-media | 3,44 | 1,31 | 2,72 | 1,37 | 2,61 | 1,40 | 2,90 | 1,27 | 0,948 | 14,278 | 0,000 |
| Correspondence with teachers | 2,58 | 1,11 | 2,76 | 1,23 | 2,33 | 1,13 | 2,83 | 1,33 | 0,982 | 4,663 | 0,003 |
| Correspondence with students | 3,79 | 1,18 | 3,54 | 1,34 | 3,10 | 1,44 | 3,53 | 1,39 | 0,977 | 6,162 | 0,000 |
| Browsing the web | 4,07 | 0,96 | 4,48 | 0,74 | 3,88 | 1,10 | 4,16 | 1,10 | 0,976 | 6,256 | 0,000 |
| Downloading course materials | 4,00 | 1,05 | 4,42 | 0,87 | 3,40 | 1,37 | 4,00 | 1,18 | 0,952 | 12,994 | 0,000 |
| Internet as an additional source | 3,86 | 1,06 | 4,20 | 0,98 | 3,71 | 1,11 | 3,79 | 1,18 | 0,984 | 4,264 | 0,005 |
| Submitting homework | 3,64 | 1,18 | 4,36 | 0,84 | 2,87 | 1,17 | 3,75 | 1,24 | 0,909 | 25,848 | 0,000 |
| Forums | 2,72 | 1,31 | 2,86 | 1,28 | 2,19 | 1,39 | 2,17 | 1,25 | 0,950 | 13,534 | 0,000 |

**Table 9** Structure matrix

| Purpose of ICT usage | Discriminant function | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Drawing/designing | 0,763 | –0,026 | 0,237 |
| Multi-media | 0,328 | –0,068 | 0,292 |
| Forums | 0,227 | 0,447 | 0,003 |
| Reading digital content | 0,127 | 0,354 | 0,047 |
| Internet as an additional source | –0,002 | 0,328 | 0,035 |
| Browsing the web | –0,093 | 0,327 | 0,205 |
| Submitting homework | –0,096 | 0,612 | 0,623 |
| Downloading course materials | –0,019 | 0,440 | 0,453 |
| Spreadsheets | –0,017 | –0,297 | 0,439 |
| Correspondence with teachers | –0,111 | 0,043 | 0,352 |
| Correspondence with students | 0,163 | 0,083 | 0,337 |
| Word processing | –0,178 | 0,159 | 0,274 |
| Statistical or mathematical packages | 0,239 | –0,159 | 0,270 |
| Presentations | –0,179 | 0,125 | 0,256 |

systematic investment in technologically advanced modes of learning and teaching in certain study programs, and encouraging students to use them can significantly intensify ICT usage by students, which will bring about increased computer and Internet usage in the process of studying. The research has revealed that the lowest level of ICT usage is interesting and somewhat unexpected that students in the field of biomedicine and health care in most of the examined cases use ICT more than their counterparts for educational purposes. Here it should be noted that the data used in the analysis were based on respondents' self-evaluation. Still, among students of professional biotechnical studies. These results indicate that additional effort should be made in order to decrease the gap between biotechnical and other fields of study. According to the results of testing, in all cases there is at least one group of respondents which exhibits statistically significant difference from the others with regard to the level of ICT usage for educational purposes.

All three determined discriminant functions are statistically significant at the level $p < 0,001$. Tab. 9 shows the structure matrix.

The first discriminant function is described by variables defined as ICT usage for the purpose of drawing/designing, and for work with multi-media. The former has a stronger correlation with the discriminant function, and the latter a weaker correlation.

The second discriminant function is described by variables defined as ICT usage for the purpose of participating in forum discussions on issues related to their studies, reading or browsing different educational content in digital form, using the Internet as an additional source of teaching content and information, and finally browsing the web-site of their polytechnic. All these variables establish a moderate and weak correlation with the discriminant function.

The remaining variables describe the third discriminant function. The strongest correlation exists between the third discriminant function and the variable defined as ICT usage for the purpose of submitting homework and seminar papers in digital form. This is actually the only variable that

**Table 10** Means of canonical variables

| Field of study | Discriminant function | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Technical studies | 0,904 | 0,000 | 0,054 |
| Biomedicine and health care studies | –0,450 | 0,932 | –0,081 |
| Biotechnical studies | –0,253 | –0,320 | –0,871 |
| Social studies | –0,523 | –0,226 | 0,206 |

achieves a slightly stronger correlation with the third discriminant function.

Tab. 10 lists the canonical variable means by group.

Compared to the remaining groups, students enrolled in technical professional studies are best discriminated by the first discriminant function. The second discriminant function manages to best discriminate students enrolled in professional studies in the field of biomedicine and health care, whereas students of biotechnical studies are best discriminated by the third discriminant function.

## 5 Conclusion

In today's world information and knowledge have become a crucial competitive advantage. Knowledge economy, with intellectual capital taking centre stage, is based on transforming information into knowledge and its ubiquitous applications. A key prerequisite for the development of knowledge economy is the advancement and implementation of ICT. These technologies have accelerated the production of knowledge and simplified the interactions in sharing knowledge, allowing it to become a fundamental factor in the production of goods and services. Production processes have come to resemble scientific and research work, resulting in breakthroughs that improve the quality of life. Due to such trends, traditional organizational structures have also begun to evolve and acquire new forms, followed by dramatic changes in qualification structure of working population.

Higher education system is responsible for the production of knowledge and people that are qualified and capable of working in a dynamic and turbulent environment. Taking into account these tasks, it can safely be maintained that higher education plays a key role in building a modern society. Since ICT have become an essential education tool and learning support, the development of higher education should be based on implementing state-of-the-art technology. Successful management of higher education development requires insights into levels of ICT equipment at students' disposal, as well as the purpose and frequency of ICT usage. Such information is crucial if one wishes to formulate an optimal development strategy for higher education.

Starting from the above premises, this research is in the function of managing the development of Croatian higher education. The basic goal was to examine different aspects of ICT usage by Croatian polytechnic students. The paper's significance arises from the fact that the issues discussed here have not been previously analyzed in an adequate manner.

According to our research results, the level of ICT equipment among Croatian polytechnic students was shown to be satisfactory. A great majority of students have their own computer, which is slightly over 1,5 years old on average, and have broadband Internet access. Although students use ICT relatively intensively, only a fraction of this time is dedicated to study purposes. In this, there are areas for which ICT is more frequently used, and others are rather neglected. Further results indicate more intensive usage of computers and the Internet for study purposes by female students and by students in the older age group in a number of the analyzed cases. With regard to the professional area, the results show that ICT as a tool and support in education is most intensively used by students of biomedicine and health care studies, as well as technical studies, and the least by students of biotechnical studies. In all the analyzed cases statistically significant discriminant functions were determined, but for the most part the variables establish only a weaker correlation with them.

On the basis of these results it is possible to formulate certain guidelines for the development of higher education, particularly of polytechnics – guidelines that would refer to the usage of modern technologies. First and foremost, it is necessary to incorporate ICT in polytechnic study programs to a greater degree, and to continuously draw students' attention to the advantages and vast possibilities of using ICT in the process of learning and education. Thus, it is advisable to put more emphasis on ICT usage at polytechnics and to strongly encourage students to make the most of it in the study process. Another important aspect is the teaching staff, i.e. ensuring that instructors possess adequate, up-to-date ICT skills. Furthermore, course materials should be available over the Internet to the highest possible degree. Unless already implemented, polytechnics need to choose and introduce one of the learning management systems as soon as possible. Polytechnics that are lagging behind have to put in additional efforts in order to reduce the existing gap, by intensifying investment in human and technical resources.

This paper has covered only a fraction of the vast area that comprises ICT usage in higher education. This, however, can be viewed as a foundation for further research, and thus a contribution to more efficient management of the Croatian higher education system.

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