1.6. Didactic conditions for the formation of students' digital competence in the process of obtaining technological education in gymnasiums and lyceums

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Iryna Holiiad,

PhD in Pedagogical Sciences, Associate Professor, Senior researcher, Department of Technological Education, Institute of Pedagogy of the National Academy of Educational Sciences of Ukraine, Kyiv, Ukraine

https://orcid.org/0000-0003-4979-828X

Vasyl Tutashynskyi,

PhD in Pedagogical Sciences, Head of the Department of Technological Education, Institute of Pedagogy of the National Academy of Educational Sciences of Ukraine, Kyiv, Ukraine

https://orcid.org/0000-0002-1842-0914

Anatolii Tarara,

PhD in Physical and Mathematical Sciences, Associate Professor, Senior Researcher, Senior Researcher of the Department of Technological Education, Institute of Pedagogy of the National Academy of Educational Sciences of Ukraine, Kyiv, Ukraine

https://orcid.org/0000-0001-7517-0651

Digital technologies are increasingly integrated into the educational process, influencing changes in methodological approaches, content, methods and teaching aids. These changes are especially relevant for technological education, which, in accordance with its mission and objectives, involves the study of technologies, a close connection with practical activities, the use of innovative tools and technical solutions.

In gymnasiums and lyceums, where key and subject competencies of general secondary education students are formed and the foundations of professional self-determination of the individual are laid, effective formation of digital competence

is a necessary component of the educational process. However, as pedagogical research shows, the introduction of digital tools into the educational process by itself does not ensure the achievement of high learning outcomes. It is no less important to create appropriate didactic conditions that will ensure targeted, systematic and motivated formation of digital competence of education students: to ensure the optimal combination of content, methods, forms and means of learning in the process of studying technologies that meet the age characteristics of education students, educational standards and modern requirements for the process and learning outcomes (State Standard …,2020).

In order to effectively form students' digital competence in the process of obtaining technological education in gymnasiums and lyceums, it is necessary to create such didactic conditions that, in aggregate, will ensure effective learning focused on the formation of digital competence as one of the keys to a successful life and professional self-realization in a modern high-tech, information society.

Based on the conducted theoretical and applied research, we include the following conditions:

- motivational support for learning;
- targeted integration of digital technologies into the content of technological education;
- optimal selection of content, methods and forms of learning;
- individualization and differentiation of learning;
- reflection and feedback in the educational process;
- organization of a digital educational environment;
- increasing the digital competence of teachers;

Effective mastery of digital technologies in the process of technological education in gymnasiums and lyceums requires taking into account the above-mentioned didactic conditions, the implementation of systemic approaches that combine practical significance, interdisciplinary integration, and activity-based learning, ensuring the achievement of the necessary results of the educational activities of general secondary education students.

One of the most important factors of effective learning is the formation of motivation for learning in students, maintenance and development of a sustainable interest in digital technologies through demonstration of examples of their application in real life, in various spheres of economic activity. Particularly relevant in the conditions of modern Ukraine are examples from the defense, agricultural and

engineering spheres, which show the applied value of digital skills and their impact on the well-being, security and innovative development of society.

Involving students in relevant socially significant projects, in particular those related to supporting the Armed Forces of Ukraine or participating in initiatives to restore damaged infrastructure, contributes to the development of personality, patriotic upbringing and the formation of a responsible attitude to learning. Participation in such projects increases the motivation of students to master digital technologies as a tool for real influence on social processes.

It is advisable to systematically include modern digital tools in the development of projects and to have students master such digital technologies as graphic editors, computer-aided design systems, visualization and modeling platforms, prototyping environments, etc. Their use ensures the development of spatial and technical thinking, skills in engineering analysis, design and solving applied problems. These digital tools should not be an addition to the lesson, but an organic part of the educational content, integrated into educational topics, projects, practical tasks and tests.

The purposeful integration of digital technologies into the content of technological education and the use of digital technologies in teaching contributes to the formation of key and subject-specific project-technological competences of secondary school students.

First of all, digital technologies affect the formation of information and digital competence. Using digital technologies, students can find the information they need and are interested in, work with data, use digital resources and online tools to search, process, comprehend and critical analyze information.

In the context of the rapid development of digital technologies and visual culture, graphic competence is becoming particularly relevant - one of the components of technological education and the basis for successful mastery of such areas as engineering, architecture, design, computer-aided design, 3D modeling, robotics and other modern industries where visualization and technical thinking are necessary (Holiiad, 2023). Knowledge of graphics allows students to read and create drawings, models, technical diagrams, navigate spatial objects and transform abstract ideas into specific visual forms. In modern technological education, graphic skills become a tool for visual thinking, which helps to analyze, plan, design, optimize technological processes.

The use of digital graphics platforms – such as graphic editors, computer-aided design (CAD) systems, 3D modeling programs – requires software proficiency, understanding of composition principles, scale, proportion, symbols, technical standards

(ISO standards). This allows students to create real professional projects that can be integrated into production or educational and research processes.

The formation of graphic skills within the framework of the educational subject «Technology» requires targeted pedagogical support: from elementary acquaintance with visual forms to the creation of complex digital models and drawings. This approach ensures the development of spatial and logical thinking in students, forms creativity, accuracy, attentiveness - qualities important for future professional growth in the digital economy. Graphic training is a necessary component of technological education of the new generation. It forms fundamental skills that combine traditional knowledge with modern digital capabilities, ensuring the readiness of students for further education, professional activity and active participation in the innovative development of society.

The processing of information from different sources by students creates ample opportunities for its comparison, comprehension and influences the development of critical thinking and creative abilities of students.

During the learning process, students can create their own digital projects, use online resources to search for information, use design software and digital modeling tools. For example, when studying methods of modeling products, you can use 3D design programs (Fusion 360, SolidWorks), which provides the opportunity to develop digital models before their physical implementation.

The use of mobile applications, such as Khan Academy, Coursera, helps to obtain the necessary additional information, increases the level of student independence, develops communication skills, creativity and entrepreneurial abilities.

However, it is necessary to study in more detail how effectively students of secondary education institutions use these opportunities in technology classes.

For digital design and planning, programs such as AutoCAD, TinkerCAD, Canva, Adobe Spark can be used.

In order to automate the design process, the result of which is a set of design documentation, it is advisable to teach students to use an automated design system (CAD). It is used on the basis of special software, automated data banks, a wide range of peripheral devices. With the help of CAD, you can develop a full set of design documentation, calculate and design technological schemes, technological equipment, prepare specifications, estimates, etc.

- CAD includes the following digital technologies:
- CAD (Computer-aided design)

- CAM (Computer-aided manufacturing)
- CAE (Computer-aided engineering)
- CALS (Computer-Acguisition and Life cycle Support).

AutoCAD has versions designed for educational purposes, which are available for free download from the Autodesk educational community website. The educational version of AutoCAD is functionally no different from the full version.

To build clothing patterns, you will need the skills to use the PatternsCAD program. This program provides the ability to build clothing patterns in their natural size or on a different scale, or according to individual measurements.

The content of technology training may also include the use of other digital technologies that are constantly developing.

Experimental studies conducted in Ukrainian lyceums prove that the purposeful use of digital technologies in the educational process stimulates the creative thinking of students, develops creativity and forms the qualities of a person with an innovative type of thinking. In particular, the use of 3D modeling, animation software (Blender, SketchUp), artificial intelligence generators contributes to the search for new ideas and their implementation in the process of project activities on technologies (Holiiad, 2023).

The study of 3D printing technology is being introduced more and more widely, not only in experimental gymnasiums and lyceums of Ukraine. For this purpose, new special courses and other forms of classes are being developed. The relevance of studying 3D printing by secondary school students lies in its ability to interest and make learning more active. As our research and study of teachers' work experience show, the advantages of implementing 3D technology in secondary school institutions are:

- formation of STEM skills of students;
- development of imagination, fantasy, spatial and technical thinking of students;
- improvement of digital interaction of students;
- increase of motivation of students for scientific and research activities;
- growth of interest in studying fundamental and applied disciplines;
- visual acquaintance with three-dimensional visualization and modeling;
- strong interdisciplinary connections in practical application;
- compatibility with other educational programs (Lego, Tetrix and others);
- the possibility of using 3D technologies at different levels of education;

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- promoting professional self-determination of high school students and their conscious choice of engineering professions.

The above arguments are weighty factors for the wider introduction of a course on 3D printing into the educational process of secondary education institutions. It should be noted that the modern educational process is characterized by a certain inconsistency between the dynamics of innovation development and the inconsistency of the content of curricula in subjects and courses related to additive technologies.

Analysis of the content of the curricula approved by the Ministry of Education and Science of Ukraine shows that the topic «Modeling and 3D printing» is studied in the interdisciplinary integrated course «STEM» for grades 7-9» (Model Curriculum …, 2024) on the examples of 3-D modeling of the human circulatory system, development of 3D architectural design of a building. The educational module «3D modeling and printing» is proposed for study in the curriculum for grades 7-9 «Technologies. STEM projects». The main tasks of the program are related to the formation of design and technological competence in students using 3D modeling. Their solution is subject to the structure and content of the modules, which correspond to the age of children in grades 7-9.

The content of the new elective course "3D Printing and Modeling" for students in grades 9, 10, and 11 of secondary education institutions logically ensures the continuation of the formation of digital competencies in senior classes. The peculiarity of the course is its focus on acquiring practical skills in using 3D printers and making 3D models, primarily in the environment of the technological educational industry.

The introduction of the elective course "3D Printing and Modeling" in secondary education institutions can contribute to the creation of an educational environment for the implementation of such general educational tasks as:

- the ability to work with a variety of information;
- the development of a tendency to scientific and research activities;
- the ability to independently design educational activities;
- the ability to carry out self-assessment and self-control;
- the desire and ability to demonstrate purposefulness,
- initiative and independence;
- the tendency to new ideas, the search for new non-standard solutions;
- the ability to respond adequately to various, often non-standard situations, etc.

Significant in the formation of digital competence of education seekers is the role of the special course «Technologies of Modern Production», which has been

experimentally tested and is already studied in academic and professional lyceums of Ukraine. The content of this special course involves the use of digital technologies and modern teaching aids in project and technological activities and mastering Industry 4.0 technologies.

It is Industry 4.0 technologies that are already contributing to the creation of effective production, influencing the increase in competitiveness and defense capability. A new generation of industrial systems using augmented reality and multimodal interaction helps to operate effectively in difficult conditions, to develop modern production, in which digital technologies are widely used.

The development of digital technologies has led to the development of cyber-physical systems (CPS), which have united the digital virtual world and the real one. CPS production systems, consisting of smart machines and logistics systems, allow for ICT-based integration for vertically integrated systems and production networks. Cyber-physical systems increase resource productivity and production efficiency.

Technological leadership and focus on modern production industries, automation and software based on embedded systems, as well as strong industrial networks lay the cornerstone for the success of Industry 4.0, which is actively developing in the world.

Industry 4.0 technologies ensure the development of smart industry and are associated with the technological evolution from embedded to cyber-physical systems (Holiiad, 2023).

Artificial intelligence is increasingly influencing the development of modern industry. Decentralized artificial intelligence will help create smart industrial networks and set up an independent control process with the interaction of the real and virtual worlds, which represent the most important new aspect of the production process. Industry 4.0 ensures the transition from centralized production to decentralized. There is interaction between the product of production and the machine. Industry 4.0 connects system industrial technologies and smart production processes to open the door to a new technological era.

Digital technologies are the foundation on which innovative solutions of the future are built.

Cyber-physical systems are high-performance technologies that combine the virtual and real worlds to create a truly networked space in which smart objects can communicate and interact with each other. Cyber-physical systems can be combined with the Internet of Things, data and services to form fully-fledged cyber-physical sys-

tems. At the same time, CPS provides the foundation for the creation of the Internet of Things, data and services, thereby making the implementation of "Industry 4.0" possible. These are high-performance technologies that, through innovative applications and processes, are able to blur the line between the real and virtual worlds. As such, they promise to revolutionize our interaction with the physical world in the same way that the Internet has changed personal communication. The interaction of high-performance embedded systems and specialized user interfaces integrated into digital networks opens up a whole new world of system functionality.

Among such new opportunities is the Internet of Things, which provides the ability to carry out many processes without direct human participation and is capable of radically interfering in the development of society and the global economy (Tutashynskyi, 2021a; p.101).

The Internet of Things has become popular for describing scenarios in which Internet connectivity and computing power extend to a large number of objects, devices, sensors, and everyday objects. The main concept of the Internet is the ability to connect things that a person can use in everyday life, for example, a refrigerator, air conditioner, car, bicycle. All these things must be equipped with built-in sensors that have the ability to process information coming from the environment, exchange it, and perform various actions depending on the information received. An example of the implementation of such a concept is the "smart home" or "smart farm" system, which can be designed by students in technology classes. This system analyzes environmental data and, depending on the indicators, regulates the temperature in the room. In winter, the heating intensity is regulated, and in case of hot weather, the house has mechanisms for opening and closing windows, thanks to which the house is ventilated, and all this happens without human intervention.

Several technologies are required to connect everyday objects into a network. To identify each object, a simple, compact technology is required. Only with a unique identification system can information about a specific object be collected and stored. Such functionality can be provided using RFID (Radio-Frequency IDentification) chips. They are capable of transmitting information to reading devices without their own power source. Each chip has an individual number. As an alternative to this technology, QR codes can be used to identify objects. To determine the exact location of an object, GPS technology, which is effectively used in smartphones and navigators, is suitable. To track changes in the state of an element or the environment, objects must be equipped with sensors. An embedded computer must be used to process

and store data from sensors. Wireless network technologies (Wi-Fi, Blutooth, ZigBee, 6 LoWPAN) can be used to exchange information between devices. Integration with the Internet should provide that devices will use the IP address as a unique identifier. Objects in the Internet of Things will not only be devices with sensor capabilities, but also devices that can perform certain actions. To a large extent, the future of the Internet of Things will not be possible without support for IP v6, therefore, the global implementation of IP v6 in the coming years will be crucial for the successful development of the Internet of Things in the future. For wireless data transmission, characteristics such as efficiency, adaptability, and the ability to self-organize play a particularly important role in building the Internet of Things.

Among the leading technologies, PLC solutions play an important role in the spread of the Internet of Things - technologies for building data transmission networks over electrical transmission lines, since many applications have access to electrical networks (for example, vending machines, ATMs, smart meters, lighting controllers are initially connected to the power supply network). 6LoWPAN, which implements the IPv6 layer over both IEEE 802.15.4 and PLC, being an open protocol standardized by the IETF, is noted as being particularly important for the development of the Internet of Things. According to analysts' forecasts, a real boom in the Internet of Things is expected in the coming years. Now IoT is no longer just a network of «smart» devices connected by wired or mobile communication channels, but also a person who communicates with them. Using the opportunities provided by the Internet of Things is transforming not only personal or social aspects of life, but has also affected most areas of business and the economy. In the world, most companies are implementing technological solutions using IoT, with electronics, transport, control systems, logistics, finance and the military sphere as a priority. Today, few people are surprised by a "smart home", in which you can control household appliances and heat, water and electricity supply using a regular smartphone. Remote car start, GPS navigators, Smart TV, smart glasses have become familiar to many. There are enough examples around us to understand how much the Internet of Things has entered everyday life and various sectors of the economy. Among the capabilities of "smart" devices are monitoring meteorological conditions, seismic hazard, the state of the atmosphere and water. It should be noted that the transition to the 5G mobile communication standard will contribute to the implementation of even greater IoT capabilities. This will reduce connection delays between devices and simultaneously support a huge number of connections, extend the service of "smart" devices, as

well as achieve incredible mobile data transfer speeds by today's standards. The military industry has also not remained aloof from global processes associated with mass «digitalization» and the transformation of the relationship between humans and devices. Technological innovations are first used to strengthen the country's defense capabilities. The technological trend of the last decade in the armies of many countries, a kind of indicator of the modernity of the armed forces, has been the use of the IoT concept. At the same time, it is difficult to surprise with aerial or ground-based unmanned aerial vehicles and robotic combat vehicles today. As new technologies emerge, the range of tasks and capabilities of military «smart devices» is expanding rapidly, starting from solving complex tasks of enemy detection and ending with monitoring the physical condition of each serviceman. Today's technical capabilities for enemy detection and the availability of high-precision weapons force high mobility and quick decision-making. This is possible only if all units involved in the operation promptly receive information from various sources in real time. One way to solve this problem is to use solutions based on the IoT concept, which are called the Internet of Battle Things (IoBT). Currently, IoT technologies are already used to monitor the current situation on the battlefield, in logistical support, and medical support for troops. IoT devices have also found wide use in various educational and training programs in virtual combat mode. For Ukraine, which is forced to counter the aggressor, the implementation of the Internet of Battle Things in practice is very relevant. In conditions of high-tech confrontation, the one who is better equipped and uses advanced high-tech things in everyday practice has the advantage. The Ukrainian army already uses individual elements from the Internet of Battle Things sphere; "Military tablets", GPS navigation devices, wireless communication devices, unmanned aerial vehicles, etc.

Providing opportunities for students to choose elective courses to study should contribute to the individualization and differentiation of learning, taking into account the interests and abilities of students, the formation of their digital competence, and the ability to interact in a digital environment.

The use of online platforms has been increasingly used in the educational process in recent years. Google Classroom, Microsoft Teams, Padlet, and other online platforms allow students to discuss projects, develop teamwork skills, and, as a result, contribute to the development of communication competence.

An important component of the educational process is the interdisciplinary integration of the subjects «Technology», «Informatics», «Physics», «Mathematics», «Art»,

which provides an opportunity to form comprehensively digital competencies and ensure the transfer of knowledge and skills to other educational and life situations. Such a combination of educational subjects contributes to a deeper understanding of the principles of digital systems, the formation of algorithmic thinking and the ability to model in the process of implementing various projects.

In conditions of martial law, an unstable educational environment and unequal access to resources, the implementation of blended and distance learning, digital laboratories and virtual modeling platforms becomes particularly relevant. They ensure flexibility and continuity of the educational process, adaptability to different educational conditions, as well as the preservation of educational interaction even in the physical absence of students in an educational institution (Bieliaieva, 2023).

For the effective formation of digital competence of education seekers, it is important to use an activity approach, which involves solving real practical problems by students, carrying out creative projects, participating in collective or individual work focused on creating their own digital or technological product. In this way, the assimilation of new knowledge, the development of initiative, creativity, responsibility, the ability to cooperate and self-education are ensured - as the main components of digital literacy and technological culture of the individual.

In the digital educational environment, technology teachers are intermediaries between the digital environment and students, actively promoting comprehension, critical perception and responsible use of digital tools. The professional and communicative role of teachers becomes key in the context of the transformation of the educational process: they must have a high level of communicative culture, be able to create a positive atmosphere of cooperation and trust, and maintain dialogue and mutual understanding with each student. It is through personal example that teachers form in students the ethics of using technology, responsibility, and digital culture, which are the basis for safe and productive interaction in the information space.

An equally important factor in effective digital transformation is the ability of teachers to use model programs creatively and create their own original methodology. The digitalization of the educational process is not reduced to the mechanical use of ready-made solutions - it requires creative rethinking, pedagogical vision and the ability to adapt approaches to a specific context. Creative technology teachers develop microcourses independently, create digital tasks, projects, combine face-to-face and distance learning formats. This approach provides flexible adjustment of the educational process in accordance with the level of training of students, the

material and technical capabilities of the educational institution, the specifics of wartime or distance learning format. The author's methodology forms a unique teaching style that activates the cognitive activity of students, forms a stable motivation for learning and ensures the achievement of expected learning outcomes.

An important condition for high-quality digital education is the teachers' comprehensive knowledge of the subject. Teachers who have deep and systematic knowledge in the field of technology, understand the principles of functioning of modern equipment, software and technological processes, are able to explain to students how a particular digital tool works, show its connection with real production, engineering, economics. Pedagogical skills of teachers are also manifested in their ability to select digital tools reasonably in accordance with the topic, type of task, age and cognitive characteristics of students. It is digital technology that should enhance visibility, accessibility, individualization, control and self-control in learning. Professional intuition and digital flexibility make it possible to turn the use of technology into a powerful tool for pedagogical influence and student development.

Increasing the digital competence of teachers is a condition that allows ensuring the quality of education, its resilience to the challenges of wartime, its openness to innovation, partnership and development. This is primarily an awareness that modern teachers act as mediators, facilitators, organizers of the educational environment in which students acquire knowledge in conditions of an excess of information and are not always ready to interpret it critically and select it for learning purposes. Modern teachers must deeply understand why and in what way it is advisable to use digital technologies in order to enhance the cognitive activity of students, to form in them critical thinking, creativity, the ability to work in a team and solve problems independently.

Mastering digital tools should be accompanied by a change in the pedagogical worldview: from the traditional transmission of information to creating conditions for independent knowledge, research, design, and application in practical activities. Teachers become participants in an open digital space, where it is important to own the means of communication, be able to demonstrate and maintain professionalism, ethics, and pedagogical tact.

A deep rethinking of the role of teachers is also associated with responsibility for the digital security of education seekers, the ecology of the digital environment, the culture of using information resources, compliance with copyright, and the formation of digital ethics in students. In the new role, teachers creatively adapt technologies to

the educational process, develop original digital products, and construct educational situations where students demonstrate and develop their abilities. Such teachers are constantly learning, are in professional interaction with colleagues, and are looking for effective pedagogical solutions that meet the challenges of the time - in particular, the threats of war, the conditions of hybrid or distance learning, and the lack of resources (Tutashynskyi, 2021b; p.137). Improving digital competence is a path to the personal and professional transformation of teachers, to rethinking their educational mission in the age of digital technologies, instability, and rapid change. This is the ability to be modern, ready for change, responsible and value-oriented leaders of education seekers in the world of modern technologies. At the same time, professional support for teachers within the framework of cluster partnership, through internships, webinars, mentoring from IT specialists and industrial practitioners is important (Multilevel system …, 2025).

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