The utility of free software in teaching of mathematics, physics and computer science for pre-service teachers

Vladyslav Ye. Velychko[1], Elena H. Fedorenko[1]

[1]*Donbas State Pedagogical University, 19 Henerala Batiuka Str., Sloviansk, 84116, Ukraine*

Abstract

The increasing digitalization of education has led to a need for pre-service teachers in mathematics, physics and computer science to develop competencies in utilizing information and communication technologies (ICT) in their teaching practice. Free and open source software presents a valuable opportunity for educators to access powerful tools without the financial and legal barriers associated with proprietary software. This article examines the theoretical and methodological foundations for integrating free software into the professional training of pre-service teachers of mathematics, physics and computer science, based on the findings of a doctoral thesis by Velychko [1]. The study proposes a system for applying free software in teacher education, encompassing conceptual, content and technological components. Experimental results demonstrate the effectiveness of the proposed system in enhancing the ICT competencies of pre-service teachers. The article highlights the benefits and challenges of utilizing free software in education and provides recommendations for its implementation in teacher training programs.

Keywords

free software, teacher training, the concept of implementation

1. Introduction

The rapid advancement of technology in the 21st century has had a profound impact on all sectors of society, including education [2]. Teachers are expected to possess not only subject knowledge but also the skills to effectively integrate ICT into their teaching practice [3, 4]. However, the cost and licensing restrictions of proprietary software can present significant barriers for educational institutions, particularly in developing countries [5]. Free and open source software (FOSS) offers a solution by providing access to high-quality tools without the associated financial and legal constraints [6, 7].

The use of FOSS in education has been a topic of research for several decades [8, 9]. Studies have shown that FOSS can be effectively utilized in various educational contexts, including engineering [10], computer science [11] and science education [12]. However, the integration of FOSS in teacher education programs, particularly for pre-service teachers of mathematics, physics and computer science, remains an underexplored area.

This article aims to address this gap by examining the theoretical and methodological foundations for applying FOSS in the professional training of pre-service teachers of mathematics, physics and computer science. The article is based on the findings of a doctoral thesis by Velychko [1], which proposed a system for integrating FOSS into teacher education programs in Ukraine. The article presents an overview of the proposed system, its components and the experimental results of its implementation. The benefits and challenges of utilizing FOSS in teacher education are discussed, along with recommendations for its effective integration into training programs.

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vladislav.velichko@gmail.com (V. Ye. Velychko); fedorenko.elena1209@gmail.com (E. H. Fedorenko)

https://ddpu.edu.ua/cc/velychko (V. Ye. Velychko); https://scholar.google.com.ua/citations?user=9hVB6f8AAAAJ (E. H. Fedorenko)

0000-0001-9752-0907 (V. Ye. Velychko); 0000-0002-1897-874X (E. H. Fedorenko)

2. Theoretical foundations

2.1. The concept of free software

Free software is defined by the Free Software Foundation as software that respects the freedom and community of its users [13]. This freedom is enshrined in four essential rights: the freedom to run the program for any purpose, the freedom to study how the program works and adapt it to one's needs, the freedom to redistribute copies, and the freedom to improve the program and release those improvements to the public [14].

The philosophy of free software aligns closely with the principles of academic freedom and the open sharing of knowledge [15]. Universities have played a key role in the development of free software, with many groundbreaking projects originating from research labs and student communities [1].

2.2. ICT competencies for teachers

The integration of ICT into education has become a global priority, as evidenced by the UNESCO ICT Competency Framework for Teachers [16]. This framework outlines the knowledge and skills that teachers need to effectively utilize ICT in their professional practice, including [17]:

- Understanding the role of ICT in education
- Curriculum and assessment
- Pedagogy
- ICT
- Organization and administration
- Teacher professional learning

For pre-service teachers of mathematics, physics and computer science, developing ICT competencies is particularly crucial, as these subjects often involve the use of specialized software tools and computational methods [18, 19]. However, research has shown that many teacher education programs do not adequately prepare pre-service teachers to integrate ICT into their teaching practice [20].

2.3. Benefits of free software in education

The use of free software in education offers several significant benefits, including:

- *Cost savings* – free software eliminates the need for expensive licensing fees, making it more accessible for educational institutions with limited budgets [21].
- *Flexibility* – the open source nature of free software allows educators to customize and adapt tools to meet their specific needs [22].
- *Skill development* – working with free software can help students develop valuable technical skills, such as programming and problem-solving [23].
- *Collaboration* – free software projects often have active communities of users and developers, providing opportunities for students and educators to collaborate and learn from each other [24].

Despite these benefits, the adoption of free software in education faces several challenges, including lack of awareness, technical support and training for educators [25].

3. A system for applying free software in teacher education

Velychko [1] proposed a system for integrating free software into the professional training of pre-service teachers of mathematics, physics and computer science. The system consists of three main components (figure 1).

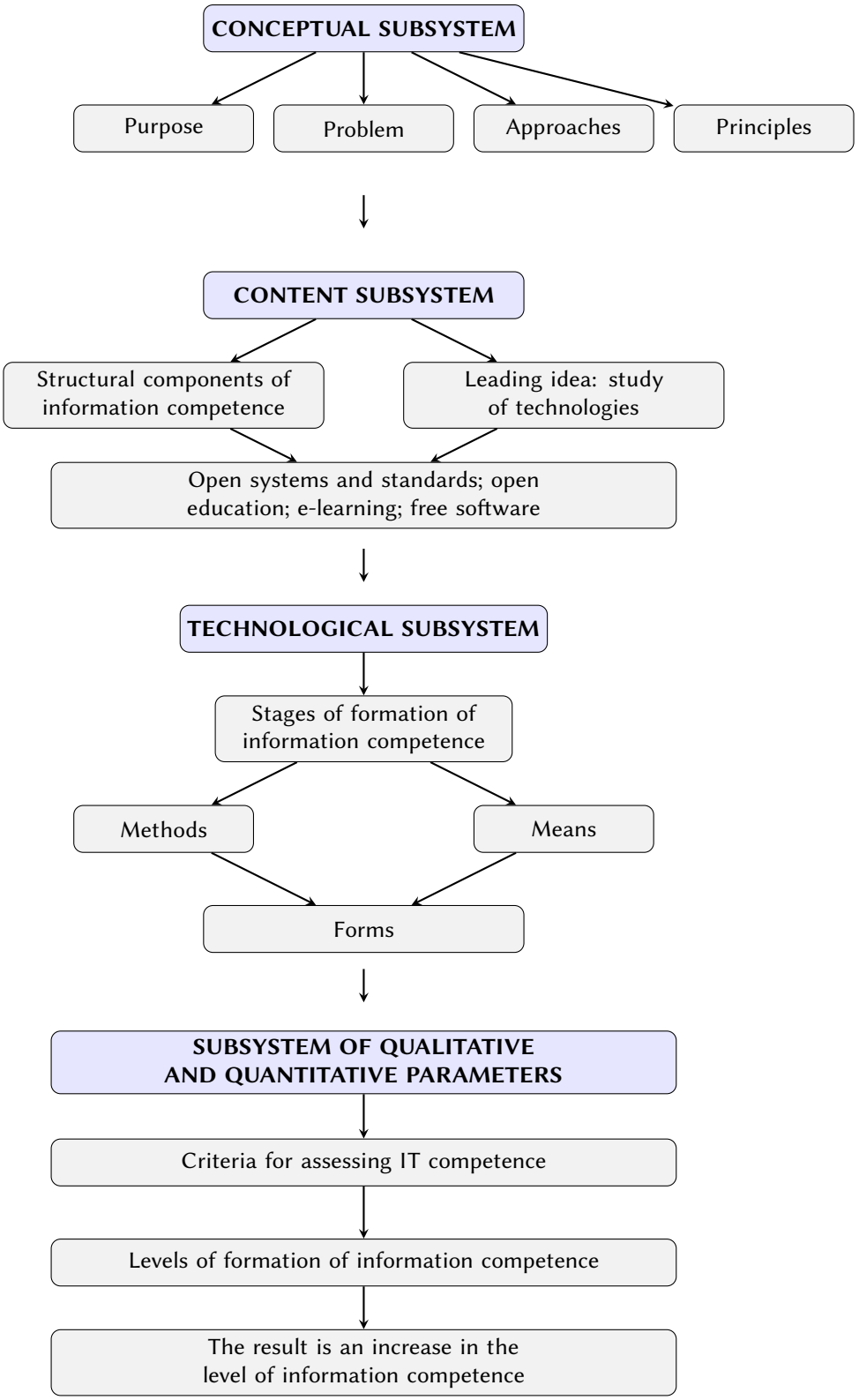

Figure 1: System for integrating free software into the professional training of pre-service teachers of mathematics, physics and computer science.

3.1. Conceptual component

The conceptual component outlines the goals, objectives, approaches and principles of the system. The main goal is to enhance the ICT competencies of pre-service teachers through the use of free

software. The objectives include providing access to powerful tools, developing technical skills and promoting collaboration. The system is grounded in competency-based, innovation-oriented and synergetic approaches to learning.

3.2. Content component

The content component defines the structure and content of ICT competencies for pre-service teachers, as well as the key concepts and ideas related to free software in education. The competencies encompass knowledge, skills and attitudes in areas such as:

- Information and data literacy
- Communication and collaboration
- Digital content creation
- Safety
- Problem-solving

The content component also emphasizes the importance of open educational resources, e-learning and the role of free software in enabling open education practices.

3.3. Technological component

The technological component focuses on the practical implementation of the system, including the stages of ICT competency development, teaching methods, tools and forms of learning. The stages of development are:

1. Motivational-purposeful
2. Exploratory
3. Orientational-planning
4. Control-evaluative
5. Regulatory-corrective

The teaching methods include problem-based learning, project-based learning and collaborative learning. The tools used are primarily free software applications for mathematics, physics and computer science, such as GeoGebra, Python and LaTeX. The forms of learning include lectures, laboratory work, independent study and project-based activities.

4. Experimental results

Velychko [1] conducted an experimental study to evaluate the effectiveness of the proposed system in enhancing the ICT competencies of pre-service teachers. The study involved 240 students from pedagogical universities in Ukraine, divided into control and experimental groups.

The results showed that the experimental group, which was taught using the free software-based system, had significantly higher levels of ICT competency compared to the control group. In particular, the experimental group demonstrated better skills in using free software tools for problem-solving, digital content creation and collaboration.

The study also found that the use of free software in teacher education had a positive impact on students' motivation and engagement in learning. Students reported feeling more empowered and confident in their ability to use technology in their future teaching practice.

5. Discussion and recommendations

The findings of Velychko [1] demonstrate the potential of free software as a valuable tool for enhancing the ICT competencies of pre-service teachers. By providing access to powerful, flexible and collaborative tools, free software can help bridge the digital divide and prepare future teachers to effectively integrate technology into their teaching practice.

However, the successful integration of free software in teacher education requires more than just access to tools. It also requires a supportive institutional environment, adequate technical infrastructure and ongoing professional development opportunities for educators [26].

Based on the findings of this study, the following recommendations are proposed for integrating free software into teacher education programs:

- Raise awareness about the benefits of free software among educators, administrators and policy-makers.
- Provide training and support for educators to effectively use free software tools in their teaching practice.
- Encourage collaboration and sharing of resources among educators, both within and across institutions.
- Integrate free software into the curriculum, not just as a separate subject but as a tool for enhancing learning across disciplines.
- Foster partnerships with free software communities and industry to provide real-world learning opportunities for students.

6. Conclusion

The integration of free software into the professional training of pre-service teachers of mathematics, physics and computer science presents a promising approach for enhancing their ICT competencies and preparing them for the challenges of 21st century education. By leveraging the power of free software, teacher education programs can provide access to high-quality tools, foster collaboration and skill development, and promote open education practices.

However, realizing the full potential of free software in teacher education requires a concerted effort from educators, institutions and policymakers. It requires awareness-raising, capacity-building and the creation of supportive environments that encourage experimentation and innovation.

As the world becomes increasingly digital, it is imperative that we equip future teachers with the skills and tools they need to navigate this landscape effectively. Free software offers a path forward that is both accessible and empowering, and it is up to us as educators to seize this opportunity and make it a reality.

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