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DIGITAL COMPETENCY SELF-ASSESSMENT OF COMPUTER SCIENCE TEACHERS IN BULGARIAN SECONDARY SCHOOLS

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Abstract. This article presents a study on the self-assessment of digital competencies among computer science and IT teachers in Bulgarian secondary education. The study aligns with the European Qualifications Framework (EQF), the Digital Competence Framework for Citizens (DigComp 2.2) and the Digital Competence Framework for Educators (DigCompEdu). The latter framework has been analyzed and adapted specifically for teachers of Computer Science (CS) and Software Engineering (SE) in secondary schools. A total of 127 teachers specializing in high-level programming instruction participated in the study, with a focus on those teaching at mathematics-focused high schools and vocational schools specializing in CS. The relevance of this study is underscored by the recent growth in educational programs aimed at professions related to CS, SE, and STEM (Science, Technology, Engineering and Mathematics) for which national educational standards have been established. The study incorporates an analysis of successful international practices in CS and SE education at the secondary level to inform the development of specific research components. Based on the findings, the article outlines challenges related to teacher qualifications and emphasizes the need for continuous updating of their specialized digital competencies. The survey was distributed among programming teachers, suggesting that participants represent those with the highest levels of digital literacy and instructional preparedness in this field.

Keywords: digital competencies; self-assessment; computer science; software engineering; EQF; DigComp 2.2; DigCompEdu; STEM education; vocational education

1. Introduction. Relevance of the Problem

Since 2003, the Bulgarian educational system has progressively embraced the principles of Competence-Based Education (CBE), which has become a core aspect of the country's approach to education. In 2016 CBE was officially embedded in the foundational law governing preschool and school education, and its influence extends even further in legislation concerning vocational education. However, despite its theoretical presence in policy, the practical implementation of CBE remains limited in scope and effectiveness. There is

an urgent need to accelerate and optimize the integration of competence-based learning to ensure that education meets the evolving demands of industry, the labor market, and society at large.

The conceptual foundation of Competency-Based Education (CBE) is well-grounded in the classical principles of constructivist theory, with labor market dynamics acting as the primary impetus for the ongoing transformations in educational frameworks. Within the domain of Information and Communication Technologies (ICT), industry requirements and labor market expectations are encapsulated in guidelines developed by the Association for Computing Machinery (ACM), derived from comprehensive analyses across the ICT sector. This research emphasizes the ACM[1] recommendations for CS[2,3] and SE[4] disciplines, alongside the criteria outlined by the European Qualifications Framework (EQF) for lifelong learning[5], and the DigComp – Digital Competence Frameworks for teachers, learners, and citizens, the requirements of EQF for lifelong learning, DigComp – Digital competence frameworks for teachers, learners and citizens (Vuorikari et. al 2022). Additionally, this study considers the European e-Competence Framework (e-CF), specifically tailored for ICT professionals – e-CF[6], as well as the DigCompEdu[7], designed to support digital competence development among educators. It is essential to recognize the existence of alternative frameworks, also based on the EQF, such as SELFIE for Teachers (Economou 2023), the ICT Competency Framework for Teachers (ICT CFT)[8], which, along with various ICT sector-specific models, serves as a comparable standard within the scope of this study.

The implementation of Competency-Based Education (CBE) necessitates a comprehensive vision from the educational organization. A suitable guide and tool in this endeavor is the DigCompOrg[9] framework, which allows the organization not only to conduct self-assessment but also to analyze and design its activities and objectives to effectively implement CBE. Furthermore, the DigCompEdu framework aligns with the TPACK model, as established by Mishra and Koehler in 2006 (Ghomi $ Redecker 2019).

In the national educational system, vocational training in the field of ICT is based on the approved State Educational Standards (SES) for the professional domain CS[10,11,12] and those for specialized training in "Software and Hardware Sciences". An excellent alternative for students under the Law on Pre-school and School Education (LPSE) is the opportunity to study a profession within the National Program "Training for IT Skills and Career"[13]. This program has been successfully implemented since 2018, with ongoing studies on its educational impact conducted in parallel (Staribratov 2020; Staribratov et al. 2021; Mollov 2020).

STEM education also requires a high level of professional competence in programming and hardware sciences. STEM serves as a bridge between general and vocational education. From an early age, students engage in activities that introduce core engineering concepts through playful experiences, such as constructing with robots and development boards. Through a combination of programming and engineering, they effortlessly bring to life basic structures in mechanics, automation, electronics, and programming.

Teachers play a key role in guiding students through this captivating exploratory process. A crucial element in quality teaching is their overall competence – professional, pedagogical, and methodological – as well as their capacity for continuous learning (DigCompEdu).

In light of the concept of Competence-Based Education (CBE) (Levine & Patrick 2019), in which assessment through reflective methods – one of which is self-assessment – is a core component, the authors consider the study of teachers' self-assessment to be a key factor for successful education. Such research can reveal not only the personal (albeit subjective) perception of teachers' competence levels but, more importantly, highlight each teacher's skill gaps and attitudes.

A key aspect of self-assessment is that it enables teachers to evaluate their own knowledge and skills, while also demonstrating their confidence in their work. This feedback offers insight into teachers' perspectives on their professional development and the type of support they need. Teachers feel that their professional needs are acknowledged, which enhances their intrinsic motivation for self-improvement. Furthermore, it fosters a sense of belonging to a community of like-minded colleagues, which makes the profession more appealing.

Self-assessment is a widely used method in pedagogy, applied to both students and educators. In Bulgarian preschool and school education, teacher self-assessment has been studied across various pedagogical fields. In the study (Koleva 2019) the author analyzes the digital competencies of teachers in the Bulgarian education system, noting that Bulgaria ranks second to last, 26th, among EU countries in this regard. Koleva evaluates the DigCompEdu framework as a tool that is "... useful for the heads of educational institutions in selecting personnel with desired competencies, as well as in planning training for professional development".

For the field of preschool education (Tileva 2019) systematizes a toolkit for applying the model of assessment and self-assessment of teachers' pedagogical and digital competencies. This includes, for the first time in Bulgaria, the development of a Framework for Evaluating Teachers' Pedagogical and Digital Competencies, a Self-Assessment Map for Pedagogical Competencies, and a Self-Assessment Map for Digital Competencies.

The issue of professional pedagogical competence in preschool education in Bulgaria has been explored in (Angelov 2007). In (Gyurova 2018) it is emphasized the importance of developing key competencies, particularly technological (digital) competencies, which she describes as "many and varied 'literacies' (or rather, competencies or cultures)".

In a study on the digital competencies of teachers of "Entrepreneurship" (Zoneva 2021), conducted using the DigCompEdu framework, it was found that teachers highly self-assess their digital competencies. They report difficulties in using multimedia systems and learning management systems, while also expressing an interest in further developing their skills as digital creators.

The authors of (Cervera & Cantabrana 2015) identifies teacher self-assessment (reflection) of their digital competency needs, along with the integration of ICT to enhance educational quality, as crucial for improving digital pedagogical competencies. Emphasis is placed on ICT-based management, curriculum development, and teacher collaboration.

In (Ghomi & Redecker 2019) it was developed an instrument based on the DigCompEdu framework to assess teachers' digital competencies, which, according to the authors, provides a reliable and valid measure of professional digital competency levels. They conclude that there is a significant, albeit slight, difference between STEM and non-STEM teachers, as well as between CS teachers and teachers of other subjects. Furthermore, teachers with experience using technology in the classroom show significantly higher scores, validating the instrument.

The study (Yadav et al. 2016) identified eight major challenges for computer science teachers, including content, pedagogy, and preparation. The results highlight the need for professional development and are used in this study to assess the digital competencies of Bulgarian teachers.

According to (Larsson & Stolpe 2023), teachers, regardless of their background (educators, engineers, or professional programmers), share a conceptual metaphor that they themselves are an asset for students to leverage for effective learning as programmers.

The study (Saeli et al. 2011) examines the reasons and concepts for teaching programming. The results show that successful teaching requires technical and pedagogical skills. Data will help develop strategies to improve computer science education in Bulgaria.

In (Hazzan et al. 2008) it is asserted that successful CS education requires a curriculum, a license to teach CS, teacher preparation programs, and CS education research.

The research methodology adopts the DigCompEdu framework, particularly suited for CS and SE teachers. While TPACK focuses on the use of technology in teaching, DigCompEdu provides a more comprehensive view

of teachers' digital readiness. An extensive comparative analysis of similar frameworks has been conducted, including TPACK, DigCompEdu, UNESCO, NETS-T, DigiLit Leicester, and in (Tomczyk & Fedeli 2021).

Mizova and Forsyth conducted a study on 281 teachers with different IT profiles, using a well-established methodology with high validity and reliability in assessing digital competence (Mizova & Peicheva-Forsyth 2024). In the present study, we apply the same self-assessment methodology, based on DigCompEdu and its six domains, to a sample of 127 teachers, out of a total of 150 in the country, who are computer science teachers. The specialization of these teachers allows for more detailed and specific results, which are likely to exceed the level of digital competence among the wider group of IT teachers.

In Bulgaria, no comprehensive study has been conducted with the focus on teachers self assessment of digital competencies using the DigCompEdu framework involved in programming for 'Computer sciences' profession students, including for those teaching CS, SE, and STEM subjects. Contemporary CBE is inconceivable without teachers being aware of its concept and capable of self-assessing their pedagogical and professional competencies, as well as identifying their development needs. Such research is foundational for an effective analysis of all teachers' digital competencies, given that CS, SE, and STEM teachers are instrumental in shaping the digital competencies of both teachers and students. In collaboration with universities and the ICT sector, they play a crucial role in enhancing citizens' digital competence. A high level of digital competence is essential for achieving greater economic progress for the country.

The survey was conducted among high-level programming teachers from vocational and specialized high schools in Bulgaria. Since there are fewer than 150 such teachers in the secondary education system, the sample of 127 respondents can be considered representative. The survey, administered online, includes questions across the six domains of digital competence: Professional Engagement, Digital Resources, Teaching and Learning, Assessment, Empowering Learners, and Facilitating Learners' Digital Competence, with responses evaluated on a Likert scale. The framework sets out a six-scale point progression model to capture educators' competence proficiency level: Newcomer (A1), Explorer (A2), Integrator (B1), Expert (B2), Leader (C1), Pioneer (C2).

The present study has been accomplished according to DigCompEdu details 22 competences framework organised in six areas:

- Professional engagement
- Digital resources
- Teaching and learning
- Assessment

• Empowering learners
• Facilitating Learners' Digital Competence The focus is not on technical skills. Rather, the framework aims to detail how digital technologies can be used to enhance and innovate education and training.

2. Correlation Analysis

The correlation analysis identified the following statistically significant and strongest relationships: There is a strong, statistically significant relationship between the scale "Level of proficiency in teaching different modules" and the scale "Supporting others in developing their digital competence" ($R = 0.606; p \leq 0.0001$). Participants who report high proficiency in teaching various modules are more likely to assist others in developing their digital competence. This likely stems from increased confidence in their abilities and motivation.

A strong, statistically significant correlation was also found between the scale "Proficiency in teaching various subjects" and "Ability to create content for programming instruction" ($R = 0.658; p \leq 0.0001$). The better a teacher masters general teaching methods, the more likely they are to create effective educational content for programming. High-quality programming content is essential for effective teaching in this discipline, as it can engage students, accelerate skill development, and lead to improved outcomes.

There is also a strong correlation between the scale "Finding information on specialized reference sites and professional forums" and "Proficiency in teaching various modules/subjects" ($R = 0.606; p \leq 0.0001$). Teachers skilled at seeking information are more effective in teaching. This could be due to the fact that by searching on specialized sites and forums, teachers can stay informed about the latest developments in their field and adapt their teaching methods accordingly.

A statistically significant relationship was also found between the scales "Finding information on specialized reference sites and professional forums" and "Supporting others in developing their digital competence" ($R = 0.685$; $p \leq 0.0001$). Teachers who are adept at finding information are more likely to assist others in developing their digital skills. This may be because regular searching on specialized sites and forums helps teachers develop a deeper understanding of digital technologies, putting them in a better position to explain complex concepts to others.

There is a strong, statistically significant correlation between the scales "Ability to use digital content in compliance with copyright" and "Supporting others in developing their digital competence" ($R = 0.660; p \leq 0.0001$). Teachers who know how to use digital content while respecting copyright are more inclined to help others develop their digital skills. Regularly using digi-

tal materials in teaching provides these teachers with a deeper understanding of digital technologies and a greater awareness of the ethical aspects of using such materials, enabling them to pass this knowledge on to others.

A very strong, statistically significant correlation is observed between "Ability to use digital content in compliance with copyright" and "Finding information on specialized reference sites" ($R = 0.736; p \leq 0.0001$). This result confirms that skills in using digital content and information retrieval are closely related and essential for modern teachers. Those proficient in these skills are better equipped to tackle the challenges of the digital age and provide high-quality education to their students.

Additional significant correlations include between: "Supporting others in developing their digital competence" and "Selecting ready-made resources for CBE implementation" ($R = 0.636; p \leq 0.0001$); "Supporting others in developing their digital competence" and "Degree of familiarity with CBE concepts" ($R = 0.635; p \leq 0.0001$); "Selecting ready-made resources for CBE implementation" and "Finding information on specialized reference sites" ($R = 0.669; p \leq 0.0001$); "Finding information on specialized reference sites" and "Ability to create content for programming instruction" ($R = 0.650; p \leq 0.0001$); "Coping with personalized learning" and "Supporting others in developing their digital competence" ($R = 0.626; p \leq 0.0001$); "Finding information on specialized reference sites" and "Coping with personalized learning" ($R = 0.641; p \leq 0.0001$).

A negative correlation was observed between the scale "Competence level in using ready-made resources for vocational training in programming-related fields" and "Willingness to improve professional competence" ($R = -0.009$; $p = 0.920$). However, it is very low and statistically insignificant, so it does not warrant further interpretation.

3. Conclusions

The study reveals that teachers expected to lead in digitalization often feel insecure. This is mainly due to two factors: the rapid development of technology keeps teachers in a constant race to catch up with the latest innovations, and the lack of adequate qualifications, which should ideally provide forward-looking knowledge and skills. School leadership often lacks an understanding of teachers' real deficiencies, and modern material resources are also lacking.

CS, SE, and STEM teachers encounter the greatest difficulties in modules related to CS – particularly in algorithms and technological modules, which is understandable given the fast pace of technological change. We recommend updating teachers' technological competencies in collaboration with practitioners from the ICT sector.

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NOTES

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