Croatian Journal of Education
Vol.26; No.3/2024, pages: 823-879
Original research paper
Paper submitted: 28th March 2024
Paper accepted: 6th June 2024
https://doi.org/10.15516/cje.v26i3.5932

Free and Open-Source Software in Higher Education

Predrag Oreški[1], Dragutin Kermek[2] and Valentina Kirinić[2]
[1]University of Zagreb, Faculty of Teacher Education
[2]University of Zagreb, Faculty of Organization and Informatics

Abstract

This paper explores the usage and awareness of free and open-source software (FOSS) among university students attending several study programs at the Faculty of Organization and Informatics (FOI) of the University of Zagreb and the Faculty of Teacher Education (FTE) of the University of Zagreb. Using the data collected via an online questionnaire on the sample of 777 students and the descriptive and inferential statistics, an analysis was carried out to determine whether the respondents are familiar with the key features of FOSS, whether they use some FOSS, whether they are aware of the advantages of FOSS, which features of FOSS are the most important to them, and how they evaluate the quality of FOSS. The data were analysed using the statistics FOSS GNU PSPP and R. The research results show that 92.66 % of the respondents use some kind of FOSS, 28.99 % are aware that they are using FOSS with all its features, and the most important FOSS feature for the respondents is that it is often cost-free. There are significant differences in the respondents' familiarity with FOSS and the number of FOSS operating systems users in terms of their faculty and gender. On a scale from 1 (insufficient) to 5 (excellent), the respondents' rating of FOSS reliability was 3.74, completeness 3.68, and overall quality 3.74. The research results indicate the need for additional education of students about FOSS, and its advantages and disadvantages.

Key words: *FOSS adoption; FOSS awareness; FOSS quality.*

Introduction

According to software properties, such as its cost, users' freedom, availability of source code, and ownership, software can be classified into specific categories, such as: free and open-source software (FOSS), public domain, freeware, shareware, and proprietary software (Muffatto, 2006; Oreški & Šimović, 2013). The two software categories which differ the most are proprietary software and FOSS.

Proprietary software

In the world of proprietary or closed-source software, its users do not have the right to access its source code. The source code is a secret, and its users cannot see it because it is prohibited. Only the original authors or the owners of proprietary software may legally copy, view, and modify that software. To use proprietary software, users must accept its license agreement, stating that they will not do anything with the software that its authors have not explicitly permitted. The limitations or terms set by the vendor/developer for proprietary software are detailed in the software's end-user license agreement (EULA), terms of service agreement (TOS), or similar user agreements (Rouse, 2017).

The intellectual property of the proprietary software is reserved and held by the creator of the software. Someone might say that they bought a piece of software, but what they actually paid for was a license to use a copyrighted work of intellectual property. The license for the commercial proprietary software comes with many restrictions, typically including what machine or machines the product (software) can be used on, who can use the product, and, most importantly, what right the user might have to pass on the intellectual property to someone else. Commercial proprietary software licenses universally share the characteristic that the licensee has no right to redistribute the software to anyone else. Any other party wishing to use the product must sign a contract with the software creator to obtain a license, which usually requires additional payment (Golden, 2004).

Commercial software is mostly proprietary and closed source software. Popular examples of its kind are Adobe Photoshop, Autodesk AutoCAD, IBM SPSS Statistics, Microsoft Windows, and Microsoft Office. Proprietary software can be expensive, and because of that, it might be illegally copied and used without a proper license.

Free and open-source software

Richard Stallman created the term free software in 1983. It stands for software that respects the users' freedom and community. Users have the freedom to run, copy, distribute, study, change, and improve the software and to access the software's source code. According to the GNU Project (n.d.-c), the meaning of 'free' in the term free software means liberty, not price (i.e., free speech, not free lunch).

"A program is considered free software if its users have the four essential types of freedom:

1. The freedom to run the program as you wish, for any purpose (freedom 0).
2. The freedom to study how the program works, and freedom to change it so it does your computing as you wish (freedom 1). Access to the source code is a precondition for this.
3. The freedom to redistribute copies so you can help others (freedom 2).
4. The freedom to distribute copies of your modified versions to others (freedom 3).

By doing this, you can give the whole community a chance to benefit from your changes. Access to the source code is a precondition for this" (GNU Project, n.d.-a). Free software is not non-commercial because it can be available for commercial use, development, and distribution (GNU Project, n.d.-c). However, free software often comes at zero cost. Some businesspeople misunderstood the term free software and considered such software as software that comes only with zero cost, so they did not accept nor support such software. Some users and developers of free software did not agree with all the free software movement's goals, and therefore, in 1998, they started to use the term open source (GNU Project, n.d.-d). This group is called the Open Source Initiative (OSI) (Open Source, n.d.-b). "Open-source software is software with source code that anyone can inspect, modify, and enhance" (Open Source, n.d.-a). Richard Stallman's Free Software Foundation (FSF) and OSI maintain formal definitions for free and open-source software. However, the definitions are substantially identical, and the decision to use one of these terms is ideological rather than functional. The FSF prefers the use of a term that explicitly refers to freedom. At the same time, the OSI believes that the dual meaning of the English word 'free' (*gratis* or *libertas*) is confusing and prefers emphasising the availability and modifiability of the source code instead (Feller et al., 2007).

The terms *free software* and *open source* now broadly refer to the same software category, but they represent fundamentally different values. For the free software movement, free software is an ethical necessity, emphasising the importance of user freedom. In contrast, the open-source philosophy focuses on practical benefits, viewing non-free software as a less effective solution to practical problems. The free software movement sees non-free software as a social issue that should be eliminated in favour of free software. In practice, the criteria for open source are slightly less stringent than those for free software. All known free software source code meets open-source standards, and most open-source software is free software, though there are exceptions. The open-source rhetoric has successfully persuaded many businesses and individuals to use and develop free software, thereby expanding the community (GNU Project, n.d.-d).

A networked community of individuals and organisations develops FOSS. Even rival firms work together in software development, and there is an example (OpenStack cloud infrastructure) of over 200 companies and organisations working together (Teixeira et al., 2015). If someone wants to be neutral between the two software groups (free software and open source), they can use the terms Free and Open-Source Software (FOSS) or Free/Libre and Open-Source Software (FLOSS). One of the goals of the FOSS community is to develop quality software.

Software quality is defined by complex software quality categories and attributes (ISO/IEC, 2024) such as functional suitability, performance efficiency, compatibility, usability, reliability, security, maintenance and portability (ISO/IEC, 2024). For ordinary users, the most important quality attributes are those which

directly impact their experience and satisfaction with the software, such as usability, reliability, performance efficiency, security, functional suitability (such as completeness), and compatibility. When considering the use of FOSS, at least the same level of software quality that is present in proprietary software is expected.

FOSS licenses

FOSS is available under its software licenses. The most important license for free software is the GNU GPL license (GNU's Not UNIX General Public License (now in Version 3)) (GNU Project, n.d.-a). It is intended to guarantee and protect types of software freedom and ensure it remains free software. Other licenses are compatible with GNU GPL, such as Apache License 2.0, Artistic License 2.0, Berkeley Database License, Modified BSD (Berkeley Software Distribution) License (3-clause BSD license), Educational Community License 2.0, FreeBSD License, Mozilla Public License (MPL) version 2.0, and many others (GNU Project, n.d.-b; Open Source, n.d.-a).

FOSS in education

Due to its properties - that it is often free (zero cost), that it can be used without limitation for all purposes, that it can be shared with others without restrictions, and that the source code is available for it, FOSS is very suitable for use in education systems. The process of software creation in open source is highly transparent. Its products and processes can be continuously evaluated by the community of developers connected on the Internet. Its peer review process is even more open than that of traditional science. Its discoveries are not kept secret, and it lets anyone, anywhere, anytime, be free to build on its discoveries and creations (Deek & McHugh, 2007). Therefore, FOSS is also a very good learning source in education.

There are many examples and experiences of using FOSS in education in countries such as Spain, Switzerland, and Italy (Oreški & Šimović, 2013). More examples include Sweden, India, Oman, Bosnia and Herzegovina, and Zanzibar. According to Lundell & Gamalielsson (2013), public schools in Sweden expect students to use various software systems, including FOSS. Schools provide many different types of FOSS, including Audacity, Blender, Bluefish, Firefox, Gimp, Geogebra, Inkscape, LibreOffice, Scribus, VLC, and others. India's Kerala state was one of the world's largest deployments of free and open-source software, impacting 6 million students and 200,000 teachers annually. The biggest challenge in adopting FOSS was inadequate resources to train the teachers (Thankachan & Moore, 2017).

In Oman (Naidu et al., 2017), it was found that many educational institutions were stepping back from game-based learning implementation because of the complexity involved in adopting such technology. These complexities involve securing funding and providing essential training to staff members for content creation. Furthermore, developing e-learning support materials requires significant

effort and time. In a pilot project, the authors utilised Scratch, a free and open-source software developed at MIT. They created educational games for children aged 7 to 10 years. Since the tools used are free and open source, they offer enhanced customisation options, promoting sustainable development in the education sector (Naidu et al., 2017).

In Bosnia and Herzegovina, Pezer et al. (2017) presented the results of research carried out on a sample of 20 computer science teachers. They reported that proprietary commercial software is found on 91.4 % of desktop computers in the classrooms, and GNU/Linux as a dual boot is found on 8.6 % of them. 95 % of computer science teachers are interested in FOSS, but only 55 % of them use FOSS in classroom teaching. The main reasons they use FOSS are because it is free, available, and because of its quality.

In Zanzibar (Shaame, 2014), some challenges were reported in the adoption of FOSS in the teaching and learning process, including academic staff resistant to change, the perception of GNU/Linux graphical user interface (which was at that time different from the popular commercial proprietary operating system), and a lack of support for FOSS.

According to Oreški & Šimović (2013), 96.15 % of the Primary Education Informatics Curriculum in the Republic of Croatia can be implemented using FOSS. At the time when their research was being conducted, there were 130 different topics in the Informatics Curriculum, and FOSS fully supported 125 of them.

Duan and Lee (2022) analysed the relevant literature available in the Web of Science database published between 2010 and 2020 and concluded that FOSS has become an important research area and that it plays an important role in the education reform and development. They also found that the research and development of FOSS in education are insufficient.

FOSS has many advantages, especially in education, some of them being: reduced license costs, simple installation of the FOSS operating system and applications, all the necessary drivers included in the distributions, resistance to computer viruses and other types of malicious software because viruses and malware software compiled to run with proprietary operating systems cannot run with the FOSS operating system, and others. FOSS gives everyone equal access to contemporary information and communication technologies, regardless of their living standard (Oreški & Šimović, 2013).

It should be noted that device drivers for the peripheral devices in FOSS operating systems can be rudimentary sometimes, containing fewer software features and options than fully featured device drivers for proprietary operating systems. Sometimes the device drivers for the latest devices for FOSS operating systems are not available instantly because the device manufacturers are focused only on the device drivers for the proprietary operating systems (which take up the largest market share).

The FOSS operating systems users often have more knowledge about computers, operating systems, application software and its security than average computer users, which complicates drawing the definitive conclusions on FOSS operating systems security.

Using FOSS might entail some disadvantages or risks, such as a possibility that customer support for its installation, maintenance, and use in the neighbourhood is very poor or non-existent. In addition, there is no formal manufacturer to guarantee that it will continue to develop, improve, add new features, or fix bugs of FOSS. Furthermore, even experienced users of proprietary software need time to get used to new FOSS user interface and learn about its capabilities. Also, there might be partial incompatibility of file formats or slight differences in the appearance of the content of a file, a lack of drivers for the latest devices and a lack of specific educational and other types of software for the FOSS platform (Oreški & Šimović, 2013).

It should be noted that FOSS comes with its source code but that does not mean that all its users are exploring or reviewing it. There is FOSS that still contains errors and vulnerabilities despite its open-source code. Despite the openness and availability of the FOSS source code to all interested developers and software companies that use it, there might still be a vulnerability that has not been noticed and it might be a matter of days when some malicious hacker will find it and exploit it. As far as FOSS is concerned, it is inevitable to mention one of the darkest moments of the FOSS community when Apache publicly disclosed on Dec 10, 2021 that Lib4J, a very popular library, has a vulnerability that could allow an attacker to use LDAP and RMI services for injecting code and infecting the local machine (Hiesgen et al., 2022).

In a paper written by Pavlina and Petrovič (2013), they presented the results of a survey on the attitudes of students to the use of open-source technology in education. The survey included 197 university students of mostly information and computer science studies and related fields. The findings indicate that 75.7 % of the respondents believe that open-source software can provide a worthy alternative to commercial proprietary software, 97.2 % of the respondents think that open-source software should be used in information and computer science education, and 91.6 % of them think open-source technologies should be included in the IT curriculum.

Oreški and Šimović (2013) present the results of the research on the FOSS usage carried out on a sample of 93 primary education Informatics teachers in the Republic of Croatia. According to the results, only one teacher (1.1 %) was using the FOSS operating system in teaching. One of the main reasons for not using FOSS in teaching was a lack of knowledge about FOSS.

Nayak et al. (2021) report the results of their research on a sample of 200 university students: about 58 % of students were well aware of FOSS, about 53 % of students

were using both proprietary and FOSS, 38.75 % of students were aware of FOSS freedom to use, 27.5 % of students were aware of FOSS availability of source code, 26.25 % of students were aware of FOSS freedom to modify software, the majority of the students were unaware of features of FOSS, such as access to the source code and that the users can modify the source code, and 82.5 % of students would like to know more about FOSS. The same study shows that the major factors influencing students' awareness of FOSS are the Internet/social media, course syllabus, and conferences/seminars. About 80 % of students use VLC Media Player, and 65 % use Mozilla Firefox web browsers, which are all FOSS. About 56.25 % of students were using FOSS because of its features, like the freedom to use it for any purpose, and approximately 38.75 % of students because this software gives them the freedom to modify, share or distribute.

On a research sample consisting of 80 students, Nayak and Binjha (2022) report that:

– 66.25 % of the students are aware of the usage and benefits of FOSS
– the percentage of students who are aware of FOSS properties:
  - FOSS is distributed freely to anyone interested - 58.8 %
  - it allows the user to modify the source code - 28.8 %
  - its license should not include unreasonable restrictions - 26.3 %
  - it allows users to access the source code - 37.5 %
– the percentage of students who are aware of the following FOSS:
  - LibreOffice - 25 %
  - OpenOffice - 37.5 %
  - Mozilla Firefox - 63.75 %
  - Chromium - 41.25 %
  - GIMP - 11.25 %
  - VLC media player - 70 %
  - Ubantu - 47.5 %
  - OpenShot - 6.25 %
  - Audacity - 12.5 %
  - MyPaint - 25 %
  - Tuxpaint - 7.5 %.

The Free Software Foundation (GNU Project, 2022) considers free software source code to be a part of human knowledge and feels it should be freely distributed in educational institutions at all levels. It also states that commercial proprietary software is secret, restricted knowledge, which is the opposite of the mission of educational institutions. The FOSS comes with its source code. It is highly transparent and secure because everyone can see and inspect the software source code and check for security vulnerabilities (or even unwanted or potentially malicious options or backdoors). FOSS is developed and maintained by the community of programmers so such potential security vulnerabilities can be

quickly resolved. Using FOSS, teachers and students can learn from programming examples and study how programs work because its source code is legally and freely available. The teachers can share programming tools and other FOSS with their students so that they can learn and use them at home as well. Teachers and students can change and adapt the FOSS to meet their specific needs.

Educational institutions often have limited budgets, and when they buy 20 or 30 desktop computers or notebooks for their classrooms, they must also acquire the operating systems and the applications for them. Although proprietary software vendors usually give discounts to educational institutions for buying their operating systems and applications, it is straightforward for educational institutions to acquire FOSS operating systems and applications without purchasing costs or limitations on the quantity or licensing problems. The FOSS is often freely available, meaning everyone can use it and get experience with a wide range of software which promotes their digital literacy.

FOSS market share

Worldwide desktop operating systems market share information shows that desktop GNU/Linux operating systems are installed only on a small percentage of desktop computers. According to Statcounter (n.d.-a), in April 2024, they were installed on 3.88 % of all desktop computers. Windows operating system was installed on 73.5 % desktop computers, OS X on 14.7 % desktop computers, and Chrome OS on 2.56 % desktop computers. Although FOSS only accounts for a small part of the desktop operating systems market share, it is much more represented in the server operating systems and server software market share. According to W3Techs (n.d.-b), the most frequently used operating system for websites is a UNIX-like OS (81.6 %), followed by Windows (18.7 %). In this UNIX-like category, GNU/Linux is used by 46.5 % of all the websites that use UNIX-like operating systems. The GNU/Linux operating system has many different distributions, all open-source.

According to W3techs (n.d.-a), the most frequently used web server software on the Internet is nginx (34.5 %), followed by Apache (31.5 %) and Cloudflare (20.7 %). Nginx is open-source software released under a 2-clause BSD-like license (Nginx, n.d.), and the Apache web server is FOSS with its Apache License v2.0, compatible with GNU General Public License v.3 (Apache Software Foundation, n.d.). WordPress is the most popular web content management software (CMS), with a market share of 43.1 % (W3Techs, n.d.-c). WordPress is also FOSS, licensed under GNU GPLv2 or later (WordPress, n.d.).

In the category of learning management software (LMS), the most frequently used software in the USA is Canvas (35 %), followed by Moodle (21 %) and Blackboard LMS (20 %) (Ménard, 2021). Canvas is proprietary software, and it is used more often in the United Kingdom and the USA (Khatser & Khatser, 2022). Moodle is

FOSS licensed under GNU GPLv2. The review by Gamage, Ayres, and Behrend (2022) shows that Moodle is mainly used within university STEM disciplines and effectively improves student performance, satisfaction, and engagement. It is increasingly used as a platform for adaptive and collaborative learning and to improve online assessment. Other examples of FOSS LMS include TalentLMS, Edmodo, EduBrite, and Sakai (Alameen & Dhupia, 2019). FOSS operating systems run all top 500 supercomputers. Supercomputers are devices built for specific purposes, requiring a custom operating system optimised for their needs (Prakash, 2023). The Android operating system has a market share of 70.79 % on mobile devices, followed by iOS at 28.44 % (Statcounter, n.d.-b). The Android Open Source Project uses Apache License v2.0 and GNU GPLv2 license (Android Open Source Project, n.d.).

Petrov and Obwegeser (2018) present the results of their research on barriers to free and open-source software adoption, in which they classify 19 factors into four dimensions: technological, organisational, environmental, and individual. The factors in the individual dimension are user perceptions, lack of early champions or boundary spanners, lack of motivation, and inability to tolerate temporary inconvenience. The individual adoption of FOSS depends on user-perceived usefulness and ease of use, on champions or sponsors who are persons who can connect organisations with external knowledge and make contact with innovations, on user motivation to accept changes, and on the ability to tolerate temporary inconvenience while transitioning towards FOSS. Frequently used terms to describe why users are reluctant to adopt FOSS are lack of motivation and resistance to change. The barriers to free and open-source adoption and significant challenges in implementing FOSS could be reduced by education about FOSS, which may positively influence the users' motivation to use FOSS and lower their resistance to change.

The aim of the research

The research presented in this paper aims to explore free and open-source software usage and awareness among university students from two faculties of the same university. The research includes university students attending several study programs at the Faculty of Organization and Informatics (FOI), University of Zagreb and the Faculty of Teacher Education (FTE), University of Zagreb. Both faculties offer study programs in the area of social sciences. FTE study programs also belong to Interdisciplinary Sciences - Education Sciences, while FOI study programs mainly belong to Information and Communication Sciences and partly to Economics. Regardless of their study programs, all students use computer software to learn and complete their faculty assignments. The aim is to determine if there are differences in the respondents' usage and attitudes towards FOSS in terms of faculty and gender.

Methodology

Considering all the properties, advantages, and possible disadvantages of FOSS for education, it is essential to find out more information about its usage among university students, their awareness of FOSS, and their attitudes towards FOSS. The research results presented in the relevant literature do not explore the usage and awareness of FOSS users with respect to their faculty or gender nor do they evaluate the quality of FOSS by university students.

The research tasks are to explore whether the respondents use some FOSS and whether they are familiar with the term and key features of FOSS; to determine if there are differences in the respondents' familiarity with FOSS between two faculties and in terms of gender; to find out which features of FOSS are the most important to them and how they evaluate the quality of FOSS; to determine the percentage of the respondents using FOSS operating systems at the two faculties, and to establish if there are differences in the number of users of FOSS operating systems between two faculties and in terms of gender.

Hypotheses

The hypotheses of this research are based on the following facts. The wide availability of FOSS (available on the Internet and free of charge) enables anyone to install and use it. The assumption is that all respondents use at least one FOSS, regardless of whether they are aware that it is FOSS or not. It is essential to explore the FOSS adoption rate in university students to see if there is a need to introduce additional educational programs about FOSS so that students may have options in choosing the software they need.

GNU/Linux operating system is one of the foundations of FOSS. According to Statcounter (n.d.-a), in April 2024, it was installed on 3.88 % of all desktop computers. It is expected that it has a similar representation in the respondents from FTE, who are usually not as enthusiastic about and interested in information and communication technology as students from FOI. At the same time, it is expected that the respondents from FOI are more interested in information and communication studies and courses at FOI which deal with all aspects of software, so there will be more than 3.88 % of them who use the GNU/Linux operating system on their personal computers. It is essential to explore the representation of this operating system because it is the foundation for using all other ranges of FOSS.

To use FOSS, its users do not need to know all its features – its freedom to run the program for any purpose, to have access to its source code, to study how the program works, to change it, and to redistribute it. To ordinary users, it may be significant only to know that some specific FOSS is useful and often free of charge. According to the research results of Nayak et al. (2021), which show that most of the students were unaware of the features of FOSS, the assumption is that more than 50 % of the respondents were not aware of all FOSS features and the types

of freedom it offers, at the time they were installing it. It is essential to explore the respondents' awareness of FOSS because if they are aware of its features, they can use it to its full extent (accessibility, budget savings, learning by the source code examples, freedom to change FOSS and adapt it to the specific needs, etc.).

If the respondents use some FOSS, they are expected to be satisfied with its quality and to rate its quality on a scale from good to excellent, with the average rate of very good. The FOSS quality features, such as reliability and completeness, are essential for users because they enable smooth operation and protect the privacy and security of their data. It is essential to explore FOSS quality because it directly influences the building of its users' trust and its adoption rate. Due to different respondents' fields of education and interests, only these three simple attributes of software quality (reliability, completeness and overall quality) were selected for evaluation by the respondents. The questionnaire defined them simply: reliability - the software works without interruptions or errors; completeness - the software contains all the necessary features for normal operation and overall quality.

It is expected that the respondents from FOI are more familiar with FOSS and use FOSS operating systems to a greater extent than the respondents from FTE because they are more interested in and enthusiastic about information and communication technology and because the study and the courses at FOI deal with all aspects of software. The respondents' interest in information and communication technologies and familiarity with FOSS is expected to influence the usage of FOSS operating systems.

Since male respondents generally tend to be more interested in studying information and communication technology subjects than female respondents (Croatian Bureau of Statistics, 2024), it is expected that they are more familiar with FOSS and use FOSS operating systems in greater numbers than female respondents.

These are research hypotheses:

First hypothese: There is a statistically significant difference in the respondents' familiarity with FOSS between the respondents from FOI and the respondents from FTE.

Second hypothese: There is a statistically significant difference in the respondents' familiarity with FOSS between the female and male respondents.

Third hypothese: At the time of downloading and installing FOSS on their personal computer, more than 50 % of the respondents were unaware that they were using FOSS with all its features.

Fourth hypothese: All the respondents regularly use at least one program from the domain of free and open-source software.

Fifth hypothese: The respondents rate the quality of FOSS (reliability, completeness, and overall quality) with at least an average grade of 4 ($3.5 \leq M < 4.5$) on a grading scale where 1 indicates the lowest value (insufficient) and 5 indicates the highest value (excellent).

Sixt hypothese: There is a statistically significant difference in the number of users of the FOSS operating systems between the respondents from FOI and the respondents from FTE.

Seventh hypothese: There is a statistically significant difference in the number of users of FOSS operating systems between the female and male respondents.

Eight hypothese: There is a significant difference in the percentage of respondents using FOSS operating systems between the respondents from FOI and the respondents from FTE.

The sample of respondents

The data were collected from 777 full-time students from ten various study programs at two faculties of the University of Zagreb – the Faculty of Organization and Informatics (FOI) and the Faculty of Teacher Education (FTE). According to their year of study, their age ranged from 18 to 24.

Both faculties are increasingly influenced by the rapid development of information and communication technology, which affects teaching and learning processes. All study programs aim to equip students with the digital competencies they need in their academic and future professional lives.

The two faculties involved in the research were chosen because they share similar importance and responsibility in promoting the idea of FOSS. The faculties are different in their study programs: FOI educates future experts in information and communication technologies, economics, organisation, communication and other related fields, and FTE educates future early childhood, preschool, and primary education teachers. There are more male than female students at FOI and more female than male students at FTE. These differences between faculties should also be visible in their students' awareness of and attitudes to FOSS.

There were 346 (44.53 %) female respondents, 416 (53.54 %) male respondents, and 15 (1.93 %) who did not want to disclose their gender (Table 1). There is a significant difference in the gender ratio of the respondents by faculty. The respondents from FOI were 24.64 % female and 73.01 % male, while the respondents from FTE were 93.33 % female and 5.78 % male.

In the research sample of two FTE study programs, there are significantly more female respondents (94 % and 92.1 %) than male respondents. In the Republic of Croatia, professional careers in early childhood, preschool, and primary education are traditionally reserved mostly for females. The respondents from FOI study programs show a different gender ratio: most respondents from almost all study programs are males (three study programs with 82.5 %, 80.3 %, and 80 % and two study programs with 77.4 % and 70.7 % male respondents), except for one study program (Economics of Entrepreneurship) which is 25 % male.

All the respondents filled out the questionnaire in its entirety, and there were no known withdrawals from the study. There were questionnaire items that could be

filled out optionally only by the respondents who use FOSS, such as the awareness of FOSS at the time of its installation (745 out of 777 respondents) and FOSS quality (reliability, completeness, overall quality) (720 out of 777 respondents).

Table 1
Respondents' demographic data

Item		Gender	Number of respondents	Group percentage	Percentage
Faculty					
	FOI				
		Female	136	24.64	
		Male	403	73.01	
		Do not want to disclose their gender	13	2.34	
		Group total	552	100.00	71.04
	FTE				
		Female	210	93.33	
		Male	13	5.78	
		Do not want to disclose their gender	2	0.89	
		Group total	225	100.00	29.06
	Total		777		100.00
Type of study					
	Undergraduate professional study		241		31.02
	Undergraduate university study		372		47.88
	Graduate university study		89		11.45
	Integrated undergraduate and graduate university study		75		9.65
	Total		777		100.00
Year of study					
	1		285		36.68
	2		226		29.09
	3		161		20.71
	4		80		10.30
	5		25		3.22
	Total		777		100.00

The instruments

The authors used a self-constructed online questionnaire (Google Forms) to collect data. It consists of the following items:

- respondents' demographic items (gender (female, male, prefer not to disclose their gender), faculty, type of study, title of the study program, year of study)
- items about the respondents' familiarity with FOSS, such as familiarity with the term FOSS and its features, and familiarity with FOSS licenses (on a five-

point Likert scale: 1 - completely disagree, 2 - disagree, 3 - neither disagree nor agree, 4 - agree, 5 - completely agree)
- an item about the level of familiarity with and use of FOSS
- an item about the FOSS properties that are most important to the respondents for their work (multiple answers)
- an item about FOSS that respondents use on their personal computers (multiple answers)
- an item about awareness of FOSS at the time of its installation (on a five-point Likert scale: 1 - completely disagree, 2 - disagree, 3 - neither disagree nor agree, 4 - agree, 5 - completely agree)
- items about the respondents' rating of FOSS: reliability, completeness, overall quality (with ratings: 1 - insufficient, 2 - fair, 3 - good, 4 - very good, and 5 - excellent)
- an item about using specific operating system - respondents could choose one or more names of the operating systems they use, such as Microsoft Windows, GNU/Linux, MacOS, Chrome OS, etc.

The items in the questionnaire were validated for content by experts in the fields of FOSS and software quality. Two groups of questionnaire items were validated for internal consistency (reliability). The first group (familiarity with FOSS) consists of the following items: familiarity with the term FOSS and its features, familiarity with FOSS licences, and the level of familiarity with and the use of FOSS. The internal consistency of three items in the familiarity group is acceptable (McDonald's Omega = 0.79). The second group (FOSS quality) consists of the following items: reliability, completeness and overall quality. The internal consistency of three items in the FOSS quality group is good (McDonald's Omega = 0.88). The internal consistency of all six items from the two groups is good (McDonald's Omega = 0.88).

The procedure

The students from both faculties were invited to participate voluntarily and anonymously in the survey using e-mail and learning management system forum messages from their university professors. The students had to be reminded once to fill out the questionnaire. Some students were invited to complete the questionnaire in the classrooms at the beginning of their professors' classes. It was planned to contact the professors who teach in different study programs, in different years of study, and different subjects to avoid the overlapping of invitations for students to participate in the survey. Eight professors from FTE and fourteen professors from FOI were involved in contacting and inviting students. No awards were given to students who participated in the survey.

The survey occurred simultaneously in both faculties in January, February, and March 2023.

The respondents' task was to fill out the online questionnaire (Google Forms) available at https://forms.gle/tciAXMnVKvuQGDEh8. Before filling out the questionnaire, the

respondents could briefly read the instructions and the purpose of the research and were informed about the anonymity of data collection and their option to refuse to participate. It took about 5 minutes to fill out the questionnaire.

The methods

In the statistical data processing, the non-parametric statistical methods were used because:

– the data is ordinal:
- five-point Likert scale: 1 – completely disagree, 2 – disagree, 3 – neither disagree nor agree, 4 – agree, 5 – completely agree;
- rating: 1 – insufficient, 2 – fair, 3 – good, 4 – very good, and 5 – excellent;

– the data do not follow normal distribution ($p < 0.001$), as shown in the results of the Kolmogorov-Smirnov test in Table 2.

Table 2
Results of the Kolmogorov-Smirnov test

	N	Z	Asymp. Sig. (2-tailed)
Familiarity with the term FOSS and its features	777	4.23	.000
Familiarity with FOSS licenses	777	4.60	.000
Awareness of FOSS at the time of its installation	745	4.61	.000
Level of knowledge and use of FOSS	777	6.50	.000
FOSS reliability	720	6.44	.000
FOSS completeness	723	6.06	.000
FOSS overall quality	720	7.02	.000

The following statistics methods were used:

– descriptive statistics (frequencies, median, mean);

– the Kolmogorov-Smirnov test for testing the normality of distribution;

– the McDonald's Omega for testing the questionnaire's internal consistency;

– the Mann-Whitney U test to explore differences in familiarity with FOSS, FOSS awareness and FOSS quality between the respondents from two faculties and in terms of their gender (male, female);

– the Chi-squared test to explore the respondents' usage of FOSS and proprietary operating systems in terms of their faculty and gender.

Statistical data processing was performed using FOSS statistical software GNU PSPP 1.6.2 (PSPP, n.d.) and The R Project for Statistical Computing 4.4.1 (The R Project, n.d.).

Results

Descriptive statistics data for the respondents' familiarity with FOSS and their evaluation of FOSS quality are presented in Table 3.

Table 3
Descriptive statistics data for items concerning the respondents' familiarity with FOSS and their evaluation of FOSS quality

	N Valid	Mdn	Range
Familiarity with the term FOSS and its features	777	3	4
Familiarity with FOSS licenses	777	2	4
Awareness of FOSS at the time of its installation	745	3	4
Level of knowledge and use of FOSS	777	2	4
FOSS reliability	720	4	4
FOSS completeness	723	4	4
FOSS overall quality	720	4	4

The range of values in Table 3 is 4, the minimum value is 1, and the maximum value is 5 for all items. Not all the respondents filled out the questionnaire's items about FOSS awareness and FOSS quality. One possible reason for that is that they do not use any FOSS.

The results of the Mann-Whitney U test for items concerning the respondents' familiarity with FOSS and their evaluation of FOSS quality with respect to the respondents' faculty (FOI, FTE) are presented in Table 4. They show a statistically significant difference between the respondents according to their faculty in all items except the item concerning the awareness of FOSS at the time of its installation. If there is a statistically significant difference between two groups and the median values are equal, the mean rank value is used to understand the difference between the two groups. These results are interpreted in more detail below.

Table 4
Results of the Mann-Whitney U test for items concerning the respondents' familiarity with FOSS and their evaluation of FOSS quality according to the respondents' faculty (FOI, FTE)

		N	Mean Rank	Sum of Ranks
Familiarity with the term FOSS and its features	FOI	552	424.26	234191.5
	FTE	225	302.50	68061.5
	Total	777		
Familiarity with FOSS licenses	FOI	552	402.09	221955.0
	FTE	225	356.88	80298.0
	Total	777		
Awareness of FOSS at the time of its installation	FOI	538	366.42	197134.0
	FTE	207	390.10	80751.0
	Total	745		
Level of knowledge and use of FOSS	FOI	552	422.52	233232.0
	FTE	225	306.76	69021.00
	Total	777		
FOSS reliability	FOI	526	396.16	208380.0
	FTE	194	263.81	51180.0

		N	Mean Rank	Sum of Ranks
FOSS completeness	Total	720		
	FOI	528	388.81	205292.0
	FTE	195	289.41	56434.0
FOSS overall quality	Total	723		
	FOI	525	394.61	207169.5
	FTE	195	268.67	52390.5
	Total	720		

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Familiarity with the term FOSS and its features	42636.50	68061.50	-7.01	.000
Familiarity with FOSS licenses	54873.00	80298,00	-2.63	.009
Awareness of FOSS at the time of its installation	52143.00	197134.00	-1.38	.168
Level of knowledge and use of FOSS	43596.00	69021.00	-6.76	.000
FOSS reliability	32265.00	51180.00	-8.10	.000
FOSS completeness	37324.00	56434.00	-6.05	.000
FOSS overall quality	33280.50	52390.50	-7.81	.000

The results of the Mann-Whitney U test for items concerning the respondents' familiarity with FOSS and their evaluation of FOSS quality in terms of the respondents' gender (male, female) are presented in Table 5. The respondents who preferred not to disclose their gender were excluded from the Mann-Whitney U tests. The tests show that there is a statistically significant difference between the respondents in terms of their gender in all items. These results are interpreted in more detail below.

Table 5

Results of the Mann-Whitney U test data for items concerning the respondents' familiarity with FOSS and their evaluation of FOSS quality according to the respondents' gender (male, female)

		N	Mean Rank	Sum of Ranks
Familiarity with the term FOSS and its features	Male	416	446.61	185788.5
	Female	346	303.22	104914.5
	Total	762		
Familiarity with FOSS licenses	Male	416	408.41	169899.0
	Female	346	349.14	120804.0
	Total	762		
Awareness of FOSS at the time of its installation	Male	406	337.98	137219.5
	Female	324	399.99	129595.5
	Total	730		
Level of knowledge and use of FOSS	Male	416	440.88	183405.0
	Female	346	310.11	107298.0
	Total	762		

		N	Mean Rank	Sum of Ranks
FOSS reliability	Male	406	398.85	161931.5
	Female	299	290.75	86933.5
	Total	705		
FOSS completeness	Male	406	387.27	157230.0
	Female	302	310.45	93756.0
	Total	708		
FOSS overall quality	Male	405	395.64	160233.0
	Female	300	295.44	88643.0
	Total	705		

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Familiarity with the term FOSS and its features	44883.50	104914.50	-9.15	.000
Familiarity with FOSS licenses	60773.00	120804.00	-3.82	.000
Awareness of FOSS at the time of its installation	54598.50	137219.50	-4.05	.000
Level of knowledge and use of FOSS	47267.00	107298.00	-8.46	.000
FOSS reliability	42083.50	86933.50	-7.44	.000
FOSS completeness	48003.00	93756.00	-5.27	.000
FOSS overall quality	43482.00	88632.00	-6.98	.000

Respondents' attitudes towards FOSS

The data in Figure 1, which presents answers to the statement "I am already familiar with the term and features of free and open-source software (FOSS)", show that a total of 306 respondents (39.38 %) are already familiar with the term FOSS and its features (agree and totally agree), 273 (35.14 %) are not (disagree and totally disagree), and 198 (25.48 %) are undecided (neither disagree nor agree).

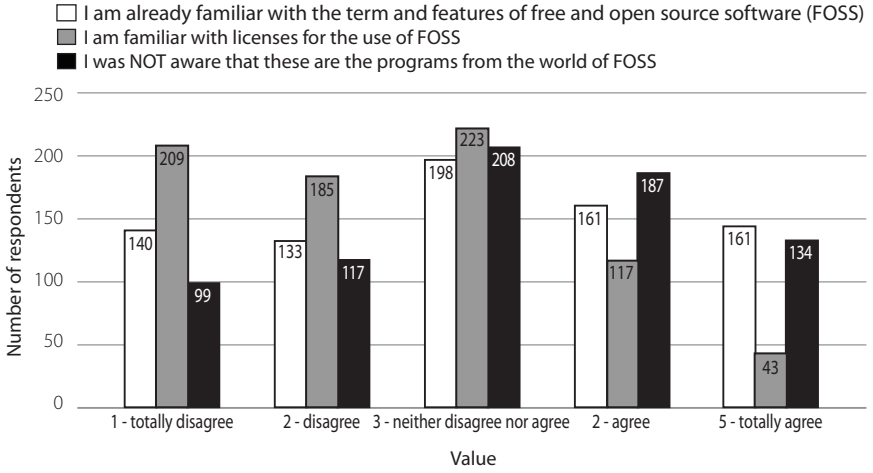

Figure 1. Respondents' familiarity with the term FOSS and its features, licences, and their awareness of FOSS

The results of the Mann-Whitney U test (Z=-7.01, p<0.001) (Table 4) show that there is a statistically significant difference between the respondents from FOI (N=552, Mdn=3) and those from FTE (N=225, Mdn=3). Mean rank values show that the respondents from FOI are more familiar with the term FOSS and its features than the respondents from FTE. The first hypothese, which states that there is a statistically significant difference in the respondents' familiarity with FOSS between the respondents from FOI and FTE, is confirmed.

When the respondents are compared in terms of their gender (male, female), the results of the Mann-Whitney U test (Z= -9.15, p<0.001) (Table 5) show that there is a statistically significant difference between the male respondents (N=416, Mdn=4) and the female respondents (N=346, Mdn=3). Male respondents are more familiar with the term FOSS and its features than female respondents. This confirms second hypothese, which states that there is a statistically significant difference in the respondents' familiarity with FOSS between the female and male respondents.

The data in Figure 1, which presents answers to the statement "I am familiar with licenses for the use of free and open-source software (e.g., GNU General Public License (GNU GPL) or Mozilla Public License)", shows that a total of 160 respondents (20.59 %) are familiar with the FOSS licenses (agree and totally agree), 394 (50.71 %) are not (totally disagree and disagree), and 223 (28.70 %) are undecided (neither disagree nor agree).

Overall, only one in five respondents is familiar with FOSS licenses. Most of the respondents disagree or neither disagree nor agree (N=777, Mdn=2) with the statement that they are familiar with FOSS licenses.

The results of the Mann-Whitney U test (Z=-2.63, p=0.009) (Table 4) show that there is a statistically significant difference in the respondents' familiarity with FOSS licenses between the respondents from FOI (N=552, Mdn=3) and respondents from FTE (N=225, Mdn=2). Those from FOI are more familiar with FOSS licenses than the respondents from FTE.

When the respondents are compared in terms of gender (male, female), the results of the Mann-Whitney U test (Z= -3.82, p<0.001) (Table 5) show that there is a statistically significant difference between the male respondents (N=416, Mdn=3) and the female respondents (N=346, Mdn=2). Male respondents are more familiar with FOSS licenses than female respondents.

The FOSS properties that are most important to respondents for their work (in comparison to proprietary software) are the following:

– it is often free (589 respondents, 75.80 %),

– possibility of use for any purpose (492 respondents, 63.32 %),

– no problem with software licenses - legal use (according to GNU GPL license or similar) (395 respondents, 50.84 %),

– possibilities of refinement and/or changes and redistribution (328 respondents, 42.21 %),

– source code availability (319 respondents, 41.06 %), and

– unlimited software copying possibilities (241 respondents, 31.02 %).

The research results presented in Table 6 show which FOSS the respondents use by showing the number of the respondents (multiple choice answers). The most frequently used ones are Mozilla Firefox (46.33 %), VLC Media Player (40.03 %), Python (32.18 %), and Geogebra (31.79 %). The FOSS listed in Table 6 is the most popular and one of its properties is that it is reliable, i.e., that it does not contain errors. However, not all FOSS in the education settings is of such quality and it can contain errors and cause crashes.

Table 6
Respondents' FOSS adoption - FOSS that respondents use on their personal computers according to the number of respondents

FOSS	Number of respondents	% of respondents
Web browser Firefox	360	46.33
Media file player VLC Media Player	311	40.03
Programming language Python	250	32.18
Learning and teaching mathematics GeoGebra*	247	31.79
Operating system GNU/Linux (distributions: Debian, Mint, Ubuntu, etc.)	230	29.60
Sound processing Audacity	228	29.34
Recording and streaming OBS Studio	214	27.54
Editing bitmap graphics GIMP	169	21.75
Set of office programs LibreOffice / OpenOffice	168	21.62
Programming language Java (OpenJDK)	142	18.28
Compiler for GNU C++	135	17.37
File transfer client (FTP) FileZilla	131	16.86
Web browser Chromium	128	16.47
Creating animations and 3D graphics Blender	124	15.96
Web browser Brave	109	14.03
Integrated development environment (IDE) Eclipse	94	12.10
Integrated development environment (IDE) VSCodium	93	11.97
I do not use any of the offered programs from the world of free and open-source software	66	8.49
Integrated development environment (IDE) NetBeans	54	6.95
Statistical data processing R	43	5.53
Email client Thunderbird	36	4.63
Video editing Shotcut	30	3.86
Vector graphics editing Inkscape	28	3.60
Video editing Openshot	27	3.47
Other	20	2.57
Media file player SM Player	11	1.42
Statistical data processing GNU PSPP	3	0.39

* The GeoGebra source code is licensed to its users under the terms of the GNU General Public License (version 3 or later) as published by the Free Software Foundation, but only for *non-commercial use.*

The number of the respondents who do not use any of FOSS on the list is 66 (8.49 %).

The number of the respondents who, at the time of installing one of the above programs on their personal computers, were not aware that these were the programs from the world of free open-source software which have greater freedom of use (freedom to run, copy, distribute, study, change and improve the program) than proprietary programs have is 321 (43.09 %) (agree and totally agree). The number of the respondents who are aware of this fact is 216 (28.99 %) (disagree and totally disagree), and 208 (27.92 %) are undecided. This is presented in Figure 1, which shows answers to the statement "At the time of installing one of the above programs on my personal computer, I was NOT aware that these are the programs from the world of free and open-source software which have greater freedom of use (freedom to run, copy, distribute, study, change and improve the program) than proprietary programs".

Most students, 529 of them (71.01 %), neither disagree nor agree, agree, or totally agree with the statement that they were unaware they were using FOSS with all its features. Third hypothese, which states that more than 50 % of the respondents were not aware that they were using FOSS with all its features at the time of downloading and installing FOSS on their personal computers, is confirmed.

The results of the Mann-Whitney U test (Z=-1.38, p=0.168) (Table 4) show that there is no statistically significant difference in the respondents' awareness of FOSS at the time of its installation between the respondents from FOI (N=538, Mdn=3) and FTE (N=207, Mdn=3).

When the respondents are compared in terms of gender (male, female), the results of the Mann-Whitney U test (Z=-4.05, p<0.001) (Table 5) and the mean rank show that there is a statistically significant difference between the male respondents (N=406, Mdn=3) who were more aware of FOSS at the time of its installation than the female respondents (N=324, Mdn=3).

The data in Figure 2 show that the number of the respondents who are not familiar with the term and features of FOSS and who do not know if they use FOSS is 269 (34.62 %). The number of the respondents who are familiar with the term but not with the details about the features of FOSS and who are not aware if they use FOSS is 196 (25.23 %). The number of the respondents who are familiar with the terms and features of FOSS but are not aware if they use FOSS is 106 (13.63 %). The number of the respondents who are familiar with the terms and features of FOSS and who use FOSS on faculty computers but not on their personal computers is 51 (6.53 %). The number of the respondents who are familiar with the terms and features of FOSS and use FOSS on faculty computers and their personal computers is 155 (19.95 %).

Overall, the respondents are mostly unaware that they use FOSS (N=777, Mdn=2).

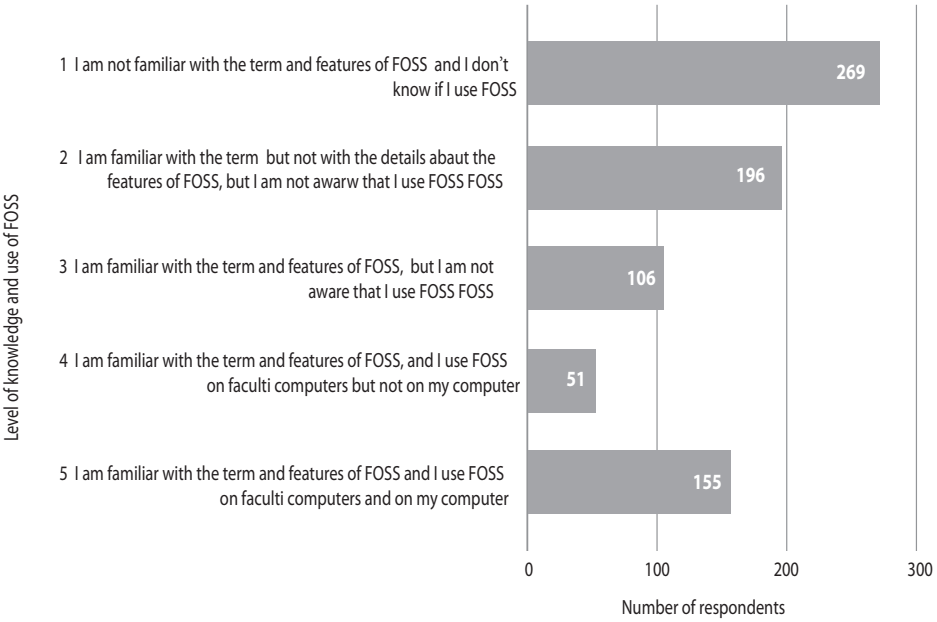

Figure 2. Number of respondents by the level of knowledge and use of FOSS

The results of the Mann-Whitney U test (Z=-6.76, p<0.001) (Table 4) show that there is a statistically significant difference in the level of knowledge and use of FOSS between the respondents from FOI (N=552, Mdn=2) and the respondents from FTE (N=225, Mdn=2). Mean rank values show that the respondents from FOI have higher knowledge and use of FOSS.

When the respondents are compared by gender (male, female), the results of the Mann-Whitney U test (Z= -8.46, p<0.001) (Table 5) show that the male respondents (N=416, Mdn=3) have a higher level of knowledge and use of FOSS than the female respondents (N=346, Mdn=2).

Ratings of FOSS quality

In the sample of 777 respondents, 57 (7.34 %) did not evaluate FOSS. The probable cause is the fact that they did not use any of it (Figure 3). Fourth hypothese, which states that all the respondents regularly use at least one program from the domain of FOSS, is not confirmed.

The respondents' rating of the FOSS quality - reliability (the program works without interruptions or errors) of all the programs they use from the world of FOSS shows the following results: overall, on a scale from 1 - insufficient to 5 - excellent, most respondents rate the FOSS reliability as very good - 4 (313 respondents, 43.37 %), then as good - 3 (238 respondents, 33.06 %) and as excellent - 5 (132 respondents, 18.33 %). Only 29 respondents rate it as sufficient - 2 (4.03 %), and eight respondents as insufficient - 1 (1.11 %) (Figure 3).

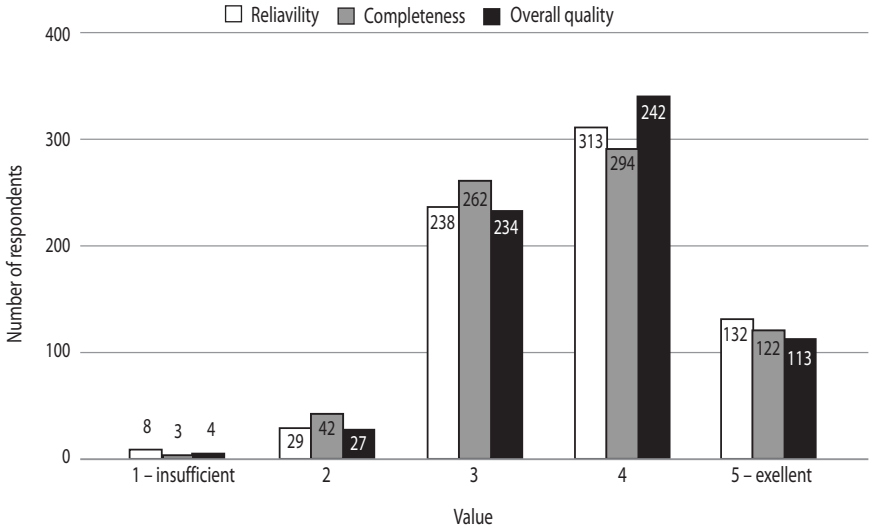

Figure 3. Respondents' rating of FOSS quality - reliability, completeness, and overall quality

Overall, on a scale from 1 - insufficient to 5 - excellent, the respondents rated the FOSS reliability mostly as very good (N=720, Mdn=4).

The results of the Mann-Whitney U test (Z=-8.10, p<0.001) (Table 4) show that there is a statistically significant difference between the respondents from FOI (N=526, Mdn=4) and the respondents from FTE (N=194, Mdn=3). The respondents from FOI rated the FOSS reliability higher than those from FTE.

When the respondents are compared in terms of gender (male, female), the results of the Mann-Whitney U test (Z=-7.44, p<0.001) (Table 5) show that there is a statistically significant difference between the male respondents (N=406, Mdn=4) and the female respondents (N=299, Mdn=3). The male respondents rated the FOSS reliability higher than the female respondents.

The respondents' rating of the FOSS quality - completeness (the program contains all the necessary features for normal operation) of all programs they use from the world of FOSS shows the following results: overall, on a scale from 1 - insufficient to 5 - excellent, most respondents rate the FOSS completeness as very good - 4 (294 respondents, 40.66 %), then as good - 3 (262 respondents, 36.24 %) and as excellent - 5 (122 respondents, 16.87 %). Only 42 respondents rate it as sufficient - 2 (5.81 %), and only three as insufficient - 1 (0.42 %) (Figure 3).

Overall, on a scale from 1 - insufficient to 5 - excellent, the respondents rated the FOSS completeness mostly as very good (N=723, Mdn=4).

The results of the Mann-Whitney U test (Z=-6.05, p<0.001) (Table 4) show that there is a statistically significant difference between the respondents from FOI (N=528, Mdn=4) and the respondents from FTE (N=195, Mdn=3). The respondents from FOI rated the FOSS completeness higher than those from FTE.

When the respondents are compared according to gender (male, female), the results of the Mann-Whitney U test (Z= -5.27, p<0.001) (Table 5) show that there is a statistically significant difference between the male respondents (N=406, Mdn=4) and the female respondents (N=302, Mdn=3). The male respondents rated the FOSS completeness higher than the female respondents.

The respondents' rating of the FOSS quality - overall quality of all programs they use from the world of FOSS shows the following results: overall, on a scale from 1 - insufficient to 5 - excellent, most respondents rate FOSS overall quality as very good - 4 (342 respondents, 47.50 %), then as good - 3 (234 respondents, 32.50 %) and as excellent - 5 (113 respondents, 15.70 %). Only 24 respondents rated it as sufficient - 2 (3.75 %), and four respondents as insufficient - 1 (0.55 %) (Figure 3).

Overall, on a scale from 1 - insufficient to 5 - excellent, the respondents rated the FOSS overall quality mostly as very good (N=720, Mdn=4).

The results of the Mann-Whitney U test (Z=-7.81, p<0.001) (Table 4) show that there is a statistically significant difference between the respondents from FOI (N=525, Mdn=4) and the respondents from FTE (N=195, Mdn=3). The respondents from FOI rated the FOSS overall quality higher than those from FTE.

When the respondents are compared in terms of gender (male, female), the results of the Mann-Whitney U test (Z=-6.98, p<0.001) (Table 5) show that there is a statistically significant difference between the male respondents (N=405, Mdn=4) and the female respondents (N=300, Mdn=3). The male respondents rated the overall quality of FOSS higher than the female respondents.

Overall, the respondents rate FOSS reliability as 3.74 (FOI 3.90, FTE 3.31), completeness as 3.68 (FOI 3.79, FTE 3.36), and overall quality as 3.74 (FOI 3.88, FTE 3.37) (Figure 3). The fifth hypothese, which states that the respondents rate the quality of FOSS (reliability, completeness, and overall quality) with at least an average grade of 4 ($3.5 \leq M < 4.5$), is confirmed.

The most frequently used operating system by the respondents is Microsoft Windows 10 (534 respondents, 68.73 %), followed by Microsoft Windows 11 (260 respondents, 33.46 %), GNU/Linux (118 respondents, 15.19 %), MacOS (22 respondents, 2.83 %), and Chrome OS (21 respondents, 2.70 %) (Figure 4).

The data on the respondents' type of operating system used show that overall, 658 respondents (84.6 %) use proprietary software, nine respondents (1.2 %) use FOSS, and 110 respondents (14.2 %) use both proprietary and FOSS operating systems.

Analysed by faculty, the results show that:

– out of a total of 9 respondents, eight respondents from FOI (88.9 %) and one respondent from FTE (11.1 %) use FOSS operating systems;

– out of a total of 658 respondents, 436 respondents from FOI (66.3 %) and 222 respondents from FTE (33.7 %) use proprietary operating systems;

– out of a total of 110 respondents, 108 from FOI (98.2 %) and two from FTE (1.8 %) use both types of operating systems.

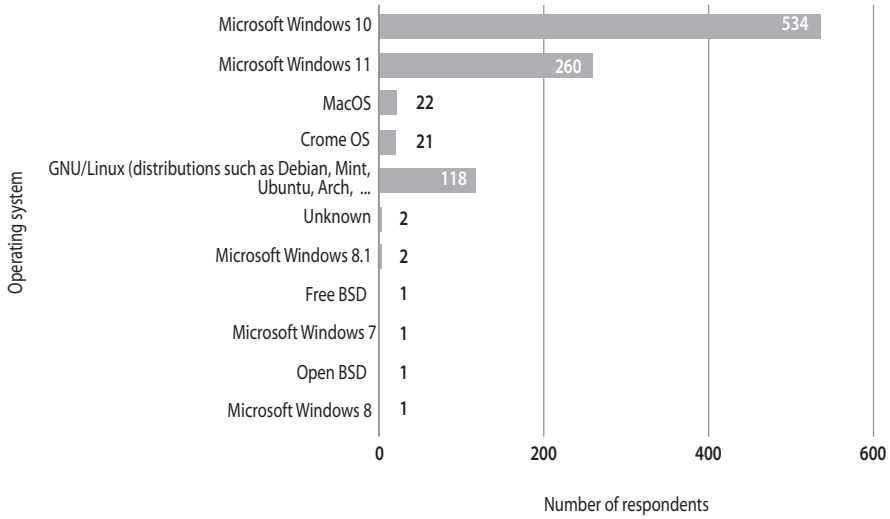

Figure 4. Number of respondents by operating systems that they use on their personal computers

The number of the respondents by faculty, operating system type, and gender is as follows:

- FOI, out of 552 respondents:
  - FOSS operating system - eight respondents (1.4 %)
    - by gender: seven male respondents and one respondent who does not want to disclose their gender
  - proprietary operating system - 436 respondents (79 %)
    - by gender: 307 male respondents, 123 female respondents, and six respondents who do not want to disclose their gender
  - both operating systems - 108 respondents (19.6 %)
    - by gender: 89 male respondents, 13 female respondents, and six respondents who do not want to disclose their gender
- FTE, out of 225 respondents:
  - FOSS operating system - one respondent (0.4 %)
    - by gender: one female respondent
  - proprietary operating system - 222 respondents (98.7 %)
    - by gender: 12 male respondents, 208 female respondents, and two respondents who do not want to disclose their gender
  - both operating systems - two respondents (0.9 %)
    - by gender: one male respondent, one female respondent.

There is a statistically significant difference in the number of users of FOSS operating systems by faculty (Pearson Chi-Square N=777, χ^2=48.09, df = 2, p<0.001). The respondents from FOI use FOSS operating systems in greater numbers than those from FTE. The sixth hypothese, which states that there is a

statistically significant difference in the number of users of the FOSS operating systems between the respondents from FOI and the respondents from FTE, is confirmed.

The results of the respondents' type of operating system use according to gender show that:

– FOSS operating systems are used by nine respondents: seven male respondents (77.8 %), one female respondent (11.1 %), and one respondent who prefers not to disclose their gender (11.1 %);

– proprietary operating systems are used by 658 respondents: 319 male respondents (48.5 %), 331 female respondents (50.3 %), and eight respondents who prefer not to disclose their gender (1.2 %);

– both FOSS and proprietary operating systems are used by 110 respondents: 90 male respondents (81.8 %), 14 female respondents (12.7 %), and six respondents who prefer not to disclose their gender (5.5 %).

There is a statistically significant difference in the number of users of FOSS operating systems by gender (Pearson Chi-Square N=777, χ^2=65.48, df=4, p<0.001). The male respondents use FOSS operating systems in greater numbers than the female respondents and respondents who prefer not to disclose their gender. This confirms seventh hypothese, which states that there is a statistically significant difference in the number of users of FOSS operating systems between the female and male respondents.

The number and percentage of the respondents who use only FOSS operating systems is rather small (9 of 777, 1.1 %). More respondents are not restricted to one operating system and use FOSS and proprietary software (110 of 777, 14.6 %). Compared by gender in using FOSS operating system (as a single operating system and in dual boot with proprietary operating system), there are roughly 80 % of male respondents and 12 % of female respondents. Rather opposite data were obtained in using proprietary operating systems with 319 male respondents, 76.7 % of total male respondents, and 331 female respondents, 95.7 % of total female respondents. These data are not unexpected because female respondents, especially those studying educational and economic sciences, are usually not focused on installing an operating system after purchasing a personal computer.

Three respondents (1.33 %) from FTE and 115 respondents (20.83 %) from FOI use the GNU/Linux operating system. The eight hypothese, which states that there is a significant difference in the percentage of respondents using FOSS operating systems according to faculty, is confirmed.

The linear regression ANOVA results suggest that the regression model is statistically significant (p<0.001), meaning that the independent variables faculty and gender, respectively, explain a significant portion of the variation in the dependent variables: familiarity with the term FOSS and its features, awareness

of FOSS at the time of its installation, level of knowledge and use of FOSS, FOSS reliability, FOSS completeness, FOSS overall quality, but not the variation in the variable familiarity with FOSS licenses ($p>0.05$). It suggests that the independent variables are significantly related to all dependent variables except the variable familiarity with FOSS licences.

Analysed by independent variable faculty, the Breusch-Pagan test shows heteroscedasticity ($p<0.05$) for the following dependent variables: familiarity with the term FOSS and its features, awareness of FOSS at the time of its installation, level of knowledge and the use of FOSS, FOSS reliability, and FOSS overall quality. There is no heteroscedasticity ($p>0.05$) for the dependent variables familiarity with FOSS licenses and FOSS completeness. The possible explanation for the heteroscedasticity in the test by faculty as the independent variable is that there are respondents from two faculties, a total of ten different types of study, and their different knowledge about FOSS.

Analysed in terms of gender as the independent variable, the Breusch-Pagan test shows heteroscedasticity ($p<0.05$) only for the dependent variables FOSS reliability and FOSS overall quality. There is no heteroscedasticity ($p>0.05$) for the following variables: familiarity with the term FOSS and its features, familiarity with FOSS licences, awareness of FOSS at the time of its installation, level of knowledge and use of FOSS, and FOSS completeness.

Based on the presented research results, seven research hypotheses are confirmed and one is not confirmed.

Discussion

The research results presented in this paper show that 39.38 % of the respondents (Figure 1) are familiar with the term and features of FOSS, less than 58 % reported by Nayak et al. (2021) and less than 66.25 % reported by Nayak and Binjha (2022).

Overall, 92.66 % of the respondents in the research presented in this paper use some FOSS, which is more than 80 % of FOSS users reported by Nayak et al. (2021).

The most important FOSS property for the respondents in the research presented in this paper is that it is often free of charge (75.80 % of 777 respondents). In Nayak and Binjha (2022), it is the most important property as well, but with a lower percentage (58.8 % of 80 respondents).

The most frequently used FOSS presented in research results in this paper (Mozilla Firefox and VLC Media Player) are compared to the research results of Nayak et al. (2021) and Nayak and Binjha (2022), and the data show that it is used by a lower percentage of the respondents than in other research results.

Overall, the male respondents are more familiar with the term FOSS and its features and use the FOSS operating systems in greater numbers. Female students generally perform better than male students in the Programme for International Student Assessment (PISA) and International Computer and Information Literacy

Study (ICILS) international skills tests. However, only one in three STEM graduates is a woman (European Commission, 2020).

Limitations

There is a significant difference in the respondents' gender ratios according to faculty. The respondents from FOI were 24.64 % female and 73.01 % male, while the respondents from FTE were 93.33 % female and 5.78 % male. Fifteen respondents (1.93 %) from both faculties did not want to disclose their gender. The male respondents are more interested in studying information and communication technology subjects than female respondents (Croatian Bureau of Statistics, 2024). All these facts influence the research results.

Because of the respondents' different fields of education and interests, their task was to evaluate FOSS quality simply only by three software quality attributes (reliability, completeness, and overall quality).

Implications

The research results show that most respondents were not aware that they were using FOSS when they installed it, so there is a need to introduce new subjects or courses in their study program curriculum, especially at FTE, that would deal with FOSS, its terms, features, licenses, and advantages and disadvantages.

Future qualitative research intends to explore why some students use FOSS and others do not, and to analyse the usage of FOSS according to the type and year of study. There is also a need to carry out research on the use and the awareness of FOSS i university teachers.

Conclusion

The research results show that the properties of FOSS that are most important to the respondents are that it is often free of charge, that it can be used for any purpose and that there are no problems with software licenses. The most frequently used FOSS by the respondents are Mozilla Firefox, VLC Media Player, and Python. Only 7.34 % of the respondents do not use any FOSS. Only 28.99 % of them were aware of FOSS and its properties when they were installing it. The respondents' most frequently used operating system is Microsoft Windows 10, followed by Microsoft Windows 11. There are 115 of 552 respondents from FOI (20.83 %) and only 3 of 225 respondents from FTE (1.33 %) who use GNU/Linux operating systems on their personal computers. This operating system is one of the foundations of FOSS and thus has the most significant influence on its users' software freedom because it enables the use of hundreds of different programs from the world of FOSS.

There is a statistically significant difference in the respondents' familiarity with FOSS between those from FOI and FTE. The respondents from FOI are more familiar with the term FOSS and its features than the respondents from FTE. There

is a statistically significant difference in the respondents' familiarity with FOSS between the female and male respondents. Male respondents are more familiar with the term FOSS and its features than female respondents. Overall, only one in five respondents is familiar with FOSS licenses. At least one program from the FOSS domain is used by 92.66 % of the respondents. The respondents rate the quality of FOSS (reliability, completeness, and overall quality) with an average grade very good.

There is a statistically significant difference in the number of users of FOSS operating systems in terms of faculty. The respondents from FOI use FOSS operating systems in greater numbers than those from FTE. There is a statistically significant difference in the number of users of FOSS operating systems by gender. The male respondents use FOSS operating systems in greater numbers than the female respondents and the respondents who prefer not to disclose their gender. There is a significant difference in the percentage of respondents using FOSS operating systems in terms of faculty. Only 3 (1.33 %) from FTE and 115 respondents (20,83 %) from FOI use the FOSS operating system.

The sample of respondents in the research presented in this paper consists of the respondents from two faculties and ten study programs. The respondents differ in their enthusiasm, interest, and ICT knowledge. These facts are visible in almost all research results of statistical analyses where the respondents are compared in terms of faculty and gender. Most respondents from FOI are future information and communication technology and business experts, and they are more enthusiastic and interested in informatics. They have more ICT courses in their study programs than the respondents from FTE, who are offered only several such courses in their study programs, except one study module (Informatics module), which contains ten more informatics courses. Some FOI study programs directly influence and encourage students to use FOSS operating systems and other FOSS (e.g. in dual boot or virtual machine) by offering the possibility to fulfil study obligations using this type of software.

There is a lot of valuable and often free-of-charge software from the world of FOSS that can be used instead of or as an alternative to expensive proprietary software, especially in the education systems. There are many advantages to its use. Educational institutions have the essential duty and responsibility to share knowledge with their students and prepare them for life in society. The teachers and other educators should have at least the basic knowledge of FOSS to choose which software (commercial proprietary or FOSS or both) they will use in their work as educators. By using specific software, they set an example for students. In a world where the market share of commercial proprietary desktop operating systems and their applications is much greater than FOSS operating systems and applications, there should be at least an opportunity for students to learn that there is an alternative software they can use for study, work, and play. It is up to

students to decide which software they want to use on their personal computers, but is essential to give them all the information they need to make that important decision.

Acknowledgment

The authors do not report any conflict of interest.
The research results presented in this paper have not been published before.

References

Alameen, A., & Dhupia, B. (2019). Implementing adaptive e-learning conceptual model: A survey and comparison with open source LMS. *International Journal of Emerging Technologies in Learning, 14*(21), 28-45. https://doi.org/10.3991/ijet.v14i21.11030

Android Open Source Project. (n.d.). Licenses. https://source.android.com/docs/setup/about/licenses

Apache Software Foundation. (n.d.). Apache License v2.0 and GPL compatibility. https://www.apache.org/licenses/GPL-compatibility.html

Croatian Bureau of Statistics. (2024). *Students, 2022/2023 academic year. Croatian Bureau of Statistics.* https://podaci.dzs.hr/media/arac4gkx/si-1726_studenti-u-akademskoj-godini-2022_2023.pdf

Deek, F., & McHugh, J. (2007). *Open source: Technology and policy*. Cambridge University Press. https://doi.org/10.1017/CBO9780511619526

Duan, C., & Lee, T. K. (2022). Educational use of free and open source software (FOSS): International development and its implications for higher education. *Interactive Technology and Smart Education, 19*(1), 39-57. https://doi.org/10.1108/ITSE-11-2020-0223

European Commission. (2020). *Digital Education Action Plan 2021-2027 - Resetting education and training for the digital age.* https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0624

Feller, J., Fitzgerald, B., Hissam, S. A., & Lakhani, K. R. (Eds.). (2007). *Perspectives on free and open source software*. MIT Press.

Gamage, S. H. P. W., Ayres, J. R., & Behrend, M. B. (2022). A systematic review on trends in using Moodle for teaching and learning. *International Journal of STEM Education, 9*(9). https://doi.org/10.1186/s40594-021-00323-x

GNU Project - Free Software Foundation. (2022). *Free software in education.* https://www.gnu.org/education/education.html.en

GNU Project - Free Software Foundation. (n.d.-a). *GNU General Public License*. https://www.gnu.org/licenses/gpl-3.0.html

GNU Project - Free Software Foundation. (n.d.-b). *Various licenses and comments about them*. https://www.gnu.org/licenses/license-list.html#GPLCompatibleLicenses

GNU Project - Free Software Foundation. (n.d.-c). *What is free software?* https://www.gnu.org/philosophy/free-sw.en.html

GNU Project - Free Software Foundation. (n.d.-d). *Why open source misses the point of free software.* https://www.gnu.org/philosophy/open-source-misses-the-point.html.en

Golden, B. (2004). *Succeeding with open source*. Addison-Wesley Professional.

Hiesgen, R., Nawrocki, M., Schmidt, T. C., & Wählisch, M. (2022). The race to the vulnerable: Measuring the log4j shell incident. In *Proc. of Network Traffic Measurement and Analysis Conference (TMA'22)*. IFIP. https://doi.org/10.48550/arXiv.2205.02544

ISO/IEC 25002:2024. (2024). *Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Quality model overview and usage.* https://www.iso.org/obp/ui/en/#iso:std:iso-iec:25002:ed-1:v1:en

Khatser, G., & Khatser, M. (2022). Online learning through LMSs: Comparative assessment of Canvas and Moodle. *International Journal of Emerging Technologies in Learning, 17*(12), 184-200. https://doi.org/10.3991/ijet.v17i12.30999

Lundell, B., & Gamalielsson, J. (2013). Open standards and open source in Swedish schools: On promotion of openness and transparency. In E. Petrinja, G. Succi, N. El Ioini, & A. Sillitti (Eds.), *Open source software: Quality verification*, *404*, (pp. 187-196). Springer. https://doi.org/10.1007/978-3-642-38928-3_15

Ménard, J. (2021). How Moodle overtook Blackboard. *Listedtech*. https://listedtech.com/blog/moodle-overtook-blackboard/

Muffatto, M. (2006). *Open source: A multidisciplinary approach*. Imperial College Press.

Naidu, V. R., Al Balushi, H., & Bhatia, S. (2017). Effectiveness of free & open source tools to enhance game based learning experience in school education. In *EDULEARN17 Proceedings* (pp. 6604-6609). IATED. https://www.researchgate.net/profile/Vikas-Rao-Naidu/publication/318706904_EFFECTIVENESS_OF_FREE_OPEN_SOURCE_TOOLS_TO_ENHANCE_GAME_BASED_LEARNING_EXPERIENCE_IN_SCHOOL_EDUCATION/links/5edabc4d92851c9c5e8691d2/EFFECTIVENESS-OF-FREE-OPEN-SOURCE-TOOLS-TO-ENHANCE-GAME-BASED-LEARNING-EXPERIENCE-IN-SCHOOL-EDUCATION.pdf

Nayak, K., & Binjha, P. (2022). Student's awareness of free and open-source software (FOSS) in higher education. *Asian Journal of Education and Social Studies, 26*(2), 81-87. https://doi.org/10.9734/ajess/2022/v26i230625

Nayak, K., Kar, S., & Binjha, P. (2021). Free and open source software (FOSS): Students awareness and adoption in higher education. *International Journal of Creative Research Thoughts, 9*(8). https://ijcrt.org/papers/IJCRT2108397.pdf

Nginx. (n.d.). nginx. https://nginx.org/en/

Open Source Initiative. (n.d.-a). *Licenses & standards.* https://opensource.org/licenses

Open Source Initiative. (n.d.-b). *Open Source Initiative.* https://opensource.org/

Oreški, P., & Šimović, V. (2013). *Slobodan softver u obrazovanju [Free software in education]*. University of Zagreb, Faculty of Teacher Education. https://www.researchgate.net/publication/353768456_Slobodan_softver_u_obrazovanju_-_Free_Software_in_Education

Pavlina, K., & Petrović, B. (2013). Students' attitudes to the use of open source technology in education. In M. Čičin-Šain, I. Uroda, I. Turčić Prstačić, & I. Sluganović (Eds.), *36th International Convention MIPRO 2013: Computers in Education* (pp. 597-599).

Petrov, D., & Obwegeser, N. (2018). *Adoption barriers of open-source software: A systematic review.* https://ssrn.com/abstract=3138085

Pezer, M., Lazić, N., & Odak, M. (2017). Free and open source software in the secondary education in Bosnia and Herzegovina. In *2017 40th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO)* (pp. 882-886).

Prakash, A. (2023). Linux runs on all of the top 500 supercomputers, again! *Itsfoss*. https://itsfoss.com/linux-runs-top-supercomputers/

PSPP – GNU Project – Free Software Foundation. (n.d.). *Obtaining GNU PSPP.* https://www.gnu.org/software/pspp/get.html

R: The R Project for Statistical Computing. (n.d.). *Download R.* https://cran.r-project.org/mirrors.html

Raymond, E. S. (2001). *The cathedral & the bazaar*. O'Reilly & Associates. https://creatingaction.stanford.edu/pdf/cathedral-bazaar.pdf

Rouse, M. (2017, February 15). What is proprietary software? *Techopedia*. https://www.techopedia.com/definition/4333/proprietary-software

Shaame, A. (2014*). The adoption of free and open source software in teaching and learning: Case study.* Zanzibar education institutions.

Statcounter. (n.d.-a). *Desktop operating system market share worldwide.* https://gs.statcounter.com/os-market-share/desktop/worldwide

Statcounter. (n.d.-b). *Mobile operating system market share worldwide.* https://gs.statcounter.com/os-market-share/mobile/worldwide

Teixeira, J., Robles, G., & González-Barahona, J. M. (2015). Lessons learned from applying social network analysis on an industrial Free/Libre/Open Source Software ecosystem. *Journal of Internet Services and Applications, 6*(1), 14. https://doi.org/10.1186/s13174-015-0028-2

Thankachan, B., & Moore, D. R. (2017). Challenges of implementing free and open source software (FOSS): Evidence from the Indian educational setting. *International Review of Research in Open and Distributed Learning, 18*(6), 186-199. https://www.erudit.org/en/journals/irrodl/2017-v18-n6-irrodl04863/1064579ar.pdf

W3Techs. (n.d.-a). *Usage statistics and market share of web servers.* https://w3techs.com/technologies/overview/web_server

W3Techs. (n.d.-b). *Usage statistics of operating systems for websites.* https://w3techs.com/technologies/overview/operating_system

W3Techs. (n.d.-c). *W3Techs - World Wide Web Technology Surveys.* https://w3techs.com/

WordPress. (n.d.). *About WordPress.* https://wordpress.org/about/

Predrag Oreški
University of Zagreb
Faculty of Teacher Education
Savska 77, 10000 Zagreb, Croatia
predrag.oreski@ufzg.hr

Dragutin Kermek
University of Zagreb
Faculty of Organization and Informatics
Pavlinska 2, 42000 Varaždin, Croatia
dragutin.kermek@foi.unizg.hr

Valentina Kirinić
University of Zagreb
Faculty of Organization and Informatics
Pavlinska 2, 42000 Varaždin, Croatia
valentina.kirinic@foi.unizg.hr

Slobodan softver otvorenoga izvornog koda u visokom obrazovanju

Sažetak

U ovom radu istražuje se korištenje i svijest o slobodnom softveru otvorenoga izvornog koda (Free and Open Source Software - FOSS) među studentima koji pohađaju nekoliko studijskih programa na Sveučilištu u Zagrebu, Fakultetu organizacije i informatike (FOI) i Sveučilištu u Zagrebu Učiteljskom fakultetu (UF). Koristeći podatke prikupljene online anketnim upitnikom na uzorku od 777 studenata te deskriptivnu i inferencijalnu statistiku analizira se jesu li ispitanici upoznati s ključnim značajkama FOSS-a, koriste li neki FOSS, jesu li upoznati s prednostima koje FOSS donosi, koja su im obilježja FOSS-a najvažnija te kako ocjenjuju kvalitetu FOSS-a. Podatci se analiziraju pomoću statističkoga FOSS-a GNU PSPP i R. Rezultati istraživanja pokazuju da 92,66 % ispitanika koristi neki FOSS, 28,99 % je svjesno da koristi FOSS sa svim njegovim značajkama, a ispitanicima je najvažnije obilježje FOSS-a da je često besplatan. Postoje statistički značajne razlike u upoznatosti ispitanika s FOSS-om i broju korisnika operacijskih sustava iz svijeta FOSS-a s obzirom na fakultet i spol ispitanika. Na ljestvici od 1-nedovoljno do 5-izvrsno, ispitanici ocjenjuju pouzdanost FOSS-a ocjenom 3,74, kompletnost ocjenom 3,68, a opću kvalitetu ocjenom 3,74. Rezultati istraživanja ukazuju na potrebu za dodatnim obrazovanjem studenata o FOSS-u te njegovim prednostima i nedostatcima.

Ključne riječi: *kvaliteta FOSS-a; svijest o FOSS-u; usvajanje FOSS-a.*

Uvod

Prema svojstvima softvera, kao što su cijena, sloboda korisnika, dostupnost izvornoga koda i vlasništvo, on se može klasificirati u određene kategorije kao što su sljedeće: slobodan softver otvorenoga koda (Free and Open Source Software - FOSS), softver u javnoj domeni, besplatni softver, *shareware* i vlasnički softver (Muffatto, 2006; Oreški i Šimović, 2013).

Dvije kategorije softvera međusobno se najviše razlikuju: vlasnički softver i FOSS.

Vlasnički softver

U svijetu vlasničkoga softvera ili softvera zatvorenoga koda njegovi korisnici nemaju pravo pristupa njegovom izvornom kodu. Izvorni kod je tajna i korisnici

ga ne mogu vidjeti jer je to zabranjeno. Samo autori ili vlasnici vlasničkoga softvera smiju legalno kopirati, pregledavati i mijenjati taj softver. Da bi koristili vlasnički softver, korisnici se moraju složiti s licenčnim ugovorom da neće raditi ništa sa softverom što autori softvera nisu izričito dopustili. Ograničenja ili uvjeti koje postavlja dobavljač/programer za vlasnički softver detaljno su navedeni u licencnom ugovoru za krajnjega korisnika, ugovoru o uvjetima usluge ili sličnim korisničkim ugovorima (Rouse, 2017).

Intelektualno vlasništvo vlasničkoga softvera zadržava stvaratelj softvera. Kada se nabavlja neki komercijalan softver, tada se on ne kupuje već se plaća licenca za korištenje djela intelektualnoga vlasništva zaštićenoga autorskim pravima. Licenca za komercijalni vlasnički softver dolazi s mnogim ograničenjima, kao primjerice na kojem se računalu proizvod (softver) može koristiti, tko može koristiti proizvod i, što je najvažnije, koja bi prava korisnik mogao imati na prosljeđivanje intelektualnoga vlasništva nekom drugom. Licence komercijalnoga vlasničkog softvera univerzalno imaju svojstvo da korisnik licence nema pravo redistribuirati softver bilo kome drugome. Bilo koja druga strana koja želi koristiti proizvod mora sklopiti ugovor sa stvarateljem softvera za licencu, što obično zahtijeva dodatno plaćanje (Golden, 2004).

Gotovo sav komercijalni softver je vlasnički softver zatvorenoga koda. Popularni primjeri te vrste su *Adobe Photoshop*, *Autodesk AutoCAD*, *IBM SPSS Statistics*, *Microsoft Windows* i *Microsoft Office*. Vlasnički softver može biti skup i zbog toga je moguće da će se nezakonito kopirati i koristiti bez odgovarajuće licence.

Slobodan softver otvorenoga izvornog koda

Izraz slobodni softver osmislio je Richard Stallman 1983. godine. On označava softver koji uvažava slobodu i zajednicu korisnika. Korisnici imaju slobodu pokretati, kopirati, distribuirati, proučavati, mijenjati i poboljšavati softver te imaju pristup izvornom kodu softvera. Prema GNU Project (n. d.-c), riječ slobodno u slobodnom softveru znači slobodu, a ne cijenu (kao sloboda govora, a ne besplatan ručak).

„Program je slobodan softver ako korisnici programa imaju četiri osnovne slobode:

– slobodu pokretanja programa kako želite, za bilo koju svrhu (sloboda 0)

– slobodu da proučavate kako program radi i mijenjate ga tako da obrađuje podatke kako želite (sloboda 1). Preduvjet za to je pristup njegovom izvornom kodu

– slobodu redistribucije kopija kako biste mogli pomoći drugima (sloboda 2)

– slobodu distribucije kopija vaših modificiranih verzija drugima (sloboda 3).

Na taj način možete dati priliku cijeloj zajednici da ima koristi od vaših promjena. Preduvjet za to je pristup izvornom kodu" (GNU Project, n. d.-a). Slobodni softver ne znači da je nekomercijalan jer može biti dostupan za komercijalnu upotrebu, razvoj i distribuciju (GNU Project, n. d.-c). Međutim, slobodni softver često je

besplatan. Bilo je ljudi iz poslovnoga svijeta koji su krivo shvatili pojam slobodnoga softvera i smatrali su da je takav softver isključivo besplatan pa nisu prihvatili niti podržali takav softver. Neki korisnici i stvaratelji slobodnoga softvera nisu se slagali sa svim ciljevima pokreta za slobodan softver te su 1998. godine počeli koristiti izraz otvoreni kod (*open source*) (GNU Project, n. d.-d) i osnovali su grupu pod nazivom Inicijativa za otvoreni kod (*Open Source Initiative* (OSI)) (Open Source, n.d.-b). „Softver otvorenoga koda je softver s izvornim kodom koji svatko može pregledati, modificirati i poboljšati" (Open Source, n .d.-a). Zaklada za slobodni softver (*Free Software Foundation* (FSF)) Richarda Stallmana i OSI održavaju formalne definicije pojmova slobodnoga softvera i otvorenoga koda. Međutim, definicije su suštinski identične, a odluka da se koristi jedan od ovih pojmova više je ideološka nego što je funkcionalna. FSF preferira korištenje izraza koji se eksplicitno odnosi na slobodu. Istodobno, OSI vjeruje da je dvostruko značenje engleske riječi free (gratis ili libertas) zbunjujuće i umjesto toga radije naglašava dostupnost i mogućnost izmjene izvornoga koda (Feller et al., 2007).

Pojmovi slobodni softver i otvoreni kod sada se uglavnom odnose na istu kategoriju softvera, ali predstavljaju bitno različite vrijednosti. Za FSF slobodan softver je etička nužnost, naglašavajući važnost slobode korisnika. Nasuprot tome, filozofija OSI usredotočuje se na praktične koristi, gledajući na neslobodan softver kao na manje učinkovito rješenje praktičnih problema. FSF vidi neslobodni softver kao društveni problem koji treba eliminirati u korist slobodnoga softvera. U praksi su kriteriji za otvoreni kod nešto manje strogi od onih za slobodni softver. Sav poznati izvorni kod slobodnoga softvera zadovoljava standarde otvorenoga koda, a većina softvera otvorenoga koda je slobodan softver, iako postoje iznimke. Retorika otvorenoga koda uspješno je uvjerila mnoge tvrtke i pojedince da koriste i razvijaju slobodan softver, čime se širi zajednica (GNU Project, n. d.-d).

FOSS razvija umrežena zajednica pojedinaca i organizacija. Čak i konkurentske tvrtke surađuju u razvoju takvoga softvera, a postoji primjer (infrastruktura oblaka OpenStack) više od 200 tvrtki i organizacija koje rade zajedno (Teixeira et al., 2015). Ako netko želi biti neutralan između te dvije skupine softvera (slobodnoga softvera i otvorenoga koda (*open source*)), onda može koristiti izraz *Free and Open Source Software* (FOSS) ili *Free/Libre and Open Source Software* (FLOSS). Jedan od ciljeva zajednice FOSS je razvoj kvalitetnoga softvera.

Kvaliteta softvera definirana je složenim kategorijama i atributima kvalitete softvera kao što su funkcionalna prikladnost, učinkovitost performansi, kompatibilnost, upotrebljivost, pouzdanost, sigurnost, mogućnost održavanja i prenosivost (ISO/IEC, 2024). Za obične korisnike najvažniji atributi kvalitete su oni koji izravno utječu na njihovo iskustvo i zadovoljstvo softverom, kao što su upotrebljivost, pouzdanost, učinkovitost izvedbe, sigurnost, funkcionalna prikladnost (kao što je kompletnost) i kompatibilnost. Kada se razmatra korištenje FOSS-a, očekuje se barem ista razina kvalitete softvera koja je prisutna i u vlasničkom softveru.

Licence za FOSS

FOSS je dostupan u skladu sa svojim softverskim licencama. Najvažnija licenca za slobodan softver je GNU GPL (GNU's Not UNIX *General Public License* (sada u verziji 3)) (GNU Project, n .d.-a). Namijenjena je jamčenju i zaštiti sloboda softvera i osiguravanju da on ostane slobodan softver. Druge su licence kompatibilne s GNU GPL-om, kao što je *Apache License 2.0, Artistic License 2.0, Berkeley Database License, Modified BSD (Berkeley Software Distribution) Licenca (3-klauzule BSD licence), Educational Community License 2.0, FreeBSD License, Mozilla Public License* (MPL) verzija 2.0 i mnoge druge (GNU Project, n. d.-b; Open Source, n. d.-a).

FOSS u obrazovanju

Zbog činjenice da je često besplatan, da se može koristiti bez ograničenja u sve svrhe, da se može dijeliti s drugima bez ograničenja i da je dostupan njegov izvorni kod, FOSS je vrlo prikladan za korištenje u obrazovnim sustavima. Proces stvaranja softvera s otvorenim kodom vrlo je transparentan, a njegove proizvode i procese može kontinuirano ocjenjivati zajednica programera povezanih internetom. Njegov postupak recenziranja još je otvoreniji od procesa tradicionalne znanosti. Njegova se otkrića ne drže u tajnosti i dopušta se svakome da bilo gdje i bilo kada slobodno dalje razvija softver na njegovim otkrićima i stvarateljskim djelima (Deek i McHugh, 2007). Stoga je FOSS i vrlo dobar izvor učenja u obrazovne svrhe.

Brojni su primjeri i iskustva korištenja FOSS-a u obrazovanju u zemljama poput Španjolske, Švicarske i Italije (Oreški i Šimović, 2013). Drugi primjeri uključuje Švedsku, Indiju, Oman, Bosnu i Hercegovinu te Zanzibar. Prema Lundell i Gamalielsson (2013), javne škole u Švedskoj očekuju od učenika da koriste različite softverske sustave, uključujući FOSS. Škole pružaju mnoge različite softvera iz svijeta FOSS-a, uključujući *Audacity, Blender, Bluefish, Firefox, Gimp, Geogebru, Inkscape, LibreOffice, Scribus, VLC* i druge. Indijska država Kerala bila je jedna od najvećih svjetskih implementacija FOSS-a, koja je godišnje imala utjecaj na šest milijuna učenika i 200 000 nastavnika. U tom slučaju najveći izazov u usvajanju FOSS-a bio je nedostatak odgovarajućih resursa za obuku nastavnika (Thankachan i Moore, 2017).

U Omanu je utvrđeno da se mnoge obrazovne institucije povlače iz implementacije učenja temeljenoga na igrama zbog složenosti uključene u usvajanje takve tehnologije (Naidu et al., 2017). Te složenosti uključuju osiguranje financiranja i pružanje osnovne edukacije stvarateljima sadržaja. Nadalje, razvoj sadržaja za podršku e-učenju zahtijeva značajan trud i vrijeme. Autori su u pokusnom projektu koristili *Scratch*, slobodan softver otvorenoga koda razvijen na MIT-u, i osmislili su edukativne igre za djecu od 7 do 10 godina. Budući da su korišteni alati slobodni i otvorenoga koda, oni nude poboljšane mogućnosti prilagodbe, promičući održivi razvoj u sektoru obrazovanja (Naidu i sur., 2017).

U Bosni i Hercegovini autori Pezer i sur. (2017) navode rezultate istraživanja na uzorku od 20 nastavnika informatike da je vlasnički komercijalni softver prisutan na 91,4 % stolnih računala u učionici, a GNU/Linux kao *dual boot* prisutan je na njih 8,6 %. FOSS je zanimljiv 95 % nastavnika informatike, ali samo 55 % njih koristi FOSS u razrednoj nastavi. Glavni razlozi zbog kojih koriste FOSS su što je besplatan, dostupan te njegova kvaliteta.

U Zanzibaru (Shaame, 2014) postoje izvješća o izazovima u usvajanju FOSS-a u nastavi i učenju, poput otpora nastavničkoga osoblja promjenama, percepcije GNU/Linux grafičkoga korisničkog sučelja (koje je u to vrijeme bilo drugačije od popularnoga komercijalnog vlasničkog operacijskog sustava) i nedostatak podrške za FOSS.

Prema Oreški i Šimović (2013), 96,15 % kurikula osnovnoškolskoga obrazovanja informatike u Republici Hrvatskoj može se realizirati pomoću FOSS-a. U vrijeme toga istraživanja u kurikulu informatike bilo je 130 različitih nastavnih tema, a FOSS je u potpunosti podržavao njih 125.

Duan i Lee (2022) analizirali su relevantnu literaturu dostupnu u bazi podataka *Web of Science* objavljenu u godinama 2010. - 2020. i zaključili da je FOSS postao važno istraživačko područje te da igra važnu ulogu u reformi i razvoju obrazovanja. Također su utvrdili da su istraživanja i razvoj FOSS-a u području obrazovanja nedostatni.

FOSS ima brojne prednosti, posebno u obrazovanju. To su: uštede na troškovima licenci, jednostavna instalacija FOSS-ova operacijskoga sustava i aplikacija, svi potrebni pogonski programi (drivers) uključeni su u paket distribucije, FOSS je otporan prema računalnim virusima i drugom zlonamjernom softveru jer virusi i zlonamjerni softver koji su namijenjeni za rad s vlasničkim operacijskim sustavima ne mogu raditi s FOSS-ovim operacijskim sustavima te druge prednosti. Korištenjem FOSS-a svima je omogućen jednak pristup suvremenim informacijskim i komunikacijskim tehnologijama, neovisno o životnom standardu (Oreški i Šimović, 2013).

Treba napomenuti da pogonski programi za periferne uređaje u FOSS operacijskim sustavima ponekad mogu biti rudimentarni, sadržavati manje softverskih značajki i opcija od potpuno opremljenih upravljačkih programa za vlasničke operacijske sustave. Ponekad upravljački programi za najnovije uređaje za FOSS-ove operacijske sustave trenutačno nisu dostupni jer su proizvođači uređaja fokusirani samo na upravljačke programe za vlasničke operacijske sustave (koji zauzimaju najveći tržišni udio).

Korisnici FOSS-ovih operacijskih sustava često imaju više znanja o računalima, operacijskim sustavima, aplikativnom softveru i njihovoj sigurnosti od prosječnih korisnika računala što komplicira donošenje konačnih zaključaka o sigurnosti FOSS operacijskih sustava.

Postoji mogućnost da korištenje FOSS-a može izazvati neke nedostatke ili rizike kao što su mogućnost da je korisnička podrška za njegovu instalaciju, održavanje

i korištenje u blizini vrlo loša ili nepostojeća, da ne postoji formalni proizvođač ili jamstvo da će se nastaviti razvijati, poboljšavati, dodavati nove značajke ili ispravljati pogreške FOSS-a. Nadalje, čak i iskusnim korisnicima vlasničkoga softvera treba vremena da se naviknu na nova FOSS-ova korisnička sučelja i upoznaju njegove mogućnosti, moguća je djelomična nekompatibilnost formata datoteka ili male razlike u izgledu sadržaja datoteke, moguć je nedostatak upravljačkih programa za najnovije uređaje te nedostatak specifičnoga obrazovnog i drugog softvera za platformu FOSS-a (Oreški i Šimović, 2013).

Treba napomenuti da FOSS dolazi sa svojim izvornim kodom, ali to ne znači da ga svi njegovi korisnici istražuju ili pregledavaju. Postoji FOSS koji još uvijek sadrži pogreške i ranjivosti unatoč svojem otvorenom kodu. Unatoč otvorenosti i dostupnosti FOSS izvornoga koda svim zainteresiranim programerima i softverskim tvrtkama koje ga koriste, još uvijek može postojati ranjivost koja nije primijećena i moglo bi biti pitanje dana kada će je neki zlonamjerni *haker* pronaći i iskoristiti. Kada se govori o FOSS-u, nemoguće je izbjeći jedan od najmračnijih trenutaka koji se dogodio FOSS-ovoj zajednici kada je *Apache* 10. prosinca 2021. javno otkrio da vrlo popularna biblioteka Lib4J ima ranjivost koja bi napadaču mogla omogućiti korištenje LDAP i RMI usluga za ubacivanje koda i zaraziti lokalni stroj (Hiesgen i sur., 2022).

Pavlina i Petrovič (2013) u svojem radu istražuju stavove studenata prema korištenju tehnologije otvorenoga izvornog koda u obrazovanju, obuhvativši 197 studenata primarno informacijskih i računalnih studija i srodnih smjerova. Rezultati istraživanja pokazuju da 75,7 % ispitanika vjeruje da softver otvorenoga izvornog koda može pružiti dostojnu alternativu komercijalnom vlasničkom softveru, 97,2 % smatra da bi se taj softver trebao koristiti u informacijskom i računalnom obrazovanju, a 91,6 % da bi tehnologije otvorenoga izvornog koda trebale biti uključene u informatički kurikul.

Oreški i Šimović (2013) prikazuju rezultate istraživanja korištenja FOSS-a na uzorku od 93 učitelja informatike u osnovnom obrazovanju u Republici Hrvatskoj u kojima navode da je samo jedan učitelj (1,1 %) koristio FOSS-ov operacijski sustav u nastavi. Jedan od glavnih razloga nekorištenja FOSS-a u nastavi bio je nedostatak znanja o FOSS-u.

Nayak i sur. (2021) iznose rezultate svojega istraživanja na uzorku od 200 sveučilišnih studenata: oko 58 % studenata bilo je dobro upoznato s FOSS-om, oko 53 % studenata koristilo je i vlasnički softver i FOSS, 38,75 % studenata bilo je svjesno slobode korištenja FOSS-a, 27,5 % studenata bilo je svjesno dostupnosti izvornoga koda FOSS-a, 26,25 % studenata bilo je svjesno slobode FOSS-a u modificiranju softvera, većina studenata nije bila svjesna značajki FOSS-a, kao što je pristup izvornom kodu i da korisnici mogu mijenjati izvorni kod te da bi 82,5 % studenata željelo znati više o FOSS-u. Ista studija pokazuje da su glavni čimbenici koji utječu na svijest studenata o FOSS-u internet/društveni mediji, nastavni plan i

program kolegija te konferencije/seminari. Oko 80 % studenata koristi *VLC Media Player*, a 65 % *Mozilla Firefox* mrežne preglednike koji su oba FOSS. Oko 56,25 % studenata koristilo je FOSS zbog njegovih značajki, poput slobode korištenja u bilo koju svrhu, a približno 38,75 % studenata jer im ovaj softver daje slobodu mijenjanja, dijeljenja ili distribucije.

Na uzorku istraživanja od 80 studenata, Nayak i Binjha (2022) izvještavaju:

- 66,25 % studenata upoznato je s upotrebom i dobrobitima FOSS-a,

– postotak studenata koji su svjesni svojstava FOSS-a:
  - FOSS se slobodno distribuira svima zainteresiranima - 58,8 %
  - omogućuje korisniku izmjenu izvornoga koda - 28,8 %
  - njegova licenca ne bi trebala uključivati nerazumna ograničenja - 26,3 %
  - omogućuje korisnicima pristup izvornom kodu - 37,5 %

– postotak studenata koji su svjesni sljedećega FOSS-a:
  - *LibreOffice* – 25 %
  - *OpenOffice* - 37,5 %
  - *Mozilla Firefox* - 63,75 %
  - *Chrome* - 41,25 %
  - *GIMP* - 11,25 %
  - *VLC media player* – 70 %
  - *Ubantu* - 47,5 %
  - *OpenShot* - 6,25 %
  - *Audacity* - 12,5 %
  - *MyPaint* – 25 %
  - *Tuxpaint* - 7,5 %.

Zaklada za slobodni softver (GNU Project, 2022) smatra da je izvorni kod slobodnoga softvera dio ljudskoga znanja i da bi se trebao slobodno distribuirati u obrazovnim institucijama na svim razinama. Također smatra da je komercijalni vlasnički softver tajno, ograničeno znanje koje je suprotno misiji obrazovnih institucija. FOSS dolazi sa svojim izvornim kodom, a to znači da je vrlo transparentan i siguran jer svatko može vidjeti i pregledati njegov izvorni kod i provjeriti ima li sigurnosnih propusta (ili čak neželjenih ili potencijalno zlonamjernih opcija (primjerice „stražnjih vrata“)). FOSS razvija i održava zajednica programera tako da se takve potencijalne sigurnosne ranjivosti mogu brzo ispraviti. Korištenjem FOSS-a učitelji, nastavnici, učenici i studenti mogu učiti na primjerima programiranja i proučavati kako programi rade jer je njihov izvorni kod legalno i slobodno dostupan. Učitelji mogu dijeliti programske alate i druge FOSS aplikacije s učenicima kako bi ih oni mogli proučavati i koristiti ih kod kuće. Svi oni mogu mijenjati i prilagođavati FOSS svojim specifičnim potrebama.

Obrazovne ustanove često imaju ograničen proračun i kada kupe 20 ili 30 stolnih ili prijenosnih računala za svoje učionice, tada moraju nabaviti i operacijske sustave i aplikacije za njih. Iako dobavljači komercijalnog vlasničkog softvera obično daju popuste obrazovnim ustanovama za kupnju njihovih operacijskih sustava i aplikacija,

obrazovnim je ustanovama vrlo jednostavno nabaviti FOSS operacijske sustave i aplikacije bez ikakvih troškova kupnje i bez ograničenja količine te bez problema s licenciranjem. FOSS je često besplatno dostupan, što znači da ga svatko može koristiti i steći iskustvo sa širokim spektrom različitoga softvera čime se promiče njihova digitalna pismenost.

Tržišni udio FOSS-a

Podatci o tržišnom udjelu operacijskih sustava za stolna računala širom svijeta pokazuju da su GNU/Linux operacijski sustavi za stolna računala zastupljeni samo na malom postotku stolnih računala. Prema Statcounteru (n. d.-a), u travnju 2024. godine, zastupljeni su na 3,88 % svih stolnih računala. Zastupljenost ostalih operacijskih sustava je kao što slijedi: *Windows* 73,5 %, OS X 14,7 % i *Chrome* OS 2,56 %. Iako FOSS zauzima samo mali dio tržišnoga udjela operacijskih sustava za stolna računala, puno je više zastupljen u tržišnom udjelu poslužiteljskih operacijskih sustava i poslužiteljskoga softvera. Prema W3Techs (n. d.-b), najčešće korišteni operacijski sustavi za mrežna mjesta su operacijski sustavi slični UNIX-u (81,6 %), a slijedi ih *Windows* (18,7 %). U kategoriji operacijskih sustava sličnih UNIX-u nalazi se GNU/Linux, koji koristi 46,5 % svih mrežnih mjesta koja koriste operacijske sustave slične UNIX-u. Postoji mnogo različitih distribucija GNU/Linux operacijskoga sustava i sve su otvorenoga koda.

Prema W3techs (n. d.-a), najčešće korišten softver za mrežne poslužitelje na internetu je nginx (34,5 %), a slijede ga *Apache* (31,5 %) i *Cloudflare* (20,7 %). *Nginx* je softver otvorenoga koda objavljen pod licencom *2-clause BSD-like license* (Nginx, n.d.), a mrežni poslužitelj Apache je FOSS sa svojom licencom *Apache v2.0* koja je kompatibilna s GNU *General Public License v.3* (Apache Software Foundation, n. d.). *WordPress* je najpopularniji softver za upravljanje mrežnim sadržajem (Content Management System - CMS), s tržišnim udjelom od 43,1 % (W3Techs, n. d.-c). *WordPress* je također FOSS, licenciran pod *GNU GPLv2* ili novijom licencom (WordPress, n. d.).

U kategoriji softvera za upravljanje učenjem (*Learning Management System* - LMS), najčešće korišteni softver u SAD-u je *Canvas* (35 %), a slijede ga *Moodle* (21 %) i *Blackboard* LMS (20 %) (Ménard, 2021). *Canvas* je vlasnički softver i češće se koristi u Velikoj Britaniji i SAD-u (Khatser i Khatser, 2022). *Moodle* je FOSS s licencom *GNU GPLv2*. Istraživanje koji su proveli Gamage, Ayres i Behrend (2022) pokazuje da se *Moodle* uglavnom koristi unutar sveučilišnih STEM disciplina i učinkovito poboljšava rad, zadovoljstvo i angažman studenata. Sve se više koristi kao platforma za prilagodljivo i suradničko učenje te za poboljšanje *online* ocjenjivanja. Ostali primjeri FOSS LMS-a uključuju *TalentLMS*, *Edmodo*, *EduBrite* i *Sakai* (Alameen & Dhupia, 2019). FOSS operacijski sustavi pokreću svih 500 najboljih superračunala. Superračunala su uređaji izgrađeni za posebne svrhe koji zahtijevaju prilagođeni operacijski sustav optimiziran za njihove potrebe (Prakash, 2023). Na mobilnim uređajima operacijski sustav Android ima tržišni

udio od 70,79 %, a slijedi ga iOS s 28,44 % (Statcounter, n.d.-b). *Android Open Source Project* koristi licence *Apache License v2.0* i *GNU GPLv2* (Android Open Source Project, n. d.).

Petrov i Obwegeser (2018) predstavljaju rezultate svojeg istraživanja o preprekama usvajanju slobodnoga softvera otvorenoga izvornog koda u kojem klasificiraju 19 čimbenika u četiri dimenzije: tehnološku, organizacijsku, okolišnu i individualnu. Čimbenici u individualnoj dimenziji su percepcije korisnika, nema predvodnika, nema motivacije i netoleriranje privremenih neugodnosti. Individualno usvajanje FOSS-a ovisi o korisnosti i jednostavnosti korištenja koje korisnici percipiraju, o pobornicima ili sponzorima koji su osobe koje mogu povezati organizacije s vanjskim znanjem i stupiti u kontakt s inovacijama, o motivaciji korisnika za prihvaćanje promjena te o sposobnosti toleriranja privremenih neugodnosti pri prelasku na FOSS. Često korišteni pojmovi koji opisuju razloge zbog kojih korisnici oklijevaju prihvatiti FOSS su nedostatak motivacije i otpor prema promjenama. Prepreke usvajanju slobodnoga softvera otvorenoga izvornog koda te veliki izazovi u implementaciji FOSS-a mogu se smanjiti obrazovanjem o FOSS-u, što može pozitivno utjecati na motivaciju korisnika za korištenje FOSS-a i smanjiti njihov otpor promjenama.

Cilj istraživanja

Istraživanje predstavljeno u ovom radu ima za cilj istražiti korištenje slobodnoga softvera otvorenoga izvornog koda i svijest o njemu među studentima dvaju fakulteta istoga sveučilišta. Istraživanje uključuje studente koji pohađaju nekoliko studijskih programa Sveučilišta u Zagrebu Fakulteta organizacije i informatike (FOI) i Sveučilišta u Zagrebu Učiteljskog fakulteta (UF). Oba fakulteta izvode studijske programe u području društvenih znanosti. Studiji na UF-u pripadaju i Interdisciplinarnim znanostima - Obrazovnim znanostima, dok studiji FOI-ja najvećim dijelom pripadaju Informacijskim i komunikacijskim znanostima te dijelom Ekonomiji. Neovisno o studijskom programu, svi studenti koriste računalne programe za učenje i ispunjavanje svojih fakultetskih zadaća. Cilj je otkriti postoje li razlike u korištenju i stavovima ispitanika prema FOSS-u prema fakultetu i prema spolu.

Metodologija

Uzimajući u obzir sva svojstva, prednosti i moguće nedostatke FOSS-a za obrazovanje, bitno je saznati više informacija o njegovoj upotrebi među studentima, njihovoj svijesti o FOSS-u i njihovim stavovima prema FOSS-u. Predstavljeni rezultati istraživanja iz literature ne istražuju korištenje i svijest o FOSS-u ispitanika prema fakultetu ili spolu i ne ocjenjuju kvalitetu FOSS-a od strane studenata.

Zadatci (problemi) istraživanja su istražiti koriste li ispitanici neki FOSS, jesu li upoznati s pojmom i ključnim značajkama FOSS-a, postoje li razlike u poznavanju FOSS-a među ispitanicima između dva fakulteta i po spolu, koje su im značajke

FOSS-a najvažnije, kako ocjenjuju kvalitetu FOSS-a, koliki je postotak ispitanika koji koriste FOSS-ove operacijske sustave s dvaju fakulteta te postoje li razlike u broju korisnika FOSS-ovih operacijskih sustava između dvaju fakulteta i po spolu.

Hipoteze

Hipoteze ovoga istraživanja temelje se na sljedećim činjenicama. Široka dostupnost FOSS-a (dostupan je na internetu, uglavnom je besplatan) omogućuje svakome da ga instalira i koristi. Pretpostavka je da svi ispitanici koriste barem jedan FOSS, bez obzira znaju li da je to FOSS ili ne. Važno je istražiti stopu usvajanja FOSS-a među studentima kako bi se vidjela potreba za dodatno obrazovanje o FOSS-u u namjeri da studenti imaju veće mogućnosti izbora softvera koji im je potreban.

Operacijski sustav GNU/Linux jedan je od temelja FOSS-a. Prema Statcounter (n. d.-a), u travnju 2024. godine bio je zastupljen na 3,88 % svih stolnih računala. Očekuje se da je slična zastupljenost i među ispitanicima s UF-a koji obično nisu tako zainteresirani i entuzijastični za informacijske i komunikacijske tehnologije kao što su to studenti s FOI-ja. Istovremeno, očekuje se da su ispitanici s FOI-ja više zainteresirani za informacijsko-komunikacijske studije i predmete na FOI-ju koji se bave svim aspektima softvera pa će ih biti više od 5 % koji koriste operacijski sustav GNU/Linux na svojim osobnim računalima. Važno je istražiti zastupljenost ovoga operacijskog sustava jer je on temelj za korištenje cijeloga niza FOSS-a.

Da bi koristili FOSS, njegovi korisnici ne moraju poznavati sve njegove značajke – njegove slobode korištenja programa za bilo koju svrhu, pristupa njegovom izvornom kodu, proučavanja kako program radi, mijenjanja i redistribucije. Običnom korisniku može biti važno znati samo da je neki određeni FOSS koristan i da je često besplatan. Pretpostavka je da većina ispitanika nije bila upoznata sa svim značajkama FOSS-a, njegovim slobodama, u trenutku kada su ga instalirali. Važno je istražiti svjesnost o korištenju FOSS-a jer ako su korisnici svjesni njegovih svojstava, onda ih mogu koristiti u punom opsegu (pristupačnost, financijske uštede, učenje na primjerima izvornoga koda, sloboda mijenjanja FOSS-a i prilagodbe itd.).

Ako ispitanici koriste neki FOSS, onda se može očekivati da su zadovoljni njegovom kvalitetom i da njegovu kvalitetu ocjenjuju u rasponu od dobar do odličan, s prosječnom ocjenom vrlo dobar. Svojstva kvalitete FOSS-a, poput njegove pouzdanosti i kompletnosti, bitna su za korisnike jer omogućuju nesmetan i kontinuiran rad, štite privatnost i sigurnost njihovih podataka. Važno je istražiti kvalitetu FOSS-a jer ona neposredno utječe na izgradnju povjerenja njegovih korisnika i na njegovu veću prihvaćenost među korisnicima. Zbog različitoga područja obrazovanja i interesa ispitanika, samo su tri jednostavna atributa kvalitete softvera (pouzdanost, kompletnost i ukupna kvaliteta) odabrana da ih ocjenjuju ispitanici. U upitniku su definirani na najjednostavniji način: pouzdanost - softver radi bez prekida i pogrešaka, kompletnost - softver sadrži sve potrebne značajke za normalan rad te ukupna kvaliteta.

Očekuje se da su ispitanici s FOI-ja bolje upoznati s FOSS-om i da u većem broju koriste FOSS-ove operacijske sustave nego ispitanici s UF-a jer su općenito zainteresiraniji i entuzijastičniji za informacijsko-komunikacijske tehnologije te zbog studija i predmeta na FOI-ju koji se bave svim aspektima softvera. Očekuje se da će zanimanje ispitanika za informacijske i komunikacijske tehnologije i poznavanje FOSS-a utjecati na korištenje FOSS-ovih operacijskih sustava. Budući da su općenito ispitanici zainteresiraniji za informacijsko-komunikacijske tehnologije nego ispitanice (Croatian Bureau of Statistics, 2024), može se očekivati da su oni bolje upoznati s FOSS-om i da u većem broju od ispitanica koriste FOSS-ove operacijske sustave.

Hipoteze istraživanja su sljedeće:

Prva hipoteza: postoji statistički značajna razlika u upoznatosti ispitanika s FOSS-om između ispitanika s FOI-ja i ispitanika s UF-a.

Druga hipoteza: postoji statistički značajna razlika u upoznatosti ispitanika s FOSS-om između ispitanika muškoga i ženskoga spola.

Treća hipoteza: u trenutku preuzimanja i instalacije FOSS-a na svoje osobno računalo više od 50 % ispitanika nisu bili svjesni da koriste FOSS sa svim njegovim značajkama.

Četvrta hipoteza: svi ispitanici redovito koriste barem jedan program iz domene slobodnoga softvera otvorenog izvornog koda.

Peta hipoteza: ispitanici ocjenjuju kvalitetu FOSS-a (pouzdanost, kompletnost i ukupnu kvalitetu) najmanje prosječnom zaokruženom ocjenom 4 ($3{,}5 \leq M < 4{,}5$) iz ljestvice ocjenjivanja pri čemu 1 označava najnižu vrijednost (nedovoljno), a 5 znači najveću vrijednost (izvrsno).

Šesta hipoteza: postoji statistički značajna razlika u broju korisnika FOSS-ovih operacijskih sustava između ispitanika s FOI-ja i ispitanika s UF-a.

Sedma hipoteza: postoji statistički značajna razlika u broju korisnika FOSS-ovih operacijskih sustava između ispitanika muškoga i ženskoga spola.

Osma hipoteza: postoji statistički značajna razlika u postotku korisnika FOSS-ovih operacijskih sustava između ispitanika s FOI-ja i ispitanika s UF.

Uzorak ispitanika

Podatci su prikupljeni od 777 ispitanika koji su bili redoviti studenti na deset različitih studijskih programa na dva fakulteta Sveučilišta u Zagrebu: Fakulteta organizacije i informatike (FOI) i Učiteljskog fakulteta (UF). S obzirom na njihove godine studija njihova dob bila je u rasponu od 18 do 24 godine.

Oba su fakulteta pod sve većim utjecajem brzog razvoja informacijske i komunikacijske tehnologije koja utječe na procese poučavanja i učenja. Svi studijski programi imaju za cilj omogućiti studentima da steknu digitalne kompetencije koje su im potrebne u akademskom i budućem profesionalnom životu.

Dva fakulteta uključena u istraživanje odabrana su jer dijele sličnu važnost

i odgovornost u promicanju ideje FOSS-a. Fakulteti se razlikuju po studijskim programima: FOI obrazuje buduće stručnjake iz područja informacijskih i komunikacijskih tehnologija, ekonomije, organizacije, komunikacija i drugih srodnih područja, a UF obrazuje odgojitelje djece rane i predškolske dobi te učitelje primarnoga obrazovanja. Na FOI-ju ima više studenata nego studentica, a na UF-u je više je studentica nego studenata. Ova razlike među fakultetima trebale bi biti vidljive u svijesti i stavovima studenata o FOSS-u.

Tablica 1

Ispitanika ženskoga spola bilo je 346 (44,53 %), muškoga spola 416 (53,54 %) i 15 ispitanika (1,93 %) koji nisu željeli otkriti svoj spol (Tablica 1). Postoji značajna razlika u omjeru spolova ispitanika po fakultetima. Ispitanici s FOI-ja bili su 24,64 % ženskoga spola i 73,01 % muškoga spola, dok su ispitanici s UF-a bili 93,33 % ženskoga spola i 5,76 % muškoga spola.

U uzorku istraživanja na dva studijska programa UF-a dominantno je više ispitanika ženskoga spola (94 % i 92,1 %) nego ispitanika muškoga spola. Profesionalne karijere u ranom djetinjstvu, predškolskom i osnovnoškolskom obrazovanju tradicionalno su u Republici Hrvatskoj rezervirane uglavnom za žene. Ispitanici sa studija FOI-ja pokazuju drugačiji omjer spolova: većina ispitanika s gotovo svih studija su muškoga spola (tri studija s 82,5 %, 80,3 % i 80 % te dva studija s 77,4 % i 70,7 %), osim jednoga studijskog programa (Ekonomija poduzetništva) kojeg čini 25 % ispitanika muškog aspola.

Svi ispitanici ispunili su upitnik u cijelosti i nije bilo poznatih odustajanja. U anketnom upitniku bilo je nekoliko stavki koje su se mogle popuniti izborno, primjerice onih koje su mogli popuniti samo ispitanici koji koriste FOSS, kao što su svijest o FOSS-u u vrijeme njegove instalacije (745 od 777 ispitanika) i kvaliteta FOSS-a (pouzdanost, potpunost, ukupna kvaliteta) (720 od 777 ispitanika).

Instrumenti

Za prikupljanje podataka autori su koristili *online* anketni upitnik koji su sami konstruirali (Google Forms). On se sastoji od sljedećih stavki:

– demografskih stavki o ispitanicima (kao što su spol (muški, ženski, radije ne žele otkriti svoj spol), fakultet, vrsta studija, naziv studijskoga programa, godina studija)

– stavke o upoznatosti ispitanika s FOSS-om kao što su upoznatost s pojmom i značajkama FOSS-a i upoznatost s licencama za FOSS (s ljestvicom Likertova tipa od pet stupnjeva: 1 - u potpunosti se ne slažem, 2 - ne slažem se, 3 - niti se ne slažem niti se slažem, 4 - slažem se, 5 - u potpunosti se slažem)

– stavke o razini poznavanja i korištenja FOSS-a

– stavke o svojstvima FOSS-a koja su ispitanicima najvažnija za njihov rad (u usporedbi s vlasničkim softverom) (mogućnost odabira više odgovora)

– stavke o FOSS-u koji ispitanici koriste na svojim osobnim računalima (mogućnost odabira više odgovora s popisa popularnoga FOSS-a)

– stavke o svijesti o FOSS-u u vrijeme njegove instalacije (s ljestvicom Likertova tipa od pet stupnjeva: 1 - u potpunosti se ne slažem, 2 - ne slažem se, 3 - niti se ne slažem niti se slažem, 4 - slažem se, 5 - u potpunosti se slažem)

– stavke o ocjeni kvalitete FOSS-a: pouzdanost, kompletnost i općenita kvaliteta (s ocjenama: 1 - nedovoljno, 2 - zadovoljavajuće, 3 - dobro, 4 - vrlo dobro i 5 - izvrsno)

– stavke o korištenju određenoga operacijskog sustava - ispitanici su mogli izabrati jedan ili više naziva operacijskih sustava koje koriste, kao što su *Microsoft Windows*, *GNU/Linux*, *MacOS*, *Chrome OS* itd.

Stavke upitnika sadržajno su provjerili i označili važećima (validirali) stručnjaci u područjima FOSS-a i kvalitete softvera. Dvije skupine stavki upitnika potvrđene su za internu konzistentnost (pouzdanost). Prva skupina (poznavanje FOSS-a) sastoji se od sljedećih stavki: poznavanje pojma i značajki FOSS-a, poznavanje FOSS-ovih licenci i razina poznavanja i korištenja FOSS-a. Interna konzistentnost tih triju stavki vezanih uz poznavanje FOSS-a je prihvatljiva (McDonald's Omega = 0,79). Druga skupina stavki upitnika sastoji se od stavki vezanih uz ocjenu kvalitetu FOSS-a: pouzdanost, kompletnost i ukupna kvaliteta. Interna konzistentnost tih triju stavki vezanih uz kvalitetu FOSS-a je dobra (McDonaldova Omega = 0,88). Interna konzistentnost svih šest stavki vezanih uz poznavanje FOSS-a i kvalitetu FOSS-a je dobra (McDonaldova Omega = 0,88).

Postupak

Studenti obaju fakulteta pozvani su da dobrovoljno i anonimno sudjeluju u anketi e-porukama i porukama s foruma sustava za upravljanje učenjem koje su poslali njihovi sveučilišni profesori. Studente se moralo jednom podsjetiti da ispune anketni upitnik. Neki studenti bili su pozvani da ispune upitnik u predavaonicama na početku nastave njihovih profesora. Korišten je plan kontaktiranja profesora koji predaju na različitim studijskim programima, godinama studija i predmetima kako bi se izbjeglo preklapanje poziva za sudjelovanje u anketi. U kontaktu i pozivanju studenata sudjelovalo je osam profesora s UF-a i četrnaest profesora s FOI-ja. Studenti nisu bili nagrađivani za sudjelovanje u anketi.

Anketa se provodila istovremeno na oba fakulteta u siječnju, veljači i ožujku 2023. Zadaća ispitanika bila je ispuniti *online* anketni upitnik (Google obrasci) koji je bio dostupan na https://forms.gle/tciAXMnVKvuQGDEh8. Prije unosa podataka u anketni upitnik ispitanici su mogli pročitati upute i informacije o svrsi istraživanja te o anonimnosti prikupljenih podataka i njihovoj mogućnosti da u svakom trenutku odustanu od sudjelovanja u istraživanju. Za unos podataka u anketni upitnik bilo je potrebno oko pet minuta.

Metode

U statističkoj obradi podataka korištene su neparametarske statističke metode zbog toga što:

– podatci su ordinalni brojevi:

- skala Likertova tipa od pet stupnjeva: 1 – u potpunosti se ne slažem, 2 – ne slažem se, 3 – niti se ne slažem niti se slažem, 4 – slažem se, 5 – u potpunosti se slažem
- ocjena: 1 – nedovoljan, 2 – dovoljan, 3 – dobar, 4 – vrlo dobar, 5 – izvrstan

– podatci ne prate normalnu distribuciju ($p < 0{,}001$), kao što je prikazano u rezultatima u Tablici 2.

Tablica 2

Korištene su sljedeće statističke metode:

– deskriptivna statistika (frekvencije, medijan, srednja vrijednost)

– Kolmogorov-Smirnov test za testiranje normalnosti distribucije

– McDonaldova Omega za internu konzistentnost stavki anketnoga upitnika

– Mann-Whitney U test za istraživanje razlika u poznavanju FOSS-a, svijesti o FOSS-u i kvaliteti FOSS-a između ispitanika s dva fakulteta i prema njihovom spolu

– Hi-kvadrat test za istraživanje korištenja operacijskih sustava iz svijeta FOSS-a i vlasničkih operacijskih sustava od strane ispitanika prema fakultetu i spolu.

Statistički podatci obrađeni su pomoću statističkoga softvera iz svijeta FOSS-a GNU PSPP 1.6.2 (PSPP, n. d.) i R projekta za statističko računanje 4.4.1 (The R Project, n. d.).

Rezultati

U Tablici 3 prikazani su deskriptivni statistički podatci o upoznatosti ispitanika s FOSS-om i njihovoj procjeni kvalitete FOSS-a.

Tablica 3

Raspon vrijednosti (Range) u Tablici 3. je 4, najmanja vrijednost (min) iznosi 1, a najveća vrijednost (max) iznosi 5 kod svih stavki.

U Tablici 4. prikazani su rezultati Mann-Whitney U testova podataka o upoznatosti ispitanika s FOSS-om i njihovoj procjeni kvalitete FOSS-a prema fakultetu ispitanika (FOI, UF). Oni pokazuju da postoji statistički značajna razlika između ispitanika prema fakultetu po svim analiziranim česticama osim po čestici koja se odnosi na svijest ispitanika o FOSS-u u vrijeme njegove instalacije. U slučajevima kada postoji statistički značajna razlika između dvije grupe, a vrijednosti medijana su iste tada se koristi vrijednost prosječnoga ranga (Mean Rank) kako bi se vidjela razlika između dvije grupe. U nastavku teksta ti se rezultati detaljnije interpretiraju.

Tablica 4

U Tablici 5. prikazani su rezultati Mann-Whitney U testova podataka o upoznatosti ispitanika s FOSS-om i njihovoj procjeni kvalitete FOSS-a prema spolu ispitanika. Ispitanici koji ne žele otkriti svoj spol isključeni su iz Mann-Whitney U testa. Testovi pokazuju da postoji statistički značajna razlika između ispitanika prema spolu na svim analiziranim česticama. U nastavku teksta ti se rezultati detaljnije interpretiraju.

Tablica 5

Stavovi ispitanika prema FOSS-u

Rezultati na Slici 1, koji pokazuju odgovore na tvrdnju „Već sam otprije upoznat s pojmom i značajkama slobodnoga softvera otvorenoga izvornog koda (FOSS-a)", pokazuju da je ukupno 306 ispitanika (39,38 %) već upoznato s FOSS-om, pojmom i ključnim obilježjima (slažem se i potpuno se slažem), 273 (35,14 %) nisu (ne slažem se i uopće se ne slažem), a 198 (25,48 %) je neodlučno (niti se ne slažem niti se slažem).

Slika 1

Rezultati Mann-Whitney U testa ($Z = -7{,}01$, $p < 0{,}001$) (Tablica 4) pokazuju da postoji statistički značajna razlika između ispitanika s FOI-ja ($N = 552$, $Mdn = 3$) i ispitanika s UF-a ($N = 225$, $Mdn = 3$). Vrijednosti prosječnoga ranga pokazuju da su ispitanici s FOI-ja bolje upoznati s pojmovima i značajkama FOSS-a nego ispitanici s UF-a. Prva hipoteza, koja tvrdi da postoji statistički značajna razlika u upoznatosti s pojmom i značajkama FOSS-a između ispitanika s FOI-ja i ispitanika s UF-a, je potvrđena.

Kada se ispitanici usporede prema spolu (muški, ženski), rezultati Mann-Whitney U testa ($Z = -9{,}15$, $p < 0{,}001$) (Tablica 5) pokazuje da postoji statistički značajna razlika između muških ispitanika ($N = 416$, $Mdn = 4$) i ženskih ispitanika ($N = 346$, $Mdn = 3$). Muški ispitanici više su upoznati s pojmovima i značajkama FOSS-a. Ovime se potvrđuje druga hipoteza kojom se tvrdi da postoji statistički značajna razlika u upoznatosti s pojmom i značajkama FOSS-a ispitanika prema spolu.

Podatci na Slici 1, koji predstavljaju odgovore na izjavu „Upoznat sam s licencama za korištenje slobodnoga softvera otvorenoga izvornog koda (npr. GNU Opća javna licenca (GNU GPL) ili Mozilla javna licenca)", pokazuju da je ukupno 160 ispitanika (20,59 %) upoznato s FOSS-ovim licencama (slažem se i potpuno se slažem), 394 (50,71 %) nije (u potpunosti se ne slažem i ne slažem), a 223 (28,70 %) je neodlučno (niti se ne slažem niti se slažem).

Sveukupno, samo je jedan od pet ispitanika upoznat s licencama FOSS-a. Većina ispitanika se ne slaže ili se niti ne slaže niti slaže ($N = 777$, $Mdn = 2$) s tvrdnjom da su upoznati s licencama za FOSS.

Rezultati Mann-Whitney U testa ($Z = -2{,}63$, $p = 0{,}009$) (Tablica 4) pokazuju da postoji statistički značajna razlika u poznavanju licenci za FOSS između ispitanika

s FOI-ja (N = 552, Mdn = 3) i ispitanika s UF-a (N = 225, Mdn = 2). Ispitanici s FOI-ja bolje su upoznati s licencama FOSS-a nego ispitanici s UF-a.

Kada se ispitanici usporede prema spolu (muškarci, žene), rezultati Mann-Whitney U testa (Z = -3,82, $p < 0,001$) (Tablica 5) pokazuju da postoji statistički značajna razlika između muških ispitanika (N = 416, Mdn = 3) i ženskih ispitanika (N = 346, Mdn = 2). Muški ispitanici više su upoznati s licencama za FOSS.

Svojstva FOSS-a koja su ispitanicima najvažnija za njihov rad (u usporedbi s vlasničkim softverom) su sljedeća:

– često je besplatan (589 ispitanika, 75,80 %)
– mogućnost korištenja u bilo koju svrhu (492 ispitanika, 63,32 %)
– nema problema sa softverskim licencama - legalna uporaba (prema GNU GPL licenci ili sl.) (395 ispitanika, 50,84 %)
– mogućnosti dorade i/ili izmjene i dijeljenja (328 ispitanika, 42,21 %)
– dostupnost izvornoga koda (319 ispitanika, 41,06 %), i
– neograničene mogućnosti kopiranja softvera (241 ispitanik, 31,02 %).

Rezultati istraživanja u Tablici 6 pokazuju koji FOSS ispitanici koriste prema broju ispitanika (bila je mogućnost višestrukih odgovora). Najčešće korišteni su *Mozilla Firefox* (46,33 %), *VLC Media Player* (40,03 %), P*ython* (32,18 %) i *Geogebra* (31,79 %). FOSS naveden u tablici 6 je najpopularniji i jedno od njegovih svojstava je da je pouzdan, tj. da ne sadrži greške. Međutim, nije svaki FOSS koji se koristi u području obrazovanja takve kvalitete i može sadržavati pogreške te uzrokovati padove, odnosno nagli i nepredviđeni prestanak rada programa.

Tablica 6

Broj ispitanika koji u trenutku instaliranja nekog od navedenih programa na svoja osobna računala nisu bili svjesni da se radi o programima iz svijeta slobodnoga softvera otvorenoga izvornog koda koji imaju veću slobodu korištenja (sloboda pokretanja, kopiranja, distribuiranja, proučavanja, mijenjanja i poboljšavanja programa) nego što imaju vlasnički programi je 321 (43,09 %) (slažem se i potpuno se slažem). Broj ispitanika koji su upoznati je 216 (28,99 %) (ne slažu se i uopće se ne slažu), a 208 (27,92 %) je neodlučnih. To je prikazano na Slici 1, koja prikazuje odgovore na tvrdnju „U trenutku instaliranja jednoga od gore navedenih programa na svoje osobno računalo, NISAM bio svjestan da su to programi iz svijeta slobodnoga softvera otvorenoga izvornog koda koji imaju veća sloboda korištenja (sloboda pokretanja, kopiranja, distribucije, proučavanja, mijenjanja i poboljšanja programa) od vlasničkih programa".

Većina ispitanika, 529 (71,01 %) su neodlučni ili se slažu ili se u potpunosti se slažu s tvrdnjom da nisu bili svjesni da koriste programe iz svijeta FOSS-a sa svim njihovim značajkama. Treća hipoteza, koja tvrdi da u trenutku instaliranja FOSS-a na njihova računala više od 50 % ispitanika nisu bili svjesni da koriste FOSS sa svim njihovim značajkama, je potvrđena.

Rezultati Mann-Whitney U testa (Z = -1,38, p = 0,168) (Tablica 4) pokazuju da ne postoji statistički značajna razlika u svijesti ispitanika o FOSS-u u trenutku njegove instalacije između ispitanika s FOI-ja (N = 538, Mdn = 3) i UF-a (N = 207, Mdn = 3).

Kada se ispitanici usporede prema spolu (muški, ženski), rezultati Mann-Whitney U testa (Z = -4,05, p < 0,001) (Tablica 5) i vrijednosti prosječnoga ranga pokazuju da postoji statistički značajna razlika između muških ispitanika (N = 406, Mdn = 3) koji su bili svjesniji FOSS-a u vrijeme njegove instalacije nego ispitanice (N = 324, Mdn = 3).

Slika 2

Podatci na Slici 2 pokazuju da je broj ispitanika koji nisu upoznati s pojmom i značajkama FOSS-a i koji ne znaju koriste li FOSS 269 (34,62 %). Broj ispitanika koji nisu upoznati s pojmom i značajkama FOSS-a i koji ne znaju koriste li FOSS je 269 (34,62 %). Broj ispitanika koji su upoznati s pojmom, ali ne i detaljima o značajkama FOSS-a i koji nisu svjesni koriste li FOSS je 196 (25,23 %). Broj ispitanika koji su upoznati s pojmom i značajkama FOSS-a, ali ne znaju koriste li FOSS je 106 (13,63 %). Broj ispitanika koji su upoznati s pojmom i značajkama FOSS-a i koji koriste FOSS na fakultetskim računalima, ali ne i na svojim računalima je 51 (6,53 %). Broj ispitanika koji su upoznati s pojmom i značajkama FOSS-a i koriste FOSS na fakultetskim računalima i svojim računalima je 155 (19,95 %).

Sveukupno, ispitanici uglavnom nisu svjesni da koriste FOSS (N = 777, Mdn = 2).

Rezultati Mann-Whitney U testa (Z = -6,76, p < 0,001) (Tablica 4) pokazuju da postoji statistički značajna razlika u razini poznavanja i korištenja FOSS-a između ispitanika s FOI-ja (N = 552, Mdn = 2) i ispitanika s UF-a (N = 225, Mdn = 2). Vrijednosti prosječnoga ranga pokazuju da Ispitanici s FOI-ja bolje poznaju i koriste FOSS.

Kada se ispitanici usporede prema spolu (muški, ženski), rezultati Mann-Whitney U testa (Z = -8,46, p < 0,001) (Tablica 5) pokazuju da muški ispitanici (N = 416, Mdn = 3) imaju višu razinu poznavanja i korištenja FOSS-a od ispitanica (N = 346, Mdn = 2).

Ocjenjivanje kvalitete FOSS-a

U uzorku od 777 ispitanika njih 57 (7,34 %) nije ocijenilo kvalitetu FOSS-a. Razlog je vjerojatno u činjenici da ne koriste ni jedan program iz toga svijeta (Slika 3). Četvrta hipoteza, koja tvrdi da svi ispitanici redovito koriste barem jedan program iz svijeta FOSS-a, nije potvrđena.

Ocjenjivanje kvalitete FOSS-a - pouzdanosti (program radi bez prekida i pogrešaka) svih programa koje koriste iz svijeta FOSS-a ispitanika daje sljedeće rezultate: sveukupno, na ljestvici od 1 - nedovoljno do 5 - izvrsno, većina ispitanika

ocjenjuje pouzdanost FOSS-a ocjenom 4 (313 ispitanika, 43,37 %), zatim ocjenom 3 (238 ispitanika, 33,06 %) i ocjenom 5 (132 ispitanika, 18,33 %). Samo 29 ispitanika ocjenjuje ga ocjenom 2 (4,03 %) i osam ocjenom 1 (1,11 %) (Slika 3).

Slika 3

Sveukupno, na ljestvici od 1 - nedovoljno do 5 - izvrsno, ispitanici su pouzdanost FOSS-a ocijenili uglavnom vrlo dobrom (N = 720, Mdn = 4).

Rezultati Mann-Whitney U testa (Z = -8,10, $p < 0,001$) (Tablica 4) pokazuju da postoji statistički značajna razlika između ispitanika s FOI-ja (N = 526, Mdn = 4) i ispitanika s UF-a (N = 194, Mdn = 3). Ispitanici s FOI-ja ocijenili su pouzdanost FOSS-a višom ocjenom od ispitanika s UF-a.

Kada se ispitanici usporede prema spolu (muški, ženski), rezultati Mann-Whitney U testa (Z = -7,44, $p < 0,001$) (Tablica 5) pokazuju da postoji statistički značajna razlika između muških ispitanika (N = 406, Mdn = 4) i ispitanica (N = 299, Mdn = 3). Muški ispitanici ocijenili su pouzdanost FOSS-a višom ocjenom od ispitanica.

Ocjena kvalitete FOSS-a - kompletnosti (program sadrži sve potrebne značajke za normalan rad) svih programa koje koriste iz svijeta FOSS-a pokazuje sljedeće rezultate: sveukupno, na ljestvici od 1 - nedovoljno do 5 - izvrsno, većina ispitanika ocjenjuje kompletnost FOSS-a ocjenom 4 (294 ispitanika, 40,66 %), zatim ocjenom 3 (262 ispitanika, 36,24 %) i ocjenom 5 (122 ispitanika, 16,87 %). Samo 42 ispitanika ocjenjuje 2 (5,81 %), a samo troje 1 (0,42 %) (Slika 3).

Sveukupno, na ljestvici od 1 - nedovoljno do 5 - izvrsno, ispitanici su kompletnost FOSS-a ocijenili uglavnom vrlo dobrom (N = 723, Mdn = 4).

Rezultati Mann-Whitney U testa (Z = -6,05, $p < 0,001$) (Tablica 4) pokazuju da postoji statistički značajna razlika između ispitanika s FOI-ja (N = 528, Mdn = 4) i ispitanika s UF-a (N = 195, Mdn = 3). Ispitanici s FOI-ja ocijenili su kompletnost FOSS-a višom od ispitanika s UF-a.

Kada se ispitanici usporede prema spolu (muški, ženski), rezultati Mann-Whitney U testa (Z = -5,27, $p< 0,001$) (Tablica 5) pokazuju statistički značajnu razliku između muških ispitanika (N = 406, Mdn = 4) i ženskih ispitanika (N = 302, Mdn = 3). Muški ispitanici ocijenili su kompletnost višom ocjenom od ženskih ispitanika.

Ocjena kvalitete FOSS-a koju su dali ispitanici - ukupne kvalitete svih programa koje koriste iz svijeta FOSS-a pokazuje sljedeće rezultate: ukupno, na ljestvici od 1 - nedovoljno do 5 - izvrsno, većina ispitanika ukupnu kvalitetu FOSS-a ocjenjuje ocjenom 4 (342 ispitanika, 47,50 %), zatim kao 3 (234 ispitanika, 32,50 %) i kao 5 (113 ispitanika, 15,70 %). Samo 24 ispitanika ocijenilo ga je ocjenom 2 (3,75 %), a četiri ispitanika ocjenom 1 (0,55 %) (Slika 3).

Sveukupno, na ljestvici od 1 - nedovoljno do 5 - izvrsno, ispitanici su ukupnu kvalitetu FOSS-a ocijenili uglavnom kao vrlo dobru (N = 720, Mdn = 4).

Rezultati Mann-Whitney U testa ($Z = -7{,}81$, $p < 0{,}001$) (Tablica 4) pokazuju da postoji statistički značajna razlika između ispitanika s FOI-ja ($N = 525$, $Mdn = 4$) i ispitanika s UF-a ($N = 195$, $Mdn = 3$). Ispitanici s FOI-ja ocijenili su ukupnu kvalitetu FOSS-a višom ocjenom od ispitanika s UF-a.

Kada se ispitanici usporede prema spolu (muški, ženski), rezultati Mann-Whitney U testa ($Z = -6{,}98$, $p < 0{,}001$) (Tablica 5) pokazuju statistički značajnu razliku između muških ispitanika ($N = 405$, $Mdn = 4$) i ispitanica ($N = 300$, $Mdn = 3$). Muški ispitanici ocijenili su ukupnu kvalitetu FOSS-a višom ocjenom od ispitanica.

Sveukupno, ispitanici ocjenjuju FOSS pouzdanost s 3,74 (FOI 3,90, UF 3,31), kompletnost s 3,68 (FOI 3,79, UF 3,36), a ukupnu kvalitetu s 3,74 (FOI 3,88, UF 3,37) (Slika 3). Potvrđena je peta hipoteza koja kaže da ispitanici ocjenjuju kvalitetu FOSS-a (pouzdanost, kompletnost i ukupnu kvalitetu) najmanje prosječnom zaokruženom ocjenom 4 ($3{,}5 \leq M < 4{,}5$).

Operacijski sustav koji ispitanici najčešće koriste je *Microsoft Windows 10* (534 ispitanika, 68,73 %), zatim *Microsoft Windows 11* (260 ispitanika, 33,46 %), *GNU Linux* (118 ispitanika, 15,19 %), *MacOS* (22 ispitanika, 2,83 %) i *Chrome OS* (21 ispitanik, 2,70 %) (Slika 4).

Slika 4

Rezultati o korištenju pojedinoga tipa operacijskoga sustava ispitanika pokazuju da ukupno 658 ispitanika (84,6 %) koristi vlasnički operacijski sustav, devet ispitanika (1,2 %) koristi FOSS operacijski sustav, a 110 ispitanika (14,2 %) koristi i vlasnički i FOSS-ov operacijski sustav.

Analizirani po fakultetima, rezultati pokazuju da:

– od ukupno 9 ispitanika, osam ispitanika s FOI-ja (88,9 %) i jedan ispitanik s UF-a (11,1 %) koristi FOSS-ove operacijske sustave

– od ukupno 658 ispitanika, 436 ispitanika s FOI-ja (66,3 %) i 222 ispitanika s UF-a (33,7 %) koristi vlasničke operacijske sustave

– od 110 ispitanika, 108 ispitanika s FOI-ja (98,2 %) i dva ispitanika s UF-a (1,8 %) koriste obje vrste operacijskih sustava.

Broj ispitanika prema fakultetu, vrsti operacijskoga sustava i spolu je sljedeći:

– FOI, od 552 ispitanika:

- FOSS-ov operacijski sustav - osam ispitanika (1,4 %)
  - prema spolu: sedam muških ispitanika i jedan ispitanik koji ne želi otkriti spol
- vlasnički operacijski sustav - 436 ispitanika (79 %)
  - prema spolu: 307 ispitanika muškoga spola, 123 ispitanika ženskoga spola i šest ispitanika koji ne žele otkriti svoj spol
- oba operacijska sustava - 108 ispitanika (19,6 %)
  - prema spolu: 89 ispitanika muškoga spola, 13 ispitanika ženskoga spola i šest ispitanika koji ne žele otkriti svoj spol

– UF, od 225 ispitanika:

- FOSS-ov operacijski sustav - jedan ispitanik (0,4 %)
  - prema spolu: jedan ispitanik ženskoga spola

- vlasnički operacijski sustav - 222 ispitanika (98,7 %)
  - prema spolu: 12 ispitanika muškoga spola, 208 ispitanika ženskoga spola i dva ispitanika koji ne žele otkriti svoj spol
- oba operacijska sustava - dva ispitanika (0,9 %)
  - prema spolu: jedan muški ispitanik, jedna ispitanik ženskoga spola.

Postoji statistički značajna razlika u broju korisnika FOSS-ovih operacijskih sustava prema fakultetima (Pearson Chi-Square N = 777, $\chi 2$ = 48,09, df = 2, p < 0,001). Ispitanici s FOI-ja koriste FOSS-ove operacijske sustave u većem broju nego oni s UF-a. Šesta hipoteza, kojom se tvrdi da postoji statistički značajna razlika u broju korisnika FOSS-ovih operacijskih sustava između ispitanika s FOI-ja i ispitanika s UF-a, je potvrđena.

Rezultati vrste korištenja operacijskih sustava ispitanika prema spolu pokazuju da:

– FOSS-ove operacijske sustave koristi devet ispitanika: sedam muških ispitanika (77,8 %), jedna ispitanica (11,1 %) i jedan ispitanik koji ne želi otkriti svoj spol (11,1 %)

– vlasničke operacijske sustave koristi 658 ispitanika: 319 muških ispitanika (48,5 %), 331 ispitanica (50,3 %) i osam ispitanika koji ne žele otkriti svoj spol (1,2 %)

– FOSS-ove i vlasničke operacijske sustave koristi 110 ispitanika: 90 muških ispitanika (81,8 %), 14 ispitanica (12,7 %) i šest ispitanika koji ne žele otkriti svoj spol (5,5 %).

Postoji statistički značajna razlika u korištenju FOSS-ovih operacijskih sustava prema spolu (Pearson Chi-Square N = 777, $\chi 2$ = 65,48, df = 4, p < 0,001). Muški ispitanici koriste FOSS-ove operacijske sustave u većem broju od ž ispitanica i ispitanika koji ne žele otkriti svoj spol. Broj i postotak ispitanika koji koriste samo FOSS-ove operacijske sustave je mali (9 od 777, 1,1 %). Time se potvrđuje sedma hipoteza koja tvrdi da postoji statistički značajna razlika u broju korisnika FOSS-ovih operacijskih sustava između ispitanika muškoga i ženskoga spola.

Više ispitanika nije ograničeno na jedan operacijski sustav i koristi FOSS-ov i vlasnički operacijski sustav (110 od 777, 14,6 %). U usporedbi prema spolu u korištenju FOSS-ova operacijskog sustava (kao jedinstvenoga operacijskog sustava i u dvostrukom pokretanju s vlasničkim operacijskim sustavom), otprilike je 80 % muških ispitanika i 12 % ispitanica. Dosta suprotni podatci dobiveni su korištenjem vlasničkih operacijskih sustava kod 319 muških ispitanika, što je 76,7 % od ukupnog broja ispitanika, te 331 ispitanica, što je 95,7 % od ukupnoga broja ženskih ispitanika. Ovaj podatak nije neočekivan jer ispitanici ženskoga spola, posebice oni koje studiraju obrazovne i ekonomske znanosti, obično nisu fokusirani na instalaciju operacijskoga sustava nakon kupnje osobnoga računala.

Tri ispitanika (1,33 %) s UF i 115 ispitanika (20,83 %) s FOI-ja koriste operacijski sustav *GNU/Linux*. Tako se potvrđuje osma hipoteza kojom se tvrdi da postoji

statistički značajna razlika u postotku ispitanika koji koriste FOSS-ove operacijske sustave s obzirom na fakultet.

Rezultati linearne regresijske analize ANOVA sugeriraju da je regresijski model statistički značajan ($p < 0,001$), što znači da nezavisne varijable fakultet i spol svaka zasebno objašnjavaju značajan dio varijacije u zavisnim varijablama poznavanje pojma i značajki FOSS-a, svjesnost o FOSS-u u trenutku instaliranja, razina poznavanja i korištenja FOSS-a, pouzdanost FOSS-a, kompletnost FOSS-a, ukupna kvaliteta FOSS-a, ali ne i varijaciju u varijabli poznavanje licenci FOSS-a ($p > 0,05$). Može se zaključiti da su nezavisne varijable značajno povezane sa svim zavisnim varijablama osim varijable upoznatosti s FOSS-ovim licencama.

Breusch-Pagan testom za heteroscedascitet za nezavisnu varijablu fakultet utvrđen je heteroscedascitet ($p < 0,05$) za sljedeće zavisne varijable: poznavanje pojma i značajki FOSS-a, svjesnost o FOSS-u u trenutku instaliranja, razina poznavanja i korištenja FOSS-a, pouzdanost FOSS-a i ukupna kvaliteta FOSS-a. Heteroscedascitet nije utvrđen ($p > 0,05$) kod varijabli poznavanje licenci za FOSS i kompletnost FOSS-a. Moguće obrazloženje za prisutnost heteroscedasciteta u testu za nezavisnu varijablu fakultet jest u tome što su prisutni ispitanici s dva fakulteta i ukupno deset različitih studija te njihova različita razina poznavanja tematike FOSS-a.

Breusch-Pagan testom za heteroscedascitet za nezavisnu varijablu spol utvrđen je heteroscedascitet ($p < 0,05$) za zavisne varijable pouzdanost FOSS-a i ukupna kvaliteta FOSS-a, a nije utvrđen ($p > 0,05$) kod zavisnih varijabli: poznavanje pojma i značajki FOSS-a, poznavanje licenci za FOSS, svjesnost o FOSS-u u trenutku instaliranja, razina poznavanja i korištenja FOSS-a i kompletnost FOSS-a.

Na temelju prikazanih rezultata istraživanja sedam istraživačkih hipoteza je potvrđeno, a jedna hipoteza nije potvrđena.

Rasprava

Rezultati istraživanja predstavljeni u ovom radu pokazuju da je 39,38 % ispitanika (Slika 1) upoznato s pojmom i obilježjima FOSS-a što je manje od 58 % koliko navode Nayak et al. (2021) i manje od 66,25 % o kojima izvještavaju Nayak i Binjha (2022).

Sveukupno, 92,66 % ispitanika u istraživanju predstavljenom u ovom radu koristi neki od FOSS-a, što je više od 80 % korisnika FOSS-a koji su prijavljeni u Nayak et al. (2021).

Najvažnije svojstvo FOSS-a ispitanicima u istraživanju predstavljenom u ovom radu jest to što je često besplatan (75,80 % od 777 ispitanika). Kod Nayaka i Binjhe (2022) također je najvažniji, ali s manjim postotkom (58,8 % od 80 ispitanika).

Najčešće korišteni FOSS prikazan u rezultatima istraživanja ovoga rada (*Mozilla Firefox* i *VLC Media Player*) uspoređen je s rezultatima istraživanja Nayaka et al. (2021) i Nayak i Binjha (2022) (Tablica 9), a podatci pokazuju da se koristi u manjem postotku nego u uspoređenim rezultatima istraživanja drugih.

Sveukupno, muški ispitanici više su upoznati s pojmom i značajkama FOSS-a i koriste FOSS operacijske sustave u većem broju. Učenice općenito postižu bolje rezultate od učenika u međunarodnim testovima vještina Programa za međunarodnu procjenu učenika (PISA) i Međunarodne studije računalne i informacijske pismenosti (ICILS). Međutim, samo jedan od tri diplomanta STEM studija je žena (Europska komisija, 2020.).

Ograničenja

Postoji značajna razlika u omjeru spolova ispitanika po fakultetu. Ispitanici s FOI-ja bili su 24,64 % ženskoga spola i 73,01 % muškoga spola, dok su ispitanici s UF-a bili 93,33 % ženskoga spola i 5,76 % muškoga spola. Bilo je ukupno 15 ispitanika (1,93 %) koji nisu htjeli otkriti svoj spol. Studenti muškoga spola općenito su zainteresiraniji za studiranje na područjima informacijskih i komunikacijskih tehnologija nego studenti ženskoga spola (Croatian Bureau of Statistics, 2024). Ove činjenice utječu na rezultate istraživanja.

Zbog različitih obrazovnih područja i interesa ispitanika, njihova je zadaća bila ocijeniti kvalitetu FOSS-a na jednostavan način pomoću samo tri atributa kvalitete softvera (pouzdanosti, kompletnosti i ukupne kvalitete).

Implikacije

Rezultati istraživanja pokazuju da većina ispitanika u trenutku instaliranja FOSS-a nije bila svjesna da koristi FOSS te zato postoji potreba za uvođenjem novih tematskih sadržaja ili predmeta u kurikule njihovih studijskih programa, naročito na UF, koji bi se bavili FOSS-om, njegovim pojmovima i uvjetima korištenja, značajkama i licencama te njegovim prednostima i nedostatcima.

Buduća kvalitativna istraživanja namjeravaju istražiti zašto neki studenti koriste FOSS, a drugi ne te analizirati korištenje FOSS-a po tipu i godini studija. Postoji potreba za istraživanjem korištenja i svijesti o FOSS-u i među sveučilišnim nastavnicima.

Zaključak

Rezultati istraživanja pokazuju da su ispitanicima najvažnija svojstva FOSS-a ta da je često besplatan, da se može koristiti u bilo koju svrhu i da nema problema sa softverskim licencama. Najčešće korišteni FOSS koji koriste ispitanici su *Mozilla Firefox*, *VLC Media Player* i *Python*. Samo 7,34 % ispitanika ne koristi ni jedan FOSS. Samo 28,99 % ispitanika je znalo za FOSS i njegova svojstva u trenutku kada su ga instalirali. Operativni sustav koji ispitanici najčešće koriste je *Microsoft Windows 10*, a slijedi ga *Microsoft Windows 11*. Na svojim osobnim računalima operacijske sustave *GNU/Linux* koristi 115 od 552 ispitanika s FOI-ja (20,83 %) i samo tri od 225 ispitanika s UF-a (1,33 %). Ovaj operativni sustav jedan je od temelja FOSS-a i time ima najveći utjecaj na softverske slobode svojih korisnika jer omogućuje korištenje stotina različitih programa iz svijeta FOSS-a.

Postoji statistički značajna razlika u poznavanju FOSS-a između ispitanika s FOI-ja i ispitanika s UF-a. Ispitanici s FOI-ja bolje su upoznati s pojmom i značajkama FOSS-a od ispitanika s UF-a. Postoji statistički značajna razlika u poznavanju FOSS-a između muških i ženskih ispitanika. Muški ispitanici bolje su upoznati s pojmom i značajkama FOSS-a nego ispitanice. Sveukupno, samo jedan od pet ispitanika upoznat je s licencama FOSS-a. Barem jedan program iz domene FOSS-a koristi 92,66 % ispitanika. Kvalitetu FOSS-a (pouzdanost, potpunost i ukupnu kvalitetu) ispitanici ocjenjuju prosječnom zaokruženom ocjenom vrlo dobar.

Postoji statistički značajna razlika u broju korisnika FOSS-ovih operacijskih sustava prema fakultetu. Ispitanici s FOI-ja koriste FOSS-ove operacijske sustave u većem broju nego oni s UF-a. Postoji statistički značajna razlika u broju korisnika FOSS operacijskih sustava prema spolu. Muški ispitanici koriste FOSS-ove operacijske sustave u većem broju nego ispitanici ženskoga spola i ispitanici koji ne žele otkriti svoj spol. Postoji značajna razlika u postotku ispitanika koji koriste FOSS-ove operacijske sustave s obzirom na fakultet. Samo tri ispitanika (1,33 %) s UF-a i 115 ispitanika (20,83 %) s FOI-ja koristi FOSS operacijski sustav.

Uzorak korišten u istraživanju prikazanom u ovom radu sastoji se od ispitanika s dva fakulteta i deset studijskih programa. Ispitanici se razlikuju po entuzijazmu, interesu i poznavanju informatike. Ove činjenice vidljive su u gotovo svim rezultatima istraživanja statističkih analiza pri čemu se ispitanici uspoređuju prema fakultetu i spolu. Većina ispitanika s FOI-ja prema studijskim programima budući su stručnjaci za informacijsko-komunikacijske tehnologije i poslovanje te su više entuzijastični i zainteresirani za informatiku te uče puno više informatičkih predmeta na svojim studijskim programima od ispitanika s UF-a. Neki studijski programi FOI-ja izravno utječu i potiču studente na korištenje FOSS-ovih operacijskih sustava i drugog FOSS-a (npr. u *dual bootu* ili virtualnom stroju) nudeći mogućnost ispunjavanja studijskih obveza korištenjem ove vrste softvera. Većina ispitanika s UF-a su budući odgojitelji djece rane i predškolske dobi i učitelji primarnoga obrazovanja, a njihov glavni interes je obrazovanje općenito, a ne informatika. Studiji na UF-u u svojim programima nude samo nekoliko informatičkih kolegija, osim jednoga studijskog modula (modul Informatika) koji nudi još deset informatičkih predmeta.

Postoji mnogi vrijedni i često besplatni softvera iz svijeta FOSS-a koji se može koristiti umjesto ili kao alternativa skupom vlasničkom softveru, posebno u obrazovnim sustavima. Njegovo korištenje ima mnoge prednosti. Obrazovne institucije imaju važnu zadaću i odgovornost dijeliti znanje sa svojim učenicima i studentima i pripremiti ih za život u društvu. Nastavnici, učitelji i drugi edukatori trebaju imati barem osnovno znanje o FOSS-u kako bi mogli odabrati koji će softver (komercijalni vlasnički ili FOSS ili oba) koristiti u svojem radu kao edukatori. Korištenjem određenoga softvera oni daju primjer učenicima i studentima. U

svijetu u kojem je tržišni udio komercijalnih vlasničkih operacijskih sustava i aplikacija za stolna računala puno veći od onoga koji čine FOSS-ovi operacijski sustavi i aplikacije, učenici i studenti trebali bi naučiti da postoji alternativni softver koji mogu koristiti za učenje, rad i igru. Studenti trebaju sami odlučiti koji softver žele koristiti na svojim osobnim računalima, ali bitno je dati im sve informacije koje su im potrebne za donošenje te važne odluke.

Napomena

Autori izjavljuju da ne postoji sukob interesa.
Rezultati istraživanja prikazani u ovom radu dosad nisu bili objavljeni.