

## MODEL OF FUNCTIONAL LITERACY FOR TEACHERS CONCERNING THE APPLICATION OF 3D PRINTING IN SECONDARY SCHOOLS

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### Abstract

The article discusses a model of functional literacy for teachers in the context of integrating 3D printing into secondary school education. Functional literacy for teachers includes basic reading and writing skills and the ability to use modern technologies effectively. Concerning 3D printing, this means that teachers must be able to understand the technical aspects of 3D printing, such as working with 3D modeling software, understanding the printing process, and troubleshooting technical issues. 3D printing represents an innovative tool that allows students to visualize and manipulate complex concepts, fostering creativity and the development of practical skills. This technology supports creativity, critical thinking, and practical skills, key competencies for the 21st century. A key aspect is the preparation of teachers, which includes technical training and pedagogical strategies for the effective use of this technology. This can include workshops, online courses, or collaboration with 3D printing experts. It is important that teachers not only understand the technical aspects but also know how to incorporate this technology into their lesson plans and use it to achieve educational goals. However, the implementation of 3D printing in schools faces challenges such as high costs for purchasing and maintaining printers, the need for technical support, and the necessity to update curricula. Teachers may also face resistance to change or a lack of time to acquire new skills. It is important to identify these obstacles and find ways to overcome them, such as through grants, partnerships with companies, or resource sharing among schools. The article also provides examples of good practices where 3D printing has been successfully integrated into teaching. It is important to emphasize that functional literacy for teachers includes the ability to adapt to new technologies and effectively integrate them into teaching. This includes not only technical skills but also pedagogical approaches that support active learning and student engagement. The document also states that the successful integration of technologies such as 3D printing requires the support of school leadership and the availability of resources for the continuous professional development of teachers. These examples show how 3D printing can enrich teaching and provide practical experiences that are very beneficial for students. The result of the article is a model of functional literacy for teachers, which is available to all interested parties and can be widely applied in pedagogical practice.

**Keywords:** *Functional literacy, 3D printing, teacher training, pedagogical strategies, educational technology.*

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### 1. Introduction

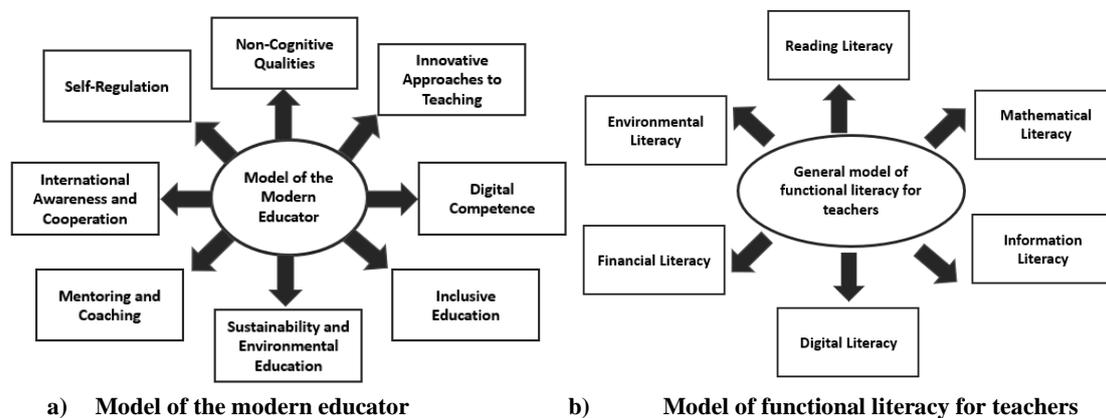
Functional literacy of teachers is a key element for effective and innovative teaching in the 21st century. This concept includes not only basic reading and writing skills, but also the ability to effectively use modern technologies in the educational process. In the context of secondary schools, functional literacy of teachers becomes essential for the integration of advanced technologies, such as 3D printing, into teaching (Schelly, Anzalone, Wijnen, & Pearce, 2015; Fernandes & Simoes, 2016; Song, 2018, Ford & Minshall, 2019; Holzmann, Schwarz, & Audretsch, 2020; Cheng et al., 2020; Anđić et al., 2023). The integration of 3D printing into teaching in secondary schools represents a significant step towards the modernization of the educational process. This technology allows students to visualize and manipulate complex concepts, which supports their creativity and the development of practical skills (Lavicza et al., 2022; Wu, Liu & Huang, 2022; Kuo, 2024). 3D printing also provides students with the opportunity to actively learn and engage in projects that have a real impact on their education (Anđić, 2022; Pearson & Dubé, 2022; Kalman, Nazim, Pavlenko, & Ivanov, 2024). Through a study of the application of 3D printing six categories of uses were identified and described: teaching students about 3D printing; teaching

educators about 3D printing; 3D printing as an assistive technology in teaching; creating didactic aids that aid learning; creating technologies; supporting outreach activities (Ford & Minshall, 2019). The aim of this article is to present a model of teacher functional literacy that includes the technical and pedagogical skills needed to effectively use 3D printing in teaching. The article focuses on the importance of teacher technical preparation, pedagogical strategies for integrating 3D printing into curricula, and overcoming the challenges associated with implementing this technology in schools. The contribution of this article to pedagogical practice is to provide a comprehensive model that can be widely applied and contribute to the development of key student competency.

## 2. Model of functional literacy of teachers

The general model of functional literacy can be considered a specific application of the broader model of the modern educator, see Figure 1 (a). While the model of the modern educator includes a wide range of competencies and skills that reflect current trends and needs in education, the functional literacy model focuses on specific skills needed to support the functional literacy of students. The model of the modern educator includes innovative approaches to teaching, digital competences, inclusive education, sustainability, mentoring, international cooperation, self-regulation and non-cognitive qualities that are not explicitly included in the functional literacy model.

Figure 1. Model of the modern educator (a) & General model of functional literacy for teachers (b).



The model of a modern educator encompasses a wide range of competencies and skills that reflect current trends and needs in education. This model includes innovative teaching approaches, digital competencies, inclusive education, sustainability, mentoring, international collaboration, self-regulation and non-cognitive skills. Innovative teaching approaches include project-based learning and gamification, which support active student engagement and the development of critical thinking. Digital competencies include cybersecurity and online learning, which enable teachers to provide a safe online environment and effectively use digital tools for distance learning. Inclusive education focuses on working with diverse groups and promoting inclusion, creating an environment where every student has the opportunity to fully participate and develop. Sustainability and environmental education include ecological literacy and green projects, which educate students about environmental issues and sustainable practices. Mentoring and coaching are important for supporting colleagues and students' personal development, while international awareness and collaboration include engaging in international projects and promoting multicultural awareness. Self-regulation includes planning and organization, impulse control, stress management, self-assessment, goal setting, and perseverance, which are key skills for effective teachers. Non-cognitive qualities such as emotional intelligence, motivation, resilience, and social skills are also essential for successful education. Communication is a key part of the modern educator model and includes effective communication with students, parents, colleagues, digital communication, cross-cultural communication, and communication in crisis situations. Overall, the modern educator model provides a comprehensive framework for teacher development that encompasses all aspects necessary for successful and modern education (Banasiak & Karczmarzyk, 2018; Gorycheva, Ignateva, & Dautova, 2020; Peng, 2023; Mirzayeva & Mengboyeva, 2024).

## 2.1. Definition and basic skills

Functional literacy is a key element of modern education that enables individuals to navigate effectively in different areas of life. This general model includes reading, mathematics, information, digital, financial and environmental literacy, which together form the basis for successful and sustainable functioning in society, see Figure 1 (b). **Reading literacy** is the ability to understand and interpret texts. This skill is the basis for critical thinking and lifelong learning, encompassing not only the ability to read, but also to analyze and evaluate information from various sources (Xiong, 2020; Otsuka, 2021; Priyatni, As'ari, Suharyadi, Ahmad, & Azizah, 2021). **Mathematical literacy** is the ability to apply mathematical skills in real-world situations, which is key to solving practical problems and developing logical thinking (Priyatni, As'ari, Suharyadi, Ahmad, & Azizah, 2021). **Information literacy** is the ability to search for, evaluate and use information effectively, which is essential in the digital age (Luthfia, Handayani, Gasa, Ramadanty, & Ridzuan, 2023; Pan, Li, Chen, & Chen, 2023). **Digital literacy** is the ability to use digital technologies and tools, which is key to success in the modern world (Tiede, Treacy, Grafe, & Mangina, 2022). **Financial literacy** is the ability to understand and manage finances, which is important for personal and professional life (Pillai, Singh, Bhosale, & Doifode, 2023). **Environmental literacy** is the ability to understand and respond to environmental issues, which is key to sustainability and environmental protection (Pillai, Singh, Bhosale, & Doifode, 2023).

## 2.2. Specific requirements for functional literacy in the context of 3D printing

The functional literacy model for secondary school 3D printing teachers includes the following skills: technical literacy, design literacy, material literacy, safety literacy, project literacy, innovation literacy, and quality literacy, see Table 1. The functional literacy of the educator for the field of 3D Printing is closely related to the Educator's competency matrix for the presentation of the product life cycle (Tomášková, Duda, Krotký, & Honzíková, 2024).

Table 1. Specific requirements for functional literacy in the context of 3D printing.

3D Printing Literacy	Characteristics
Technical Literacy	The ability to understand and use 3D printers, including their maintenance and troubleshooting.
Design Literacy	The ability to create and modify 3D models using CAD (Computer-Aided Design) software.
Material Literacy	Knowledge of the different materials used in 3D printing and their suitability for different applications.
Safety Literacy	The ability to follow safety procedures when working with 3D printers and materials.
Project Literacy	The ability to plan and implement projects involving 3D printing, including time and resource management.
Innovation Literacy	The ability to use 3D printing to solve problems innovatively and support student creativity.
Qualitative Literacy	The ability to ensure high quality outputs from 3D printing, including quality control, optimization of printing parameters, and evaluation of results.

## 3. Integrating 3D printing into education

Pedagogical approaches and teacher preparation include technical training and pedagogical strategies that are key to effective teaching. Workshops, online courses, and collaborations with external partners and 3D printing experts help teachers integrate this technology into lesson plans and achieve educational goals. However, implementing 3D printing in schools faces challenges such as financial costs, technical support, curriculum updates, and resistance to change, as well as time constraints and the need for continuous professional development. Examples of good practice show successful integration of 3D printing into teaching, pedagogical approaches that support active learning and student engagement, and concrete projects that have a positive impact on the educational process (for example: analysis and study of the quality of the printing process and materials (Krotký, Honzíková, & Moc, 2016); demonstration of Taylor-Couette flow (Duda, Klimko, Skach, Uher, & Uruba, 2018); realization of experiments such as demonstration of Bernoulli equation, Taylor-Couette flow, effect of viscosity to scales and decay of turbulence and Galilean transformation inside an axial compressor (Duda, Yanovych, & Uruba, 2022); demonstration of time-symmetry breaking in a jet flow (Duda, Tomášková, Yanovych, Krotký, & Uruba, 2024); Support from school leadership and teacher professional development are essential, with school leadership playing a key role in supporting technology integration, ensuring the availability of resources for continuous professional development, and seeking funding opportunities and collaboration with external partners.

#### 4. Conclusions

In today's rapidly evolving technological era, it is important that teachers are equipped with the skills and knowledge to effectively integrate modern technologies into their teaching. One such technology is 3D printing, which offers a wide range of opportunities for innovative and hands-on learning. The model presented in this article focuses on the specific skills needed to support the functional literacy of students, especially in the area of 3D printing applications in secondary schools.

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