Chapter # 12

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

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ABSTRACT
Teachers' functional literacy includes not only basic reading and writing skills but also the ability to use modern technologies effectively. In the context of 3D Printing, this requires understanding technical principles, working with 3D modeling software, managing the printing process, and addressing technical issues. 3D Printing serves as an innovative educational tool that enables students to visualize and explore complex concepts, fostering creativity, critical thinking, and practical skills essential for the 21st century. Teacher preparation plays a crucial role and includes technical training as well as pedagogical strategies for meaningful integration of this technology into instruction. This may involve workshops, online courses, or collaboration with experts. However, the implementation of 3D Printing also brings challenges such as financial costs, the need for technical support, and curriculum updates. Identifying barriers and seeking solutions—through grants or resource sharing among schools—is therefore essential. The chapter presents examples of good practice and emphasizes that teachers' functional literacy also includes adaptability to new technologies. Successful integration of 3D Printing requires school leadership support and continuous professional development. The chapter concludes with a model of teachers' functional literacy applicable in educational practice.

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

1. INTRODUCTION

Functional literacy of teachers is a basic prerequisite for quality education in the 21st century. Functional literacy can be defined as the ability to effectively use knowledge and skills in real-life situations, encompassing not only reading and writing, but also information literacy, digital competence, communication skills and critical reflection. In the literature, this concept is understood as "a set of technical, strategic and sociocultural competences that enable an individual to use written language to achieve communicative goals in a variety of contexts" (Verhoeven, 1994). This approach is in line with the UNESCO definition, which emphasizes that functional literacy means the ability to use reading, writing and numeracy skills to participate in everyday activities and for personal and community development, with an emphasis on the application of these skills in real-life social, economic and cultural contexts (UNESCO, 2025). It is not only the ability to read and write, but a comprehensive set of skills that enable teachers to work effectively with information, use digital technologies, communicate across disciplines and reflect on their own pedagogical practice. In an era of rapid social and technological change, functional literacy is becoming a key tool for the development of innovative and inclusive education. At the university level, this

literacy should be systematically developed already during the preparation of future teachers. Higher education has a unique opportunity to shape not only the professional knowledge of student teachers, but also their ability to adapt to the changing demands of the school environment. Studies should include practical experience with digital tools, work with professional texts, the development of presentation and communication skills and the support of critical thinking. This preparation is directly reflected in teaching in secondary schools, where teachers are expected to be able to guide students to independent thinking, work with information and use technology responsibly. This approach is in line with the conclusions of the study by Nsiegbe et al. (2025), which emphasizes that inclusive education is not only a human right but also a catalyst for sustainable development. The authors identify four key areas: accessibility, curriculum design, teaching methods and support services. Accessibility includes physical, digital and socio-economic barriers that need to be removed to ensure that all students – including those with special needs – have equal opportunities. Similarly, the curriculum needs to reflect diverse perspectives and be flexible, supporting individual student needs. As the authors state: "The choice of teaching methods significantly influences the inclusiveness of the educational experience. Employing student-led approaches, differentiated instruction, and principles of Universal Design for Learning (UDL) enables educators to effectively respond to the diverse needs of students" (Nsiegbe et al., 2025). The functional literacy of teachers is closely linked to these principles. A teacher who is digitally competent, information literate, and aware of cybersecurity is able to create an inclusive environment and effectively use technology to support learning. As Kanvaria & Yadav (2024) emphasize, the integration of ICT into education not only brings new opportunities for personalization and interactive learning, but also challenges associated with the digital divide, insufficient teacher preparation, and the need for continuous professional development. The authors state: "Teacher professional development is critical to maximizing the benefits of ICT in education. Teachers should receive ongoing training and support in integrating digital tools into their pedagogy" (Kanvaria & Yadav, 2024).

Universities have a unique opportunity to systematically develop these competencies during the preparation of future teachers, through practical experience with digital tools, working with professional texts, developing presentation and communication skills, and supporting critical thinking. As Charles-Zalakoro (2025) suggests, teacher preparation should include digital content creation, information literacy, and cybersecurity awareness, which are key to inclusive and technology-oriented classrooms. Practical experience with digital tools, working with professional texts, developing presentation and communication skills, and supporting critical thinking are essential for teachers to be able to guide students to think independently, work with information, and use technology responsibly. As Kiuppis (2022) states, the provision of comprehensive support services is key to overcoming barriers to education and creating an environment that supports student well-being. Of particular importance is the functional literacy of teachers in the areas of project-based learning, environmental education, or problem-based learning, where it is shown how important the teacher's ability to think in broader contexts and lead students to deeper understanding is. Functional literacy thus becomes not only an individual competence of the teacher, but also a part of the school culture and a prerequisite for its development. Its systematic development in universities and school practice represents an investment in the quality of education and in the future of the entire society.

In the context of secondary schools, teachers' functional literacy becomes essential for integrating 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). Integrating

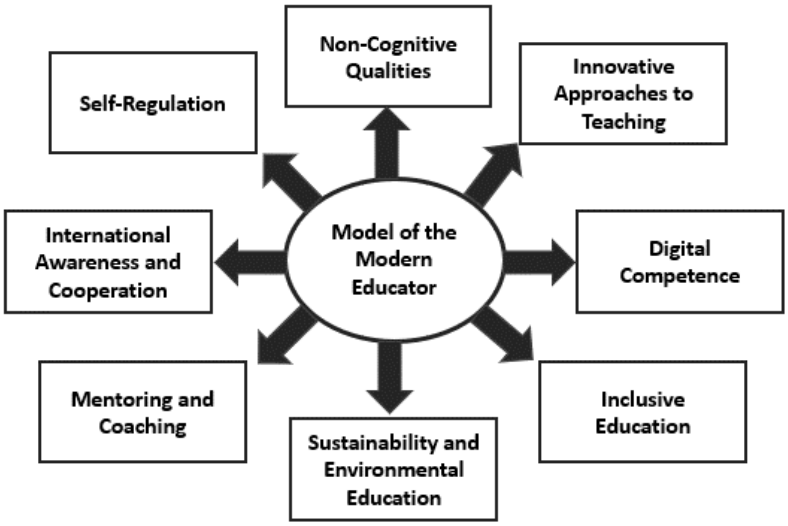
3D printing into secondary school teaching represents a significant step towards modernizing the educational process. This technology allows students to visualize and manipulate complex concepts, which supports their creativity and the development of practical skills (Lavicza et al., 2022; Wu, Liu & 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). Studies of 3D printing applications have identified six categories of use: teaching students about 3D printing; educating teachers about 3D printing; 3D printing as an assistive technology in teaching; creating teaching aids; creating technologies; supporting popularization activities (Ford & Minshall, 2019). Studies of 3D printing applications have identified six categories of use: teaching students about 3D printing; educating teachers about 3D printing; 3D printing as an assistive technology in teaching; creating teaching aids; creating technologies; supporting popularization activities (Ford & Minshall, 2019).

The aim of this chapter 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 chapter 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 chapter to pedagogical practice is to provide a comprehensive model that can be widely applied and contribute to the development of key student competency. The approach presented is not an empirical study, but a theoretical-methodological contribution, which aims to synthesize available knowledge and propose a structured framework of competencies. This framework can serve as a support for teachers, curriculum designers, school leaders and researchers in planning professional development and integrating innovative technologies into the educational process.

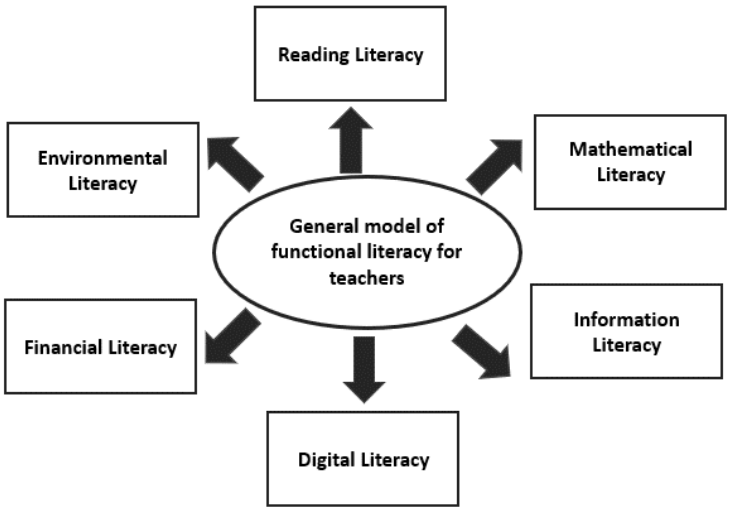
2. MODEL OF FUNCTIONAL LITERACY OF TEACHERS

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 functional literacy for teachers.



a) Model of the modern educator



b) General model of functional literacy

The modern teacher model is a comprehensive framework of professional competencies that reflect current challenges, trends and needs of the education system. At a time when education takes place in the context of rapid technological change, social diversity and global challenges, it is essential that teachers have a wide range of skills that will allow them to respond effectively to the changing conditions of teaching. This model includes not only professional knowledge, but also the ability to approach teaching innovatively, use digital

technologies, support inclusion, develop sustainable thinking, lead colleagues and students, collaborate across cultures and reflect on their own professional development. Innovative teaching approaches, such as project-based learning or gamification, bring new possibilities to teaching, how to actively involve students, support their critical thinking and connect the curriculum with real-life situations. A teacher who masters these methods is able to create an environment in which students learn through their own experience, collaboration and creativity. Digital competences, including working with online tools, cybersecurity and the ability to conduct distance learning, are becoming an essential part of pedagogical practice. Teachers must be able not only to technically master the digital environment, but also to use it meaningfully and safely, taking into account the needs of students. Inclusive education emphasizes respecting individual differences, creating a supportive environment and working with diverse groups of students. A modern teacher must be prepared to work with students with different cultural, linguistic or educational needs, while promoting equal opportunities for all. In the area of sustainability, the teacher becomes a bearer of ecological literacy, an initiator of green projects and a guide for students in finding a responsible relationship with nature and society. Environmental education should be a natural part of teaching, connected to everyday topics and activities. Mentoring and coaching are important tools for developing professional communities, supporting beginning teachers and strengthening cooperation between colleagues. A teacher who masters the principles of mentoring can guide not only students but also colleagues to deeper reflection, self-development and professional growth. International cooperation and multicultural awareness are increasingly important in a globalized world where education takes place in an international context. Involvement in international projects, exchange programs and the development of intercultural competences allows teachers and students to broaden their horizons and learn in different cultural environments. Self-regulation as a set of skills including planning, organization, self-assessment, stress management and perseverance is key to effective pedagogical activity. A teacher who is able to reflect on their own work, set goals and adapt to new situations is able to lead students not only professionally but also humanly. Non-cognitive skills such as emotional intelligence, motivation, resilience and social competence play a crucial role in building relationships, creating a safe environment and supporting a positive climate in the classroom. These qualities affect not only the quality of teaching, but also the overall atmosphere of the school. Communication competences form a cross-cutting element of the entire model. A teacher must be able to communicate effectively with students, parents, colleagues, and manage digital communication, intercultural interactions, and crisis situations. The ability to listen, formulate ideas, engage in dialogue, and resolve conflicts is essential for everyday pedagogical practice. The model of a modern teacher should be systematically integrated into teacher training at universities, where individual competences can be developed through the connection of theory with practice, reflection, collaboration, and research activities. At the same time, it should serve as a framework for the further professional development of teachers at all levels of education, including secondary schools, where the above areas are directly reflected in everyday pedagogical activities. Scientific and research reflection on this model can contribute to a deeper understanding of the teacher's professional identity, to the innovation of educational programs, and to the creation of support systems for pedagogical development. Overall, the modern teacher model represents a comprehensive framework of professional competencies that includes all aspects necessary for successful and modern education. This approach corresponds to the conclusions of Banasiak and Karczmarzyk (2018), who emphasize the role of the teacher as a leader and manager capable of leading the pedagogical process innovatively. Similarly, Gorycheva, Ignateva and Dautova (2020) point to the structural and

content characteristics of didactic competencies that are key to adapting to current challenges. Peng (2023) emphasizes the importance of the teacher as a central actor in modern education, while Mirzayeva and Mengboyeva (2024) develop a view on how a modern educator should be prepared for global and technological changes. Together, these studies confirm that the modern teacher model is not just a theoretical concept, but a practical framework that connects professional knowledge, digital competences, inclusion, sustainability and the ability for lifelong professional development.

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 definition of these competencies is based on an analysis of available literature, which emphasizes the need for teachers to have technical, design, project and innovation literacy when integrating 3D printing into teaching. Schelly et al. (2015) and Ford & Minshall (2019) state that the successful use of 3D printing in education requires not only technical skills, but also the ability to connect technology with pedagogical goals. The study by Anđić et al. (2023) confirms the importance of design literacy and the ability of teachers to guide students to think creatively through 3D modeling. Lavicza et al. (2022) and Wu et al. (2022) emphasize that project literacy and an innovative approach are key to engaging students in practical tasks and developing their competencies. Pearson & Dubé (2022) add that qualitative literacy, i.e. the ability to control and optimize outputs, is essential to ensure the effectiveness of teaching. The teacher's functional literacy for the area of 3D printing is also closely linked to the educator's competency matrix for product life cycle presentation (Tomášková, Duda, Krotký, & Honzíková, 2024). These findings form the basis of the proposed model of teacher functional literacy, which is based on the general framework shown in Figure 1 and is expanded with specific competencies for the area of 3D printing.

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.

In technical education in secondary schools, 3D printing is becoming not only a tool for supporting creative thinking, but also a means for developing comprehensive functional literacy of teachers and students. Effective integration of this technology into teaching requires specific competencies that go beyond the framework of ordinary technical proficiency. Functional literacy in the field of 3D printing includes seven key areas that form the basis for the professional training of educators in technically oriented fields. Technical literacy refers to a deep understanding of the principles of additive manufacturing, including knowledge of types of 3D printing technologies, such as FDM (Fused Deposition Modeling - a technology based on layering of thermoplastic material), SLA (Stereolithography - a technology using laser curing of photopolymers) and SLS (Selective Laser Sintering - a technology that sinters powdered material with a laser). The teacher must be able not only to operate the equipment, but also to interpret error messages, optimize printing parameters (e.g. nozzle temperature, extrusion speed, layer height) and perform basic service interventions. Design literacy includes the ability to work with CAD software (Computer-Aided Design) such as Autodesk Fusion 360, TinkerCAD or SolidWorks, create parametric models, modify object geometry and prepare files for printing in STL (Standard Tessellation Language – a format for 3D models based on surface triangulation) or OBJ (Wavefront Object – a format supporting geometry and textures). The educator should understand the principles of structural design, tolerances, support structures and orientation of the model on the printing surface with regard to mechanical loads and output quality. Material literacy refers to knowledge of the physical, chemical and mechanical properties of printing materials such as PLA (Polylactic Acid – a biodegradable thermoplastic based on corn starch), ABS (Acrylonitrile Butadiene Styrene – a tough plastic with higher heat resistance), PETG (Polyethylene Terephthalate Glycol – a modified PET with good strength and chemical resistance) and TPU (Thermoplastic Polyurethane a flexible material suitable for printing soft and elastic parts). The teacher must be able to evaluate the suitability of the material for a specific application, taking into account its temperature stability, adhesion to the print bed, hygroscopicity and environmental impacts. Safety literacy is essential to ensure the safe operation of the equipment. It includes following the rules when handling hot

components, preventing the risks associated with VOC (Volatile Organic Compounds) emissions when printing from ABS, proper ventilation of the work area, using protective equipment and training students in safety protocols. Project literacy is the ability to plan, implement, and evaluate projects involving 3D printing. The teacher must be able to manage a timeline, allocate material and technical resources, document the process, and reflect on the outcomes with respect to educational goals. This competency is key to integrating 3D printing into project-based learning. Innovation literacy is the ability to use 3D printing as a tool for solving technical problems, supporting design thinking, and developing student entrepreneurship. The teacher acts as a facilitator who guides students to apply the principles of rapid prototyping, iterative testing, and functional optimization of designs. Qualitative literacy includes the ability to analyze print outputs in terms of accuracy, surface quality, mechanical integrity, and functionality. The teacher must be able to interpret measurement results (e.g., using a caliper, micrometer, profilometer), identify the causes of defects (e.g., stringing, warping, underextrusion) and suggest corrections to printing parameters. This technically oriented framework of functional literacy in the field of 3D printing provides a basis for systematic education of teachers of technical disciplines and at the same time serves as a methodological tool for evaluating the quality of teaching in the field of additive manufacturing. Its application in educational practice supports not only the professional growth of teachers, but also the development of technical thinking, creativity and practical skills of students.

3. OTHER 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)). In the current educational environment, which is characterized by rapid technological development, increasing demands for digital competences and an emphasis on innovative pedagogical approaches, the role of school leadership is becoming crucial in creating conditions that enable meaningful and sustainable integration of technology into teaching. School leadership is no longer just an administrative function, but a strategic actor that shapes the school culture, supports the professional growth of the teaching staff and creates an environment conducive to pedagogical innovation. One of the key aspects of this role is the active support of teachers' continuous professional development, both in the area of technical skills and in the area of pedagogical-didactic integration of technology. School leadership should systematically identify teachers' learning needs, support their participation in professional training, workshops and communities of

practice, while creating space for sharing experiences and mutual learning within the school. Ensuring the availability of technical and material resources, including modern equipment, software licenses, technical support and access to digital educational tools, is also an important element. Equally important is the ability of school management to actively seek funding opportunities for technological innovations, both from public sources (e.g., national and European grant programs) and through cooperation with external partners such as universities, research institutions, technology companies or non-profit organizations. This cooperation can take the form of joint projects, professional internships, sharing of know-how or the school's involvement in wider innovation networks. From a research perspective, it is important to analyze how specific school management strategies influence the degree and quality of technology integration into teaching, what impact does leadership support have on teachers' motivation and self-confidence in using digital tools and what factors contribute to the sustainability of these changes in the long term.

The issue of pedagogical leadership also deserves special attention, i.e., the ability of school leadership to inspire, guide and support teachers in their professional growth, not only through formal structures, but also through a culture of trust, openness and shared responsibility for the quality of education. In the context of technology-oriented schools and programs, where the integration of technology is not only desirable but also necessary, it seems that the synergy between visionary leadership and professionally prepared teaching staff is a key prerequisite for the successful transformation of teaching. Research shows that pedagogical leadership has a fundamental influence on the formation of teachers' professional identity, which is a dynamic process shaped by the interaction of individual and collective factors (García-Martínez & Tadeu, 2018). Professional identity develops from the initial preparation of a teacher to his or her experience in practice, with a culture of collaboration, sharing of practice and support from school leadership playing a key role. Distributed and shared leadership, based on collaboration and teacher empowerment, is proving to be an effective way to strengthen professional capital and improve the quality of teaching. At the same time, it is clear that pedagogical leadership is closely related to effective educational governance. A study from the Peruvian environment confirms that when school leadership applies pedagogical leadership in all administrative and academic processes, there is better teamwork and the achievement of institutional goals through quality management (Rodriguez et al., 2023). Key factors are motivation, strategic use of resources, curriculum planning, support for teacher professional development and the creation of a supportive environment. Together, these elements ensure the effective functioning of the school and increase the quality of education. Furthermore, it is shown that traditional models of “learning-centred leadership” are limited in the current context, as they focus on outputs and results, while pedagogical leadership emphasizes learning processes, the epistemic nature of pedagogy and the creation of “pedagogical communities” (Male & Palaiologou, 2012). This approach emphasizes relationships between teachers, students, families, and the community, encourages knowledge sharing and collaboration, and responds to the challenges of the digital age. Educational leadership thus becomes a dynamic, evolutionary process that connects theory and practice, respects cultural and social context, and focuses on the development of knowledge, not just its transmission.

4. FUTURE RESEARCH DIRECTIONS

Given the growing importance of technological integration in education and the key role of school leadership in this process, a promising area of research is a deeper analysis of school leadership strategies in different typological school contexts

(e.g., technology-oriented schools, schools with an inclusive focus, schools involved in international projects). Future research should examine how specific forms of leadership support influence the level of technology adoption, pedagogical innovation, and professional self-reflection of teachers. Another area of research is the effectiveness of professional development models focused on digital competences, including a comparison of formal and informal education, mentoring, communities of practice, and online learning platforms. Special attention should be paid to the sustainability of professional development, i.e., how it affects pedagogical practice, teacher motivation, and teaching quality in the long term. Research on inter-institutional cooperation, especially between schools, universities, technology companies, and research centers, can also be considered key. This raises the question of what forms of cooperation are most effective for the development of school technical infrastructure, the transfer of know-how and the innovation of educational methods. Last but not least, it is necessary to examine the impact of technological integration on students, not only in terms of their academic performance, but also in terms of the development of digital literacy, critical thinking, independence and the ability to work in a project mode. Research should reflect differences between subjects, age groups and socio-economic backgrounds of students. Future research should be interdisciplinary, combining pedagogy, didactics, technology, psychology and management, and should contribute to the creation of evidence-based recommendations for school policy, educational practice and systemic innovations.

5. CONCLUSION/DISCUSSION

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 chapter focuses on the specific skills needed to support the functional literacy of students, especially in the area of 3D printing applications in secondary schools. The proposed model of functional literacy for teachers represents a comprehensive framework that responds to current demands for technical education. It defines seven key areas of competence: technical, design, material, safety, project, innovation and quality literacy necessary for the effective use of 3D printing in education. These competences include not only technical knowledge, but also the ability to connect technology with pedagogical strategies, support creativity and ensure the safety and quality of outputs. The model is therefore an appropriate expression of the skills that teachers need in the digital age, as it combines technological proficiency with project-based learning, critical thinking and innovative approaches. This creates a basis for active student engagement and sustainable integration of modern technologies into education. The linking of the model with the support of pedagogical leadership, as presented in Chapter 3, emphasizes that successful implementation depends not only on teacher expertise, but also on institutional conditions and a culture of collaboration. This approach makes the chapter a significant contribution to the discussion on innovation in education.

The proposed model of functional literacy for teachers in the field of 3D printing represents a significant contribution to the modernization of technical education. The model is based on the general framework of functional literacy (Figure 1) and expands it with seven specific competencies necessary for the effective integration of 3D printing into education: technical, design, material, safety, project, innovation and quality literacy. These competencies are supported by current research (Schelly et al., Ford & Minshall, Anđić et al., Lavicza et al., Wu et al., Pearson & Dubé) and connected to the educator's competency

matrix for product life cycle presentation (Tomášková et al., 2024). The chapter thus offers a theoretical and methodological framework that responds to current trends in digital technologies, supports the development of key teacher skills and contributes to the innovation of educational practice. This approach emphasizes not only technical aspects, but also pedagogical strategies, leadership and sustainability, thereby creating a comprehensive basis for further research and practical implementation.

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ACKNOWLEDGEMENTS

The chapter was created with the support of the GRAK 2025 grant competition at Faculty of Education, University of West Bohemia in Pilsen, project number: GRAK_25_05.

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