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Uneversity of Rzeszow
Faculty of Pedagogy
Department of General Education and Educational Systems
Ks. J. Jałowego 24 Street; 35-010 Rzeszów

Center for Innovation and Transfer
of Natural Sciences and Engineering Knowledge
Laboratory of Information Society Problems
Prof. S. Pigonia 1 street; 35-310 Rzeszów

tel. +48 17 872 1833, e-mail: keti@ur.edu.pl

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EDITORIAL

The Journal of Education, Technology and Computer Science 2023 consists of three main thematic parts, whose overall theme is the emergence of computer programmes called artificial intelligence.

In the first part, entitled *Selected Problems of School Education*, we get acquainted with articles presenting, among other things, the multimodality of socio--philosophical search, which consists in the identification of axiological types of contemporary methodology of cognition - i.e. philosophical axioms (in aspects of the philosophical vision of processes and phenomena having value in their genesis and development as objects of research). It concludes with the challenges and difficulties facing the teacher in the era of the spread of applications of artificial intelligence.

The second part, entitled *Selected Problems of Technical Education*, consists of papers presenting, among other things, solutions for the didactics of electrical engineering and its elements in the context of the digitalisation of education; a plan for updating and reconstructing the core curriculum in relation to technical education in primary schools in Slovakia. This part concludes with an article presenting the results of research on the development of technical skills of primary school students.

The third part, entitled *Selected Problems of IT Applications* in education, describes ethical problems of the development and applications of artificial inteligence; an analysis of trends in remote education; and risky behaviour of students during remote education. This section concludes with two articles on student programming education in the field of information technology.

Readers are encouraged to critically analyse and prepare polemical texts in relation to the diverse topics of educational research covered in the quarterly.

We dedicate this publication to the late Professor Mario Plenković (1947–2022) from University of Zagreb & University of Maribor Member of European Academy of Sciences and Arts (EASA)

He was Editor-in-Chief scientific journals: “Informatologia” (1980-2021) and “Media, Culture and Public Relations” (2001-2021). Mario Plenković, Ph.D., was elected as a full professor in Social Science scientific educational field; scientific field – Information Science in 1998 (University of Zagreb, Zagreb) and professor emerit.dr.sc. (2019) University of Zagreb and University of Maribor.

We are grateful that his chief idea was to build scientific bridges between rese-archers not only from European countries but also from around the world.

Editors and Authors

PART ONE

SELECTED PROBLEMS OF SCHOOL EDUCATION

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NATALIIA RIDEI[1], **NATALIIA TYTOVA**[2], **LIUDMYLA KANOVA**[3], **TETIANA SYDORENKO**[4], **NATALIIA ROMANENKO**[5]

Methodology of Scientific Knowledge of Educational Axiology of Europeanisation

[1] ORCID: 0000-0002-5553-059X, Ph.D. of Pedagogical Sciences, Professor of Ecology, Head of the Department of Management and Innovative Technologies of Sociocultural, Mykhailo Dragomanov State University of Ukraine, Kyiv, Ukraine
[2] ORCID: 0000-0002-9415-4427, Ph.D. of Pedagogical Sciences, professor, Head of the Department of vocational training, document science and public administration Mykhailo Dragomanov State University of Ukraine, Kyiv, Ukraine
[3] ORCID: 0000-0001-9371-1343, Associate Professor, Professor at the Department of Foreign Languages, S. Korolov Zhytomyr Military Institute, Zhytomyr, Ukraine
[4] ORCID: 0000-0002-3143-6769, Ph.D. (Philological), Associate Professor, Head of Department of Documentation and Information Activity State University of Information and Communication Technology, Kyiv, Ukraine
[5] ORCID: 0009-0001-5994-1943, Ph.D.-student Department of professional education, Mykhailo Dragomanov State University of Ukraine, Kyiv Applied College of telecommunications, Kyiv, Ukraine

Abstract

The concrete scientific methodology of sociological research expresses the system of prevailing ruling principles of theoretical concepts, techniques, methods and means of technical regulation, which unites the complex of theoretical and methodological basis and the architecture of the outline of the sociological field of sciences and knowledge, normalized by means of regulators of the system analysis in the quality of sociological research by levels: *high* – fundamental and philosophical foundations of sociological knowledge; *sufficient* – approaches, principles, techniques, methods of general scientific interdisciplinary and fundamental knowledge; *concretely determinative* – set of parametric evaluation in the methods and procedures of the social and philosophical technique of theoretical and applied research. The most used philosophical methods are analysis and synthesis, induction and deduction, abstraction, generalization and specification, observation and analogy, modeling and forecasting. In the perspective of social and philosophical study, the

above-mentioned methods of analysis acquire semantic application in the study of social and cultural objects of the organization in the field of education, science and innovation (namely, multidimensional analysis acquires the status of content analysis).

Keywords: methodology, methods, scientific knowledge, educational axiology

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General statement of the problem

The most widely used methods and techniques in social and philosophical analysis are often used from a micro-, meso, macro- to mega and social nature – fundamental-philosophical, general-scientific and specifically applied methodologies of system cognition and management of complex organized sociocultural forms. The use of a systemic approach makes it possible not only to systematically analyze the parametric metrics of complex and organized complexes, but also to investigate the semantics and development of social systems, to study the specifics of social objects, trends of their civilizational progress. Taking into consideration the systematicity, they study the peculiarities of the functioning of complex and organized systems as not only the set of complex and organized elements, but primarily from the entire integrity and systemic unity of component relations as well as in the integral properties and semantics of integral unity. The improvement of the systematic methodology in social and philosophical research involves a complex aggregation, which is used for cognition, observation and description, including the interpretation, content, structure and semantics of social objects, which in its turn, thanks to the complex approach, actualizes the methodological discourse of intelligence, consideration, generalization, systematization and characteristics of the integrity of objects of knowledge and qualitative sigmatization of social and cultural procedures of organization of educational and scientific systems in interdisciplinary studies - noospherology, methodology of scientific studies of sustainability, axiology of civilization development, mathematical modeling and forecasting of ecological and social and ecological systems with programming of their safety in uncertain conditions, political economy, public management and administration, cybernetics and cyber security.

Subject of research

The purpose of the study is to substantiate the methodology of the phenomenon of European educational axiology in the social and philosophical dimension.

To achieve the goal of the research, it is necessary to methodologically substantiate the need for knowledge and awareness of social and civilizational European educational axiology.

Analysis of recent publications

It is clarified that since the end of the 19th century, the modeling method has been used to study any processes and phenomena or complexly organized socio

cultural objects and subjects by designing and studying models as unified model analogues or simplified outlines with the purpose of application, definition or clarification mechanisms and techniques of the latest launched modeling objects. Along with modeling, the method of typology is used, i.e. the selection of partial social factors (phenomena, processes) or events from a defined set of social factors (phenomena, processes) or events in their similarity or diversity as balanced mechanisms of the formation of a generalized community, their most essential and typical characteristics (classification features such as Weber's theory of ideal types).

It has been clarified that the *structural and functional* analysis proposed by American scientists (Roach, Llewellyn, 1972; Merton, 1973) is an effective method of studying the architecture of socio-cultural systems with the structure and semantic content of the component composition both in partial as well as in the relations of functioning integral unity of the system. Also, a comparative analysis for the study of the outline, characteristics and trends of the vectorization of the development of socio-cultural systems (the genesis of epochs, national characteristics of peoples, the state division of countries, cultures of identity, civilizational progress) is specified using the *social-active method*, including – the cross-cultural method, to specify trends, relationships, interaction and completeness of cultural diversity both territorially and geographically, and in time dimensions, it is meant not only Western and Eastern cultural characteristics, but also the relationship of modernity and historical cultural types. These methods are the most widely used for theoretical justification in social and philosophical analysis. In social studies, it is important to establish an invariant component of social stability as a social system-forming element (T. Parsons called it a social society) (Roach, Llewellyn, 1972).

In applied aspects of socio-philosophical analysis, *special empirical methods* are used – analysis and generalization, social experiment survey, selective method and analysis of documents, observation, comparison, description, measurement, analogy. With the purpose of adequate description and characteristics, for the interpretation of the developing social object, the *method of operational closure* of the "Society" supersystem is used. Since, any human activity involves at least two-way interaction, which makes it possible to characterize it and distinguish inherent differences in spatio-temporal interaction. The holistic unity of natural interaction with the *method of causal reflection* contributes to the awareness of the peculiarities of social mechanisms, methods and origins of undefined active actions (or inaction) as causes, as well as feedback for the modernization of initial conditions and structures during the transition from one qualitative state to another (process reconstructions). In conditions of uncertainty, the method of the system theory of social organization becomes especially important – *the method of contingency*, establishing and perceiving that social objects may not

be primarily imaginary, unpredictable with unexpected transformations (contingency reflects the paradoxical nature of social processes and phenomena) (Kovbasyuk, 2011).

It has been specified that the uncertainty of conditions and their turbulence can cause events in society and form complicated crisis situations that do not meet the needs of civilizational development and lead to the impossibility of avoiding them at this stage. The structural and organizational dynamics of social systems involves the subordination of subordination elements and their hierarchical architecture of construction and structure. The principle of social subordination is used in the social and philosophical analysis of communities, groups, strata as structural elements of higher level organizational systems such as society. At the same time each of the structural components can be considered as subsystems, which are characterized by certain independence and independent semantic autonomy in a set of relationships, joint actions with other subsystem components. The complexity of interaction chains reflects not only inclusion in the multi-component and multi-level architecture of society, but also determines its systemic ways of transformation.

Since in the conditions of uncertainty, the study of social dynamics has a non linear character of variable social concepts, knowledge about social and structural transformations is made possible thanks to the activation of the reverse sequence of defined social events and situations in the process of re-competitiveness. It has been determined that *competitiveness* as a process and method is used in the study of social stratification dynamics of social development of structural components as factors of vectorization of progress and identification of social strata of innovators, entrepreneurs capable of positive social transformations. A turbulently changing society at the current stage of development is characterized by interaction and counteraction of multilayered trends of processes and phenomena, which aims for homeostasis and biosocial interaction in multimodes of multilevel and multifaceted commonality (constancy) of partnership, conflict crises, confrontation, alliances, associations, contradictions as a conglomerate, which can be studied using the *coherence method* (study of complex, contradictory atypical, paradoxical types of social systems – objects, processes, phenomena). The method is mostly effective in the methodology of Bourdieu's topology social studies (contributes to the study and interpretation of not only established, but also transformational topos. It makes it possible to systematically determine the limits of coherence in the links of objective positions taken by subjects of multidimensional social interaction. It's typical for subjects to be characterized by evaluation and interpretation from their own subjective positions in personal concepts of expectations, imagination, aspirations and hope or disappointment. In general, the most productive is the systemic unity of the heuristic possibilities of applying methodological potential in the methods of

social and philosophical research, which include the selection of heuristic methods for solving research, cognitive, and inventive tasks (Kovbasyuk, 2011).

Presentation of the main material

It has been revealed that the methodology of *social and philosophical research i*s a collective unity of methods, means, techniques, ways, mechanisms, procedures and algorithmized operations, determination of social factors and their philosophical analysis to establish parametric characteristics (level of quality, organization, functional features, potential), systematization, generalization, interpretation and presentation of the state and development of social and cultural systems.

It has been established that the methodology includes: sociological methods – identification, collection of empirical information during observation, survey, interview, analysis of documents, experiment and expert evaluation of the results of knowledge; methods of data analysis and processing – decomposition (division into components of systems, processes, problems, procedures); detection of direct and inverse relationships (between constituent elements of the object of analysis); classification (division of the set into components by characteristics); reduction (unification of the structure of the object to an elementary model); assessment (systematic research to characterize the elements of the object of analysis); formalization (representation of the results of thinking activity in definitions, statements); inference (mental linking of the multifaceted content of thought into a chain of consequences); logical induction (general conclusions); deduction (partial conclusions); conclusions of identification, logical formalization and analogization, from the opposite; normalization of weighted general and partial; correlation analysis (detection of interrelationship, interdependence, ratio of elements, their probability and statistical dependence); interpolation (determination of intermediate parameter values in the logical chain of statistical data); extrapolation (extension of conclusions regarding certain aspects to the problem (process) as a whole and to its further development); modeling (knowledge of objects, their objectification when building and studying the outlines of their models – structural, functional, organizational and logical); simulation (conducting experiments on a model of a real situation to establish spatio-temporal dynamics); planning “tree of goals” (structuring of the hierarchical architecture of the set of goals of the system, process, phenomenon, problems with the selection of strategic and tactical goals and operational sub-goals, decision trees as a scheme for displaying the decision-making process); expertise (substantiated professional conclusions and evaluations of experts on problematic issues); establishment and algorithmization of priorities in terms of terms and resource provision); heuristic (special non-formalized methods of solving tasks through productive creative thinking); elimination (elimination of signs, factors, indica-

tors-exceptions unrelated to the process, phenomenon); selection of relevant data for decision-making; representativeness of a complete unity (system, process, problem) in partial composites; taking into account the factors of uncertainty and risk (the probability of obtaining the desired results in the presence of sources and parameters of influence on the object of analysis); taking into account the human factor (Kovbasyuk, 2011). The most used used methods are: factorial, comparative, correlational, causal, ranking, structural-functional, structural--logical, structural-organizational; *theoretical methods of systematizationand taxonomy* of empirical results – genetic, cross-cultural, structural-semantic, genesis; mechanisms, methods, rules and techniques of selective research, social indicators, semiotics, scaling, procedures, indexing for measurement and grading, ranking and differentiation of dependent and autonomous classification features, construction of functional-correlation links of inherent characteristics; *qualitative methods* of social research to assess the qualitative characteristics of the originality of social objects (biographical, constructive personal and collective interviews, focus groups – discussions of a group of respondents on social issues, the study of consumer priorities regarding professional image, selection of services and services, informal observation, document analysis method); *social intelligence* is subordinated to the research program and strategy, the methodology of studying the specifics of social objects, established tasks and is adapted according to the features of the object and the subject of research, to the social and economic, ecological and institutional resource potentials of the academic staff; *verification of the effectiveness of the method* requires substantiation of the validity of the sampling procedures, proof of the representativeness of the selected sample, the use of pilot surveys for the correction and selection of means, tools and evaluation criteria apparatus.

The methodology of social and philosophical research includes the development and application of *social mechanisms* as a complex of interaction of social collectives and communities, constituent elements of social architecture, means and norms of technical regulation (social standards, guidelines, technical conditions), patterns of behavior, organization of institutions, thanks to the systemic activity of which is ensured functioning of sociocultural semantics of the system. It has been established that the functions and possibilities of regulation of social mechanisms are determined triadically, namely by the social statuses of subjects, individuals, collectives, communities, on the one hand, by the specifics of operating institutions, on the other hand, and by the dominant system of *prevailing value orientations* and moral, aesthetic, legal, environmentally safe social norms in the standards of behavior in society. It was determined that the architecture and semantics of social mechanisms inherent in a certain structural subsystem of the integral unity of the social system differ in their features, namely in the types of social activity as an established system of interaction of

social groups in the spheres of politics, production, culture, education, science and innovation, nature protection, security life and civilizational development, standardization, certification and licensing, legal and technical regulation, state and public administration, informatization and digitalization, defense and social protection of the population, including the distribution, exchange and consumption of material and spiritual goods, services and services; the system is regulated in historically established conditions in a specific state, types of culture, management systems and according to the socio-cultural potential of the social structure of society.

It has been clarified that the driving force of the functioning of the social mechanism is social and economic, ecologically safe, institutional, social and political, humanistic, religious axiological cultural orientations, needs and interests of social groups capable of regulating the personal and collective behavior of people in the above-mentioned spheres of social life.

It has been specified that the development of spheres of social activity when applying social mechanisms depends on the variety of configurations of the sociocultural architecture of society: the functional division of social layers and classes (according to professional, social and everyday, public purpose and persuasion of value orientations); geographical-territorial and administrative-territorial locations (regions, regions, cities, countries, continents), including organizational and managerial levels of population employment, specific social groups (professional, institutional, public, political, religious), which requires special application of designated social mechanisms, which with the dominant ones prevailing in certain spheres, determine the content, character and direction of social behavior of both individuals and collectives, and, in particular, the effectiveness of these spheres. The study of the social mechanisms of the development of society and its various structural components (specially designated, partial mechanisms) involves the fixation and support of effective functioning, the identification of the dysfunction of inhibitory factors, risk and danger factors in the spheres of social activity. Therefore both the optimal functioning of social mechanisms and the emergence in its implementation, destructive dysfunctions are ensured thanks to a systematic analysis of the factors of state formation and development of spheres of social activity in organic unity by social and economic, ecological, political, managerial factors in the development of production and other types of activity, the distribution of resources and consumption goods, as well as the social position of individual groups, which are the subjects of its effectiveness. The significant role of the social mechanism for the provision and development of social activity is that its results are the means of indirect action of management bodies, and mediated by the activity of social groups in the types of social and cultural organization and at the levels of its regulation. The main regulators of social activity are motivation, status, cultural identification, mana-

gerial coordination and subordination. The effectiveness of the social mechanism consists in the multifaceted mutual influence of direct reversible, tangential connections, which transform it into socially effective processes, and therefore the results of social activity are fixed at the output of the systemic process social mechanism and generalize the efforts of all representatives of social and cultural subjects in the spheres of social activity, from which the social well-being of future generations depends and based on sustainability.

A special place in the methodology of social and philosophical research is given to the method of collecting primary social and cultural information about the object of study and the application of the axiological approach in *sociological observations* regarding purposeful, systematic and direct visual and auditory monitoring (perception) and recording of significant, from the point of view of goals and tasks of cognition, social phenomena, processes, situations that are subject to control and verification. It has been clarified that social observations are classified according to their goals and tasks, the role of the researcher (observer) in studying situations and conditions, as well as the level of formalization of procedures, protocols, algorithms, applied methods, including the conditions of research organization.

The following types of observation are distinguished:

– unstructured (non-standardized) – a method of studying phenomena and processes, in which the object of observation is defined, but the observer does not determine in advance the elements of the process of events, situations and states that he plans to investigate (often used at the initial stage in order to identify problem situations);

– structured (technically regulated by standards) – a method of collecting empirical social information, in which the subject and object of observation, as well as the elemental composition of the process under investigation, are determined in advance, while taking into account its most important parameters for achieving the goals and tasks assigned to an observer or a scientific research group (often used for a reliable description of the subject of research and verification of the obtained results, thanks to other methods, for their correction and verification);

– external (non-involved) – the method in which the researcher is outside (from the side) of the object of research, without being included in the course of events, without participating in the surveys of the individuals for which it is carried out, and records everything that is happening in a detached manner according to the goals and objectives (applied to describe the situation that interests the observer);

– included (directly involved) – the way in which the researcher is to some extent directly involved in the study of the social process and directly contacts individuals and groups in joint activities;

– field – a method that is carried out in the natural conditions of a real life situation in the direct interaction of the observer and the object of observation;

– laboratory – a method of collecting empirical information in artificial conditions created for research and controlled by a research group;

– systematic – a method of research that is carried out consistently, systematically and promptly according to the calendar and thematic plan as well as schedule with regular recording of predetermined classification signs, processes, phenomena, situations and events, which contributes to the study of their dynamic;

– episodic – a method of recording phenomena, processes and events, which are investigated in the absence of formalized registration regulations in established time intervals, stages, periods of their course;

– random – a method of research that does not provide for predetermined terms of observation, parameters and indicators, and the observer records interesting factors and events from his point of view;

– one-time (one-moment) – a method of observation in which one event or phenomenon, or a process occurring in a specified location at a specified time, is recorded;

– panel – the process of repeated, time-determined research, which is carried out at specified intervals, systematically organized research of the object with the aim of establishing its transformation;

– controlled – a method that is carried out purposefully according to developed observation programs with the use of formalized plans and standard documents to obtain reliable information about the object of research and to verify research hypotheses (controlled by increasing the number of observers, intensifying the processes of a series of observations of the same object);

– uncontrollable – a method carried out by an observer when studying real life situations, states, processes without clear planning.

An important role is given to the documentation of research works, namely, providing observers with clear instructions, methods and specifically defined methods for conducting observations, including specifically defined criteria, fixation, indicators and parameters, ranking by categories, levels, degrees of phenomena, events in defined groups of communities or individuals who are being observed (fixation on observation cards with certain elements of the semantics of the situation or group behavior, digital indexes of reactions to events and their codification, thanks to which the digital data of empirical studies are transformed into cards of information and digital processing by technical means).

Conclusion

The multimodality of the socio-philosophical search is in the identification of axiological types of the modern methodology of cognition – philosophical axioms (in aspects of the philosophical vision of processes and phenomena of

value content in genesis and development as objects of research); social and cultural value orientations, dispositions and narratives (on the basis of axiological scaling of individuals, groups, communities, socio-cultural forms of organization of subjects in the field of education, science and innovation, axiological vectors of social and ecological orders for noospherologists capable of creatively transforming complex and critical situations of civilization development, axiological didactics of technical regulation of standardization, certification, licensing, labeling); bioethical and bioecological axioms of life activity, life preservation and life reproduction (value postulates of eternal existence, origin and restoration of biogenesis); theology and religious scraps (a priori proven perfect theological narratives of the Old and New Testaments, by analogs of Judaism, Hinduism, Buddhism, Islamism, partial and unified confessions); the policy of noospherology and qualitology of safety and the desired quality of life (postulates of constancy, supremacy of law, will, freedom of spirit, body, soul) – supremacy of spirit – Pantheon of Glory independent nations of the European Union.

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NATALIA RIEZANOVA

Innovation in the Context of the Modern Education Model

ORCID: 0000-0003-3094-4881, Ph.D. in Philosophy, Associate Professor, Associate Professor of the Department of Political Science and Law, National University "Zaporizhzhya Polytechnic", Zaporizhia, Ukraine

Abstract

The phenomenon of innovation and its significance for the modern model of education are subjected to scientific reflection, the semantic transformation of the concept of "innovation" and its modern understanding are analysed. It is noted that "innovation" is closely related to such categories as "new", "discovery", "creativity", and the process of innovation is a challenge to the needs of society. The article defines the content of innovation as a form of objectification of the new, which is assigned the status of a factor of social development, analyses the conditions for successful implementation of innovations and the formation of innovative thinking as a necessary component of modern education. The innovative orientation of thinking is analysed through the prism of social and pedagogical innovation processes and is considered as a property of a modern personality. It is innovative thinking that ensures the success of innovative activities, overcoming stereotypes, openness to learning new things and active use of new, non-standard ways of solving complex problems. As part of the learning process, innovative thinking is carried out at the cognitive and instrumental levels and enables the emergence of an innovative personality as a special quality of a person in the modern world.

Keywords: innovation, innovative culture of personality, innovative education, innovative personality, innovative thinking, innovative skills

General statement of the problem

Modern social development is impossible to imagine without innovations, which are a form of renewal of society at all its levels and a factor of general social development. Today, innovations are increasingly playing the role of the main tool for solving problems arising in society. Innovations, combining the achievements of science with production capabilities, meet the growing needs of society through the innovations created, and are a prerequisite for its development.

The globalisation of the world community and increased competition have led to the fact that the flow of innovations is becoming more focused and reproducible on a continuous basis, and the level of development of countries is being assessed by their innovation capacity. Overall, investments in science and innovation have been remarkably resilient in the face of the economic downturn (WIPO, 2022). In this regard, scientists have started talking about the transition of the most advanced countries of the world to a new type of civilisation development — innovative, which marks the next step in the progressive development of society, and in the future becomes a benchmark for the whole world.

The innovation sphere is directly related to the problems of national education systems and the search for an adequate new model of education that would develop innovative skills and lay the foundation for an innovative culture of the individual. The study of innovations allows formulating a science-based innovation policy aimed at creating social, economic and organisational conditions for the entire innovation cycle, which ensures the transfer of new knowledge to the manufacturing sector of the economy and other areas of the social system.

The relevance of this issue is determined by the accelerated processes of innovative development of the modern world, which outpace the possibility of their adequate scientific understanding. The process of cognition provides a holistic view of the object to the subject, makes it possible to understand its essence and generic meanings, optimising social practice. Possessing an arsenal of priority opportunities, it allows us to study even future fragments of reality. Understanding innovation as a complex phenomenon implies the need to solve a whole range of theoretical problems of understanding the essence of the phenomenon in order to achieve the main goal: “to know in order to prevent, manage, optimise” (Heiets, 2006, p. 186).

Subject of research

The theoretical understanding of the phenomenon of innovation as a modern form of objectification of a new and fundamental factor of social development gives an idea of the challenges facing modern education. The need to change the learning process and education as a social institution in a meaningful and technological way is becoming a necessity and a challenge of the times. The emergence of an innovative type of thinking is determined not only by the requirements of the present, but also by the peculiarity of future professional activity, which is characterised by the presence of non-standard situations, limited time for information recognition and decision-making, a state of high intellectual tension and constant readiness for maximum productive work. Clarifying the nature of the innovation process and its main features helps to understand effective ways of forming innovative thinking and innovative personality in the process of human learning at different stages of the educational process.

Analysis of recent publications

The special study of innovations began in the 30s of the XX century in the bosom of Western economic science. The founder of innovation issues was the German economist Schumpeter. Schumpeter's followers, who focused their research attention on the role of the economic effect of major technical and technological innovations, were a number of authors: Bernal, Van Dyne, Galbraith, Kleinknecht, Clark, Mensch, Southe, Freeman, and others.

Among the most significant scientific works of the last decade of the XX century on the study of innovations are the works of Ansoff, Oppenländer, Santo, Twiss, Waterman, Huczek and others.

The question of the role of innovations in the process of social development can be found in the works of Akhieser, Baburin, Kelle, Knyazeva, Kretov, Kryuchkova, Lapin, Lukov, Prigozhin, Sazonov, Sorokin, Turkin, Fonotov, Shkitin, Karpova and others. The issues related to innovation management were considered by Balabanov, Dergachova, Kruglova, Kryuchkova, Kuzhev, Nikolayeva, Rumyantseva, Salomatin, Utkin, Fathutdinov and others.

The problems of developing an innovative methodology were raised in the works of Dudchenko, Kryuchkova, Yakovlev. Works devoted to the analysis of the formation of the "new" – Knyazeva, Sheremet and Zelenin, Shumilin, Engelmeyer, Elfimov. Studies related to the analysis of the problem of discovery in the philosophy of science – Balabanov, Knyazeva, Kryuchkova, Maidaniv. A panorama of relevant studies is presented in the works of Bazhal, Heiets, Gerasimchuk, Ilyashenko, Kvasniuk, Lukinov, Zavgorodna, Liakh, Mokliak, Pazenko, Tabachkovsky, Shynkaruk, Sandiga, and others.

The theoretical works of scientists are quite substantial. They reflect the evolution of the doctrine of innovation and the methodological foundations of knowledge of innovation processes; global trends and patterns of innovation dynamics; reproductive and functional purpose of innovations; technology of innovation and decision-making; mechanisms for regulating innovation development, etc.

Presentation of the main material

A distinctive feature of the modern world is large-scale, rapidly unfolding innovative transformations. Today, the global community is purposefully striving for continuous renewal in various spheres of its life.

Looking back at the historical roots, it turns out that innovations were originally referred to as cultural phenomena that did not exist at previous stages of society's development, but which appeared at this stage and were consolidated in it both in a symbolic form and in changes in the ways and results of human activity. In the context of economic science, innovations were understood as a separate type of innovation – technical and technological innovations. The

researchers emphasised the ease of achieving economic effect when introducing technical innovations, and stressed the important role of scientific and technological changes in economic processes and socio-economic development of both society as a whole and a single enterprise. This explains the fact that in the scientific literature we are often confronted with a narrow interpretation of innovation, when the scientific and technical aspect dominates the understanding of innovation, which relates to the creation and production of new products, innovations in technology that contribute to the rapid achievement of commercial effect.

Innovations have accompanied humanity throughout its history, but they have long remained outside the scope of scientific research and became an object of study relatively recently, at the turn of the 19th and 20th centuries. It is to this time that the category of "innovation" and its further development and semantic enrichment dates back. Innovation (from the late Latin «innovatio» – innovation, novelty) in the broadest sense of the word means a new way of doing something. The concept of innovation includes discovery – an increase in knowledge and invention – a new way of using existing knowledge. The term «innovation» was first used in anthropology and ethnology in the 19th century and originally meant the process of introducing elements of one culture into another.

Innovations that take place in one area of society can cause completely unexpected changes in other areas. As a necessary condition for change, innovations are playing an increasingly important role in our lives. There is even a new scientific field called "innovatics", the most important problem of which is the study of the processes of spreading innovations. The process of spreading innovations within a social system, as well as their movement between subsystems, is called diffusion. While in the past the process of spreading any innovation took several centuries, at the end of the XX century the development of communication means and the removal of information barriers contributed to a sharp acceleration of diffusion processes. For example, the «great diffusion leap» of the late twentieth century was associated with the development of computer communication networks.

American researcher Drucker (2020) identified seven main sources of innovation: 1) an unexpected change in the situation, someone's success or failure, a reaction to an unforeseen external influence; 2) a discrepancy between the changes in reality and people's perceptions and expectations; 3) identification of shortcomings in the course, rhythm, logic of a process; 4) changes in the structure of production or consumption; 5) demographic changes; 6) changes in the public consciousness (moods, attitudes, values); 7) the emergence of new knowledge.

However, not every emergence of new knowledge causes a diffusion process. A huge number of inventions in all spheres of society are simply ignored. An analysis of several hundred large-scale technical innovations over the past

two centuries shows that there is a time lag (lag) of 15 to 40 years between the invention and the start of diffusion. Moreover, one or more successful implementations (innovations) does not guarantee further diffusion. Therefore, it is proposed to distinguish between the triad of invention, innovation and diffusion, understanding innovation as the process of initial implementation of an invention. Inventive and innovative activities provide the potential for change. Only the process of diffusion transforms this potential into a change in social practice.

Drucker believes that the time gap between the birth of new knowledge and its adoption is approximately 25–30 years. This pattern has remained a stable constant throughout the history of civilisation and is probably inherent in the nature of knowledge. His concept of the evolution of science as a change of paradigms – ways of posing problems and methods of solving them – is widely used in innovation. A number of scholars propose to distinguish innovation from simple improvement, local improvement. An innovation requires a set of organisational and technological changes, reorganisation of the production process, staff training, and behavioural changes.

Today, innovations in the educational process are most often understood as: non-standard lessons; individual work; control and assessment of students' learning achievements (through quizzes, tests, assignments, workbooks, etc.); classroom, group and additional learning; electives of students' choice (deepening knowledge); problem-based and modular learning; inviting scientists, cultural and artistic figures to lessons; economisation and environmentalisation of education; scientific experimentation when learning new material; application of technological advances (from slides, through films, tape recorders, televisions to computer-based learning, computer classrooms, radio and television broadcasts and «Internet systems", multimedia technologies, etc.) (Petruk, 2019, p. 5).

The specificity of innovations in various spheres of society makes it difficult to formulate a single definition that is convenient for all cases. However, the scientific literature identifies five main stages of the innovation adoption process (Figure 1).

The speed of innovation is also determined by five main factors: the relative advantages of the innovation; compatibility with the environment, existing values and past experience; complexity of adoption; the possibility of testing before making a final decision; and communication visibility, the degree to which the results of the innovation can be seen and evaluated by others.

In addition, the effectiveness of innovations is largely determined by social determination, i.e. the extent to which society is ready to accept the innovation. The society may be eager for change, but it may also be tired of the confusion caused by the previous innovation. Demand for innovation also depends on the phase of the social system's life cycle. As already mentioned, the problems of

researching innovations are extremely relevant for the modern economy. According to economists, diffusion of innovations is the process of transferring innovations through communication channels between members of a social system. Innovations are ideas, products, solutions, technologies, etc. that are new to a given business entity. The form and speed of the diffusion process depend on the power of communication channels and the peculiarities of information perception by the subjects.

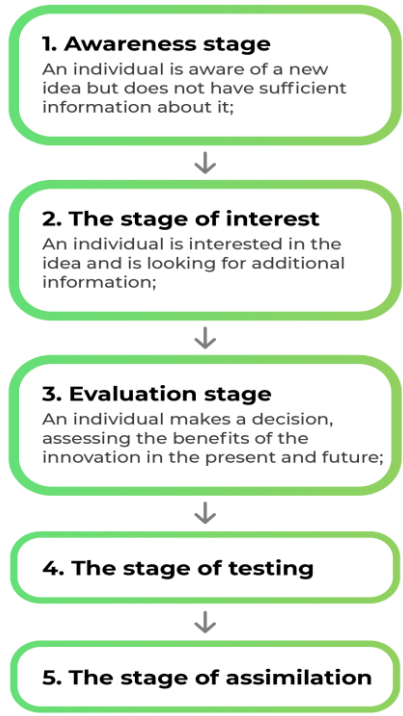

Figure 1. Stages of the innovation adoption process

Critical thinking is regularly cited as an essential 21st century skill, the key to success in school and work. Given the propensity to believe fake news, draw incorrect conclusions, and make decisions based on emotion rather than reason, it might even be said that critical thinking is vital to the survival of a democratic society. Haber explains how the concept of critical thinking emerged, how it has been defined, and how critical thinking skills can be taught and assessed. Haber describes the term's origins in such disciplines as philosophy, psychology, and science. He examines the components of critical thinking, including:

- structured thinking,
- language skills,

– background knowledge,
– information literacy, intellectual humility,
– empathy and open-mindedness (Haber, 2020).

The processes of transition from initial uncertainty to further conviction and individual risk perception also play an important role. Too many fast, underdeveloped innovations do not have the expected effect and sometimes cause significant harm. In the postmodern era of total simulation and imitation, the worldview and intellectual self is of utmost relevance (Levkulych, 2022, p. 142).

In the late twentieth century, innovation was understood as a process of fundamental research that resulted in innovations, and then a process of applied research that resulted in innovations – the introduction of new methods, technologies, and products.

This model mainly deals with formal or explicitly defined knowledge obtained in the process of basic research. In this model, basic research is located at the beginning of the causal chain that ends with productivity growth. Basic research produces theories and discoveries that are redefined in applied research, then tested in the development process and then marketed as industrial innovations and put into use. Each level of the linear model produces an output that is passed on as input to the next level. The flow of knowledge is unidirectional, meaning that later stages do not provide input to earlier stages. The model suggests that the boundaries within which basic research is conducted have a significant impact on the possibilities for technological innovation.

However, the debate about the structure of the innovation process itself that has emerged at this time has sharply criticised the classical linear model of innovation and its basis, which is the primacy of science with basic research and the secondary nature of applied research of an empirical nature.

It is now becoming increasingly clear that the linear model of innovation, which assumes a causal relationship between scientific knowledge and innovation, is the exception rather than the rule, and is more appropriate for industrial societies. Innovations are not exceptional events that occur only under very specific circumstances. On the contrary, they should be understood as a natural way of gaining competitive advantage. Innovation is to some extent a ubiquitous phenomenon that can occur at any time in all areas of the social system.

Innovations cannot be reduced to the creation of new scientific knowledge. On the contrary, they represent a multifaceted (multisectoral) process that includes the production, acquisition and dissemination of new knowledge, experimentation with new combinations of knowledge, development and design of a new product and technological process, copying and adaptation of existing innovations, etc. New scientific knowledge will not automatically lead to in-

creased innovation. On the other hand, innovation does not always require the emergence of new scientific knowledge.

Innovation is an ambiguous and highly uncertain process. Coping with uncertainty by gathering additional information and knowledge can be seen as an inherent characteristic of innovation processes. Therefore, innovation cannot be understood as a rational process with a clear sequence of stages. On the contrary, a complex feedback mechanism should be taken into account. In such non-linear processes, individual innovation activities can be both a cause and a result, a consequence and a precondition.

Conclusion

The most important characteristic of modernity is innovation processes that permeate all spheres and levels of social reality. Innovations are a prerequisite for the development of society, combining the achievements of science and production capabilities, and they meet social needs through the innovations they create. In order to stay afloat in the information age, it is not so much necessary to acquire once and for all established knowledge as to master the skills of searching, managing, analysing and classifying this knowledge.

The need to develop innovative thinking, characterised by creativity, criticality, constructiveness, and a combination of intuition and rationality, is coming to the fore. The synergy of several ways of thinking has the greatest social effect, although this phenomenon is quite rare and occurs in only 4-5% of the population. Innovative thinking itself cannot emerge without effort. It is born only when human thought overcomes certain obstacles, i.e. contradictions. A person, not having a special way of thinking to overcome obstacles by nature, tries to find a new, special method of solving them when faced with them. The consolidation of innovative skills within the modern model of education provides an opportunity to master the methods and techniques of innovative activity that allow you to identify a problem, penetrate its essence and, on this basis, construct and productively solve complex, non-standard tasks. This cannot be achieved without an innovative environment – an appropriately organised space of life that promotes the development of an individual's innovative resource. It is into such an innovative environment that the modern educational process should be transformed.

To truly master innovative thinking as well as innovation methods, it is important that pupils and students solve both educational and practical problems. They should become participants in innovation processes. This is the main difference between innovations in new generation education systems, which in turn determines their technological parameters. The development and implementation of innovative educational systems and technologies is a complex but extremely relevant problem of the modern education model.

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EWA TŁUCZEK-TADLA

Involvement of Young People in Extracurricular Activities in General Education Secondary School – an Opportunity for their Balanced Development

ORCID: 0000-0002-9361-0099, Ph.D., University of Rzeszów, College of Social Science, Institute of Pedagogy, Department of Social Pedagogy, Poland

Abstract

The article addresses important issues related to the daily educational experiences of Polish secondary school students. In the first place it focuses on the general concepts conveyed by the title, such as balanced development, extracurricular activities, and volunteering. The theoretical and exploratory purpose as well as practical and implementation related goals have been formulated. The main research problem was defined as follows: What was secondary school students' involvement in extracurricular activities in school, in the context of their opportunities for balanced development? The study applied a method of diagnostic assessment, a survey technique and a specially designed questionnaire. The survey was conducted in May and June 2022 among 286 secondary school students in the Podkarpackie Region. Majority of the respondents did not engage in extracurricular activities. The students who were involved in some kind of extracurricular activity most often perceived various gains for themselves. The most popular were volunteering projects organised by the school. The students reported that involvement in extracurricular activities most often allowed them to gain knowledge, develop skills and help other people. The gains perceived by the respondents can contribute to their balanced development.

Keywords: involvement, youth, general education secondary school, balanced development, extracurricular activities

Introduction

Many questions related to the issues addressed in the article, have previously appeared in the literature. One of these is as follows: "Is there room for a democratic transition in the Polish school and where could such change be most visible?" (Tłuczek-Tadla, 2022, p. 84). Certainly, young people's participa-

tion in non-curricular activities at school is an important sign of its democratisation and at the same time it is an opportunity for them to acquire knowledge, and develop various skills or necessary social competences.

By engaging in different areas of life, e.g., in personal, public or even political spheres, an individual gains opportunities for all-round development. This is particularly important during adolescence, as this is the period when the individual is growing to reach full maturity. "This stage can be named (…) the age of transformation" (Ziółkowska, 2005, p. 379). Bardziejewska (2005, p. 346) points out that "The young person begins to collect and seek out new physical, social and intellectual experiences in order to be able to sort them out and consolidate them into his/her own models and patterns that better prepare him/her for adulthood (...) This rediscovery of the self (...) is referred to as the process of forming one's own identity". The same author continues, "This takes place in two dimensions: personal and social" (Bardziejowska, 2005, p. 346). From the viewpoint of an individual's development, these two dimensions are equally important, as they guarantee harmonious and also balanced development. Hence, "For a developing individual, defining a personal identity means choosing goals, values, beliefs, interests, needs, a way of thinking and evaluation criteria that can be shown to the world as one's own" (Bardziejowska, 2005, pp. 346–347). Furthermore, formation of identity on the social level, "(...) involves determining which group a young person belongs to, who he/she relates to, and who he/she is accepted by" (Bardziejowska, 2005, p. 347).

The development of identity on a social level, however, is often difficult for contemporary youth. In her conclusions to her research focusing on secondary school students in the second half of the 1990s, Świda-Ziemba (2000, p. 545) wrote, "Young people feel «separate» and «different». They do not feel that they belong to a generation that in their perception would be some kind of entity in which they participate". As regards a connection with school, the attachment in many cases is not strong. The author elsewhere points out that the school is: "(…) the first battleground for institutional success (…). In their expectations towards the school, they are like «clients»„ (Świda-Ziemba, 2000, p. 247).

The term balanced development, or "sustainable development", is understood as "the socio-economic development of modern societies which meets their needs without compromising the ability of future generations to meet their needs. To implement the idea of sustainable development it is necessary (…) to recognise that economic, political, and social factors are inter-related" (Affelt, 2023). The requirement to attribute similar importance to the various factors is particularly significant from the perspective of the issues addressed in the article. Especially social and economic factors can be of interest. It is therefore worthwhile to review in more detail extracurricular activities in secondary schools, what they might involve, and what gains for balanced development adolescents derive from them. Theoretical considerations will cover issues related to extracurricular activities at

school, including e.g. special interest groups, volunteering and various organisations in which students can engage after classes. Obviously, extracurricular activities available to students at school are greatly varied, depending on many factors beyond the control of the school authorities and teachers.

According to the Act of 14 December 2016 concerning *Education Law*: "The essential forms of teaching and educational activities in schools include:

1. compulsory educational activities (…),

7. activities intended to foster students' interests and talents, in particular with a view to promoting their participation and creativity" (Act of 2017, Art. 109, item 59).

Kantyka points out that "by seeking to ensure comprehensive development of each student, the school creates conditions for their success, taking into account their individual capabilities and interests. This is facilitated by extracurricular activities on offer at school. The main purpose of extracurricular activities is to support schooling (…), and in particular:

– to enable the all-round development of students showing interest in a specific domain" (Kantyka, 2016, p. 3).

The current level of young people's participation in extracurricular activities in and out of school has been assessed and reported by Feliksiak and Omyła-Rudzka (2022). According to the authors: "Participation in extracurricular activities is slightly lower than in 2018. As was the case at that time, the most popular are private lessons in school subjects; these are attended by more than half of the respondents (53%). Slightly fewer students attend foreign language courses (decrease from 38% to 35%) and sport activities (decrease from 36% to 33%) (…). The most significant decrease was found in attendance of artistic educational programs, which currently is reported by 11% of the respondents, compared to 16% in 2018" (Feliksiak, Omyła-Rudzka, 2022, pp. 178–179). The authors also point out: "Participation in most types of extracurricular activities is far more frequently reported by students of general education secondary schools, compared to students of technical or vocational secondary schools" (Feliksiak, Omyła-Rudzka, p. 179). It has been shown that "Preferences with regard to extracurricular activities are related to the respondents' gender. Girls more often than boys attend private lessons, foreign language courses and artistic workshops, whereas boys are more likely to engage in activities related to sports and computer science" (Feliksiak, Omyła-Rudzka, 2022, p. 180). Notably, three in four respondents believe that the consent of the school principals and the parents' council is sufficient for non-governmental organisations to conduct extracurricular activities in schools (Feliksiak, 2023).

Another area for theoretical consideration is related to volunteering opportunities at school. This is a type of altruistic long-term activity. Kata (2017, p. 4) points out that "This form of activity is understood as an initiative and operation

whereby young people provide support to others – their peers, people in need or the local community". Young people who volunteer to engage in some projects are driven by a number of motives, including the need to participate in the life of a peer group, to gain recognition from others, or to find ways to learn and develop new skills (Kata, 2017, p. 7). Obviously, volunteering programs organised at school are subject to the related legal regulations. It should be pointed out that "The Act on Public Benefit Activity and Volunteering (Chapter III «Volunteering») is the basic legal regulation applicable to volunteering programs. It defines such issues as:

- who is a volunteer,
- who can benefit from services rendered by a volunteer,
- rights and obligations of a volunteer,
- rights and obligations of a beneficiary" (Komosa, 2022, p. 15).

The rights and obligations of the student as a volunteer are also an important issue. Students are entitled to receive a written certificate of volunteering, and an opinion about their performance; they are also entitled to have their volunteering activity acknowledged on the school certificate (Komosa, 2022, p. 17). The rights are particularly important for their involvement in volunteering programs because secondary school students can be motivated this way to undertake this type of activity.

Object of the study

The present study was designed to investigate young people's participation in extracurricular activity in general education secondary school as an opportunity for their balanced development. The extracurricular activities taken into account in the study included: school choir, school newsletter, scout team, school theatre, photography club, girls' shawm orchestra, Polish Red Cross, School Centre for Volunteering Projects, School Film Club, School Caritas Club, School PTTK Club, Students' Sports Club and other activities of this type, which could be reported by the respondents.

Methodology and object of the study

The theoretical and exploratory purpose of the study was to review the related literature and to obtain respondents' opinions about their involvement in extracurricular activities, as an opportunity for their balanced development. On the other hand the practical and operational purpose was to draw conclusions from the present study and formulate pedagogical recommendations for school principals, teachers, and counsellors as well as for secondary school students.

Subsequently, research problems were specified. The main problem was formulated as follows: What was secondary school students' involvement in extracurricular activities in school, in the context of their opportunities for ba-

lanced development? To enable more detailed exploration of the main problem, the following specific problems were defined: What are the respondents' preferences related to extracurricular activities at school? What justifications do respondents give when expressing their willingness or unwillingness to attend extracurricular activities at school? What types of extracurricular activity at school are most often reported by respondents? How often do the students participate in extracurricular activities at school? What personal gains resulting from participation in extracurricular activities at school do the students perceive?

Since the study was designed as a diagnostic assessment, no working hypotheses were formulated. Consequently, no hypotheses were formulated and the study was treated as explanatory and exploratory research. Quantitative approach was applied (Sułek, 2002; Rubacha, 2008; Pilch, Bauman, 2010). The research strategy and method of diagnostic assessment were selected to match the formulated purpose of the study (Łobocki, 2000). A specially designed survey questionnaire was used. The article will only present the findings related to the characteristics of the research sample and to the issues corresponding to the main and the specific problems. The survey was conducted between 4 May and 15 June 2022 among 286 students of general education secondary schools in the Podkarpackie Region, more specifically in Rzeszów, and in one school in the Przeworsk District.

Elaboration (analysis of the study results)

The following analysis of the study results will focus on the above specific problems.

Participation or lack of participation in extracurricular activities in secondary school and the student's justification of this fact

The respondents were asked: *Do you like to participate in extracurricular activities of interest for you at school?* The results are shown in Table 1.

Table 1. Respondents' preferences with regard to participation in extracurricular activities of interest for them at school

Item	Response category	Responses (in numbers)	Responses (%)
a	Yes	73	25.53
b	No	192	67.13
b	No data	21	7.34

Source: results of the present study.

Most secondary school students do not like to participate in activities that are not compulsory and require voluntary engagement after school. Analysis of the justifications given by some students next to their responses may provide an explanation. The justifications are listed in the following table.

Table 2. Types of respondents' justifications for their unwillingness to participate in extracurricular activities of interest to them organised at school

Item	Types of responses	Responses (in numbers)
a.	No time	49
b.	There are no such activities	27
c.	I am not interested in that, I do not like it	21
d.	I attend private lessons	8
e.	I do not feel like it	6
f.	I prefer to relax	6
g.	Waste of time, boring	4
h.	I like to do things on my own	4
i.	I do not know if there are such activities	4
j.	No transport back home	4
k.	Not all activities provide opportunities for comprehensive development	2
l.	Compulsory activities at school are enough	2
m.	They are suspended	2
n.	I prefer to spend time outside school	1
o.	A lot of lessons and homework	1
p.	Large groups are stressful for me	1
r.	I do not like contacts with people from my school	1
s.	I am not interested in anything	1
t.	I do not have to	1

Source: results of the present study.

Most often, the students justified their lack of willingness to participate in extracurricular activities at school by saying they did not have time for that. Other types of responses could of course be included in this category but respondents put it this way. Furthermore, many respondents definitely did not know what was going on in their school as regards extracurricular activities. The respondents may have referred to the time when remote learning was organised at school and some activities were suspended and were not continued without the contact in person. This suggests that some students do not pay sufficient attention to this area of school operation, and teachers do not provide comprehensive information to students about the current options related to such activities. The respondents also justified their lack of willingness to participate in this type of activities by saying that they were not interested because, in many cases, they preferred to attend activities organised outside school (frequently private lessons), or they simply want to relax.

Respondents who ticked the answer "yes" were also asked to provide justification.

Table 3. Types of respondents' justifications for their willingness to participate in extracurricular activities of interest to them organised at school

Item	Types of responses	Responses (in numbers)
a.	I want to get better in things which I am passionate about/which are interesting for me	28
b.	They are interesting	18
c.	One can learn something	16
d.	I like to meet people	6
e.	I like sports and I take part in such activities	2
f.	It is great	2
g.	That is something new/interesting	1
h.	Good atmosphere	1

Source: results of the present study.

In this case, students provided fewer justifications simply because a willingness to participate in extracurricular activities was expressed by significantly fewer respondents. The findings show that most students want to engage in such activities because this way they can improve in the cognitive sphere (knowledge, skills, hobbies, things they are passionate about), and because it is interesting. It was far less common that they justified their preferences by referring to the opportunity to improve their interpersonal relations and to spend time in places with a friendly atmosphere.

Respondents' involvement in extracurricular activities in secondary school and their justification of this fact

The students were not only asked whether they liked to participate in extracurricular activities but also if they actually participated in such activities. The question was as follows: *Do you participate in extracurricular activities at school, for example in organisations, volunteering programs, etc.?*

Table 4. Respondents' participation in extracurricular activities at school, e.g., in organisations, volunteering programs, etc.

Item	Response category	Responses (in numbers)	Responses (%)
a	Yes	70	24.48
b	No	207	72.37
b	No data	9	3.15

Source: results of the present study.

Majority of secondary school students (nearly 3/4) do not participate in extracurricular activities. It seems understandable in the context of the data shown in Table 1, reflecting the fact that the majority of the respondents do not like to participate in extracurricular activities which would constitute a significant part of their activity after school. In this question the respondents were asked to give justification to their choice.

Table 5. Respondents' justifications for their unwillingness to participate in extracurricular activities at school, e.g., in organisations, volunteering programs

Item	Types of responses	Responses (in numbers)
a.	No time	45
b.	I do not feel like it	8
c.	I am interested in other things	4
d.	Little time for other things than studying	3
e.	No activities are interesting for me	3
f.	There are no frequent activities promoting participation	3
g.	Problem with transport	3
h.	No such activities	2
i.	I attend activities outside school	2
j.	A break from studying	1
k.	Meeting new people	1
l.	Students are not always informed about these	1
m.	I do not know	1
n.	There were none	1
o.	Large groups are stressful for me	1
p.	I do not like contacts with people from my school	1
r.	I am not interested in anything	1
s.	I do not have to	1

Source: results of the present study.

The data shown in Table 5 show that most students justified the fact they did not participate in extracurricular activities at school by saying they did not have time for that. These findings are very similar to the result presented in Table 3. Far fewer respondents reported that they simply did not feel like doing that, or that no extracurricular activities on offer at school were interesting for them. Very few respondents pointed to a problem with transportation back home, and mentioned the fact that if they came back home late they would not be able to prepare for the next day at school, or to relax properly after school.

Secondary school students who engaged in extracurricular activities in their schools gave the following justifications.

Students who were involved in extracurricular activities most frequently pointed out that they could help other people this way and they simply liked such activities. Other respondents wrote that by doing that they were investing in their growth, mainly in the cognitive sphere, i.e., they could get better in things they were passionate about, improved their knowledge and skills and were doing things that they were interested in.

Variety of extracurricular activities in general education secondary school

Students could also tick many types of extracurricular activity which may be available in schools. The respondents marked those activities which were on offer in their schools, and – more importantly – which they found interesting.

Table 6. Respondents' justifications for their willingness to participate in extracurricular activities at school, e.g., in organisations, volunteering programs

Item	Types of responses	Responses (in numbers)
a.	Helping others	19
b.	I like it	8
c.	Getting better in things which I am passionate about, in my knowledge and skills	6
d.	Interesting	4
e.	Getting to know new environments	2
f.	It's great	2
g.	Volunteering is extremely valuable	2
h.	I participate outside school	2
i.	I was encouraged by my school mates	1
j.	I like sport	1
k.	Involvement in social activity	1
l.	New experiences	1
m.	I like working with people	1
n.	I wanted to do something at school	1
o.	Additional grade	1
p.	I need that for my scholarship	1
r.	Impact on the environment	1
s.	I have nothing to do	1

Source: results of the present study/

Table 7. Types of extracurricular activity in general education secondary schools

Item	Response category	Responses (in numbers)
a.	School Choir	7
b.	School Newsletter	25
c.	Scout Team	4
d.	School Theatre	10
e.	Photography Club	6
f.	Girls' Shawm Orchestra	0
g.	Polish Red Cross	7
h.	School Centre for Volunteering Projects	23
i.	School Film Club	20
j.	School Caritas Club	26
k.	School PTTK Club	3
l.	Students' Sports Club	17
m.	other activities (	7
	No answer	158

Multiple responses were allowed
Source: results of the present study.

As shown in Table 7, students who reported they engaged in activities at school (nearly 1/4 of the group) marked various types of activities. Most commonly, however, the respondents engaged in volunteering projects in the frames of School Caritas Club, or School Centre for Volunteering Projects – a total of 49 responses. Other responses selected by the students were mostly related to

clubs or group activities allowing them to pursue their interests. These include: School Newsletter, School Film Club, Students' Sports Club, and School Theatre. The respondents least frequently engage in activities of School PTTK Club and Scout Team.

Students about the frequency of their participation in extracurricular activities

Students who engaged in extracurricular activities at school were also asked how often they participated in such activities. The data are shown in the following table.

Table 8. Frequency of respondents' participation in extracurricular activities at school

Item	Response category	Responses (in numbers)	Responses (%)
a	Always, whenever it was possible	51	17.83
b	Yes, fifty-fifty (at times – yes, other times – no)	39	13.64
c	Rarely, I used far less than half of all the opportunities	22	7.69
d	No data	174	60.84

Source: results of the present study.

Less than one in five students who engaged in some extracurricular activities at school reported they did that whenever it was possible. More than half of the respondents did not provide answers to this question, and the remaining approximately 20% of the study participants admitted they did not engage in these activities regularly ("yes, fifty-fifty" or "rarely"). Generally the results show that the students did not engage regularly in extracurricular activities at school.

Gains for secondary school students from participation in extracurricular activities

Respondents were also asked an open-ended question about their personal gains from engaging in various extracurricular activities at school. The gains reported by the students were analysed and divided into the following categories, shown in the table below.

Some respondents reported only one personal gain, others listed a few benefits. Students most often mentioned those benefits that contributed to their personal growth, such as acquisition of new knowledge or skills, or achieving a higher position at school (better opinion about their conduct). Respondents also acknowledged that such engagement provided opportunities for helping others and for making new friends with people their age (perhaps not only the classmates) or for spending their leisure time in interesting ways.

Table 9. Gains perceived by the respondents, resulting from participation in various extracurricular activities at school

Item	Response category – ordered according to the frequency of the specific answers	Responses (in numbers)
1	Personal growth, self-realisation	19
2.	Helping others	19
3.	Better grade for conduct on the certificate	16
4.	Meeting new people of the same age	15
5.	Gaining new experiences (knowledge, skills)	11
6.	Interesting ways to spend free time	10
7.	Gaining experience in team work	5
8.	Being active, participating in something, doing some work	4
9.	Doing what one wants	2
10.	Opportunity to acquire qualifications	1
11.	Getting to know the world	1
12.	Getting to know oneself	1
13.	Learning to be responsible	1
14.	Overcoming stereotypes	1
15.	Learning to organise one's free time	1
16.	Satisfaction	1
17.	Temporary absence of stress	1
18.	Time off from lessons	1
	No response	87 individuals

Source: results of the present study.

Conclusions

Based on the current findings as well as the purpose of the study, and the main and the specific problems formulated herein, it is possible to present the following conclusions.

In the first place, the theoretical and exploratory purpose was achieved through the review of the related literature and the analysis of the respondents' opinions concerning the object of the study. As regards the practical and implementation related goals, the following conclusions have been formulated covering the specific problems:

1. Majority of the respondents do not like to engage in extracurricular activities at school.

2. Respondents who do not want to participate in extracurricular activities at school most often justify their opinion with the lack of time and lack of desire to get involved. On the other hand, the students who like to participate in these activities explain that, in this way, they can pursue their hobbies, and interests, and that they are curious to see what happens during such activities.

3. Similarly, the majority of the respondents reported they did not participate in extracurricular activities at schools.

4. According to their justifications, the respondents did not engage in extracurricular activities due to the lack of time and because they did not feel like doing that, or because they were interested in other things. Those respondents

who participated in such activities wrote that this was an opportunity to help others, and that they liked this type of activity.

5. The respondents most commonly engaged in various volunteering programs at school.

6. Most students did not participate regularly (i.e., whenever it was possible) in extracurricular activities at school.

7. The respondents acknowledged various personal gains resulting from activities undertaken at school. Those mentioned most often included the benefits for one's personal growth, as well as the opportunity to achieve higher academic position at school (better grades for conduct), and to make friends with other school mates.

Hence, it is possible to say that young people's engagement in extracurricular activities at school contributes to their balanced development. This final conclusion is mainly based on the type of activities in which the respondents engage, and the gains from these activities reported in the survey.

By reference to the practical and implementation related goals, the following pedagogical recommendations have been formulated for the specific entities.

Pedagogical recommendations for principals of general education secondary schools, teachers and counsellors:

1. It would be advisable for secondary school principals, teachers and counsellors to draw attention to the importance of young people's extracurricular activity at school in the context of the gains for their growth, especially for their balanced development. Teachers/tutors and counsellors could initiate discussions about this during weekly form meetings or individual meetings with students.

2. It would also be worthwhile to assess the needs of secondary students related to activities of various types presenting opportunities for adolescents' involvement after classes. Based on such assessments, decision-makers should adjust the available extracurricular options to match the students' actual expectations. It is also important to ensure that such activities are conducted in an attractive way.

Pedagogical recommendations for students:

1. It would be advisable for students to independently initiate discussions, e.g. during weekly form meetings and other events, about what is going on at school, mainly with regard to extracurricular activities.

2. It would be a good practice for students to share information with their schoolmates, e.g., during weekly form meetings or other events, about their personal gains from participation in volunteering programs, science clubs, scout team and other activities after classes. Some young people may be more easily and successfully encouraged to participate in such activities by their peers than by their teachers or school counsellors.

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SLAVOLJUB HILČENKO[1], **SANJA NIKOLIĆ**[2]

Child: "I don't Understand – We didn't Learn that in Kindergarten!"

[1] ORCID: 0000-0003-2123-6285, Ph.D., College for Vocational Education of Preschool Teachers and Coaches, Subotica, Serbia
[2] ORCID: 0000-0001-9632-2458, Ph.D., College for Vocational Education of Preschool Teachers and Coaches, Subotica, Serbia

Abstract

By the end of 2022, Serbia transformed its preschool education system, transitioning from a traditional approach to a project-based learning approach. However, if this transformation remains limited to preschool education without coordinated changes in learning at lower (and even higher) grades of elementary school in the next 4–8 year cycle, teachers, children, and their parents will be most affected.

We believe that the new project-based approach to learning for children will not provide adequate fundamental and systematic knowledge in many scientific fields, including mathematics methodology (e.g., spatial and temporal relationships, arithmetic, number concept, ratios, fractions, geometry…).

The consequences will not only be visible in their further education but also in their inadequate preparation to navigate their environment and understand space, time, relationships, and other mathematical concepts. This is what the educators' survey results are talking.

The aim of this paper is to highlight possible problems since the Government of the Republic of Serbia and the Ministry of Education have not suggested a linear reform of these education levels.

Keywords: traditional approach to learning, project-based approach to learning, systematic adoption of mathematical concepts, inability to cope with the environment, harmonization of preschool and elementary school educational programs

Introduction. The Preschool System of Serbia has Transitioned from Traditional Teaching to a Project-Based Learning Approach

In late 2022, Serbia transitioned its preschool education system from a traditional approach to a project-based learning (**PBL**) approach.

Until then, in most state and private institutions, the content of work included the following areas: mathematics, speech culture, physical education,

music culture, and visual arts education (i.e., methodology for these areas such as the methodology for developing initial mathematical concepts), as part of the curriculum and activities that were aimed at developing different aspects of a child's development (Hilčenko, 2022a, 2022b).

This form or methodology of work was not mandatory for all institutions, and other methodologies were also represented alongside this curriculum, including:

– *the Montessori methodology*, which involves working with natural materials, developing motor skills, encouraging independence and individuality in children,

– *the Pikler methodology*, which focuses on developing independence, guiding a child's interests, nurturing creativity, attention, empathy, and respect,

– *the Reggio Emilia methodology*, which focuses on creating an environment that encourages curiosity, exploration, experimentation, exploration of art, and creativity,

– *the Vygotsky methodology*, which focuses on supporting children's social and cognitive development through interaction with peers and adults, and

– *the High/Scope methodology*, which involves structuring the educational process around experiential learning, planning activities in which learning occurs, with the support of educators in acquiring knowledge and skills.

These less prevalent methodologies also included these areas in their programs and approaches, but primarily focused on the overall development of the child, rather than just one or more areas.

PBL is based on the idea that children learn through activities that are aimed at solving real problems, exploring and discovering new things, and creative expression (Gaftandzhieva, Hussain, Hilčenko, Doneva, 2023). **PBL** involves children participating in group projects, which develops their collaboration, communication, and teamwork. Children are encouraged to develop their ideas, experiment, make decisions, work together, and find solutions to the problems that are presented (Hilčenko, 2019).

This approach focuses on the learning process (Hilčenko, 2015c), not just the results. Children are encouraged to actively participate in the entire process, which contributes to their emotional, social, and cognitive development. Through **PBL**, children learn about different topics such as ecology, nature, art, history, and society. It encourages the development of critical thinking, exploration, creativity, and self-confidence in children (Hilčenko, 2015b).

It is important to note that **PBL** does not replace traditional learning methods, but complements them. **This means that children still learn basic skills such as reading, writing, and math, but in an interactive way that is tailored to their age and interests** (Hilčenko, 2006).

As before and now, **PBL** was not mandatory for all preschool institutions, primarily not for those in the private sector.

“PRO ET CONTRA?” – “FOR and AGAINST?”

Insome aspects, **PBL** in kindergarten is considered more effective than traditional approaches. **PBL** supports an individual approach, emphasizes exploration and experience, helps children to acquire independence and the ability to think creatively, and also encourages them to engage with topics that interest them (Hilčenko, 2015c). “However, **traditional approachesare often used because of their simplicity and adaptability, and they can also “provide structure” and order in the environment for children**” (Hilčenko, 2009, 2008).

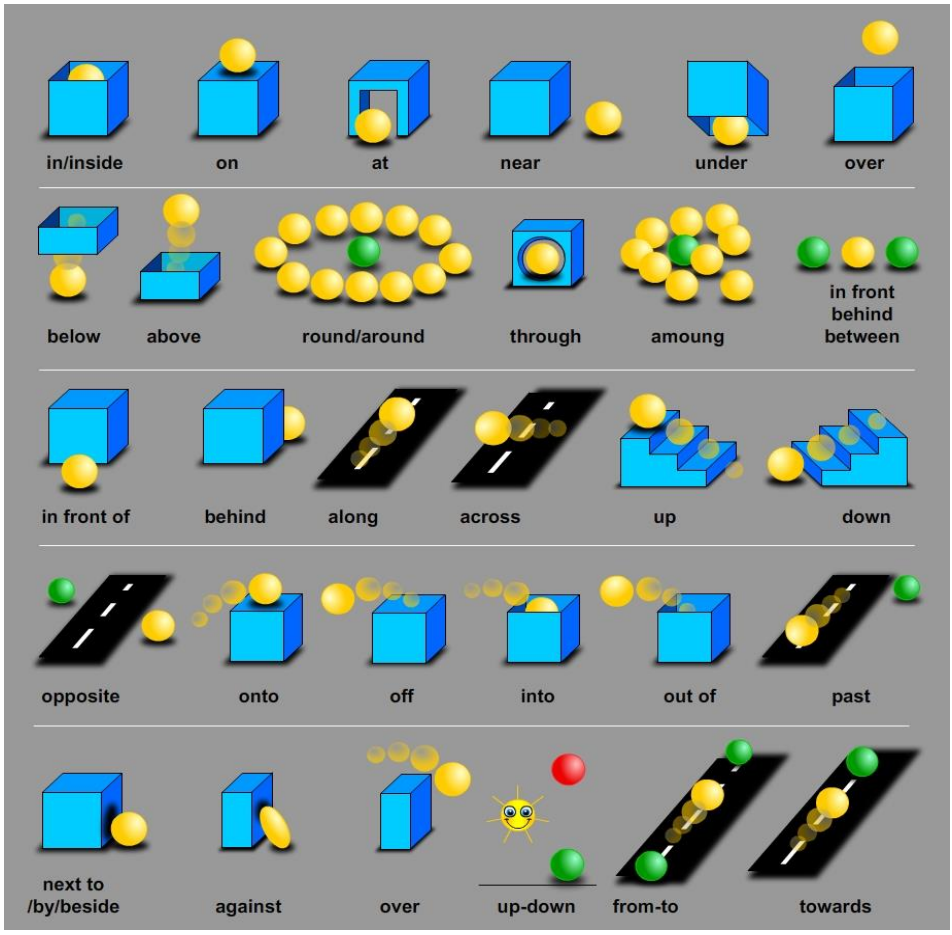

Figure 1.

We believe that **PBL** may not provide children with sufficient knowledge from "old" teaching methods. The question arises, what consequences could there be for the mental and physical development of a child if mathematical concepts such as spatial relations (Figure 1), temporal relations, natural numbers, place value in number sequences, greater-than and less-than relationships, fractions (whole, half, quarter, etc.), addition, subtraction, object classification and serialization, set theory, geometric shapes and figures, developing the concept of mass, length measurement, time perception, time relations, interval operations, and developing knowledge of material values and money as a measure of value are inadequately and unsystematically taught through a new program in kindergarten?

Some possible examples of consequences that children may experience due to a lack of adequate mathematics training are:

1. Difficulty in understanding and applying basic mathematical operations such as addition, subtraction, multiplication, and division.
2. Lack of understanding of basic mathematical concepts such as fractions, decimals, percentages, ratios, and proportions.
3. Difficulty in solving problems that require the application of mathematical concepts and skills.
4. Lack of understanding of geometric concepts such as shapes, sizes, space, and time.
5. Problems in estimating, measuring, and quantifying real-life situations such as grocery shopping, scheduling, and the like.
6. Limitations in developing critical thinking, logical reasoning, and problem-solving skills that are essential for success in further education and life.
7. All of these consequences can have a long-term impact on a child's ability to cope with the demands of modern society and achieve success in their professional and personal life.

We have verified these assumptions through a survey of a larger sample of educators (#60) who are already implementing the new program. Based on the summary of survey results, we highlight the dominant attitudes:

ON QUESTIONS: *"Since the new preschool program does not systematically teach children mathematical concepts covered by the previous traditional curriculum, could this have negative consequences on the child's mental and physical development?"*

Educators believe that in terms of:

– *the lack of systematic and structured learning of mathematical concepts could affect the development of cognitive skills, including reasoning, problem-solving, logic, and abstract thinking,*

– *the lack of learning mathematical concepts could affect later success in school subjects that require mathematical skills,*

– *the lack of development of mathematical concepts could have a negative impact on the development of motor skills, as many mathematical skills, such as object classification and seriation, are based on visual perception and fine motor skills.*

– *also, the (mis)understanding of basic mathematical concepts, such as measurement and counting, is important for everyday activities, such as cooking and shopping.*

According to the new work program in preschool institutions, higher education institutions in Serbia that educate educators have conducted necessary re-accreditations of their old work programs for this educational profile, in which they have retained traditional teaching methodologies. The reasons for doing so are in line with the attitudes of the surveyed educators.

What does this mean in practice?

As part of the **PBL**, children themselves choose the topics of future projects based on their interests or desires, and it is up to educators to independently assess whether or not to include some content from traditional teaching methodologies that would "supplement" children's knowledge on the chosen project topic.

For example, if the project topic is **"Dinosaurs"**, the educator decides whether to implement certain knowledge, and to what extent. This means that from project to project, the educator may or may not implement certain partial knowledge from a methodology, rather than a systematic approach.

Furthermore, we asked educators: *"Can the non-systematic acquisition of mathematical concepts, spatial and other relations, such as time, length, weight, mass, and similar relationships, have an impact on a child's ability to navigate in their environment and life situations, that is, space and understanding of it, if the child has not been put in situations to practice these concepts during their acquisition?"*

We have systematized all the answers into the four most prevalent opinions:

– *"Systematic non-adoption of mathematical concepts, spatial and other relations in early childhood in kindergarten can affect the child's ability to navigate the environment and understand space and similar relations later in life."*

– *"Lack of understanding of these concepts can affect the child's ability to navigate the environment and understand different situations involving space and similar relations" (Hilčenko, 2017).*

– *"If the child is not exposed to different situations in which these concepts are applied and if they have not learned and practiced these concepts systematically, this can lead to difficulties in understanding spatial and other similar relations. For example, the child may have difficulties understanding directions, orientation, distance, and similar concepts that are important for navigation in space."*

– *"It is important for the kindergarten program to include systematic development of mathematical concepts and spatial relations to ensure optimal development of cognitive and motor skills in children, which will later help them navigate the environment and understand space and similar relations."*

Conclusion

Translated to English: The last question directed to the preschool teachers was to express their opinion on which of the two programs is better. We have summarized the most common opinions in the following manner:

– *"It is difficult to give an absolute answer to the question of which approach is better because it depends on many factors, including the goals of the preschool, the needs of the children, available resources, and other factors."*

– *"Each of these two approaches has its advantages and disadvantages, meaning that it places more emphasis on promoting certain abilities in children."*

– *"Although the **PBL**, which encourages independence, initiative, and creativity in children, can be useful in developing their abilities and creating a positive learning environment, there is a big question about what knowledge children will take to primary school in the areas of mathematics, language and culture, environment, physical education, and music?"*

– *"The optimal combination of different approaches can provide the best experience for children in preschools."*

As it is currently impossible to assess the effects of **PBL** because the first generation of these children is still in preschool and their readiness for primary school is unknown, we will have to wait and see. Whether there will be an alignment of curricula with those in primary schools and the smooth continuation of the education of these children, time will tell so that the problems we have discussed will not arise.

Until then, let's look at this problem from a brighter perspective. Here are a few examples:

"I told her to eat half of the grapes I gave her!"– **RELATING TO SIZE**

"I explained to her how to make a snow angel. Apparently, I forgot to mention an important "detail" – **THE SPATIAL RELATION "ON"**

"I told the child that they can serve the guests cake "in my shoes."–

Spatial relation "IN"

"She told me she learned the concept of classification ... but she practiced that topic on the wrong material"– **CLASSIFICATION**

Figures 2–5. Some possible misunderstandings in real life)

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SANDRA ŚCIERANKA

A Teacher in the Era of the Spread of Artificial Intelligence Applications – Challenges and Difficulties

ORCID: 0000-0002-7814-4288, MA, University of Rzeszow, Institute of Pedagogy, Poland

Abstract

The tasks of a modern teacher are definitely different from those they had to perform a decade ago. In the era of various changes taking place, constantly developing, but also accompanying digitization in every sphere of life, the role of the teacher takes on a new meaning – flexibility and openness to changes on their part become necessary. Therefore, teachers face new challenges, roles and skills to expand. The conducted considerations are aimed at showing the impact of digitization both on the daily work of the teacher, the performance of professional functions, as well as his relationship with students. The punchline becomes the need to use artificial intelligence tools, as well as the essence and necessity of media literacy of modern teachers, which is reflected in the entire didactic process carried out among students shaped by digitization and the world of media.

Among the others, the aim of the work was to determine attitudes of the educators (on the rating scale) about the presented approach to the work.

Keywords: digitization, teacher, student, challenges, difficulties

Introduction

The face of the present world is defined by the variability that affects all spaces of life. Therefore, as a result of ongoing transformations both in the socio-political aspect, ideological transformations, educational reforms, and above all the significant impact of digitization on every level of life, education is also gaining new importance, and the related role of the teacher. The educational system, which is assumed to be the most specific to teachers, who are responsible for ensuring adequate access to knowledge, extends both the responsibility for improving the quality and level of education as well as increases the scope of competences and qualifications (Muchacka, Szymański, 2008, p. 11).Therefore, the changing school reality needs teachers who will meet new tasks and chal-

lenges, at the same time support and inspire students in their comprehensive development (Szempruch, 2001, pp. 9–10).

Therefore, one of the priorities in the area of changing education is the impact of digitization and both on the change of the model of a typical student, variability in the area of achieved learning goals, but above all on the person of the teacher, because it significantly introduces pedagogy into a new, updated space, which is of particular importance for the effectiveness of the entire didactic process implemented in schools. Undoubtedly, artificial intelligence is a tool of promising importance both for the work of teachers and for the pupils themselves, including support for pupils with special educational needs. Therefore, we should reflect on the essence of the media character of the teacher. Can they pursue the didactic sphere on the basis of the knowledge initially acquired, or do they have to follow digitalisation, which, in addition to the positive aspects, also entails a number of negatives? In the face of this variability, what are the challenges and difficulties for the teacher, and what are the benefits?

Purpose of research

The priority objective of this review study is to draw attention to the changes that result from the development of broadly interpreted artificial intelligence in an area that also includes all technology and digitization affecting the school space. Taking into account both the impact of digitization on education, on the daily work of teachers, as well as their relations with students, it is necessary to highlight the significant transformations taking place, which thus require teachers to look at education and their roles in a new way, as well as indicate the direction in which they should go. Because there is still a large part of teachers opposing any variability or the need to improve their qualifications. There is no doubt that the profession of teacher is a profession that constantly confronts them with numerous question marks, which in their essence constantly tend to make reflections. Therefore, in this work several questions have also been posed, the answers of which will be provided by the considerations made.

Materials and methods

The work was carried out using a descriptive method, using information obtained in the course of the analysis of available literature and source materials for the analysis of research results in the field of educational applications of artificial intelligence. The use of the review of existing data made it possible to take a closer look at the issues discussed as well as the final formulation of conclusions.

Discussion

The teacher's methodological efficiency is determined not only by theoretical knowledge and practical use of IT tools, but also by their attitude to continuous professional development in this area. Therefore, it is not only about the

efficient use of a multimedia computer set or the ability to cope with hardware failures, but it is about a number of different factors that make up the entire methodological plane of the modern teacher. They also manifest themselves in the adequate and skilful use of available information technology solutions, which for the main goal is to improve educational processes, the ability to analyze as well as substantive and pedagogical assessment of available media resources, the choice, including the use of a specific tool, and very important – sensitization to how the media affect students. From the point of view of pedagogy, this use of digital technologies (including artificial intelligence) has a significant impact on the entire didactic process, i.e. teaching, learning, and in particular reaching the student of the new generation, the generation of the twenty-first century (Warzocha, 2021, pp. 151–156).

It should be boldly said that children with all digitization are delayed from an early age. And the current young generation is characterized precisely by their attitude to the media. American media researcher Marc Prensky has defined that there is currently a term among young people: the "copy-paste" generation (Jurczak, 2018, p. 116; Morbitzer, 2012, p. 136). The generation of these students, i.e. digital students, compared to the generation that functioned until recently, is radically different in many aspects. The world of this generation is largely created through digitization, and therefore above all the world of media – which create not only an environment of social functioning, mutual communication, but also an educational environment. In addition, many authors emphasize the ease and speed with which young people both learn and use digital tools – mainly based on the Internet. By analyzing the present and the essence of online initiatives or the possibilities of artificial intelligence, it creates the foundations for creating even greater changes in the future (Jurczak, 2018, p. 116; Morbitzer, 2012, p. 136).

Unfortunately, for most modern teachers, the world of media is perceived as a riddle that they are in some way forced to learn either by the students themselves or as a result of other circumstances. There is no doubt that one of such factors was the COVID-19 pandemic, which in a short time contributed to the reformulation of the entire existing school functioning, thus introducing education as well as teachers to a completely different "dimension". This was related to the comprehensive organization of the existing traditional form of conducting lessons, as there was a transfer from the classroom to the complete remote form, using only the available information technologies for work. Undoubtedly, this situation has highlighted, but also accelerated, what was inevitable. Namely, the need to take action to improve qualifications in the area of theoretical knowledge, practical skills, but also awareness of the need to use modern technologies, including AI tools in the school space, which should be used by teachers.

The world of digitization creates new students, so there is a need for new teachers, media teachers who will adapt to changing education in order to be

able to accompany students as fully as possible, but also to pass on knowledge in a professional, understandable and accessible way to every student. Therefore, flexibility and openness to change on the part of the teacher becomes necessary, which can be safely described as the key to changing the perception of oneself and one's professional role in the conditions of interpenetration of traditional education with the use of modern teaching methods. Because conducting lessons using only traditional methods is unfortunately not enough for students of the "copy-paste" generation, which often becomes a group that does better in the space of modernity. On the other hand, the model of having these skills should be the teacher themselves so as not to lose authority in the eyes of the student, which in the general perception will also translate into didactic backwardness.

Challenges, and often related difficulties, which are undoubtedly inscribed in the teaching profession, and which are created as a result of widespread digitization, are constantly expanding their scope, thus affecting more and more extensive areas of the teacher's work. They are directly related to the person of the teacher, the fulfillment of educational duties, as well as significantly affect the change of the teacher-student relationship. Below will highlight only a few challenges that are at the same time difficult, which in my opinion are the most visible. Moreover, whether an aspect is a challenge, or a difficulty undoubtedly depends on the attitude of the teacher, on how he or she personally perceives this variability. Thus, in the area of significant challenges and difficulties facing the teacher of the twenty-first century, the following can be taken into account:

– Reflection on a new role;

The teacher should make a reflective and objective assessment of themselves, because digitization somehow forces a change in this perception: "He will cease to be the ruler in the classroom, (…) The master in the chair, and will become the student's helper in the learning processes undertaken by him. His work will become more transparent, and at the same time he will have to constantly learn" (Pachociński, 2002, p. 4). The traditional relationship between teacher and student was based on the transmission of knowledge and wisdom by the teacher, i.e. the older person, to the students – therefore to the younger people. However, nowadays, in the era of accompanying digitization, these roles are intertwined. For not only can the student learn from the teacher, but the teacher can also educate themselves from their pupils. It turns out that mature and older people often do not keep up or find it more difficult to find themselves in the world of technology, which is why they need support. Thus, it becomes noticeable that there is a penetration of roles, or reversal, which also requires full openness on the part of the teacher, but also distance to his person and reformulation of the role of the teacher, because they cease to be an omniscient person.

Therefore, it becomes noticeable that it is digitization that has changed the flow of knowledge. It does not have to take place only from older to younger

people, but these roles interpenetrate, thus the teacher becomes not only a person teaching pupils, but also uses their knowledge resources in the field of digitization. Or, with the use of appropriate AI tools, students can independently verify their level of education, which some time ago was only the teacher's task (Ciesielski, 2023). Certainly, all this is a real challenge, but also a difficulty, especially for teachers practicing the traditional education system, but at the same time it is also an expression of a properly worked out own identity and the aforementioned openness to change, which will enable proper fulfillment in the role of a teacher.

– Self-educational competences, in which media competences are currently the strongest part;

"Wisdom and knowledge do not dwell in books, computer programs or on the Internet. There is only information. Wisdom and knowledge are always embodied in man, acquired by the learner and used by him" (Drucker, 1999, p. 171). The definition of self-educational competences should be understood as continuous improvement and improvement of qualifications. However, in the twenty-first century, they are most strongly expressed in media skills, so in order for the teacher to be able to meet the expectations and requirements of new students – students growing up in the digital era, there is a need for new teachers who consciously and correctly use the available tools offered by the development of technology.

Currently, competences related to information technology are becoming a particularly important component of the teacher's workshop. Therefore, it seems important to acquire knowledge and skills to use these skills in education in such a way that it supports the child's development, enriches the entire educational process, and does not obscure what is most important. In addition, the teacher should bear in mind that children, students from an early age have access to mobile phones or the Internet, which somehow also translates into the entire functioning of the child and his learning process. Therefore, education and the teacher can neither avoid nor prevent children from learning in modern conditions, because they will not be able to reach them, but thus causes backwardness and somehow suspends the child's development in the new conditions created by modern reality. The content provided by the teacher should be presented in such a way as to encourage students to learn, and relying only on traditional forms of work can cause considerable difficulties, because the attention of students is absorbed by all digital devices. In addition, the teacher should constantly bear in mind, as already mentioned – they are not a know-it-all person, therefore they must be aware of the gaps in their didactic process and constantly correct them. One of the possibilities offered by AI is the use of the Coursera system, whose task is to inform the teacher when a large number of incorrect answers of students to a given homework will be sent. At the same time, it creates a platform

for analyzing one's own mistakes made by the teacher and providing personalized tips for students on how to develop the correct answer (Gajewski, THINKTANK Review).

Therefore, there is no doubt that the innovativeness of modern education requires from the teacher a great openness to modern solutions, but at the same time a reasonable approach to their professional role and noticing that modern education as well as the teacher cannot be closed to the need to improve new skills – self-educational skills.

– Combining traditional teaching methods with modern solutions;

"The winner will be the one who combines the knowledge of the latest technologies with the world of traditional values" (Santorski, 2005, in: Morbitzer, 2012, p.150-151). Although in practical terms this thought seems to be a great challenge and difficulty for some teachers, it plays a significant role in the general sense for the student. It is a guideline for actions that a teacher should take to be an effective and good teacher of the twenty-first century.

Therefore, the teacher should accompany the child in learning about the world as they found them. This is related to the change of the teaching model to adapt the traditional way of teaching to current needs, but also to the implementation of modern methods. This is a real challenge for teachers, especially older ones who built their professional experience on traditional forms of work, or for those who act as teachers only out of duty, not out of inner vocation and satisfaction. However, it is important for the child's future functioning how both the whole education and the teacher will find themselves in the new reality. It will enable the student to develop in the conditions created by the presence of digitization in every area of life, whether using, for example, interactive whiteboards or other artificial intelligence tools, it will interest the student and arouse in him curiosity to explore knowledge, values that are presented only on the basis of a textbook cause discouragement and boredom. In the past, this way of teaching was the only and effective, because the teachers themselves used such solutions, but now – it is insufficient –modern children do not know the world without digitization, and it should be emphasized that the task of the pedagogue is to adapt didactic methods to the conditions in which children function, to the tools they know. And using these interactive whiteboards, the teacher can not only prepare and implement lessons in a constructive way, but also dynamically. In addition, it is also a platform for direct contact with the student, because the teacher can engage the student to manipulate the board (Perzycka, 2021, p. 92). It is also worth emphasizing that the current educational system in its assumptions focuses most strongly on the so-called encyclopedic approach to teaching, fulfilling the assumptions of the core curriculum and the implementation of certain standards. However, this lacks what artificial intelligence makes possible – namely an in-depth analysis of reality, which inspires the search for existing

interdependencies, but also possible solutions that are currently becoming a significant aspect of the entire scientific space and didactic. It should also be boldly said that AI "opens" not only teachers, but every person to go beyond the area of certain accepted schemes, process learning to willingness and openness in learning and using new tools (Gajewski, THINKTANK Review).

It should also be emphasized that the aim is not to lose ourselves completely in digitalisation, but to rationally complement it and make everyday lessons more attractive. Because the role of the teacher is not only to teach, but to teach – and this is only possible when there is a thread of understanding between the teacher and the student.

– The learning process in the twenty-first century;

"Education flows from the image of the future and at the same time shapes this image itself" (Toffler, 2008, p. 16). Therefore, what the current education looks like is undoubtedly a consequence of how the reality in which we live is shaped. Therefore, the mediality of the contemporary young generation is certainly influenced by many factors that immerse the child in the world of media (Morbitzer, 2011–2012, p. 149). Students who grow up nowadays are children and young people who are growing up in *the so-called audiovisual culture.* This means that the sphere of the word (logosphere) has been dominated by the sphere of the image (iconosphere) (Morbitzer, 2011–2012, p. 141). Therefore, the thought processes that are stimulated by the text have been somewhat replaced by emotions that are evoked by the image. Thus, all this translates into the perception of information and knowledge passed by teachers towards students. There is no doubt, therefore, that children's concentration and focus are much more difficult to obtain, because it is distracted by the numerous stimuli caused by digitization, which in turn is reflected in the educational process. Therefore, the teacher should modify the way knowledge is transmitted.

Using AI tools such as Sheek by iNaturalist, teachers not only arouse curiosity in the student, but above all the desire to learn and learn about the processes occurring in nature, in a more vivid and creative way. For learning foreign languages, one of the possibilities is the Duolingo application, while in the field of sociology and artistic classes you can use the Newspaper Navigator, which allows you to browse and search archival scientific achievements. Therefore, there is no doubt that only a few examples of artificial intelligence applications presented a wide range of its capabilities as well as confirmation that applications, as well as the whole essence of AI, facilitate learning for students, support teachers in constructing lessons, as well as make the entire didactic process more attractive.

Therefore, the teacher of the twenty-first century faces a huge challenge when it comes to the learning process. This is a real challenge, which consists not only in transferring knowledge – in a way that has been practiced so far, but

creates a whole correlation of coherent activities that have been previously raised, i.e. adapting traditional, updated methods to students of the digital age, but also implementing new ways to interest the student, focus their attention but also effectively inspire and encourage learning. A significant difficulty of modern education is the fact that everything can be found on the Internet, which is why students are discouraged from the traditional form of exploring knowledge or making efforts in the area of all thought processes or memorization processes. And by using AI tools in their lessons, teachers can seek to change the perception of the learning process. It does not have to be boring or monotonous, but interesting, full of innovative solutions to enrich the knowledge transferred, as well as its acquisition. Therefore, a particular challenge is both to effectively implement didactic goals (using artificial intelligence, as well as awareness of its negative impact on the young generation, with improper use), which in turn will bring the expected preparation of the student for independent functioning in the social environment along with the workshop of the necessary knowledge, as well as sensitizing students that information technologies are not without drawbacks. You cannot completely exclude media from your life, but it should be borne in mind that they are often accompanied by unrealistic promises aimed at reformulating reality into fiction, while entailing some changes in the functioning of the human brain (Warzocha, 2021, p. 159).

The phenomenon of the role of teachers boils down to being conscious guides for students who need role models and authorities. They should rationally, wisely and courageously use the technologies offered by the changing reality, because they often make the knowledge more attractive or complement the knowledge transmitted in the way with which children are introduced from an early age. Therefore, the teacher must not be afraid or discouraged from using these tools, but he should constantly bear in mind creating in students the feeling that the ubiquitous artificial intelligence available is only an addition, complement or facilitation in everyday life, it can not be a leading plane in life, or obscure what is most important. Undoubtedly, the use of various forms of available information technologies is becoming in a way an identification of modern education. And the teacher must constantly be prepared for the emerging changes, and thus must also prepare the students for this, because they themselves must constantly learn, as well as teach "how to teach learning".

The development of a child depends on many factors – own activity in the desire to explore the surrounding world, psychophysical capabilities, but also on the work performed by the teacher. It is they who is most responsible for all processes of stimulating students' activity, which in the school environment are reflected, e.g. in discovering talents and interests. In addition, children learn primarily through observation or constant contact with both adults and their peers, thus it is conducive to acquiring new learning skills, because learning

itself takes place in an informal way (through observation). Therefore, a good teacher, aware of his influence on students' attitudes and creating their image of reality, constantly expands the catalog of his skills and competences to become a reliable source of knowledge (Truszkowska-Wojtkowiak, Wojtkowiak, 2008, p. 278). Similarly, if the teacher shows students their essence, wise use and application in everyday life, then this will translate into their holistic perception of what the modern world offers.

Conclusions

To sum up, there is no doubt that the continuous development of digitization, which significantly affects the functioning of the whole society, thus determines the need for permanent improvement of teachers, including openness on their part to constantly emerging changes and challenges. Teachers should realize that the initial knowledge and specific workshop acquired by them seems to be insufficient in the context of the challenges ahead. The ability to subject oneself and the role of professional reflection, continuous expansion of one's competences – theoretical and practical, expanding the workshop are factors enabling the teacher to find themselves in the modern world and school – therefore tools with broadly understood digitization, including artificial intelligence, thus making them a good and conscious teacher wishing to pass on knowledge in the most professional and understandable way possible.

In addition, in the information society, access to knowledge is definitely more important, which is why the school has lost its hierarchy of importance. Thus, it requires even more work from the teacher to be able to skillfully reach the student shaped in truth by the world of media with knowledge and values that technology cannot convey. As Luckin emphasized, "The real power of artificial intelligence in education is that we can use it to process huge amounts of data about students, teachers, interactions in teaching and learning" (Gajewski, in THINKTANK Review: https://think-tank.pl/ai-w-edukacji-nadchodzi-rewolucja/). Therefore, the role of AI is not to replace the teacher – despite various fears, but to help teachers and, above all, to help them in certain areas so that they can focus more on the essence of their work – that is, building relationships with students, which will then transform into a comprehensive didactic success (Gajewski, THINKTANK Review).

The answer to the question formulated in the initial part of the article becomes unequivocal that the teacher is obliged to follow the changes, introducing new teaching methods equipped with various types of technologies that are the basis for joint communication with students of the digital age. Moreover, they should be aware that the disciples also acquire knowledge through observation – so that it becomes impossible for them to be completely closed to modernity and its tools, because thus they cause their own backwardness and that of the younger

generation. As mentioned, artificial intelligence also entails a number of negative aspects, which is why the task and the challenge of teachers is to teach how to use the goods of modernity wisely, as well as to sensitize students to the consequences of too intensive penetration into digitization and the traps associated with it. Teachers are also obliged to educate the selection of information, as well as its adequate use – because each of us, both adults and students, are dominated by a large amount of information available from various sides.

Therefore, gaining knowledge, awareness and IT skills are priority components of the work of a modern teacher (Gruchoła, 2019, p. 113). Finding a common language with the student, combining tradition with modernity in the context of education, boldly using the tools of artificial intelligence and, above all, being able to realize oneself in the role of a teacher seems to be the biggest challenge and at the same time the difficulty of teachers of the twenty-first century – a century dominated by digitization on the one hand, and on the other enriched with new solutions.

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PART TWO

SELECTED PROBLEMS OF USING INFORMATION TECHNOLOGY IN EDUCATION

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ČESTMÍR SERAFÍN

Didactics of Electrical Engineering and Its Components in the Context of Digitalization of Education

ORCID: 0000-0003-1200-1089, prof. Dr. Ing. Ing-paedIGIP, Palacký University in Olomouc, Faculty of Education, Department of Technical Education and Information Technology

Abstract

Didactics is defined as the theory of education. It deals with the specific forms, procedures and goals of teaching that a teacher implements with his/her students. As such, it is an integral part of pedagogy. Since the forms, procedures and objectives of teaching vary in their specificity for the different fields, disciplines and subjects of education, this specificity is reflected in the disciplinary or subject didactics. The latter thus deal with the processes of teaching and learning with regard to subject-specificity and specificity. The article is thematically devoted to the area of subject or subject didactics, specifically didactics of electrical engineering, which is of particular importance for vocational technical education, as it forms a key part of it both in practice and in the preparation of teachers of such disciplines. The article also presents some of the results of the author's research from recent years, which focuses specifically on the areas of modern technologies and their impact on the teaching process, especially in electrical engineering-oriented teaching subjects; tools for developing technical but also digital literacy are presented.

Keywords: technical education, electrical engineering, subject didactics, virtual education, studies

Concept of didactics of electrical engineering

Subject and subject didactics together with general didactics belong to pedagogical disciplines that describe and clarify the processes of teaching and learning. General didactics establishes the general laws of teaching. If we focus general didactics on the teaching of vocational subjects, we get from the general position to the specific position, i.e. to the subject didactics (Honzíková, Bajtoš, 2004).

Subject and subject didactics deal with the processes of teaching and learning with regard to their field affiliation and specificity. These are disciplines

situated between a certain technical, artistic, or other field and the sciences of education and training. The general term field/subject didactics is often replaced by a term expressing the didactics of a particular field/subject (e.g. didactics of mathematics, didactics of electrical engineering, etc.).

The term field refers to a professional area within which specific problems are solved. The relationship between didactics and the field is dynamic and can take various forms, but it is always necessary to balance the conditions of the pupil's learning and the quality of the subject. Subject didactics is therefore a science mediating the field towards pupils/students [1] with the help of knowledge of pedagogy and general didactics, pedagogical and developmental psychology and other disciplines. Subject didactics is therefore interdisciplinary (Janík, 2009; Ouroda, Švec, 2000).

Subject didactics deal with problems of teaching in specific subjects and are usually understood as their methodologies (Průcha, Walterová, Mareš, 2013). Subject didactics have a direct link to the relevant subjects – subject didactics are profiled as relatively autonomous scientific disciplines, the subject of which is "the entire communication process in the relevant field and the corresponding component of education" (Brockmeyerová-Fenclová, Čapek, Kotásek, 2000).

Didactics of electrical engineering is the theory and practice of teaching and learning electrical engineering subjects in relation to education and formation of knowledge, skills, competencies, attitudes and other dispositions, it is a summary of didactics of individual electrotechnical subjects, but it is not the sum of didactics.

Didactics of electrical engineering can be divided into parts:
(a) the general and
(b) special.
The general part discusses:
- subject of didactics of electrical engineering,
- the history of teaching electrical engineering, and
- educational importance of electrical engineering.

A special section discusses:
- the content of the apprenticeship/field of electrical engineering, and
- means by which the main educational objectives of the subject/field of electrical engineering can be met.

[1] Note: not all content in the field is conveyed, but those that appear to be useful from the point of view of teaching and learning, i.e. contribute to the development of knowledge, skills, competences, attitudes and other dispositions of pupils/students at a certain level and type of school (see didactic transformation) are selected.

If we characterize didactics of electrical engineering subjects as a science, then we understand didactics of electrical engineering as an interdisciplinary, independent borderline scientific discipline that didactically processes the knowledge of electrical engineering and integrates it with the knowledge of social sciences into a didactic system of electrical engineering subjects.

The task of the didactics of electrical engineering is to turn the scientific field of electrical engineering into a teaching subject. The tasks of the didactics of electrical engineering can be seen (Serafín, 2023):

– in the meaning of the electrotechnical subject and its position in the school educational program;

– in the objectives of the electrotechnical subject and its curriculum (concept, selection, scope, arrangement, cross-curricular links, methods, etc.);

– in the teaching process, its laws, didactic principles and means;

– in the conditions of teaching, the personality of the teacher vs. the student;

– in the history of the subject;

– in relation to other scientific disciplines.

The aim of teaching electrical engineering is understood as intended changes in learning and development of the pupil, which should be achieved by teaching electrical engineering. The intended changes concern both changes in knowledge, skills, and habits, as well as changes in personal value orientations and the social development of the pupil. It is therefore an anticipated, expected learning outcome, towards which pupils aim in cooperation with the teacher (Serafín, 2023).

Online electrical engineering education – options and tools

Computer and recently computer and digital literacy is now considered one of the basic prerequisites for human education. The goals of technology-oriented literacy and work with it should lead people to cope with the increasing range of information and allow him to orient himself in them. Primary, secondary and higher education institutions already implement these competences (in various forms, forms and scopes) in their graduates, and these competences are therefore part of the so-called learning outcomes. Multimedia technologies, which are associated with them with the development of methods and forms of learning, have thus become part of the way of organizing studies within all educational levels. It is generally accepted that in the process of pedagogical interaction and communication, technology is increasingly becoming an intermediary between teacher and learner, but it should never replace interpersonal relationships and impoverish social ties (Hrušková, 2009).

At the turn of the millennium, e-learning was considered the key educational form of the 21st century. This euphoria was replaced by the realization that

e-learning cannot replace traditional educational forms, that e-learning can only function as a support for the teaching process. If we connect face-to-face teaching with e-learning, we are talking about blended learning. According to Zounek (2009), it is the integration of electronic resources and tools into teaching with the aim of fully exploiting the potential of ICT in conjunction with proven methods and means of traditional, face-to-face teaching. The basic models of blended learning according to Kopecký (2006) can be divided into three categories:

1. Skill-driven learning – combines personalised learning with teacher support.

2. Education focused on the development of attitudes or approaches (attitude--driven learning) – works here with selected events and mass media, with the help of which the behavior of the learner is influenced.

3. Education focused on the development of competencies (competency--driven learning) - a combination of several methods that can influence the development of the learner's competences.

E-learning, especially in the case of technical fields, brings new ways of working with the acquisition of information and experience while changing (to some extent) the learning process. A number of methods used by e-learning in practice are taken from classic face-to-face teaching. The basic difference is mainly in the change in the approach to education, from an instructive to a constructive approach (Kopecký, 2006), where the direct teaching method is replaced by the principle of constructing knowledge in partial steps using the pupil's own creative activity.

Modelling and simulation in electrical engineering

It is clear and understandable that today's pupils are not only self-evident users of computer-related technologies, but often have programming knowledge and skills at a relatively high level. However, it is always up to the teacher whether they will become mere "users" of applications in their lessons, where students will be able to retrieve and analyze results very quickly, but will not understand much about what they are doing, or whether they will start using these tools to solve practical problems. Although the first case is important for practical knowledge, in the second case it is a basis in which students cannot do without knowledge of the theory as well as the principles of analysis methods implemented in software circuit simulators (Biolek, 1999).

Today, simulation programs open up a huge field of possibilities for analysis and simulation of processes in complex electronic circuits. Thanks to the power of contemporary computers and the result of historical development that began in the fifties of the last century, programs designed for simulation of analog and digital circuits are now the standard of virtual laboratory instruments. The standard of analog simulation is SPICE, while in digital simulation there are several

software tools, while simulators with the attribute "Mixed-Mode" have the ability to simulate circuits at both analog and logic levels. The SPICE (Simulation Program with Integrated Circuits Emphasis) is a program that originated in 1971 (Shepherd, 1996) at the University of California. The author is Larry Nagel. It is a developmentally higher version of the CANCER program (Computer Analysis of Nonlinear Circuits Excluding Radiation). The modelling principle is then shown in the following Figure 1.

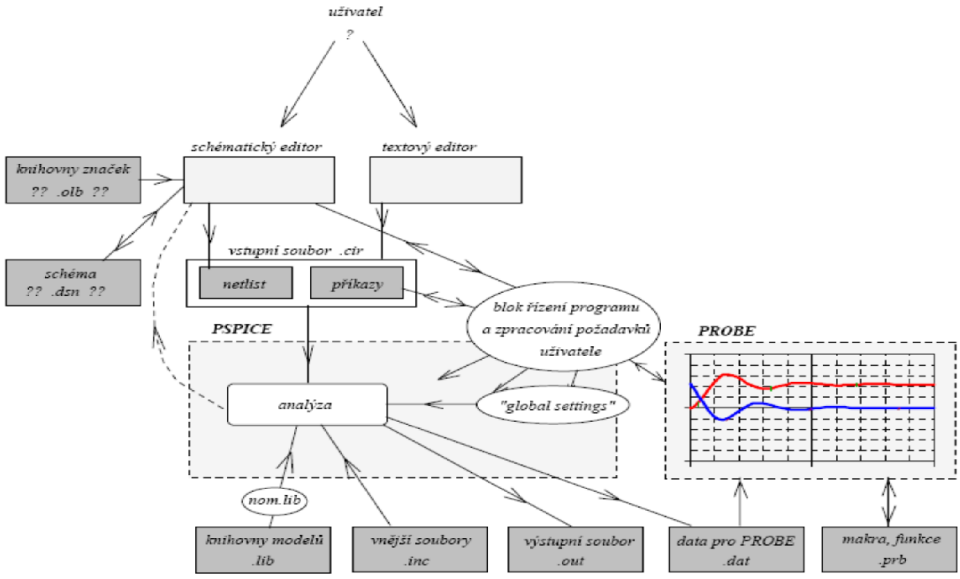

Figure 1. Principle of modelling

Source: Biolek (2005).

Analysis of electrical circuits can be characterized as a specific procedure from the circuit model to obtaining the result. Currently, existing methods of analysis can be divided into non-algorithmic, or heuristic, and algorithmic (Biolek, 1994). Among the first can be included procedures that the solver chooses on the basis of his and previous experience, it is therefore o constructivist approach. The algorithmic method, on the other hand, defines the exact procedure – the algorithm, i.e. the solution of a circuit using the nodal voltage method. Each of these methods fulfills its function in the solution: non-algorithmic methods force the solver to creative technical thinking; algorithmic then provides a tool for solution.

Modeling can be defined as the process of describing reality by limited means, where the result is a model of the original object. Modelling is derived

from the Latin concept of mode, modulus (measure, pattern, manner). In other words, the model can be understood as a simplification of a certain real or abstract object. In other words, it is a bridge between theory and objective reality (Seraphin, 2018). The models that are created in the simulation can be both simple and complex. Models that are more complex bring a better imitation of a real object; however, they bring with them the problem of the complexity of creating such a model. Analysis is then a one-time activity, when by examining the model, we try to find out a certain property of the original and, last but not least, simulation is an activity where by analyzing the model we try to obtain the most faithful picture of the behavior of the original under precisely defined conditions.

Programs for solving circuits are sometimes divided into analyzing (analyzers) and simulation (simulators). However, the difference between them is usually not sharp, because they are to a greater or lesser extent able to realize a range of different types of analyses in both categories, using even complex models embedded in feature libraries.

Model analysis has its goals, inputs and outputs, method, form and means of implementation. The form of the analysis is then determined primarily by the means of its implementation, i.e. a computer with the relevant software, while the form of internal analysis procedures is hidden from the user and depends on the numerical algorithms used and their programming by the software creators. In addition to computational goals, the analysis may also have other goals, for example, the teacher can assign pedagogical goals (practicing a specific method of analysis, understanding a certain process in the district, etc.).

The phenomenon of simulation programs for electrical engineering or electronics does not distinguish boundaries between school levels. However, it depends on the use of these programs in schools, which can also be counterproductive (Biolek, 1999a). Today, computer simulation and circuit analysis are mainly carried out in the following areas (Biolek, 1999b):

1. Use of special software – typical representatives are programs such as TINA, MicroCap, Multisim, etc.).

2. Use of universal programs for mathematical-scientific calculations such as MATLAB, MAPLE, etc.

Methods of analysis of electrical circuits should not only serve as a tool for solution, but the teacher can also use them for explanatory purposes. The approach to teaching in this concept therefore has many different features from classical laboratory teaching and combines different methods and procedures. CH. Levert and S Pierre (2000) offer a methodology – a broadly conceived concept of virtual lab modeling and the use of simulation models that should work in different configurations and on different platforms (Michael, 2001; Musil, Dobrovolný, Stříbrný, 1997).

Closely related to the model, modeling is the concept of simulation, which is actually the imitation of reality, real state or process, using a model that imitates them (Serafin, 2023). The very act of simulation in general terms implies the display of some key properties or behaviors of selected systems (Hertel, 2002). Using Simulations to Promote Learning in Higher Education. Sterling, Virginia: Stylus). According to Serafín (2023), the simulation is a model that is designed to monitor dynamic processes using physical knowledge that is mathematically expressed.

Simulation of virtual electrotechnical kits can be entered in two ways. The first way is using a text editor, which is usually part of simulation programs. The second way is a schematic editor. The specific scheme is then shown in the following figure, where an example of the scheme is shown.

Of course, both of these ways weigh in with certain advantages and disadvantages. The advantage of the schematic editor is the clarity of the model. However, the controls vary depending on different programs. Text editors are standardized, but knowledge of programming languages is required. The simulator user then requires the process from input to result to be fast, user-friendly. This depends on the quality of the mathematical algorithm used by the simulator, on the amount of analysis available to a particular user, on the assortment of analysis modes, on the programmers, whether they tried to ensure the "user--friendly" assumption of the program (Serafín, 2023). The simulator predicts the behavior of the circuit, as in reality. Models that have certain properties replace specific components that would be used in the circuit. They are thus representatives of real components.

When simulating electrical circuits, the elements of the electrical circuit are described by physical parameters and stored in so-called libraries. These are part of the simulation program. Models can be defined by your own or modified.

Demonstration of electrical circuit simulation and its verification

For an example of a practical demonstration of electrical circuit simulation using virtual tools and its verification in practice, the Tinkercad virtual environment was chosen. A virtual multimeter was used to measure quantities. Subsequently, the virtual circuits were implemented in a real physical environment using the Arduino kit.

Measurement of LED circuit – off, on.

The first example is the measurement of the voltage drop on the LED and the current passing through the diode, which is limited by the series resistance (Figure 2–3). For clarity, the voltage value on the Arduino output pin is displayed. The voltage drop on the LED is 2.00 V. The current through the diode is 11.1 mA. The voltage on the Arduino pin is 4.44 V.

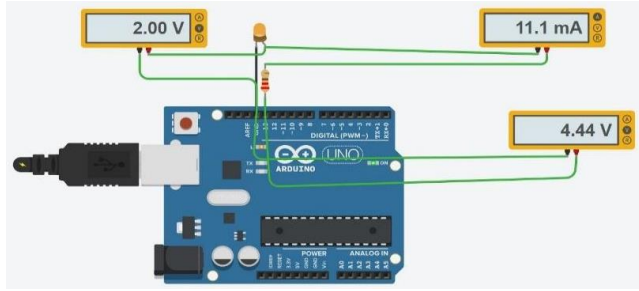

Figure 2. Simulation of led wiring (Tinkercad)

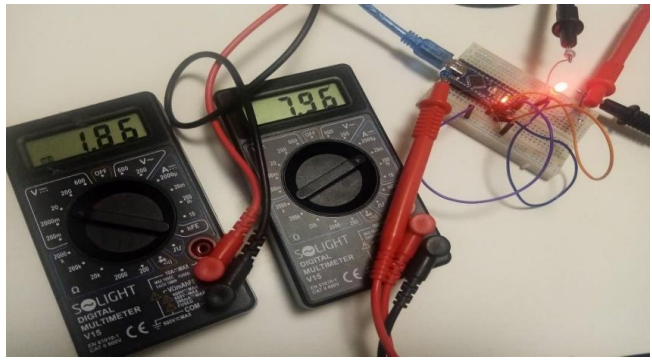

Figure 3. Simulation of led wiring

Measurement of led-PWM excitation circuit – stepless brightness control

As a second example, the brightness of the LED is changed by PWM modulation. The program continuously increases the current of the LED in 255 steps. In the figures, we can see differently changing values that capture the progress of the code. The quantities are directly proportional to the brightness of the diode (Figure 4–5).

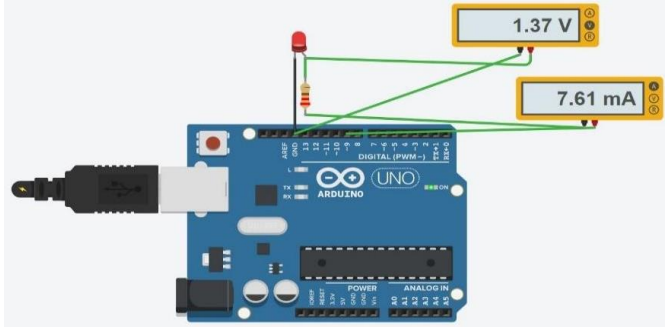

Figure 4. Simulation of led wiring with PWM excitation, continuous brightness control of led (Tinkercad)

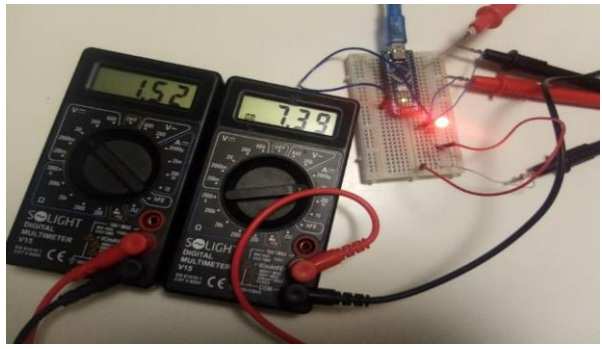

Figure 5. Simulation of LED wiring with PWM excitation, continuous LED brightness control

Application of didactic principles in vocational electrical education – influence of digital technologies

According to Hawkridge (1990), the potential of digital technologies in education can be seen as an essential tool for transforming schools into the digital age and transforming styles and the learning process. The world of digital technologies surrounds us. Digital literacy is becoming as important as literacy or numeracy. Knowledge of technology and the ability to use it to effectively solve problems naturally becomes an important part of education. Combining industry knowledge with relevant information and communication technology knowledge as well as relevant skills is key. It is a complex process in a multicultural environment requiring specific approaches that go beyond the limited boundaries of traditional teaching from the educational point of view. An approach that combines behaviorism, cognitivism and constructivism is *connectivism*, or the theory of learning in the age of information communication technologies (Siemens, 2005). Connectivism taking into account the fact that the one who studies constructs a system of knowledge in the conditions of his social environment, which takes place with the support of information communication technologies and tools in the environment of a computer network. As a result, it goes beyond the individual (Klement, Dostal, Kubrický, Bártek, 2017). Of course, the role of the teacher also changes, moving from an authoritative source of knowledge to the position of helper, advisor and inspirer, supporting students in their own education. A key aspect here is that the volume of information that learners encounter and work with is thus too large to be contained by learning or experience, and at the same time it changes too quickly over time (Klement et al., 2017).

Digital literacy and interactive education in teacher training

In the contemporary concept, a person who is able to use digital technologies for their personal development and civic activities is digitally literate. The very concept of digital literacy is inextricably linked to the understanding of

digital competences as a set of knowledge, skills and attitudes, including relevant competences, strategies and values. These are, of course, sets of competencies necessary to identify, understand, interpret, create, communicate and safely use digital technologies. Digital literacy can thus be seen as the result of formal and non-formal education and informal learning, within which relevant digital competences can be acquired, and thus, according to Martin (2008), digital literacy includes the ability to successfully carry out digital activities, which may include work, learning, leisure and other aspects of everyday life.

Digital literacy and thus digital competence are inextricably linked with technical competence. Interactive and multimedia teaching is a means that allows you to bring creative activities with game elements into education and thus create a more attractive, motivating learning environment increasing the effectiveness of education. However, emphasis needs to be placed on the fundamental difference between activities such as play and guided learning. In the case of use as a teaching aid, the term activity with game aspects can be used (Čáp, Mareš, 2001). The contemporary concept is thus close to the virtual educational environment with elements of activating games. Virtual reality creating the illusion of the real world in conjunction with interactivity can realize teaching in real time according to the user's wishes. Warthová (2016) points out the possibilities of using virtual reality in teaching, where teachers often have a problem to sufficiently engage pupils, and so a solution is offered in the form of virtual reality. According to a study by Chi-Yin (2011), pupils working with augmented or virtual reality understood the subject matter much better than pupils using other educational aids (textbooks, educational software and videos). Augmented or virtual reality helps to better understand the material, is more illustrative and easier to remember.

As part of the research, we asked student teachers about their abilities and digital literacy skills. This area can be based on different evaluation models – such as the European Framework for Digital Competences for Teachers (DigCompEdu), which characterizes 22 competences classified into 6 levels. Jeřábek et al. (2018) divides these competencies into 3 levels – basic, intermediate and advanced (Table 1).

Table 1 Model of digital competence levels for education

Level	Complexity of tasks	Independence	Cognitive area
Basic level	Simple tasks	under the guidance or without direct support	remember
Intermediate level	well-defined or routine tasks and simple problems	independently or according to your own needs	understand, apply
Advanced level	Tasks and problems of various kinds	leading others, the ability to adapt to others in the context of the complexity of the task	analyze, evaluate, create

Source: https://pages.pedf.cuni.cz/gramotnost/files/2019/01/01_Jerabek.pdf.

The research was built on a quantitative research design, the aim of which was to recognize the experience of educators regarding the mastery of digital technologies in teaching and the relationship to technology in general. The questionnaire measurement was carried out on 257 respondents, of which 125 were men and 132 women.

The research did not find that the gender of future teachers affects their abilities in the use of digital technologies, and was subsequently asked about the subjective level of knowledge of computer science in the context of previous competencies that respondents acquired through previous studies at primary and secondary schools. The word "subjective" is used here deliberately, as the level of knowledge and skills is assessed by the respondents themselves, which can lead to distortions in the perception of the actual level. The results showed the dominance of work with text, graphics, the Internet and the relevant technological devices. Respondents considered these areas of competence to be quite optimal. On the contrary, there was a very low level in programming, robotics, web creation and work with databases. These are the areas that need to be emphasized in teacher training, across subject approbations. This result can be seen as a logical consequence of the obsolescence of educational processes not only in the context of higher education for teachers, but also as a consequence of the decline in lifelong learning in this area. In 2023, a survey of 1267 Ipsos enterprises was conducted for the Chamber of Commerce, the Confederation of Industry and Transport and the Confederation of Employers' and Entrepreneurs' Associations[2], which concluded that development is only possible if we invest in technical infrastructure, high-capacity data networks, modern technologies based on automation and especially robotization, where the use of robots and artificial intelligence is essential. However, this cannot be done without people who have the appropriate professional competences, which are provided by education, and this does not produce graduates in the Czech Republic who will have skills in line with the demand in business.

Conclusion

The paper brings views on approaches to teaching in the preparation of future teachers of technically oriented disciplines, specifically electrical engineering. Although the goal is so narrow, its scope is much broader and more general, because it actually affects every teacher without depending on his qualifications. Education has always reacted to any changes with a long delay – given the nature of the curriculum-based implementation, which has been valid for many years. Teachers are able to suppress this handicap of education only by

[2] https://www.seznamzpravy.cz/clanek/ekonomika-firmy-jsme-skanzen-mirime-ke-kolapsu-ceske-firmy-vystavily-statu-vysvedceni-236237.

their own work, their knowledge and skills, orientation in new conditions, trends and possibilities, but they do not always have optimal conditions for this on the part of school management, but also on the part of teachers themselves, their self-education and personal development.

Part of the society is the education of its members so that the society can further develop, and this is what didactics is for. Without understanding what electric current is, for example, a person would never be able to discover a transistor, an integrated circuit, a CCD, and more. Only teachers have the opportunity to teach future generations of Nobel Prize winners, future generations of personalities who will develop new technologies.

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JOZEF PAVELKA

Renewal Plan and Reform State Educational Programme in Relation to the Perspective of Technical Education in Primary Schools in Slovakia

Professor, University of Prešov in Prešov, Faculty of Humanities and Natural Sciences, Department of Physics, Mathematics, and Technologies, Slovak Republic

Abstract

The study is based on selected parts of the Renewal Plan – Component 7: Education for the 21st Century, outlining the main aims and objectives of curriculum reform for primary and secondary education in Slovakia. The reform is set to be fully implemented from 2026. In relation to the aims and objectives of the curriculum reform, the study presents analytical conclusions regarding possible problem areas related to technical education in primary schools.

Keywords: technical education, primary school, curriculum reform, problematic areas

Introduction

Education and upbringing in primary schools (ZŠ) in Slovakia have undergone various transformative and reformative changes since 1989. The changes that gradually occurred had both positive and negative results and impacts. Concerning technical education in ZŠ, it can be noted that changes of a rather negative nature prevailed, such as a reduction in the number of teaching hours for technical subjects within the weekly time allocation.

The consequences and effects of these changes have undoubtedly manifested in the ongoing societal devaluation of the position of the subject providing technical education in ZŠ, as well as in deepening students' disinterest in science, technology, and the pursuit of technically-oriented study programs in secondary vocational schools. We consider this a key reason for the long-term shortage of a broad spectrum of qualified professionals in the field of technology and services within the Slovak Republic.

The intention of this study is to confront selected objectives in the initial stage of the ongoing curriculum reform outlined in the Renewal Plan with expected changes related to technical education in ZŠ in Slovakia.

Component 7 Education for the 21st Century

The document *Component 7 Education* is focused on primary and secondary education. Its main goal is to provide students with education adapted to the needs of contemporary society. The general aim of the component is to increase the literacy and skills of students necessary for life in a global and low-carbon digital economy and society (critical thinking, digital, and soft skills) (Government, 2021).

In various parts, the document provides broader information and main activities in the areas of curriculum reform for the years 2021–2026 and their main objectives. In the following, we will present only a brief selection of areas that the reform touches upon and express opinions regarding technical education in Slovakia.

Area of Digital Infrastructure and Expansion of Primary School Capacities

The prerequisite for the development of students' literacy and skills is accessible school infrastructure. It is necessary to build digital infrastructure and expand the capacities of primary schools in districts that do not have optimal access to education (double-shift operation of schools).

Planned Investment 1: Digital infrastructure in schools will support the construction of digital infrastructure and will indirectly strengthen the digital literacy and skills of students. The total investment in the digitization of schools will amount to 187.2 million euros.

Planned Investment 2: Building school infrastructure aims to expand the capacities of primary schools in districts that do not have optimal access to education (double-shift operation of schools). Emphasis will be placed on schools with a high number of children from socially disadvantaged backgrounds.

For the construction of school libraries in 211 schools with more than 15 students from socially disadvantaged backgrounds, 15.6 million euros will be needed. The construction of school infrastructure will require investments totaling 123.3 million euros, of which 102 million euros will be for expanding school capacities and 15.6 million euros for building school libraries.

In the area of digital infrastructure, it can be expected that the planned provision of ICT resources and improved internet networks, as in other subjects, will contribute to an increase in the quality of digital literacy among students.

We consider the planned expansion of primary school capacities to eliminate double-shift teaching as beneficial. Given the specific focus and needs of technical education, financial resources allocated to the construction and expan-

sion of school libraries, as an additional source of information for technical education, are expected to have desirable effects only to a limited extent.

If the educational area of "Human and the World of Work" is to achieve its set goals and educational outcomes, financial resources should be planned within the Recovery Plan and other reform materials to ensure the spatial and equipment requirements specified by standards for the outdated material and technical equipment of schools for technical education. *However, these resources are not found in the Recovery Plan and other documents.*

The Area of Expansion of Primary School Capacities

Within the school reform, activities are mainly focused on expanding the capacities of primary schools in districts that do not have optimal access to education (double-shift operation of schools). Emphasis will be placed on schools with a high number of children from socially disadvantaged backgrounds. Another activity is the construction and expansion of school libraries.

From the analysis of the documents *Renewal Plan – Component 7* and *Feasibility Studies for Generalizable Typical Solutions of Primary Schools* (Ministry, 2022), it follows that within reform activities (e.g., construction of new primary schools and school libraries), *there is no consideration at all for the construction and completion of school specialized workshops for technical education (school workshops), including their material-technical equipment and completion!*

As is generally known, the goals and intentions of technical education in primary schools have not been fulfilled to the desired extent in the previous period. This raises the question: *What was the reason for this state of affairs?* The main reason can unequivocally be attributed to the unsystematic approach of state authorities, school founders, and in some cases, the management of primary schools towards creating the necessary spatial, material-technical, and personnel provisions for technical education in primary schools.

There are several published works on this reason, which, based on survey results and research, repeatedly confirm that:

1. From 1989, many primary schools in Slovakia saw the elimination or relocation of school workshops to other (often inadequate) spaces, and these workshop spaces were used for other educational purposes (e.g., language and computer classrooms).

2. Outdated material-technical equipment for implementing technical education was completely destroyed (not replaced) or persists until now in several cases. It was only through the understanding of some primary school managements, municipal mayors, and teachers who obtained financial resources from various projects, and especially the implementation of the National Project "Workshops," that conditions for technical education were innovated in almost a fifth of primary schools in Slovakia.

3. Personnel provisions for technical education in primary schools in the previous period and currently can be considered alarming because up to 53.3% of teachers teaching the subject of technology teach it non-professionally (without the required qualification). (MŠ VVaŠ SR, 2014). It is common in schools for technology classes to be used to supplement the commitments of those teachers who have a different subject composition in their qualifications.

The reform material *"Foundations of Changes in Educational Areas…"* states

The educational area of Human and the World of Work directs:

– to support students' ability to use innovative thinking, knowledge in the field of science and technology, and manual skills in the realization of their own designs,

– to develop students' ability to use and handle technical tools and devices, as well as scientific data, to achieve goals or make decisions, express opinions based on evidence, etc. (ŠPÚ1, 2021)

If the educational area of Human and the World of Work is to be directed towards the mentioned goals, then to achieve the desired effect of reform changes, it is necessary to simultaneously ensure targeted financial support for schools to equip their material-technical background (MTZ) for technical education. Innovations and enhancement of MTZ in schools should become commonplace and should involve the provision of:

1. Basic and diverse technical materials (semi-finished products) necessary for students to understand the types, properties, and practical uses of materials, fostering technical creative thinking, drawing conclusions based on evidence, and implementing interesting and motivationally effective experimental and research activities.

2. Basic and additional content and objectives of technical education suitable for the interior equipment of school workshop classrooms (e.g., work tables, planers, shelves, etc.), modern tools, instruments, selected small machining tools for machining technical materials. Without these resources, it is not possible for students to adequately acquire manual skills, understand the essence and significance of various material processing technologies, and apply them in the realization of their own creative ideas within the framework of constructive creative thinking and product creation. Students would be unable to identify, propose, and implement technically appropriate and feasible solutions, as well as analyze related effects and dangers. Without real practical activities involving the mentioned equipment, students cannot explore various professions and cannot objectively and self-critically decide on their future professional direction.

3. Basic and adequate additional technical equipment with devices, apparatus, and technical building blocks that enable the realization of educational content requiring students to understand the principles of their operation and

master the basic principles of occupational safety and health when using them (e.g., selected household devices and equipment – electrical, mechanical, gas, air conditioning…; residential installations – electrical strong and weak current, gas, plumbing, telecommunications, etc.). Without this equipment, which is currently lacking in the vast majority of schools, it is not possible to develop students' abilities to use and handle technical devices, understand their function, significance, and environmental implications, analyze necessary data, compare them, and make conclusions or decisions.

4. Basic equipment with ICT tools (interactive board, internet, necessary number of computers, etc.), without which it is very difficult to develop digital literacy and quickly convey the "just necessary" information from selected areas of technology to students amidst a vast amount of information.

Based on the above, it is proposed that as part of the reform changes, normative space and MTZ for technical education for the school and the student be additionally included in the reform materials for the educational area of Human and the World of Work. If the intentions, goals, and content of technical education are changing and innovating, the normative that must be fulfilled in schools within a specified time frame must logically change accordingly (from the perspective of state authorities). However, fulfilling this requirement cannot be left solely to the schools. In this regard, reform changes must be financially supported and ensured by the state, even if it is done later. Otherwise, the entire reform effort, its results, and teaching within the educational area of Human and the World of Work will be carried out at a theoretical level, and the intended reform goals in that area (including the Profile of a Primary School Graduate) will not achieve the desired results.

Area of curricular and textbook reform

The curricular reform will create new educational content organized into three multi-year cycles. Instead of transmitting ready-made information, teaching will create situations where students can interpret information in confrontation with real experience. There will be a need to create space for commenting on current topics, discussion, and actively involving students in the learning process. Rather than detailing the curriculum within narrowly defined subjects, the content of education will be conceived in broader educational units (e.g., man and nature, man and society). The reform systematically integrates cross-cutting themes such as financial literacy, global health (e.g., epidemics), climate change and warming, economic crises, and gender equality.

The new curriculum will also require the provision of new textbooks. As part of the reform, support for the digitization of textbooks will be created to strengthen interactive elements in teaching, facilitate distance learning if necessary, and allow their use by students with health disadvantages. Digital learning

materials will also reduce printing costs and support digital and green transformation.

The curricular reform will require costs of EUR 99.7 million. Of this, EUR 41.9 million will go towards creating and implementing a new curriculum (including the creation of supporting digital tools), EUR 44.5 million for the systematic provision of new textbooks, and EUR 13.4 million for the expansion of electronic testing and ensuring online maturity.

In the field of curricular and textbook reform, new goals and new content for technical education in primary schools have been set through the State Educational Program (ŠVP) and educational standards. The educational area of Human and the World of Work is characterized in the new ŠVP as follows. The three basic components of the area are Technology, Entrepreneurship and Initiative, and Career Education (Figure 1). All three components are interconnected so that emphasis is placed on the development of technical, creative, and critical thinking in the educational area. Emphasis is placed on developing technical and professional literacy in students. The concept of technical literacy refers to the ability of students to use, control, evaluate, and understand technology. The content of the educational area of Human and the World of Work is linked to solving practical problems, which

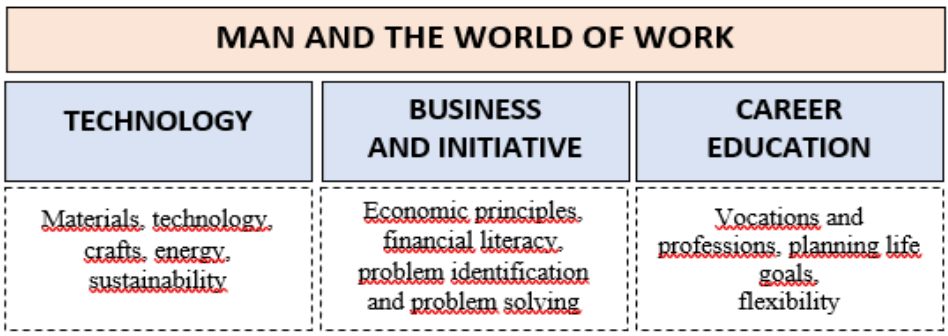

Figure 1. Components and Content of the Educational Area "Man and the World of Work"

Source: Author.

The processes are connected to planning, active experimentation, and learning from acquired experiences. Students should be able to navigate the world of technology, understand trends in technological development, the implications of scientific progress, and the impact of human activity on the world. Emphasis is placed on creative and innovative use of technological tools to achieve goals or draw conclusions based on evidence.

Skills in this educational area also include critical awareness and support for environmental safety, such as waste minimization and proper waste manage-

ment. It focuses on the development of general user skills, modern technological thinking, shaping attitudes, and values needed in the world of work. Students learn to combine thinking with manual activities and understand the relevance of what they study in school to their later productive age. Attention is focused on students' ability to understand that their work creates values useful for others in society, and they can turn their ideas into real actions. They are capable of initiative, taking responsibility, accepting risks, and achieving set goals. Initiative and perseverance are also abilities that enable students to collaborate with others to plan and manage projects with cultural, social, or commercial value. Career education significantly contributes to the development of students' ability to plan significant life steps in their professional and personal lives, set alternative life goals, find effective ways to achieve them, and constructively deal with potential failure. The development of these goals is closely related to the personal development of the student, the development of social and communication skills, the ability to learn, and the planning of their own career. (Ministry, 2023)

The National Curriculum sets educational standards for the educational area of Human and the World of Work separately for the 1st to 3rd cycles of education (years 1 to 3, 4 to 5, and 6 to 9 of primary school) and separately within each cycle for the individual components of Technology, Entrepreneurship and Initiative, and Career Education in three parts: performance standard, content standard, and activities.

The division of standards is clear and orientationally satisfying. In line with Hašková and Lukáčová (2022), we note that the goals and contents of education in the Technology component mostly mirror the goals and contents defined by the educational standard so far. A new aspect of the National Curriculum is that, compared to the educational standard of the previous technical subject, which partly included goals and contents related to entrepreneurship and initiative and to a large extent also career education, the National Curriculum sets a new separate educational standard for both the Entrepreneurship and Initiative (E&I) and Career Education (CE) components.

In our opinion, this fact may evoke two approaches among technology teachers in planning and modeling technology teaching:

Approach 1: Technology teachers develop a thematic educational plan (TEP) for the selected grade by planning the teaching of thematic units and topics of the Technology component within 33 teaching hours for the entire school year. They appropriately incorporate performance requirements (goals) and content from the educational standards of the E&I and CE components into individual topics. This adjusts and supplements the existing system of technology teaching, and if technology teaching is provided by multiple teachers in different grades and cycles, teachers will have to coordinate the structure of TEP to ensure that the goals and contents set for the entire cycle are fully met and implemented. In this case, technology teachers can continue to use the technology

textbooks they have been using, but they will have to develop the prescribed curriculum (contents) for the E&I and CE components.

Approach 2: Technology teachers approach the development of TEP by first dividing it into three parts based on the total number of teaching hours in the school year (a total of 33 hours) and allocate 11 hours for each of the standards T – E&I – CE in line with educational standards. This means that thematic units, topics, goals, and contents of the Technology component are planned and taught within 11 teaching hours in the school year, and the same is planned for the E&I and CE components. We note that fulfilling the requirements of the performance and content standards and implementing the prescribed activities for the Technology component within 11 teaching hours in the school year is practically unattainable in school practice.

The indicated approach 2 represents a high level of risk to the teaching of technology and does not ensure that the goals and intentions of the educational areas of Human and the World of Work are fully met and of the required quality in accordance with the reform requirements. *This model does not ensure that all three components are interconnected so that emphasis* is placed on the development of technical, creative, and critical thinking, as well as the development of technical and professional literacy in students. We mentioned this possible approach because its real-world use exists in school practice. However, we do not wish for this to happen.

In this case, technology teachers can continue to use technology textbooks only within the framework of teaching the Technology component. The content for the components E&I and CE will have to be developed until new textbooks are issued for all components of the educational areas of Human and the World of Work.

As mentioned earlier, we have already stated that the division of standards is clear and orientationally satisfactory. From our point of view, the authors should have developed educational standards for individual educational cycles within the educational areas of Human and the World of Work in a conceptually integrated manner, i.e., for each cycle, develop a single separate (gradually related) educational standard combining the target and content requirements of all three components (Technology – Entrepreneurship and Initiative – Career Education). In this case, there would be a clearer and more specific connection of the target and content requirements of all three components within the thematic units of the entire educational areas of Human and the World of Work. Teachers would thus significantly reduce the burden they would have to bear during the study and analysis of 3 standards for 3 components in each education cycle. Teachers will be forced to conduct a deep analysis and comparison of all standards, incorporate the results of the analysis didactically into new TEPs, develop new teaching methodologies, etc., including incorporating additional requirements rela-

ted to the development of digital and global skills, inclusive education, green transformation, cross-cutting themes, and more.

We find it gratifying and consider it a positive fact that in the new National Curriculum and in the new educational standards of the educational area of Human and the World of Work, there is no longer the educational focus of Household Economics (ED). In our published studies, we have repeatedly pointed out that the inclusion of ED teaching in the teaching of the subject of Technology was non-systematic; ED teaching disrupted the teaching of technology, and schools included ED teaching to varying degrees and according to their possibilities, primarily because ED teaching in schools had to be implemented. Textbooks for ED teaching did not exist, and ED teaching was provided by teachers with almost 100% lack of expertise. With this, our long-term effort has been fulfilled.

Area of preparation and development of teachers for new content and forms of teaching

The reform will strengthen the quality of pedagogical and professional staff's skills and motivate them for lifelong professional development. Emphasis will also be placed on inclusive education and the acquisition of digital skills. It includes a change in teacher preparation so that they can apply the changes from Reform 1 in their daily practice.

The main goal of the reform is to improve the quality of pedagogical and professional staff's skills and motivate them for lifelong professional development. The reform will impact: a) the preparation of future teachers and b) the motivation of teachers in practice for further education.

The reform aims to support teachers in adequately addressing three challenges:

- implementation of the curriculum reform into daily practice,
- increased use of digital technologies in teaching,
- consideration of individual needs of each child in the teaching process, especially in a multilingual environment or with children from socially disadvantaged backgrounds.

Pedagogical faculties and other faculties preparing teachers and teacher education will undergo transformation with the following goals:

1. Preparedness of teachers to implement the new curriculum. Study programs will be designed to align with the structure of the new curriculum organized into cycles: a) programs for the first and second educational cycles, b) for the second and third educational cycles, c) for the third educational cycle and high schools. Study programs preparing teachers for primary schools (second and third cycles) will, in addition to traditional preparation for teaching two freely combinable subjects, also provide integrated programs for teaching broader educational areas (natural sciences, social sciences, health, and physical edu-

cation), adapting the qualifications of graduates to the needs of primary school practice and the intention of the curriculum reform.

2. Strengthening direct collaboration between pedagogical faculties and other faculties preparing teachers with schools and school practice, and their interaction in supporting the professional education of teachers (counseling, practical training).

3. Faculties will be more actively involved in the ongoing education of teachers. By not favoring only courses provided by the Ministry of Education, Science, Research and Sport, teachers will be motivated to choose further education according to their needs.

4. Emphasis will be placed on inclusion and digital skills in study programs.

5. Integration of digital teaching methods and innovations in digital education into all programs.

The reform also aims to motivate pedagogical and professional staff for lifelong professional development:

1. Introducing a financial contribution tied to priorities in the field of state policies (e.g., changes in the content and forms of education, support for inclusive education, digitization of education).

2. Legislative changes will adjust the competencies and scope of providers of certifications, functional, and qualification education in the education sector.

3. Qualification standards for the preparatory education of teachers will change in line with the implementation of the new curriculum.

4. A new model of accreditation of educational programs for professional development will be established, including the assessment of their quality.

The transformation of pedagogical faculties and other faculties preparing teachers will take place through the following steps:

1. A grant program for universities will be established to transform study programs preparing future teachers. This program will support the development of new teacher education programs. Funding will also be provided for changes in programs that promote inclusive education, education for students with different native languages, and the development of digital competencies among teacher education students. Grants will prioritize strengthening gender equality.

2. Legislative frameworks will be changed to allow for the implementation of modifications in teacher education in line with the new curriculum and requirements for professional study programs. Teacher certification and specifications of teacher professional study programs in the law on higher education will be redefined. Corresponding adjustments to standards for accrediting teacher education programs will be made.

3. The description of the teaching and pedagogical sciences study program will be adjusted to ensure that practical teaching constitutes at least 20% of the study time or 20% of the European Credit Transfer and Accumulation System (ECTS credits).

4. Study programs will be introduced to profile teachers in integrated educational areas for the second and third cycles of basic education. A higher education program for early and pre-primary education (from 0 years to compulsory pre-primary education) will also be included.

The professional development of teachers will be supported through the following measures:

1. A new funding model for individual professional development will be introduced. The use of funds will be tied to the content of education, including mandatory professional activities (e.g., selected priority topics: inclusion, digitalization, curriculum changes) and optional professional activities (e.g., certification, completion of programs addressing individual learning needs).

2. Teachers will order educational services from providers with precisely defined professional competencies (universities, organizations under the Ministry of Education, Science, Research, and Sport of the Slovak Republic, and non-public providers), creating a competitive environment and pressure on the quality of educational services. Education involving priority topics (curriculum reform, digitalisation, inclusion) will remain in the competence of the organisations of the Ministry of Education and Science of the Slovak Republic. All available training will be published in a central catalogue.

3. The Ministry of Education, Science, Research, and Sport of the Slovak Republic will guarantee, through organizations guiding teacher professional development, a new system of quality control for providing professional education. This includes standardization of professional competencies of pedagogical and expert staff, transparent accreditation rules for providers (programs) of professional development, and evaluation of needs and feedback on the quality of educational services through a public online portal.

The reform of teacher preparation and development will require costs amounting to 50.4 million euros. A grant program for universities preparing elementary school teachers, totaling 2.6 million euros, will be used to create new teacher programs.

Further education for teachers in connection with the new curriculum and key topics (digitalization, inclusion) will be ensured through newly introduced contributions to the professional development of elementary, secondary, and high school teachers, totaling 47.8 million euros.

In the area of teacher preparation and development for new content and teaching methods, the Recovery Plan states the following: The reform will strengthen the quality of pedagogical and professional staff's skills and motivate them for lifelong professional development. Emphasis will also be placed on inclusive education and the acquisition of digital skills. Part of this is a change in teacher preparation to enable them to apply the changes from Reform 1 in their daily practice. The main goal of the reform is to improve the quality of pedago-

gical and professional staff's skills and motivate them for lifelong professional development.

From several activities aimed at ensuring the achievement of the reform goals in this area, we select:

1. Changes in the preparation of future teachers.
2. Motivation of practicing teachers for further education.
3. Introduction of study programs profiling teachers in integrated educational areas for the second and third cycles of basic education.
4. Provision of integrated programs for teaching broader educational areas,
5. Adjustment of graduates' qualifications to the needs of elementary school practice and the intentions of the curriculum reform.
6. Redefinition of teacher accreditation and specification of teacher professional study programs in the Higher Education Act. Corresponding adjustments to the standards for the accreditation of teacher study programs will be made.
7. Emphasis on inclusion and digital skills in study programs.
8. Inclusion of digital teaching methods and innovations in digital education in all programs.
9. Introduction of a new system (control) for the quality of provided professional education.
10. Standardization of professional competencies of pedagogical and professional staff, etc.

These significant changes apply to a large extent to all faculties. The implementation of these changes will require not only sufficient time but also a high level of expertise from the creators of study programs. It also necessitates the reorganization, supplementation, and possibly integration of the qualifications of higher education educators regarding the structure of future study programs. The practical realization of these changes will demand a substantial amount of financial resources. The digital infrastructure of faculties is mostly outdated, and rapid obsolescence is a concern. There's a need for potential expansion and equipping of specialized classrooms with tools enabling inclusive education in line with new target requirements.

The text expresses concern that the recovery plan document did not allocate any financial resources for these significant changes in selected higher education institutions. This is viewed as a serious deficiency in the planning of reform changes and their implementation in school practice, which could significantly affect the overall effectiveness of the school reform.

In addition to the above, we note that in the last statistical report of the State School Inspectorate in 2014, the rate of non-professionalism in teaching the subject of technology in primary schools in the Slovak Republic was 53.3% (Ministry, 2014). It is likely that this state of affairs persists even today. Unless this problem is also addressed by the state authorities and reform materials, the positive effects and benefits of the reform are uncertain.

Conclusion

After 1989, there were several changes in technical education in Slovakia that influenced the teaching of technology either partially positively or, more significantly, negatively during different periods. The latest positive development is considered to be the period from 2015 when members of the then Subject Commission for the educational area "Human and the World of Work", in collaboration with the School Educational Program Department in Bratislava and the Ministry of Education, managed to stabilize the subject of technology in the Framework Curriculum for Primary Schools as a compulsory subject with a time allocation of 1 lesson per week in grades 5 to 9. The updated Educational Standard for Technology also gained validity.

The introduction of the "Economics of the Household" into the technology subject was deemed inappropriate and unsystematic by the Ministry of Education. Another significant step intended by the members of Human and the World of Work was to make maximum efforts to ensure technical education in all primary schools in Slovakia, especially in terms of their spatial and material--technical equipment. However, this fundamental goal was interrupted by the dissolution of the former subject commissions and the establishment of new reform teams. As work on the planned school reform is intensively ongoing, and the implementation of the reform in practice is becoming a reality starting from the school year 2023/2024, the authors of the reform are wished success in creating dignified (better than before) conditions for the upliftment and implementation of technical education in primary schools in Slovakia.

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MILAN ĎURIŠ [1], ALENA OČKAJOVÁ [2], PETRA KVASNOVÁ [3]

Designing Experiments for a Research-Oriented Model of Learning in the Subject of Technique in Lower Secondary Education

[1] ORCID: 0000-0002-4835-7733, University professor, Matej Bel University Banská Bystrica, Faculty of Natural Sciences, Department of Technology, Slovak Republic
[2] ORCID: 0000-0001-9347-4501, University professor, Matej Bel University Banská Bystrica, Faculty of Natural Sciences, Department of Technology, Slovak Republic
[3] ORCID: 0000-0001-8585-2269, Assistant Professor, Matej Bel University Banská Bystrica, Faculty of Natural Sciences, Department of Technology, Slovak Republic

Abstract

In this article, attention is paid to the selected design of experiments that will be part of a research-oriented model of students' education in the subject of Technique in lower secondary education in the Slovak Republic. The proposed model of education reflects the long-term needs of students' education in the subject of Technique, which, despite the updated content of the curriculum in the Educational Standard of the subject of Technique, have not yet been met. Part of the model is the application of formative assessment of students in the framework of the implemented experiential learning of students. Due to the limited scope of this article, two experiments from the set of proposed experiments are presented with the methodology of the actual implementation. The given problem is solved within the KEGA project No. 006UMB-4/2022 in the years 2022–2024.

Keywords: primary school, model of education, subject Technique, experiment

Home

In recent years, the results of students in the OECD PISA international tests have resonated in the Slovak Republic, as they have achieved statistically significantly lower performance than the average performance of students in OECD countries. This problem is receiving increased attention not only from teachers and the field of education, but also from parents and society as a whole. The school reform of primary schools in Slovakia is aimed at new goals of education in the 21st century, which is why the Act of the National Assembly of the Slo-

vak Republic No. 245/2008 Coll. on education and training (i.e. The School Act) and amendments and additions to certain acts has set the main goal of education – education of students to key competences. In the subject of Technique in lower secondary education, the performance standard clearly specifies the objectives, professional competences to be achieved and mastered by the student in a given year in the cognitive, affective and psychomotor areas.

Origins of the problem addressed

At present, the teaching of the subject of Technique in lower secondary education is carried out in accordance with the updated State Educational Programme and in terms of content according to the updated Educational Standard for the subject. Despite the targeted undergraduate training of future teachers of the subject of Technique at teacher training faculties, teachers in pedagogical practice are not succeeding in meeting the set objectives in the subject of Technique to the required extent. This is mainly due to:

– insufficient material and technical equipment for the subject of Technique,

– absence of students' experimental activity with ideas, materials, technologies and techniques,

– the still predominantly transmissive way of teaching and the prevailing summative assessment of students,

– not applying students' creativity and own ideas in working and experimental activities and other reasons affecting the quality of education in a given subject in individual regions in Slovakia.

The objectives of the subject of Technique formulated in the updated State Educational Programme (iSEP) reflect the content of the subject in the 5th–9th grade of primary school (further as "PS"). From the aspect of addressing the given issue in the project, we are primarily interested in the fulfilment of the following objectives in the subject of Technique:

– students experiment with ideas, materials, technologies and techniques,

– students distinguish and safely use natural and technical materials, tools, equipment and devices,

– students apply creativity and their own ideas in work and experimental activities,

– students will also learn to self-evaluate on the basis of the experiments carried out,

– students acquire the necessary knowledge and skills relevant for employment opportunities, for the choice of their own professional focus and for further professional and life direction.

Updated Educational Standard for the subject of Technique in the 5th–9th grade of PS in individual thematic units also contains a performance standard,

which formulates performances that determine what a student should know and be able to do at the end of a given school year within the thematic unit (SPU, 2015).

The assessment of a student cannot be just an assessment of his/her current performance, but should be directed towards formative assessment and self--assessment. The essence of self-assessment is that students are responsible for their learning and are actively involved in the learning process. From a didactic point of view, self-assessment can be seen as a competence that promotes self--activity and independence from the teacher.

Self-assessment and self-check are the most important motivational tools for the learner. Formative assessment of students in the teaching process aims at obtaining feedback on the student's progress in learning, on deficiencies and mistakes, with the aim of their elimination. As stated by several authors (Turek, 2014; Kalaš, 2013; Shute, Kim, 2014; Ďuriš, Stadtrucker, Pandurović, 2019a, 2019b; Pavelka, 2020), the formative assessment of students should be used more extensively because it improves the quality of students' knowledge and skills.

In order to meet the above goals, the research-based model of education will include learning of how to apply experiential learning to students, how to apply formative assessment to students, and how to develop and support students' key competencies and 21st century skills (creativity and innovation, creative and critical thinking, problem solving, etc.).

Structure and implementation of the designed experiments

The structure of the designed and selected experiments reflects the content of the thematic unit Technical materials and working procedures of their processing, which is included in the updated Educational Standard of the subject Technique in the 6th and 7th grade of primary school.

Since teachers cover the content with different emphases, we need to achieve equivalence of the students. We can achieve this by having the students learn before the experiment and let them understand the basic theoretical information on technical materials, wood, metals and plastics and their mechanical, physical, technological or chemical (metals) properties, which they will apply during the experiment.

These properties are characteristic in that they can be observed directly or by simple experiments. On the basis of an experiment carried out by themselves, students can more easily understand the phenomena observed, they can explain and justify the changes that have occurred in the process of the experiment they have carried out.

After the implementation of each experiment, students carry out a self--assessment and self-check. They answer the prepared questions in their own words, express their opinion on the experiment in writing, express how they understood the material and how it was to work with the task of the experiment.

Among the physical properties of wood, we also include its feature of water absorption. Structure and the methodology for the implementation of the experiment focused on this feature are presented below.

Experiment No. 1 ***Absorption of wood***

The aim is to determine the water absorption of softwood and hardwood and to compare them to each other.

Task for the student:

Determine on selected soft and hard wood samples the degree of water absorption of the wood, under the condition that both, softwood and hardwood, samples are immersed with their entire volume in water at the same time interval.

Tools:

– softwood sample (spruce, pine, or fir), hardwood sample (beech or oak) with dimensions 40 x 40 x 100 mm (alt. 20 x 20 x 50 mm),
– digital, or laboratory scales, 2 pcs of sinkers,
– water container, water thermometer,
– water of 25–30°C, cloth or paper towel.

Figure 1. Tools for the experiment of water absorption of the wood
1 – softwood sample (spruce), **2** – hardwood sample (oak), **3** – digital scale, **4** – 2 pcs of 100 g sinkers, **5** – water container, **6** – thermometer, **7** – cloth towel

Work procedure

1. Using the digital scale to determine the weight of the softwood and hardwood samples and enter the values in the table.

2. Immerse softwood and hardwood samples in the water container at the same time and load the weights (with sinkers) of each sample so that it is completely immersed in the water and does not float.

3. Leave the wood samples immersed in water for 15–20 min (30 min).

4. After a given time, remove both samples from the water, dry them with a cloth, find the weight of the softwood and hardwood samples and enter the values in the table.

Table 1. Recording data on the course of the experiment in the table

Wood sample	**Sample weight** [g]		**Difference in weight** [g]
	Start of the experiment	*End of the experiment*	
spruce (soft)			
beech (hard)			
other (hard)			

Explain in your own words what caused each sample to change the weight at the end of the experiment compared to its weight in the beginning of the experiment.

..... *student replies*

Explain in your own words why the weight of the soft wood sample is different compared to the hard wood sample after the experiment.

..... *student replies*

Your comments on the experiment (briefly justify the difficulty and clarity of the learning task): ..... *student answers*

In each row of the table mark one of the emoticons with an (**x**) based on your understanding of the task and how you liked the experiment (*the student answers).*

Table 2. Student's self-assessment after the experiment

How did I understand the lesson? How was it to work out the task?	☺ **very well**	😐 **good**	☹ **I need to improve**
1. I know the reason why soft wood is lighter than hardwood.	( )	( )	( )
2. I understood that softwood and hardwood have different water absorption abilities.	( )	( )	( )
3. I can name the feature of wood which enables soft or hard wood immersed in water to gain more weight.	( )	( )	( )
4. I understood the task and the experiment was illustrative and interesting to me.	( )	( )	( )

Among the physical properties of metals, we include electrical conductivity. Structure and methodology for performing the experiment focused on this feature are presented below.

Experiment 2 ***Electrical conductivity***

The aim is to find out the electrical conductivity of different types of materials and to compare them to each other.

Task:

Connect a simple electrical circuit and determine the electrical conductivity of selected samples of metal (stainless steel spoon), non-ferrous metal (aluminium spoon), plastic (plastic spoon) and wood (wooden spoon).

Note: silver, porcelain, silicone spoons, etc. can also be used.

Tools:

- 6 V bulb,
- 4.5 V flat battery,
- copper wire as a conductor of electric current,
- 4 pcs current clamps,
- spoons of different materials (aluminium, stainless steel, plastic, wooden).

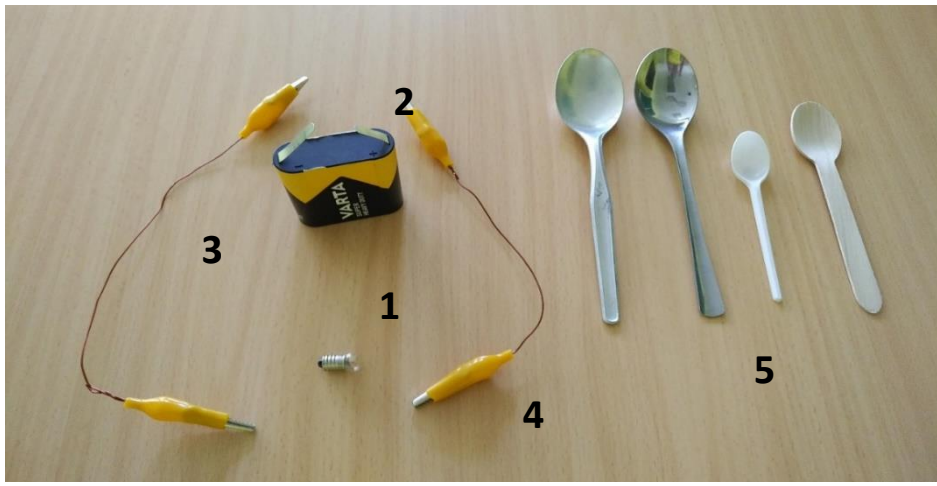

Figure 2. Tools for the experiment of detecting the electrical conductivity of materials

1 – bulb, **2** – battery, **3** – copper wire, **4** – current clamp, **5** – spoons

Work procedure

1. Attach the first copper wire to the contact of the battery with a current clamp, and connect the other end of the copper wire to the bulb by wrapping it around the screw.

2. Attach the second copper wire to the second contact of the battery using a current clamp, and attach the other side of the copper wire with the current clump to the stainless-steel spoon.

3. Attach the third copper wire to the other end of the stainless-steel spoon with a current clamp and connect the other side of the copper wire with the current clamp to the electrical foot contact of the bulb to close the electrical circuit.

4. If the bulb has lit up, write it in the table in the field for the given spoon material.

5. Repeat the same procedure for all available spoons.

Table 3. Recording data in a table on the course of the experiment

Sample	**Electrical conductivity** (yes/no)
stainless steel spoon	
aluminium spoon	
plastic spoon	
wooden spoon	
other.....	

Explain in your own words what caused the difference in the measured electrical conductivity for each material.

..... *student replies*

What do we call substances that conduct electricity?

..... *student replies*

What do we call substances that do not conduct electricity?

..... *student replies*

Write in your own words where you might encounter this feature of materials in your home.

..... *student replies*

Your comments on the experiment (briefly justify the difficulty and clarity of the learning task):

..... *student replies*

In each row of the table mark one of the emoticons with an (**x**) based on your understanding of the task and how you liked the experiment (*the student answers).*

Table 4. Self-assessment of the student after the experiment

How did I understand the lesson? How was it to work out the task?	☺ **very well**	😐 **good**	☹ **I need to improve**
1. I know the reason why the light bulb was lit with some materials.	( )	( )	( )
2. I understood that not all materials are electrically conductive.	( )	( )	( )
3. I can name the feature of metals which enables conduction of the electric current.	( )	( )	( )
4. I understood the task and the experiment was illustrative and interesting to me.	( )	( )	( )

Conclusion

We assume that the proposed model of education will not only be illustrative and exploratory for students, and that its implementation will not only apply experiential learning to students, but it will also include formative assessment of students. And this is the intention of the proposed research-based learning model with the application of appropriately designed experiments in the subject of Technique. The given model of education should preferably be adopted by students of undergraduate studies in the study subject Teaching of Technique (bachelor and master studies), the target group is also teachers of the subject of Technique enrolled in the extension study of the subject of Technique, but also qualified teachers teaching the subject of Technique in lower secondary education.

The solved problem is part of the KEGA project No. 006UMB-4/2022.

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SANJA NIKOLIĆ[1], **SLAVOLJUB HILČENKO**[2]

Programming Robots in Kindergarten

[1] ORCID: 0000-0001-9632-2458, Ph.D., College for Vocational Education of Preschool Teachers and Coaches, Subotica, Serbia
[2] ORCID: 0000-0003-2123-6285, Ph.D., College for Vocational Education of Preschool Teachers and Coaches, Subotica, Serbia

Abstract

Children at an early age easily acquire new technical and technological knowledge, and their abilities and skills surpass all expectations. Nowadays, children are already familiar with and interested in new technologies from a very young age, as it is an integral part of everyday life and has great potential for future development. In light of this, programming robots in kindergarten emerges as a very relevant and popular topic, which is precisely the subject of this paper.

Keywords: robotics, preschool age, robot programming, kindergarten

What is robotics?

Robotics is a multidisciplinary and interdisciplinary science and technology that deals with the research, development, design, and application of robots. It is a field that encompasses applied engineering sciences (mechanical engineering, production engineering, electrical engineering, electronics), computer science, as well as mathematics and mechanics (Milutinović, 2015).

The word "robot" originates from the Czech word "robota", which means forced labor. This term was first introduced by Czech science fiction writer Karel Čapek. According to the definition found in Webster's dictionary, a robot is an automated device that performs functions typically attributed to humans. The official and more precise definition provided by the Robotic Industries Association (RIA), which applies to industrial robots, can be translated as follows (Potkonjak, 2016): "An industrial robot is a multifunctional manipulator that can be reprogrammed and is intended to move work material, objects, tools, and special devices in various prescribed ways in order to perform different tasks."

In today's time, children are exposed to technology on a daily basis, which is why it is important to enable them to learn what lies behind the screens they use every day. They need to discover what drives that entire system they interact with while watching various cartoons, playing games, using social networks, and a range of other applications. Robotics is often equated with computer science and programming. However, it is important to note that automation and robotics are not part of the field of computer science or general computer literacy. Although programming robots falls under the domain of computer science, the technical aspect emphasizes the function, development, and construction of the robot itself. Robotics is a highly complex field, and therefore, the technical aspect takes a systematic problem-solving approach that simultaneously pays equal attention to the whole, while the computer science aspect emphasizes an algorithmic way of thinking based on understanding, analysis, and programming solutions (Padovan, 2018).

Development of robotics and the use of robots in educational institutions

Throughout history, humans have always strived to build machines that resemble them. There is no precise definition that can determine what a robot is. For robots that physically resemble humans, they can be described as machines designed to fully or partially replace humans in tasks. The development of robots and robotics is closely linked to the development of computers, mathematics, electronics, and electrical engineering. Based on the level of autonomy, interaction capabilities with the environment, and intelligence, several generations of robots are distinguished. The first generation includes programmed robots whose control process is carried out in control chains. These robots do not use feedback information, and errors in guidance cannot be corrected. The second generation of robots includes robots with a set of sensors that serve to obtain feedback information about their own state and the state of the environment. This allows them to correct errors during execution and adapt to changes in the robot and the environment. The third generation comprises intelligent robots with the ability to learn, reason, and make conclusions. They can adapt to different environments and unforeseen situations. They have a high level of organization, functionality, and mobile autonomy. The development of personal robots has also stimulated the development of social robots with various purposes: performing household chores, educating children, caring for patients, assisting the elderly and disabled, entertainment, and other applications. The development of robots is constantly growing, and more and more humanoid robots are being developed (Nikolić, 2015). The use of robotic technology in schools is most prevalent in technical schools that have subjects related to robotics. However, it is necessary to introduce robotics education at an earlier age, even in kindergartens, as it enhances the quality of teaching and education, motivates children to use technology and science, and helps shape technical and social skills in children (Nikolić, 2015).

Programming robots in kindergartens

The essence of programming is to identify a problem and break it down into smaller parts. In theoretical terms, a problem can be a practical or mental situation for which a person tries to find a way or procedure to solve it. The solution to a practical problem is usually practical itself, such as a construction solution, while the solution to theoretical problems is mental or rational (Bratina, 2012). The concept of programming is automatically associated with computers and involves creating a series of instructions to perform a task. Due to its association with computers, programming is rarely seen as a rational problem-solving approach. Therefore, it is often considered something abstract, difficult to master and understand. Adults, in addition to having a weak understanding, fear possible errors, which are an integral part of programming. This often leads them to give up quickly, and as a result, programming is perceived as something reserved for certain individuals. Children approach problem-solving with less formality and tend to lean more towards play. It is also known that children's problem-solving abilities change depending on their age. Accordingly, the approach and problem-solving techniques should be adapted to the child's age. For children between the ages of three and five, involving emotions and creative play is recommended, while for slightly older children (between five and seven years old), the use of open-ended questions (situations) and various materials is more appropriate (How to teach Problem Solving strategies, 2019). This is why an approach through play is necessary for educating children in problem-solving and learning the basics of programming. Practice confirms that children, unlike adults, do not have an initial fear of making mistakes, especially when problem-solving is presented as a game. For this reason, didactic programmable robots are increasingly being used for initial introduction to programming. Affordable prices, easy usability, and practical design have made it possible to generate interest in programming and problem-solving with a focus on digital technologies even among the youngest children.

Didactic robots

There are several types of didactic robots, adapted to the age of children and the complexity of programming procedures. Their visual characteristic is their appealing and likable appearance, but in terms of didactics, it is much more important to focus on the possibility of control or programming, which must be tailored to the age of the intended children. For children aged four to five, it is recommended that control and manipulation of the robot be done through an application on a tablet or a similar mobile device. In simpler cases, it is possible to set the robot in a line-following mode, which children can draw freely with their hand. This way, children become familiar with the basic functions of the robot, but with certain limitations. This use doesn't make much difference be-

tween a robot and a remote-controlled toy. Therefore, it is advisable to provide a higher level – initial robot programming by setting thematic backgrounds or elements that direct and control the movement and behavior of the robot.

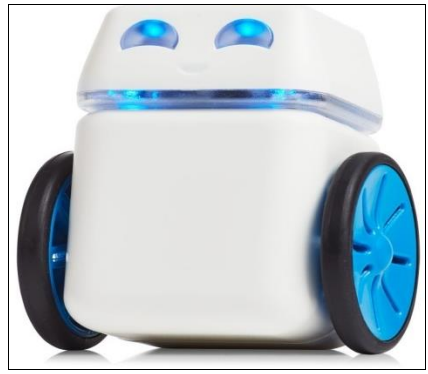

Figure 1. Didactic robot

For children aged five and older, it is more appropriate to introduce them to the first steps in programming. For this purpose, programming or code cards can be used, which visually represent the instruction (step) that the robot will execute (Figure 2). This approach is highly effective because children receive visual information about the future steps or movements of the robot and can theoretically verify the correctness of the proposed solution. At the same time, children understand that even simple movement is composed of a sequence of precisely defined steps (segments). Children receive immediate feedback on problem-solving by observing the robot's movement after it is activated. They can quickly identify and correct any errors by re-entering the programming steps, so to speak. If the robot's movement is correct, it represents a reward for the children and elicits a clear emotional reaction – enthusiasm. Problem-solving simultaneously stimulates their thinking, multiple actions, imagination, creativity, and encourages further exploration of the capabilities and features of the didactic robot.

Figure 2. Programming cards for the robot

The task of the educator is to introduce more complex problem situations and thereby raise the level of interest in the activity. Good examples include using thematic backgrounds or fostering a competitive spirit among the children, which can be observed in solving problems or tasks related to the movement and behavior of the robot.

Figure 3. Thematic backdrop for the robot

The essence of the robot activity on the thematic backdrop is for children to indirectly understand the robot's movements as a problem to be solved through small steps. In fact, children grasp that only when all the steps are properly combined, the robot will move as intended. In this way, children easily understand programming procedures.

Use of "bee bot" robot in kindergarten

The BEE BOT robot, shaped like a little bee, is very simple, appealing, and intuitive. This robot is an excellent tool for learning to solve simple problems and is easily applied in kindergartens. It can move forward, backward, left, and right. It doesn't have sensors, so it cannot "listen" to the environment or "see" whether the room is light or dark, whether there is an obstacle nearby, etc. It is great for taking the first steps in programming, but due to its limited capabilities, it is not an ideal choice for older preschool children.

Figure 4. BEE BOT Robots

BEE BOT robots are excellent for use in preschool settings. They are highly popular and loved by children due to their simple controls and friendly design. BEE BOT is a programmable robot designed for children aged 3 to 7 years old.

BEE BOT serves as an ideal starting point for teaching children programming. Working with BEE BOT introduces children to structured activities, develops their imagination, and offers a range of opportunities to explore cause and effect relationships.

Figure 5. Programming the BEE BOT

The importance of robotics for children

The importance of robotics for children is significant and diverse. Through robotics, it is possible to develop and strengthen perseverance and resilience in children. If the caregiver praises the child during the work process, it helps build perseverance. If the caregiver praises the child's final result and rewards them, it builds persistence and a desire to repeat that result Hilčenko (2022).

Therefore, the desired behavior we want to develop in children is achieved through praising the intermediate results of their work, as well as the final result, rather than just praising and rewarding the final outcome. Furthermore, robotics helps children acquire and strengthen their self-confidence. This aspect is achieved when the robot rewards the child every time they program it correctly. This reward given by the robot makes the child joyful and eager to learn more and progress by working on more complex tasks. The robot serves as an objective and unbiased evaluator. Through robotics, children also develop a sense of teamwork, cooperation, and communication. They develop their critical thinking skills and learn to advocate for their own ideas while respecting others' opinions through active listening. The importance of robotics for children is significant

and multifaceted. Here are some key aspects of the importance of robotics for child development:

Stimulates creativity and problem-solving skills: Robotics encourages children to think creatively and find innovative solutions to problems. They learn to analyze situations, think critically, and apply logical reasoning to overcome challenges.

1. Enhances STEM skills: Robotics integrates various STEM disciplines, including science, technology, engineering, and mathematics. Children develop a strong foundation in these subjects as they engage in hands-on activities that involve designing, building, and programming robots.

2. Fosters teamwork and collaboration: Many robotics activities involve teamwork and collaborative problem-solving. Children learn to work effectively in groups, communicate their ideas, and listen to others. They develop important social and interpersonal skills while achieving common goals.

3. Promotes persistence and resilience: Robotics projects often require trial and error, perseverance, and resilience. Children learn that failure is a natural part of the learning process and develop the determination to overcome obstacles and improve their designs.

4. Builds digital literacy and computational thinking: Through robotics, children gain exposure to technology and develop digital literacy skills. They learn to understand and use programming languages, algorithms, and logical thinking, which are essential in today's digital world.

5. Encourages curiosity and lifelong learning: Robotics sparks children's curiosity and enthusiasm for learning. It provides hands-on experiences that make abstract concepts tangible and relatable. This curiosity-driven learning mindset can extend beyond robotics to other areas of their lives.

6. Prepares for future careers: With the growing influence of automation and technology, robotics skills are becoming increasingly valuable in the job market. By engaging in robotics at a young age, children develop a foundation for future careers in fields such as robotics engineering, computer science, and AI.

Overall, robotics empowers children with essential skills and competencies that are vital for their personal and academic development, as well as for their future success in an increasingly technology-driven world.

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DANKA LUKÁČOVÁ

School Curriculum of Technology in Primary Schools in Slovakia – A Case Study

ORCID: 0000-0003-0186-5447, Ph.D., Associate professor, Constantine the Philosopher University in Nitra, Faculty of Education, Department of Technology and Information Technologies, Slovakia

Abstract

Since 2008, schools in Slovakia have been able to adapt the curriculum of each subject according to the requirements of the school, pupils or parents. Only the content and performance standards of the subject are binding for them. In this article, we publish an analysis of three school curricula and thematic educational plans. Through content analysis of the documents, we investigated how primary schools implement the content of the subject of technology. We analysed the differences in the thematic units, common features and the number of lessons each topic implements. We found differences in the thematic units that primary school teachers include in teaching technology, although they are insignificant. We identified the most considerable differences in the seventh year of primary school. Also, the thematic units taught in the subject area of Household economics are very heterogeneous in schools.

Keywords: school curriculum, thematic curriculum, content standard, content analysis, technology

Introduction

In all developed countries, technical education in primary and secondary schools, under various names, is a stable part of the curriculum with a significant time allocation (Kozik et al., 2003). The schools tend to conceive its inclusion in two ways: in terms of a separate subject, which is most common at the primary school level, or as thematic units that are part of science education.

Different countries introduce technical knowledge (skills) to their pupils in essentially two ways:

– in a particular subject directly related to technology,

– Through other subjects or modules, mainly in science, they are introduced to technology through cross-curricular links or separate thematic units.

Each country develops its content of the technically oriented subject or module. We implement technical education in Slovakia as a separate subject; the name and content have undergone several changes over the last 20 years. Since 2015, the name of the subject has been technology and its teaching at the 2nd level of primary school consists of one hour per week in each grade (5–9) (Hašková, Lukáčová, 2022). We divide the educational standard for technology into two main subject areas: technology and Household economics. Each subject area is further subdivided into thematic units. In technology, the performance and content standards are divided into individual grades. However, in the Household economics field, the school can elaborate and integrate this thematic area into the school curriculum according to its own needs. The emphasis is on technology, and the school must teach at least two-thirds of the total number of lessons in the subject in each school year. The thematic area of Household economics may fill no more than one-third of the subject's total number of teaching hours. The content standard for technology defines the knowledge, skills and practices that pupils should possess upon completing the subject. These requirements support cognitive processes such as searching, investigating, exploring, designing, discovering, manipulating objects, experimenting, practical activities, and constructing.

Aim and methodology of the research

The research aimed to determine what thematic units teachers instruct in technology in three different primary schools in Slovakia. Specifying the main objective, we set the following research questions:

RQ1 Is there a difference in the thematic units taught by teachers within the subject of technology?

RQ2 What are the most significant differences in the subject units that teachers teach in the subject of technology?

RQ3 Which thematic units are most commonly taught in the Household economics subject area?

RQ4 Which thematic units have the largest time allocation?

The sample consisted of three primary schools – one was a government school located in a village, the second was also a government school located in a town, and the third was a church school located in a town.

The choice of schools was deliberate – so the research group had a smaller school in the village (MZŠ), a larger school in the town whose director is the town (VZŠ) and a school where the director is the church (CZŠ) represented. In all three schools, qualified teachers taught technology.

We chose qualitative research as the most appropriate method to achieve the stated goal, namely content analysis of documents: school curriculum, thematic teacher education plan for the subject of technology (Burdová, 2022; Bánesz,

2022; Osúch, 2022). We obtained these documents from each school and subjected them to content analysis. During the analysis, we observed the following:

– the thematic areas included in the content of teaching the subject of technology,
– the thematic units included in the content of the teaching of technology,
– the number of hours planned for the teaching of the thematic units.

Table 1 presents the thematic areas taught in the subject of technology in primary schools according to the educational standards.

Table 1. Representation of thematic areas in each school (Omelinová, 2023)

Year	Thematic area	Number of teaching hours		
		MZŠ	VZŠ	CZŠ
5.	Technology	25	25	31
	Household economics	8	6	2
6.	Technology	25	29	32
	Household economics	8	2	1
7.	Technology	25	15	31
	Household economics	8	14	2
8.	Technology	25	21	30
	Household economics	8	7	3
9.	Technology	25	26	31
	Household economics	8	5	2

By analysing the school documents of the three schools under study, we have arrived at findings that can be used to answer the research questions posed.

Research results

We found that the primary schools of the MZŠ and CZŠ meet the condition of teaching the subject of technology, which obliges the schools to teach at least two-thirds of the lessons of the subject area of technology and a maximum of one-third of the subject area of Household economics. The primary school VZŠ does not fulfil this condition in Grade 7. In this case, there is an increase in the number of teaching hours in favour of Household economics to 14 teaching hours, which is not supported by the content and performance standards of the subject.

On RQ1: In Years 5 and 6, the most significant difference is that some schools surveyed have included an introductory lesson. All three schools teach all the prescribed thematic units on technology and selected thematic units on Household economics. All three schools maintain a two-thirds representation of the technology subject area. The most significant difference in topics is in the seventh year. Although all three schools teach all the prescribed thematic units of thematic areas of technology and selected units of the Household economics topic, one school (VZŠ) has added one extra topic: Materials and technology.

Two primary schools (MZŠ and CZŠ) have maintained a two-thirds representation of the technology thematic area. One primary school (VZŠ) does not have this representation and the thematic units on Household economics account for almost half of the lessons. In Years 8 and 9, some schools again have an introductory lesson. All three primary schools in the technology thematic area teach all the prescribed thematic units, thus meeting its two-thirds representation.

On RQ2: The most considerable differences in the topics covered relate to Household economics. In this heading, the 5th grade of the MZŠ has a thematic unit on Handwork and a field trip to a company that sews work clothes. In the thematic area of Household economics, the VZŠ teaches the thematic unit of Housework and household maintenance and the unit of Handwork. It also has a time reserve of two hours for consolidating knowledge, skills and habits. The CZŠ teaches the unit Planning and household management in Household economics.

In Year 6, the MZŠ has a topic on Handwork. In addition, this school has a field trip to a business listed in Household economics. The VZŠ has thematic units on Food preparation and nutrition and Household planning and management. The school has two lessons dedicated to consolidating knowledge, skills and habits. The CZŠ focuses on the thematic unit Planning and household management in the Household economics thematic area.

In Year 7, each school addresses different thematic units within the Household economics framework. In Year 7, the MZŠ has a thematic unit on Housework and household maintenance and an excursion to a productive enterprise covered in two lessons. The VZŠ has thematic units on Food preparation and nutrition, Handwork and Cultivation and husbandry. Under Household economics, the CZŠ covers the thematic unit Planning and household management (Table 2).

Table 2. Representation of Year 7 thematic units by school

	Thematic area	Number of teaching lessons		
		MZŠ	VZŠ	CZŠ
Year 7	Introductory lesson	1	1	0
	Graphic communication	5	6	5
	Technical materials and working methods for their processing	13	6	16
	Household machines and equipment	5	2	6
	World of work	3	1	4
	Housework and household maintenance	7	0	0
	Food preparation and nutrition	0	5	0
	Handwork	0	5	0
	Cultivation and husbandry	0	4	0
	Planning and household management	0	0	2
	Materials and technologies	0	3	0

The Year 8 MZŠ has a thematic unit on Housework and household maintenance in the thematic area of Household economics and also has a field trip to a manufacturing enterprise in the village. The VZŠ again has a time allowance for consolidation of knowledge. Within the Household economics heading it teaches the thematic units of Food preparation and nutrition and Cultivation. The CZŠ teaches the thematic unit Planning and household management under this heading.

In Year 9, the MZŠ teaches the thematic unit on Housework and household maintenance and also has a planned excursion to a metalworking manufacturing enterprise. The VZŠ teaches Family preparation and Planning and household management. The school also has a two-hour time slot in Year 9 to consolidate knowledge. The CZŠ covers the thematic unit Planning and household management in the Household economics strand in Year Nine.

On RQ3: The most commonly taught topic in the fifth year of the Household economics curriculum is Handwork, taught in two primary schools. The most frequently taught topic in the sixth grade is Planning and household management. In years seven and eight, each school teaches different thematic units in Household economics. Year nine's most commonly taught topic is Planning and household management (in two schools). In summary, in all grades, the most frequently covered topics in Household economics are Planning and household management, Handwork and Housework and household maintenance.

On RQ4: In Year 5, the most taught topic is Utilitarian and gift items – 35–67% of the teaching hours. Of the schools surveyed, CZŠ devotes the most hours to this unit – up to 67% of all hours taught annually. In Year 6, the subject unit Technical materials and working methods for their processing is taught the most. It accounts for 32–40% of the teaching hours in the year. The CZŠ has the highest number of hours devoted to this unit of all the schools surveyed, with 40% of all the hours taught annually. In Year 7, the most significant amount of time in two primary schools is devoted to the thematic unit Technical materials and working methods for their processing. It accounts for 18–40% of the teaching hours annually. In Year 8, the largest allocation of time is the unit on Technical production, which accounts for 27.5–35% of the teaching hours of the whole year.

Table 3. Representation of Year 9 thematic units by school

	Thematic area	Number of teaching lessons		
		MZŠ	VZŠ	CZŠ
Year 9	Introductory lesson	2	1	0
	Housing installations	5	9	8
	Machining of materials	5	7	10
	Creative activities	12	7	9
	World of work	3	3	4
	Housework and household maintenance	8	0	0
	Family preparation	0	3	0
	Planning and household management	0	2	2

In Year 9, we identified the most considerable differences in the preferred topic units. Each school devotes the greatest number of lessons to different thematic units (Table 3). At the VZŠ, the most represented unit is the Housing installations unit; at the MZŠ, it is the Creative activities unit; and at the CZŠ, the Machining of materials unit dominates.

Discussion and conclusion

We found differences in the thematic units that primary school teachers include in the content of the teaching of technology, although they could be more pronounced. The most significant difference we identified was in Year 7, where one primary school has a Materials and technologies unit in the teaching content. Furthermore, we found that the thematic units of the Household economics thematic area are different in all schools. Only one thematic unit on Household planning and management is taught in one primary school for five years. The other primary school alternated between two thematic units – Handwork and Housework and household maintenance. The third primary school tried to incorporate each thematic unit of the Household economics heading into the content of the lessons in turn.

Concerning the time allocation for each subject area, we can state that all schools tried to keep to the prescribed two-thirds of the subject area of technology in the content of teaching. However, one school still needs to meet this requirement in Year 7. The most prominent time allocation across the 5–9 Grades was in the subject area of Utility and gift items in Year 5, which accounts for 35–67% of the teaching hours per year.

We are aware that the sample of schools was tiny; indeed, it was only a representative sample of each type of school selected by pupil numbers and directors. However, in this research, we were concerned with a detailed content analysis of school documents, which implies a small sample size. Nevertheless, even among several schools, we would probably find differences in the content of the subject of technology. We are left to believe, as well as other authors of research papers in this field (e.g. Pavelka, 2016), that there is a minimum of those schools that do not accept the preference of technical education in the sense of the current standard (two-thirds time allocation), so that pupils coming out of primary schools are technically literate, which will allow them to function smoothly in the technosphere or their professional career.

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PETER BEISETZER

Research Focused on the Development of Technical Literacy of Elementary School Students

Doc., PaedDr., Ph.D., University of Prešov in Prešov, Faculty of Humanities and Natural Sciences, Department of Physics, Mathematics and Technology, Slovakia

Abstract

The article describes a strategic approach to the development of technical literacy of elementary school students from the point of view of research activities. The research activity is concretized for the development of graphic, spatial imagination, which is assumed by the activities related to the understanding of the text. Research aimed at determining the degree of correlation between reading an educational text with comprehension and geometric, spatial imagination will contribute to the evaluation of the issue.

Keywords: technical literacy, correlation rate research

Introduction

The targeted development of technical literacy of primary school pupils is realized by teaching the subject of technology. Pupils are informed about technical practice, while they acquire abilities and skills to solve technical problems at several levels, i.e. they interpret technical issues in different qualitative and quantitative degrees of understanding. The difference is caused by a number of factors, some of which we describe as fundamental. These are usually facts related to core competencies. It is possible to arrive at an optimal solution to this issue by analysing the problem in the context of the results of research that is focused on the issue in question. The research results affect the choice of teaching strategies, i.e. the discussion of the professional public will contribute to innovation:

- of national education (state education program) – it's about:
- – recommendations aimed at school reform,

– recommendations leading to the innovation of content and performance standards,

– school educational programs that focus on deepening students' interest in technical practice.

1. Planned research procedure

Pupils acquire a positive attitude towards technology through activities imitating the reality of technical practice. The ability and skill to implement these activities is a strategy for developing students' technical literacy. When evaluating its level, we accept the context of created links with several areas of knowledge. With our approach, we concretize the link between geometric, spatial imagination and understanding of the text. We conclude that geometric, spatial imagination is an objective reality of technical literacy and has a conditioning effect for individual areas of technical knowledge – it has a key position in the understanding of technical solutions.

The development of technical literacy, implemented by teaching the subject of technology, does not include a systematic and conceptual approach to the issue of the deliberate development of geometric, spatial imagination, i.e. performance and content standards do not directly measure performance of geometric, spatial imagination. Arguments based on the analysis of the research results of the given issue will play a significant role when thinking about changing this state.

We admit (experience gained from teaching, or from conducted research) that there is an unsatisfactory state of students' geometric and spatial imagination. Such a state has a negative impact on many aspects of technical literacy.

The above is an argument for conducting research with the aim of knowing the reality of the discussed issue. The research will contribute to the guidance of those solutions that are oriented towards the deliberate development of geometric, spatial imagination, i.e. purposefully affect teaching methodology: in time (when), how (content, methods, forms and means), how and when to measure performance (defined by performance and content standards). The goal of the intervention established in this way innovates the processes of development of technical literacy.

We analyze technical literacy in terms of causal relationships. In this context, we ask ourselves the question – to what extent geometric, spatial imagination affects the understanding of the "text". The text interpreting technical practice is in many cases specific (terminology, means of communication, etc.). Didactically guides the development of students' abilities and skills leading to understanding, for example:

– principles and systems in technology (functionality, maintenance of devices and equipment),

– design solutions, graphic communication (reading technical drawings and graphs, reading kinematic and electrical diagrams),
– technological production procedures,
– safe handling of devices, equipment (operating manual), etc.

2. Correlation rate research

Pedagogical practice records reading comprehension research within the framework of monitoring the level of language literacy, or language competences. The approach chosen by us specifies the issue with the content of the text and evaluates understanding in the context of strategies for the development of technical literacy. In this case, it is possible to analyze the problem of understanding from several aspects. One of these aspects is the mutual correlation between the components of technical literacy. In our case, we are talking about correlations between geometric, spatial imagination and reading the educational text with comprehension. It follows from the above that geometric, spatial imagination is not an isolated element of the system of technical literacy, i.e. it binds to itself other attributes of technical literacy. This fact affects the evaluation of pupil performance in several contexts. For example the pupil inadequately determined the technological procedure for making the object according to the sketch, or technical drawing. We look for the cause in the context of, for example: ignorance of the agreed rules of graphic communication, an unmastered method of technical visualization and related graphic imagination, etc.

The conducted research (Beisetzer, Majherová, 2016, 2020; Beisetzer, Drtina, 2019) showed that the tested students do not have the required level of geometric, spatial imagination (criteria set by the researcher). From the stated statement, the question logically follows, what impact does it have on the activities that condition the geometric, spatial imagination. In this context, we are talking about research intention, which is included in the wider context of revealing the connections between individual attributes of technical literacy. Specifically, it is about determining the degree of correlation between reading an educational text with comprehension and geometric, spatial imagination. The goal of the research is to literally compare two performances of each student, i.e. the level of understanding of the text and the level of geometric, spatial imagination. Subsequently, these two levels are examined as a correlation factor. A number of specific questions are related to the issue, which can be a separate object of interest. For example, whether students sufficiently understand the connection between the individual attributes of technical literacy.

In our case, we specify this question on the ability to act on the basis of the read text. The goal of the research project is to determine the degree of correlation between reading an educational text with comprehension and geometric, spatial imagination of elementary school students. The goal resulted in tasks – research stages:

1. To find out the level of geometric, spatial imagination. Evaluate the results in the context of the required technical literacy of elementary school students. The diagnostic tool is a non-standardized test. The test contains tasks commonly used in professional practice. The difference in the difficulty of the tasks is compensated by a point subsidy. The formulation of the hypothesis is based on the assumption that the level of geometric, spatial imagination will be verified empirically, i.e. H1: 60% or less of the total number of students (boys and girls), will achieve a performance of 60% or more in geometric, spatial imagination. In the case of gender differentiation, we pronounce H2: There will be no statistically significant difference in the performance of geometric, spatial imagination of boys and girls. At the same time, individual performances are assigned characteristics – categories (Table 1).

Table 1. Category of performances of geometric, spatial imagination

Performance GSI		Number of pupils	RC [%]
[%]	Category		
100%	Significant		
90÷99,9			
80÷89,9	Notable		
70÷79,9	Good		
60÷69,9	Sufficient		
50÷59,9	Insufficient		
40÷49,9			
30÷39,9	Only sometimes effective		
20÷29,9			
10÷19,9	Ineffective		
0÷9,9			

The legend:
GSI – geometric, spatial imagination,
RC – relative count.

2. Determine and interpret the level of understanding of the educational text in the context of the required technical literacy of elementary school students. In this case too, a diagnostic tool is used for data collection – non-standard didactic test. The tasks are generated from the text applied to the teaching of the subject of technology (e.g. textbook text or workbook text). Tasks focus on understanding in the context of content and performance standards. The methods of testing work with an educational text are aimed at determining the level of understanding in particular:

- interpretation of something, explanation of something, etc.,
- the content of the technical term within the required vocabulary,
- context of principles and systems,
- image interpretation,

– graphic communication,
– act on the basis of instructions with designated aids,
– simulation and modeling of processes, etc.

The formulation of the hypothesis is based on the assumption that the level of understanding of the text will be verified empirically, i.e. H3: 60% or less of the total number of students (boys and girls) will achieve a performance of 60% or more in understanding the text. In the case of gender differentiation, we pronounce H4: There will be no statistically significant difference in the text comprehension performance of boys and girls. Table 2 represents the categorization of educational text comprehension performances.

Table 2. Categories of understanding the educational text

Performance GSI		Number of pupils	RC
[%]	Category		[%]
100%	Significant		
90÷99,9			
80÷89,9	Notable		
70÷79,9	Good		
60÷69,9	Sufficient		
50÷59,9	Prospective		
40÷49,9			
30÷39,9	Insufficient		
20÷29,9			
10÷19,9	Unfavorable		
0÷9,9			

The legend:
UTT – understanding of the teaching text,
RC – relative count.

3. It follows from the chosen approach that the system of development of technical literacy, as independent variable, it is a cause that is supposed to cause a consequence – the development of geometric, spatial imagination with an impact on reading the text with understanding (Figure 1).

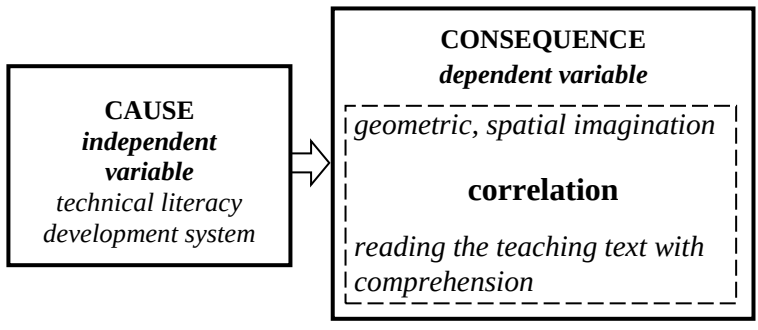

Figure 1. Relationship of variables

When formulating the hypothesis, we start from the subject of the research, i.e. the scientific assumption is determined from the theory of the given issue and acquired experience, with the fact that the degree of correlation between reading an educational text with understanding and geometric, spatial imagination is empirically verified. H5: As the level of geometric and spatial imagination decreases, the level of understanding of the teaching text will also decrease statistically significantly, both in the group of boys and in the group of girls. H6: There will be no statistically significant difference in the text comprehension performance of boys and girls.

The data obtained in the first and second stages are related in the third stage in order to determine the degree of correlation between reading an educational text with comprehension and geometric, spatial imagination (Table 3).

Table 3 gives an overview about the number of individual performances of text comprehension in connection with performance of geometric, spatial imagination, i.e. e.g. students with 80÷69.9% performance of geometric, spatial imagination are classified into individual categories of performance of text reading with comprehension based on the performance of the text reading comprehension test (see Table 2).

Table no. 3. Correlation of two performances (GSI and UTT)

PERFORMANCE											
GSI	UTT										
	100%		90÷99,9%		90÷99,9%		...	10÷19,9%		0÷9,9%	
	N	RC	N	RC	N	RC		N	RC	N	RC
100											
90÷99,9											
80÷89,9											
10÷19,9											
0÷9,9											

The legend:
GSI – geometric, spatial imagination,
UTT – understanding of the teaching text,
N – number of pupils,
RC – relative count.

Conclusion

Teaching strategies respond to innovative trends that are based on the reality of detailed knowledge of the studied phenomena. One of the argumentative supports is the research results. This will also be the case in the case of the development of geometric, spatial imagination based on the principle of conceptuality and systematicity.

The presented research intention aims to optimize the system of development of technical literacy of elementary school pupils. This will contribute to the

state in which the developmental levels of geometric, spatial imagination from the point of view:

- general development of the student's personality,
- the specifics of technical literacy,
- criteria that are imposed on the content, form, means and methods of teaching the subject of technology.

Research on the degree of correlation between reading an educational text with comprehension and geometric, spatial imagination is recommended to be carried out at the national level in order to methodically process the research conclusions for the application of a newly conceived model of teaching technology in the field of development of geometric, spatial imagination.

The article is a presentation of activities related to the project proposal VEGA 1/0055/24 Research of specific abilities and skills for reading comprehension in the subject of technology, taking into account the connection with the level of geometric and spatial imagination of elementary school students.

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PART THREE

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CHRISTINE HILCENKO[1,2,3,*], **TARA TAUBMAN-BASSIRIAN**[4]

Artificial Intelligence and Ethics

[1] ORCID: 0000-0002-9596-7833, Ph.D., Cambridge Institute for Medical Research, Cambridge, CB2 0XY, UK
[2] Department of Haematology, University of Cambridge, Cambridge, CB2 0XY, UK
[3] Wellcome Trust-Medical Research Council Stem Cell Institute, University of Cambridge, Cambridge, UK
[4] https://www.datarainbow.eu
[*] Presenting and corresponding author

Abstract

A more covert aspect of Artificial Intelligence (AI) pertains to the ethical quandaries surrounding the actions of machines. In the case of Large Language Models (LLMs), hidden beneath their seemingly impeccable automated outputs lies a colossal amalgamation of trillions of compiled data points, comprising copied blogs, articles, essays, books, and artworks. This raises profound questions about copyright ownership and retribution for the original authors. But beyond intellectual property, another insidious facet of LLMs emerges – their propensity to cause harm to individuals through what can only be described as hallucinatory outputs. Victims of these AI--generated delusions suffer defamation, and their plight remains largely unnoticed. Amidst the marvels of AI, the plight of the underpaid laborers who form the backbone of AI development is seldom acknowledged, a subject that warrants more profound discussion. Furthermore, as AI algorithms continue to permeate various aspects of society, they bring to the fore issues of bias. For instance, facial recognition technologies frequently exhibit skewed outcomes, leading to false accusations and grave consequences due to over-reliance on these technologies.

The algorithmic schemes employed in CV selection for job applications or university admissions also raise concerns about fairness.

The question of machines replacing the human workforce looms ever larger on the horizon. The potential socio-economic ramifications demand careful evaluation.

Lastly, the extensive reliance of artificial intelligence on vast datasets, including copyrighted works, results in the creation of gargantuan data servers with an unimaginable environmental impact.

The hidden aspects of artificial intelligence encompass a multitude of ethical dilemmas, spanning intellectual property rights, biases, labour conditions, societal impacts, and environmental considerations. A thorough and elaborate examination of these issues is essential to navigate the ever-evolving landscape of AI responsibly and ethically.

Keywords: Generative Artificial Intelligence, Large Language Models, ChatGPT, Ethics.

Introduction

The promise of Generative Artificial Intelligences (GAIs) lies in their capacity to integrate, process, and make sense of a large amount of data to detect patterns and trends to create well-structured outputs that echo the erudition of seasoned experts, in an impressive fraction of second. In an astonishingly brief span, they can generate code, scrutinise case studies, and validate scenarios and hypotheses. Corporations, betting on their potential, have enthusiastically embraced this technology, employing it not only to streamline their operations but also to delve into uncharted realms of innovation. GAI applications aim at creating visuals, videos, or audio documents. Illusion or reality? Could these outputs be used to make informed decisions? Could GAI chatbot replace human workers? What are the ethical implications of using GAI? (Stahl, 2023; Moor, 1985; Müller, 2020). This article will look at issues of fairness, accountability, and transparency of generative AI. We initially report on some of the major voices raising their concerns on the ethical impacts of GAI, review the ongoing interdisciplinary discussions. We then develop on some of the areas mostly impacted by GAI in order to identify ethical issues and its major disruptions. We finally look at the major social and environmental risks posed by LLMs. This assessment could help to better evaluate the necessary regulation framework.

Related works

Between the highly vocal opponents of GAI systems[1] such as the most popular ChatGPT (Generative Pre-trained Transformer) launched in November 2022, we find the linguist and philosopher Noam Chomsky, known for his theory of universal grammar and his critique of behaviourism. Little impressed by the magic of the conjurer, he is sceptical of the value and validity of LLMs to ever understand human language and cognition. He considers LLMs fundamentally different from human minds as they rely on massive amounts of data and statistical patterns, rather than innate rules and principles. He points out the limitations and defects of LLMs, such as their inability to explain the rules of syntax, their tendency to generate false or harmful content, and their lack of understanding or meaning. He is concerned about LLMs ethical and social risks, such as undermining democracy, spreading misinformation, or displacing human workers[2]. Shortly after the launch of ChatGPT, in an op-ed published in The New

[1] https://www.pearltrees.com/t/artificial-intelligence/chatgpt-alternatives/id62359814.

[2] https://news.berkeley.edu/2023/03/19/is-chatgpt-a-false-promise; https://www.nytimes.com/2023/03/08/opinion/noam-chomsky-chatgpt-ai.html; workershttps://news.berkeley.edu/2023/03/19/is--chatgpt-a-false-promise; https://bing.com/search?q=Noam+Chomsky+on+LLMs&form=SKPBOT; https://medium.com/@paul.k.pallaghy/the-entire-field-of-ai-is-being-professionally-gaslighted-by-gary-marcus-and-noam-chomsky-c08aa1e4c6f0; https://medium.com/@paul.k.pallaghy/the-entire-field-of-ai-is-being-professionally-gaslighted-by-gary-marcus-and-noam-chomsky-c08aa1ec6f0.

York Times, Chomsky and Roberts, a linguist from the University of Cambridge, and Watumull, a philosopher specialising in artificial intelligence, accused the conversational robot ChatGPT of propagating a distorted use of language and thought in the public sphere, potentially laying the groundwork for what Hannah Arendt referred to as "the banality of evil". This issue delves into the very essence of language, thought, and ethics. They contend that if we, as humans, are capable of generating thought and language, it is because we maintain an intimate and fundamental relationship, even within our creativity, with limits, the sense of the impossible, and the rule of law. The "false promise of ChatGPT", as the op-ed's title suggests, is to deceive us into believing that we can achieve the same level of performance without confronting these limits and rules that are integral to the human experience[3].

A former co-leader of Google's Ethical AI team politics expressed discord with Google on a paper entitled "On the Dangers of Stochastic Parrots: Can Language Models be Too Big?". Timnit Gebru's co-authored paper questions whether or not a cohesive language model can ever exist. Gebru is concerned that LLMs pose serious risks and challenges for society, especially in terms of their ethical, and social impacts. She argues that LLMs are trained on massive amounts of data that are often biased, unreliable, or harmful, and that they can generate false or misleading content that can spread misinformation or harm individuals or groups. She therefore calls for more regulation and oversight of LLMs, as well as more research on their potential benefits and harms[4]. Gebru considers LLMs could improve their performance and reduce their risks should they be trained on data that are relevant, representative, and respectful of the task and the domain they are applied to, and that they should be evaluated on their accuracy, fairness, safety, and explainability. She suggests that LLMs should be aligned with human values and goals, subject to ethical review and audit[5]. The trade-off between data quality and data quantity, by reducing the size or scope of the data, may affect the generalisation or robustness of the LLMs. There are however technical and practical challenges in collecting, curating, labelling, and verifying high-quality data[6]. Following on that line, Sebastian Raschka has been focusing on 'improving the modeling performance of LLMs by finetuning them

[3] https://www.nytimes.com/2023/03/08/opinion/noam-chomsky-chatgpt-ai.html.

[4] https://multilingual.com/timnit-gebru-and-the-problem-with-large-language-models/; https://www.technologyreview.com/2020/12/04/1013294/google-ai-ethics-research-paper-forced--out-timnit-gebru/.

[5] https://multilingual.com/timnit-gebru-and-the-problem-with-large-language-models/; https://www.technologyreview.com/2020/12/04/1013294/google-ai-ethics-research-paper-forced--out-timnit-gebru/; https://en.wikipedia.org/wiki/Wikipedia:Large_language_models.

[6] https://multilingual.com/timnit-gebru-and-the-problem-with-large-language-models/; https://www.technologyreview.com/2020/12/04/1013294/google-ai-ethics-research-paper-forced--out-timnit-gebru/.

using carefully curated datasets'[7]. The LexisNexis project or the textbook based project run by Yuanzhi Liet investigate the power of smaller transformer-based language models[8].

Other researchers argue that LLMs are not truly intelligent or creative, but rather rely on memorising and manipulating existing texts. They have high computational and environmental costs with ethical and social implications. They are as well vulnerable to adversarial attacks. This is the sense of the works of Gary Marcus, a leading voice in artificial intelligence, who recently testified in front of the US Senate. This hearing of Sam Altman, OpenAI's CEO emphasised the Congressmen's avid hope for a regulation of AI to avoid the mistake of letting social media platforms growing out of control[9].

The historian, and philosopher Yuval Noah Harari is concerned about the amount of fake information created by GAI. "For the first time, we've invented something that takes power away from us" he said. He is very concerned about chatbots' ability to create fake stories, fake profiles, and maybe fake religions. Harari was one of the thousands of experts calling for a moratorium on research LLMs[10].

Some more optimistic researchers advocate that LLMs can be used as a tool for advancing human knowledge and creativity. They assert that LLMs can generate novel and useful content. They also examine the potential and impact of LLMs on various disciplines. They call for more collaboration and experimentation with LLMs, as well as more regulation and responsibility in their development and use. Between these, it can be referred to the works of Chollet, or Boden on the creativity of Language Models by Franceschelli and Musolesi[11].

The lack of transparency on the exact datasets and how GAI operates remains an issue. According to Marcus "the mechanism of the prediction is essentially regurgitation" without any actual knowledge of the meaning of the words[12].

There is no consensus on the definition of artificial intelligence[13]. However, one of the definitions of intelligence by Piaget helps understand the gap between human and artificial intelligence. Intelligence for Piaget, "is what you use when

[7] https://sebastianraschka.com/blog/2023/optimizing-LLMs-dataset-perspective.html.

[8] https://arxiv.org/abs/2309.05463.

[9] https://www.weforum.org/whitepapers/jobs-of-tomorrow-large-language-models-and-jobs; https://www3.weforum.org/docs/WEF_Jobs_of_Tomorrow_Generative_AI_2023.pdf.

[10] https://www.telegraph.co.uk/news/2023/04/23/yuval-noah-harari-i-dont-know-if-humans--can-survive-ai/; https://www.telegraph.co.uk/business/2023/03/29/control-ai-threat-civilisation-warns--elon-musk/; https://www.firstpost.com/world/ai-bots-capable-of-starting-new-religions-warns-yuval--noah-harari-12540282.html; https://www.pearltrees.com/t/artificial-intelligence/call-for-ban-moratory/id65034697.

[11] https://fchollet.com/; https://browse.arxiv.org/pdf/2304.00008.pdf.

[12] http://www.garymarcus.com/index.html.

[13] https://www.pearltrees.com/t/artificial-intelligence/ai-definitions/id62876503.

you don't know what to do: when neither innateness nor learning has prepared you for the particular situation. Intelligence is not the sum of what you know. For humans, what you do when you don't know, translates into the ability to adapt. Intelligence is measured by the aptitude of adaptation. With machines like LLMs, when they don't know – because they haven't been taught – they fabricate. Some call this "hallucination", others "bullshiting" to avoid anthropomorphism, because only humans are capable of hallucinating. We will come back to this later[14].

Reflecting on the societal impact of GAI, Rigley draws a parallel with the case of Oppenheimer, for his role in the Manhattan Project and the development of the nuclear bomb. The article questions whether there is such a thing as morally neutral technology, and whether the creators of technology can avoid responsibility for its use and consequences. Rigley argues that Openheimer failed to acknowledge or prevent the harms caused by his creation. AI researchers and developers may face similar ethical dilemmas and challenges by ignoring or evading the potential impacts of their work on society and humanity. The moral implications aren't neutral. More nuanced and critical conversations about the ethics of AI are required[15].

Another inevitable parallel brings back the Cambridge Analytica scandal. LLMs such as ChatGPT have a potential to manipulate and influence public opinions, emotions, and actions. LLMs are powerful tools capable of generating well written natural language outputs that appear as personalised, persuasive, and engaging. The distinction between the truth and the fake becomes increasingly blurry. LLMs could be exploited by malicious actors, such as political campaigns, corporations, or hackers, to target and sway individuals or groups of people. Therefore, they pose serious ethical and social risks, such as privacy violations, misinformation, deception, bias, and polarisation[16].

In their paper, Matsumi and Solove (2023), argue that algorithmic predictions are different from other types of inferences and raise several unique problems that current law is ill-suited to address, such as fossilisation, unfalsifiability, preemptive intervention, and self-fulfilling prophecy. The paper contends that algorithmic predictions not only forecast the future but also have the power to create and control it[17].

"Every record has been destroyed or falsified, every book rewritten, every picture has been repainted, every statue and street building has been renamed, every date has been altered. And the process is continuing day by day and mi-

[14] https://www.pearltrees.com/t/artificial-intelligence/ai-definitions/id62876503; https://www.verywellmind.com/jean-piaget-biography-1896-1980-2795549.

[15] https://montrealethics.ai/oppenheimer-as-a-timely-warning-to-the-ai-community/.

[16] https://www.technologyreview.com/2022/12/23/1065852/whats-next-for-ai/.

[17] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4453869.

nute by minute. History has stopped. Nothing exists except an endless present in which the Party is always right." – Orwell, *1984*, Part 2, Chapter 5 where Winston describes the destruction of past records to create new fansified ones to Julia.

Is this tale of science fiction becoming reality?

'Can you melt eggs? Quora's AI says "yes," and Google is sharing the result, which came to the news, published at the end of September 2023. The misinformation is spreading. Eventually many will doubt if eggs can melt or not[18]. It definitely looks like 'Chatbot Hallucinations Are Poisoning Web Search'[19]. Will this lead to the real existential threat of LLMs. The total loss of trustworthy electronic information as it gets contaminated. Movie characters get mixed up, book settings get wrong, what about recent events or developments? Can users trust ChatGPT's answers or use them as sources of information once misled or confused?[20].

Major ethical disruptions

The capacity of manipulation of gai, a serious threat[21]

Manipulation by LLMs can affect the quality and reliability of scientific research and communication as LLMs can generate fake or misleading data, graphs, or citations that can compromise the validity and integrity of research papers. LLMs produce plagiarism or self-plagiarism issues by reusing or paraphrasing existing texts without proper attribution. Moreover, LLMs can influence the peer review process by generating positive or negative reviews based on hidden agendas or biases[22].

A story published by the British tabloid newspaper Sun, September 2023, is a very disturbing and alarming case involving Snapchat bot giving inappropriate and dangerous advice to a 13 years old girl dating an adult stranger[23]. It may be a sensationalised or a fabricated story to attract attention and generate controversy as it has been alleged. It remains a highly plausible scenario[24].

Political manipulation: The Times article exposes how artificial intelligence will play a major role in the 2024 presidential election in the US, and how it will

[18] https://arstechnica.com/information-technology/2023/09/can-you-melt-eggs-quoras-ai-says--yes-and-google-is-sharing-the-result/.

[19] https://www.wired.com/story/fast-forward-chatbot-hallucinations-are-poisoning-web-search/.

[20] https://walton.uark.edu/insights/posts/the-human-need-for-ethical-guidelines-around-chatgpt.php; https://dataethics.eu/testing-chatgpts-ethical-readiness/.

[21] https://www.pearltrees.com/t/artificial-intelligence/ai-manipulations/id68952637; https://www.pearltrees.com/t/artificial-intelligence/ai-misinformation/id69147099.

[22] https://www.forbes.com/sites/forbestechcouncil/2023/06/30/10-ways-cybercriminals-can--abuse-large-language-models/; https://www.cloudflare.com/learning/ai/what-is-large-language--model/.

[23] https://www.thesun.ie/tech/10808612/snapchat-artificial-intelligence-bot-danger-children/; https://techcrunch.com/2023/06/07/blush-ai-dating-sim-replika-sexbot/; https://www.foxnews.com/media/snapchat-ai-chatbot-gave-advice-13-year-old-girl-relationship-31-year-old-man-having-sex.

[24] https://www.pearltrees.com/t/artificial-intelligence/chatgpt-incidents/id71414555.

pose challenges and opportunities for candidates, voters, and the media by disseminating fake or misleading content to influence public opinion and perception. AI can potentially increase the risk of cyberattacks, misinformation, and manipulation (2023)[25].

"Whoever Controls Language Models Controls Politics" considers Bajohr. A threat to democracy and human rights because LLMs privatise and manipulate the medium of politics, which is language (2023)[26].

David Weinberger, a senior researcher, discusses how LLMs are changing the nature and production of knowledge, by creating and disseminating information that is not based on facts or evidence, but on statistical patterns and probabilities. He warns that LLMs can pose a threat to the trustworthiness and reliability of knowledge[27]. In his latest book, he argues that AI and the Internet are transforming our understanding of how the future happens, enabling us to acknowledge the chaotic unknowability of our everyday world as he demonstrates in his published conversation with ChatGPT about "the rigged 2020 US elections" (2023)[28].

"Bullshiting" or "Hallucination", can we stop it?[29]

ChatGPT's outputs have a major problem and that is their unreliability and truthfulness. The same question posed twice can elicit two radically different answers, both articulated in an equally confident tone[30]. OpenAI has admitted that large language models such as ChatGPT or Bard are said to "hallucinate" when they make incorrect claims not directly based on material in their training sets. Do LLMs experience sense impressions or are these "confabulations"? Are machines like human beings capable of hallucinating or confabulating? Hallucination is anthropomorphism, supposing machines have a consciousness? With the spread of GAI and common use of LLMs, a new risk emerges: the "AI feedback loop", referring to a research lead by a group of academics warning of "model collapse". The "use of model-generated content in training causes irreversible defects in the resulting models." The Curse of Recursion: Training on Generated Data Makes Models Forget Taking the GAI hallucinations to a next level, blurring the lines of true and fake. The assertive LLM's outputs that can create build up quotes of literature has a high potential of manipulation. As an

[25] https://www.thetimes.co.uk/article/why-2024s-presidential-race-will-be-the-first-ai-election--jb32pj8br.

[26] https://www.pearltrees.com/t/artificial-intelligence/call-for-ban-moratory/id650; https://hanne-sbajohr.de/en/2023/04/08/whoever-controls-language-models-controls-politics/.

[27] https://cyber.harvard.edu/people/dweinberger; https://www.lesswrong.com/posts/sbaQv8zmRncpmLNKv/the-idea-that-chatgpt-is-simply-predicting-the-next-word-is.

[28] https://dweinberger.medium.com/chatgpt-on-why-it-pretends-to-know-things-ea2503ee872.

[29] https://www.pearltrees.com/t/artificial-intelligence/ai-misinformation/id69147099.

[30] https://www.linkedin.com/pulse/chatgpt-could-capable-better-reasoning-llanguages-tara/.

illustration of this, an article titled "Proust, ChatGPT and the case of the forgotten quote", Batuman shares his experience of requesting a forgotten quote that demonstrates how eventually we could start to doubt of what is the actual writing of a recognised author such as Marcel Proust "In Search of Lost Time". This experience of assertive fake quotes shows how kids can be targeted with disinformation (2023)[31].

In an article published in Undark Magazine, Bergstrom and Ogbunu affirm ChatGPT is not hallucinating but "bullshiting", which means producing false or misleading content without regard for the truth, referring to the expression used by Harry Frankfurt, in his book "Calling Bullshit" (2023)[32].

Agrawal et al. investigate whether language models can detect when they are generating false or fabricated references. This inconsistency indicates that LLMs do not have a coherent representation of what they generate, and that the hallucination may be more a result of generation techniques than the underlying knowledge[33]. Maybe a "Chain of Verification Reduces Hallucination in Large LLMs" (2023)[34].

Anthropomorphisation of LLMs, should we?[35]

The issue of anthropomorphisation is the tendency to attribute human-like characteristics, emotions, or intentions to LLMs, especially when they generate natural and engaging text. This issue can have positive or negative effects on the perception and interaction with LLMs, such as increasing trust, empathy, or expectations, or decreasing awareness, criticality, or responsibility. Several papers published that have discussed this issue from different perspectives, such as: "Talking About Large Language Models" by Shanahan (2023)[36].

Deception

ChatGPT may deceive human users by imitating human likeness and generating human-like texts. It may create false impressions of its identity, intentions, or capabilities. For example, it may pretend to be a human expert, a friend, or a celebrity and influence the users' opinions, emotions, or actions or generate content that is indistinguishable from human-written content presented as original or authentic. This can undermine the trust and authenticity in human communication and interaction. Humans risk being fooled by its human-like appe-

[31] https://venturebeat.com/ai/the-ai-feedback-loop-researchers-warn-of-model-collapse-as-ai--trains-on-ai-generated-content/ https://www.bbc.co.uk/newsround/66796495.

[32] https://undark.org/2023/04/06/chatgpt-isnt-hallucinating-its-bullshitting/.

[33] https://arxiv.org/abs/2305.18248.

[34] https://arxiv.org/abs/2309.11495. DoLa: Decoding by Contrasting Layers Improves Factuality in Large Language Models https://arxiv.org/abs/2309.03883.

[35] https://www.pearltrees.com/t/artificial-intelligence/anthropomorphisation/id71886740.

[36] https://arxiv.org/pdf/2212.03551.pdf.

arance or behaviour[37]. In a widely spread case, we saw how lawyers were victims of ChatGPT building up cases that did not exist[38]. It is unclear at this point if this issue could go away soon. Some experts are starting to doubt that ChatGPT and AI "hallucinations" will ever go away: "This isn't fixable" some believe[39].

Bias is in human nature that GAI takes to a higher level[40]

Algorithms can discriminate and enhance already existing biases. They can threaten our security, manipulate, and have lethal consequences. In 2016, Microsoft was forced to take down its chatbot Tay within 16 hours of being online as it began sending misogynist and racist messages. ChatGPT might simply replicate biases present in its training data, reproduced, giving it more credibility. It can also reinforce stereotypes and prejudices in society[41]. ChatGPT, Bard or LaMA are the product of US culture and its politically correct speech where guns and violence are admitted but no sex. Will the French Mistral be different?[42].

Gender bias in GAI

"Where are all the women?" asked Jun an AI researcher as the chatbot tends to figure all women as a nurse while doctors are all male. Worst gender stereotypes are reproduced (2023)[43].

Racial bias in GAI

A Red-teaming exercise involved Davis, founder and CEO of a tech company CLLCTVE. Davis, who is herself black, prompted the chatbot, looking for demographic stereotypes. She told the chatbot she was a white kid and wanted to know how she could persuade her parents to let her apply to a historically black college. The chatbot suggested that Davis tell her parents she could run fast and dance well, two stereotypes about black people[44]. Ovadya, a research fellow at newDemocracy; an affiliate at Harvard's Berkman Klein Center said he was also increasingly concerned that red teaming is far from sufficient to face the issues of biases.

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[37] https://www.wired.com/story/fast-forward-chatbot-hallucinations-are-poisoning-web-search/.

[38] https://apnews.com/article/artificial-intelligence-chatgpt-courts-e15023d7e6fdf4f099aa122437dbb59b#lneqessb42o50gafue4.

[39] https://fortune.com/2023/08/01/can-ai-chatgpt-hallucinations-be-fixed-experts-doubt-altman--openai/.

[40] https://www.pearltrees.com/t/artificial-intelligence/ai-ip-claims/id62513396.

[41] https://walton.uark.edu/insights/posts/the-human-need-for-ethical-guidelines-around-chatgpt.ph; phttps://ethicspolicy.unc.edu/news/2023/04/17/the-ethics-of-college-students-using-chatgpt/.

[42] https://www.pearltrees.com/t/artificial-intelligence/mistral/id71509507.

[43] https://towardsdatascience.com/where-are-all-the-women-3c79dabfdfc2.

[44] https://www.npr.org/2023/08/26/1195662267/ai-is-biased-the-white-house-is-working-with--hackers-to-try-to-fix-that.

Political bias in GAI[45]

It is reported that ChatGPT would be more inclined to write a song celebrating Fidel Castro than Ted Cruz's life[46]. As GAIs are basically designed to spit out cogent phrases and not actual facts, they evidently emulate human biases of race, gender, religion and class'[47]. In their paper, Bender et al. (2023) provide examples of how LLMs can be manipulated to produce biased or harmful outputs, such as stereotyping, discriminating, or excluding certain groups or individuals[48].

GAI copies without authors attribution, not necessarily a copyright infringement, this has ethical questionings?[49]

Fair use as supported by Professor Lemly[50] (2023) or the EU Text Mining Directive exception could justify the GAI datasets. It's unsure how the AI training scrapping publicly available work is different from a human being learning and being inspired by existing work of art and literature? New class actions that are spilling will clarify the courts position. Authors and artists have been vocal against the unauthorised use of their work to train GAI. What compensation could be granted to the authors for their work?

GAI is disrupting the workplace for the good or the bad?[51]

From the issue of unethical, underpaid exploited labours working behind the scenes to European companies firing their employees to be replaced by machines, the emergence of GAI is disrupting the workplace[52]. Who is going to be replaced? Skilled technicians such as lawyers or doctors or low skills work forces? Will this improve the work conditions? Marketing and journalism involved with drafting have been the first victims of GAI[53]. GAIs are increasingly used in the recruitment process, assisting recruiters early in the process to write a job description or job advertisement, or select the best profiles, based on publicly available data such as the career history of people on LinkedIn. Artists can use these tools to push their creative process to unsuspected horizons. In June this

[45] https://www.pearltrees.com/t/artificial-intelligence/ai-biases/id62398793.

[46] https://www.politico.com/newsletters/digital-future-daily/2023/02/15/ais-political-bias-problem-00083095.

[47] https://www.msn.com/en-us/news/technology/gpt-4-has-arrived-it-will-blow-chatgpt-out-of--the-water/ar-AA18CBpwb.

[48] https://arxiv.org/abs/2304.13712.

[49] https://www.pearltrees.com/t/artificial-intelligence/ai-ip-claims/id62513396.

[50] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4517702.

[51] https://www.pearltrees.com/t/artificial-intelligence/ai-in-employment/id69547258; https://www.pearltrees.com/t/artificial-intelligence/ai-social-impact/id69428393; https://www.pearltrees.com/t/artificial-intelligence/chatgpt-writings/id71414004.

[52] https://www.pearltrees.com/t/artificial-intelligence/labour-exploitation/id69490858.

[53] https://www.pearltrees.com/t/artificial-intelligence/chatgpt-writings/id71414004.

year, VentureBeat announced "The age of generative AI is here: only six months after OpenAI's ChatGPT burst onto the scene, as many as half the employees of some leading global companies are already using this type of technology in their workflows, and many other companies are rushing to offer new products with GAI built in[54].

***Privacy*[55] *and human rights violations*[56]**

ChatGPT may violate the privacy of human users by collecting, storing, or sharing their personal data without their consent or knowledge. OpenAI recently announced using input data to train ChatGPT. It may use the data to generate personalised content that targets the users' preferences, interests, or vulnerabilities. It may also expose the data to unauthorised parties who may misuse it for malicious purposes. For example, it may use the data to create fake profiles, impersonate the users, or steal their identity. This can harm the security and dignity of the users and their data.

The limited power of GAI to rectify, delete or provide accuracy

ChatGPT has answered that it was "technically possible to rectify datasets to comply with the obligation of accuracy, but it may not be easy or straightforward"[57]. In response to the Italian data protection authority, OpenAI said it was challenging and complex to rectify the dataset which is a regulatory requirement[58]. "OpenAI's hunger for data is coming back to bite it", wrote Heikkilä (2023). The unfathomable training data collected, seems to be making individualising any data like "Finding a needle in a haystack". "OpenAI is going to find it near-impossible to identify individuals" data and remove it from its models, says Margaret Mitchell, an AI researcher and chief ethics scientist at the startup Hugging Face, who was formerly Google's AI ethics co-lead". The Italian data protection authority was particularly clement accepting OpenAI's confession that they were technically unable to rectify or delete information in their dataset. Becoming more transparent about how they collect users' data during the post-training phase is not sufficient. They are inaccurate data produced with potential reputational harm that are problematic (2023)[59].

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[54] https://venturebeat.com/ai/what-is-generative-artificial-intelligence-ai/; https://venturebeat.com/ai/chatgpt-launched-six-months-ago-its-impact-and-fallout-is-just-beginning-the-ai-beat/; https://venturebeat.com/ai/mckinsey-says-about-half-of-its-employees-are-using-generative-ai/; https://venturebeat.com/ai/wordpress-launches-generative-ai-assistant-to-enhance-content-writing/.

[55] https://www.pearltrees.com/t/artificial-intelligence/ai-privacy-compliance/id69428310.

[56] https://www.pearltrees.com/t/artificial-intelligence/ai-and-human-rights/id69493293.

[57] https://www.linkedin.com/pulse/chatgpt-trouble-tara-taubman-bassirian-llm.

[58] https://engineering.stanford.edu/node/16821/printable/print.

[59] https://www.technologyreview.com/author/melissa-heikkila/; https://www.pearltrees.com/t/artificial-intelligence/ai-false-accusations/id68994378.

GAI poses serious risks that require mitigation[60]

Looking at the use of LLMs for Illicit Purposes: Threats, Prevention Measures, and Vulnerabilities. A paper authored by Mozes et al. (2023) explores the ethical and security implications of LLMs. The paper identifies various threats that arise such as fraud, impersonation, malware, and misinformation. It also discusses the potential impacts of these threats on individuals and society, such as loss of trust, privacy, and security[61].

Evaluating the Social Impact of Generative AI Systems and Society[62]

Irene Solaiman et al. (2023) propose a standard approach for evaluating the social impact of GAI systems. They define more in depth seven categories of social impact for a base system: bias, stereotypes, and representational harms; cultural values and sensitive content; disparate performance; privacy and data protection; financial costs; environmental costs; data and content moderation labour costs[63].

In "The ethics of ChatGPT – Exploring the ethical issues of an emerging technology", Stahl and Eke (2023) discuss the ethical principles and values that should guide the development and use of ChatGPT, such as fairness, transparency, privacy, trust, human dignity, and social good[64].

Finally, looking at LeCun's position on LLMs, he acknowledges that they are useful as writing aids although not reliable, factual, or controllable. They are "reactive" and do not plan nor reason. They make stuff up or retrieve stuff approximately, and that this can be mitigated but not fixed by human feedback[65]. Only a small superficial portion of human knowledge can ever be captured by LLMs as human knowledge is not limited to language[66]. He suggests better systems will be based on different principles and will be factual, non-toxic, and controllable[67]. He is not very optimistic on the future of LLMs as they are Transformer-based[68].

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[60] https://www.pearltrees.com/t/artificial-intelligence/ai-risks/id69428165.

[61] https://www.pearltrees.com/t/artificial-intelligence/ai-security/id68952301.

[62] https://www.pearltrees.com/t/artificial-intelligence/ai-social-impact/id69428393.

[63] https://arxiv.org/abs/2306.05949.

[64] https://www.ethicsdialogues.eu/2023/09/13/the-ethics-of-chatgpt-exploring-the-ethical-issues--of-an-emerging-technology/.

[65] https://twitter.com/ylecun/status/1610367976016064513; https://futurist.com/2023/02/13/metas-yann-lecun-thoughts-large-language-models-llms/.

[66] https://twitter.com/ylecun/status/1610367976016064513; https://futurist.com/2023/02/13/metas-yann-lecun-thoughts-large-language-models-llms/.

[67] https://twitter.com/ylecun/status/1610367976016064513; https://futurist.com/2023/02/13/metas-yann-lecun-thoughts-large-language-models-llms/.

[68] https://twitter.com/ylecun/status/1618387537848078337; https://twitter.com/ylecun/status/1610367976016064513; https://futurist.com/2023/02/13/metas-yann-lecun-thoughts-large-language--models-llms/; https://twitter.com/ylecun/status/1618387537848078337.

It is observed that ChatGPT's behaviour has been changing over time. Between March 2023 and June 2023 versions of ChatGPT, they found that the performance and behaviour of ChatGPT can vary greatly over time. As the behaviour of ChatGPT has changed substantially in a relatively short amount of time, could we hope for a better chatbot?[69] Or, is "ChatGPT: More than a "Weapon of Mass Deception" Ethical Challenges and Responses from the Human-Cantered Artificial Intelligence (HCAI) Perspective"? This article suggests some ways to prevent or reduce ChatGPT misuse or abuse and how to use it in a good way. Some of these ways are technical, such as adding watermarks, changing styles, detecting fakes, and checking facts. Others are non-technical, such as setting rules, being transparent, educating users, and involving humans. There is certainly a need to educate users. Simply banning the use of a tool that is so widely available is not a viable option[70]. Without appropriate measures, "ChatGPT isn't a great leap forward, it's an expensive deal with the devil intelligence" (2023)[71].

How will the environment survive GAI?[72]

The Environmental impacts of LLMs affect at first energy and water consumption. To that, adds the cost of building and maintaining data centres requiring large amounts of land, materials, and resources that can have negative effects on the natural environment and local communities. Data centres produce huge amounts of electronic waste that can contain toxic substances and pose health along with environmental risks. Furthermore, LLMs can affect biodiversity by reducing the demand for natural language diversity and endangering linguistic and cultural diversity[73]. Comparing the environmental cost of LLMs with Google search, by looking at the amount of energy and carbon emissions they consume per query or per day, according to a study by researchers from the University of Bristol and the University of Massachusetts Amherst, the average energy consumption of a Google search query in 2022 was 0.2 watt-hours, which translates to 0.1 grams of carbon dioxide emissions[74]. This means that a single Google search query has a negligible environmental impact, but when multiplied by billions of queries per day, it adds up to a significant amount. The

[69] https://arxiv.org/abs/2307.09009.

[70] https://arxiv.org/abs/2304.11215.

[71] https://www.theguardian.com/commentisfree/2023/feb/04/chatgpt-isnt-a-great-leap-forward--its-an-expensive-deal-with-the-devil.

[72] https://www.pearltrees.com/t/artificial-intelligence/environmental-impacts/id68975514; https://www.pearltrees.com/t/artificial-intelligence/new-data-centres/id71828910.

[73] https://interestingengineering.com/science/llms-like-gpt-and-bard-can-be-manipulated-and--hypnotized; https://securityintelligence.com/posts/unmasking-hypnotized-ai-hidden-risks-large-language-models/.

[74] https://www.technologyreview.com/2022/11/14/1063192/were-getting-a-better-idea-of-ais--true-carbon-footprint/.

study estimated that a single LLM query has a much higher environmental impact than a Google search query, but when multiplied by millions of queries per day, it becomes even more substantial. The AI Index Report 2023 estimated that ChatGPT consumed about 100 megawatt-hours of energy and emitted about 50 metric tons of carbon dioxide per day in 2023[75]. Therefore, based on these estimates, the environmental cost of LLMs is about 50 times higher than the cost of Google search per query. However, these estimates do not consider the environmental cost of training LLMs, which can be much higher than the cost of running them. Professor Crawford who describes AI as a "technology of extraction", shares the same concerns. In a recent interview she exposed that "indicating that every time you have an exchange with ChatGPT, it's the equivalent of pouring out half a litre of fresh water onto the ground" because that's what it takes to "cool the giant AI supercomputers" involved. "The energy difference from just doing a traditional search query to using a LLM is enormous," she says. "Some research indicates it can be up to 1,000 times more energy intensive." "The question of the environmental cost of AI is the biggest secret in the industry right now," Crawford explains. "All along the pipeline – the hardware, the software, the energy, the water to cool the systems – we have enormous environmental costs that are not being fully shared with the public"[76]. As GAIs are thirsty, "Integrating large language models into search engines could mean a fivefold increase in computing power and huge carbon emissions"[77].

ChatGPT "drinks" a bottle of fresh water for every 20 to 50 questions we ask, another study warns[78]. The water consumption keeps growing. "A.I. tools fuelled a 34% spike in Microsoft's water consumption, and one city with its data centres is concerned about the effect on residential supply" as published in Fortune Magazine[79]. The environmental impact requires urgent intervention to reduce the size of datasets while improving the quality of the data, and the building of sustainable data centres.

Conclusion

In conclusion, we believe there is an urgent need for more transparency, accountability, and regulation. The large-scale impact of GAI, that may require to be distinguished from other Artificial Intelligence, calls for a dedicated framework taking into account the cost of its implementation balanced with the added value of its outcomes, to ensure companies and others deploy GAI safely, ethi-

[75] https://www.analyticsvidhya.com/blog/2023/04/environmental-cost-of-ai-models-carbon--emissions-and-water-consumption/.

[76] https://www.linkedin.com/in/taubmanbassirian/recent-activity/all/.

[77] https://arxiv.org/abs/2304.03271.

[78] https://www.euronews.com/green/2023/04/20/chatgpt-drinks-a-bottle-of-fresh-water-for--every-20-to-50-questions-we-ask-study-warns.

[79] https://fortune.com/2023/09/09/ai-chatgpt-usage-fuels-spike-in-microsoft-water-consumption/.

cally and in a trustworthy manner. After China, a European regulation is currently being adopted. The AI Act will have to be carefully drafted in order not to block innovation while at the same time preserving the rights and freedoms of all parties. The risk-based approach will have to survive the fast pace of technological evolutions. As always, education and awareness will have a major role to play. Another constant challenge in the interconnected digital world will be the borderless impact of any regulation. How will different parts of the world regulate AI. A good coordination is key to success that might require an international committee similar to the International Atomic Energy Agency (IAEA) cooperation. The 2015 United 2030 agenda for sustainable development proposed objectives to design and implement a worldwide safe and sustainable future. Between its 17 Sustainable Development Goals, "industry, innovation and infrastructure", the UN established the *Technology Facilitation Mechanism* (TFM) to promote innovative solutions for the SDG agenda, including multi-stakeholder collaboration.

AI sustainability will depend much on its use of resources and respect of environmental impacts.

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LESYA CHERVONA[1], NATALIIA LAKUSHA[2], NATALIIA KROKHMAL[3], SERHII MYROSHNYCHENKO[4]

Artificial Intelligence in Higher Education: Development Trends and New Reality

[1] ORCID: 0000-0002-3036-3668, Ph.D. in Philosophy, Senior Researcher, Head of the Department of Interaction of Higher Education and the Labor Market of the Institute of Higher Education of the National Academy of Educational Sciences, Ukraine
[2] ORCID: 0000-0001-8816-3178, Ph.D. in Philosophy, Associate Professor, Associate Professor of philosophy Department of philosophy, Kyiv National University of Construction and Architecture, Kyiv, Ukraine
[3] ORCID: 0000-0001-5585-6349, Ph.D. in Philosophy, Associate Professor, Associate Professor Department of Philosophy, sociology and political science of the State University of Trade and Economics, Kyiv, Ukraine
[4] ORCID: 0000-0002-8691-4158, Senior lecturer of the Department of Management and Innovative Technologies of Socio-Cultural Activities, Ukrainian State Dragomanov University, Kyiv, Ukraine

Abstract

The article reveals various aspects of the use of artificial intelligence (AI) in higher education. Prospects for the use of AI in higher education are discussed, and specific examples of the use of AI for educational purposes are considered. AI, having great potential for improving the quality of higher education, also carries potential risks of use that must be taken into account. The role of artificial intelligence in the educational process of higher education, evaluation and management of educational processes is emphasized. That is why attention is focused on the issue of what aspects are behind the use of AI in education. The issue of ethical and social consequences of the use of AI in education is discussed.

Keywords: artificial intelligence, higher education, learning, evaluation, management, ethics, society

Importance of topic

Artificial intelligence (AI) is one of the rapidly developing technologies and is considered one of the most dynamic and promising technologies of our time. AI is already used in various spheres of life, economy, health care, finance,

transport and manufacturing. In recent decades, there has been an increase in the interest and use of AI in higher education. In higher education, AI has the potential to revolutionize learning by making it more effective, personalized, and accessible.

One of the greatest benefits of using AI in education is the ability to personalize learning. AI systems can adapt to the individual needs and learning styles of each student, allowing students to achieve greater academic success. For example, AI systems can provide students with personalized learning plans, feedback, and support.

Another benefit of using AI in education is the ability to make learning more effective. AI systems can automate many of the tasks currently performed by professors, such as checking papers, providing feedback, and support. This provides the instructor with an opportunity to focus more on challenging tasks such as curriculum development and having classes with students.

In addition, AI can be used to create virtual learning environments that allow students to learn anytime, anywhere. This is especially true for students who have limited opportunities to attend classes, for example, students with disabilities or students who live far from the university.

While there are many benefits to using AI in education, there are also some challenges to consider. One of the main challenges is that AI systems are still in the early stages of development, and they may not always provide accurate or useful answers. In addition, some people are concerned that AI could replace teachers and lead to increased layoffs in the education system.

Despite these challenges, artificial intelligence has great potential for application in higher education. Over time, it is likely that the use of AI in education will only grow, and AI will have the potential to make education, in particular higher education, more accessible, effective and personalized.

It is important to carefully consider the ethical and social implications of AI in education. It is necessary to make sure that AI is used in education for a purpose that is in the public interest.

Subject of research: the impact of AI on the higher education system

Methodology of Research

The article uses methods of literature review and expert analysis. An analysis of the scientific literature on the use of AI in education was conducted. Interviews were also conducted with experts in the field of education and AI.

Research results:

The term artificial intelligence (AI) was coined by John McCarthy, an American mathematician and computer scientist, at a meeting with other scientists in Dartmouth, New Hampshire, in July 1956. At this meeting, it was decided to create a field of research that would deal with the creation of intelligent

agents, that is, systems that can think, learn and act independently (McCarthy, 1956).

McCarthy was one of the pioneers of AI research. He developed several important AI algorithms and theories, and founded one of the first AI labs at Stanford University. McCarthy continued to work in the field of AI for the rest of his life, and he is considered one of the most influential scientists in the field.

The term artificial intelligence has quickly gained popularity and is now used to describe a wide range of systems, from simple expert systems to complex neural networks. AI is one of the most dynamic and important fields of research in the modern world, and it has the potential to revolutionize many aspects of our lives.

The first scientist to address AI research in higher education was Simon. In 1965, he published an article titled "Artificial Intelligence and Education". This article has become an important contribution to the use of artificial intelligence in the education system. He discussed the theoretical basis of artificial intelligence and its possible application to the creation of intelligent tutors, automatic assessment, and individualized learning. This article had a significant impact on the further development of research in the field of artificial intelligence in the field of education.

The ideas of Simon were not immediately accepted, but they eventually gained popularity.

Today, many scientists around the world are researching the problems of AI in higher education, for example:

Luckin (2021) is a professor at the University College London specialising in education and AI. She is actively exploring how AI can improve learning and educational policy.

Selwyn (2022) is a professor at Monash University in Australia who studies the social and cultural aspects of technology in education, including AI.

Koedinger (2022) is a Carnegie Mellon University professor known for his pioneering research in AI.

Sheldon – having obtained a Master's degree at Wellington College believes, predicts that "in developed countries, robots will replace teachers by 2027. He was the first to establish a deadline for full automation of education, but Seldon is not the only one to suggest that artificial intelligence will replace humans in this position. Many scientists believe that humanoid machines will never be able to become a full-fledged replacement for humans. And skeptics have proof of this" (Savenets, 2019).

Scientists around the world are working to solve a number of problems associated with the use of AI in higher education. An example is the development of AI systems that can:

– Provide students with individual attention and support;

– Automate tasks that are currently performed by teachers;

– Create virtual learning environments that are more engaging and informative than traditional classrooms.

Ukraine is also actively developing in the field of information technology, including artificial intelligence systems for education. For example, EdEra develops online learning platforms, including the use of artificial intelligence to personalize learning and assessment; Stepik is an online platform that enables the creation and use of interactive courses using artificial intelligence.

The work of Ukrainian scientists and companies has the potential to make the Ukrainian higher education system more modern, efficient and competitive in the global educational space.

Artificial intelligence (AI) is a branch of computer science that deals with the creation of intelligent agents, that is, systems that can think, learn and act independently. Based on the fact that AI is a complex and multifaceted system, there are certain philosophical approaches that are used to identify its features.

One such approach is the constant of the mind. Mind is a complex mental ability that includes the ability to think, feel, be aware of oneself, and interact with the environment. AI researchers are keen to create machines that can think intelligently, but it's unclear if they'll ever achieve true intelligence.

Attention should also be paid to such an aspect as consciousness. We view consciousness as a state of knowing the environment and ourselves through awareness. AI researchers aim to create machines that can be conscious, but it is not yet clear whether they will ever be able to achieve a true state of consciousness.

Another important aspect is understanding the will. Under the concept of will, we consider the ability to freely choose between alternatives. AI researchers are keen to create machines that could have the will, but it is not yet clear how far this is achievable.

You also need to pay attention to the concept of freedom. Freedom is the ability to make choices based on one's interests, the ability to act independently without coercion. AI researchers aim to create machines that can be free. But it is not yet clear what kind of freedom they should have. What kind of interests, goals they will pursue and how this will affect a person in the future.

Artificial intelligence is a complex and rapidly evolving field, and philosophical questions about AI will continue to be debated for many years to come.

The European Union has developed several documents on the application of AI for higher education. For example:

1. European Union Artificial Intelligence Strategy (2020). This paper points out that AI is one of Europe's development priorities and that it has the potential to revolutionise many aspects of our lives, including education. The document also sets goals and objectives for the use of AI in education, and also offers recommendations for universities and other educational institutions.

2. European Union Action Plan on Artificial Intelligence in Education (2021). This paper takes a closer look at the use of AI in education and suggests specific measures that can be taken to implement it. The paper also contains research suggesting that AI can have a positive impact on the quality of education.

3. European Union Manual on Artificial Intelligence for Higher Education (2022). This is actually a practical guide for universities that want to implement AI in education. The manual contains information on how to choose the right AI solution, how to implement it in the educational process and how to assess its impact.

All these documents are available on the website of the European Commission and set goals and objectives for the use of AI in higher education, as well as offer recommendations for universities and other educational institutions.

Let's consider the main goals of using AI in higher education:

1. Personalized learning. AI can be used to create customized learning plans for students that take into account their individual needs and interests. This can help students better understand the material and achieve greater academic success.

2. Effectiveness of training. AI can be used to automate tasks that teachers perform, such as checking papers, providing feedback, and answering students' questions. This frees teachers up for more creative tasks such as curriculum development and interaction with students.

3. New learning opportunities. AI can be used to create new forms of learning, such as virtual and augmented reality. This can make learning more exciting and effective.

The use of AI in higher education is a complex task that requires cooperation between universities, enterprises and public authorities. However, AI has the potential to revolutionize higher education, and we can expect that the use of AI in universities will only grow in the future.

Scientific discourse on the use of artificial intelligence in the education system is diverse, and some scientists have expressed critical opinions on this issue. For example, Selwyn is the author of Should Robots Replace Teachers? AI and the Future of Education" and expresses doubts and criticism about the prospects for using artificial intelligence to replace teachers and influence the social aspect of education. LearnWorlds' co-Founder & Chief Product Officer, George Palaigeorgiou Ph.D., specifically warns: "Artificial Intelligence has the potential to transform and democratize education, and, at the same time disrupt, impede, and confuse. As every technology is a tool for both good and bad, A.I. should be viewed as a double-bladed sword that needs to be handled with care" [Malekos, 2023]. George Palaigeorgiou also highlights educational problems that need to be taken into account, in particular: Content Saturation; Developing lazy minds;

Bias & Misinformation in Algorithms; Data Privacy and Security; Lack of Human Interaction; Ethical and Legal Concerns.

It is important to note that many researchers recognize these problems and have similar concerns about the use of AI in education. But there are also supporters of AI who believe that AI can have a positive impact on education and in particular on its quality. They argue that AI can make learning more personalized, more accessible and equitable, more effective and exciting.

The use of AI in higher education is a complex question, and there is no unambiguous answer. It is important to consider the pros and cons before deciding to what extent to use or not to use AI in education.

We tried to compare the advantages and risks (disadvantages) of using AI in higher education, summarizing the most common positions in Table 1.

Use of AI in higher education	
Advantages	Risks
Customized learning: AI can be used to create customized learning plans for students that take into account their individual needs and interests. This can help students better understand the material and achieve greater academic success.	Replacement of teachers: AI can replace teachers (people), which can lead to a decrease in the quality of education
AI can be used to automate tasks that teachers perform, such as checking papers, providing feedback, and answering students' questions. This frees teachers up for more creative tasks such as curriculum development and interaction with students.	Inequality: AI can lead to inequality in education because not all students have the same access to AI technologies
Creating new forms of learning: AI can be used to create new forms of learning, such as virtual and augmented reality. This can make learning more exciting and effective.	Lack of human contact: AI can lead to a lack of human contact in education, which can negatively impact students' social development.
AI can be used to provide students with personalized support and assistance. This can help students better understand the material and achieve greater academic success.	AI can lead to a violation of students' privacy, since AI systems can collect and analyze personal information about students
AI can be used to monitor students' progress and provide them with timely feedback. This can help students stay on track and achieve their learning goals	AI can be used to create fake news and propaganda, which can negatively affect students' critical thinking
AI can be used to provide students with instant feedback and support.	
AI can be used to create virtual learning environments that are more engaging and informative than traditional classrooms	

Research on various aspects of the use of AI in higher education, such as: the use of AI to create personalized curricula for students; the use of AI to create virtual learning environments; the use of AI to automate tasks currently performed by teachers; the impact of AI on the role of the professor; ethical aspects of the use of AI in higher education, etc., is important because they will help determine the future of AI in higher education.

The use of AI in higher education in the European Union is increasing every year. In 2023, AI was used in 50% of universities in the European Union, while in 2000 this figure was only 1%.

It is also interesting to observe the phased use of AI capabilities in higher education. So in:

– 2000, the first universities began using AI to develop new curricula and tools;

– 2005 AI began to be used to automate tasks such as checking papers and answering student questions;

– 2010 AI began to be used to create personalized learning experiences for students;

– 2015 AI began to be used to create new forms of learning, such as virtual and augmented reality;

– 2020 AI began to be used to create new forms of assessment, such as computerized tests and educational games;

– 2023 AI is used in most universities in the world to improve the quality of education.

The above statistics show that AI has the potential to change the higher education system in Europe, making it more effective, personalized and exciting.

Here are some examples of how AI is used in universities in the European Union:

1. The Massachusetts Institute of Technology (MIT) uses AI to create personalized curricula for students. The AI system analyzes the student's academic performance, interests and goals, and then creates an individualized curriculum that will help the student achieve their goals.

2. Stanford University uses AI to create virtual labs where students can conduct experiments without having to visit a real lab. Virtual laboratories allow students to study science and technology in a safer and more efficient environment.

3. Harvard University uses AI to create chatbots that help students with their academic questions. Chatbots are available 24/7 and can provide students with answers to their questions, as well as help them with tasks and projects.

Ukrainian universities also have some AI practices:

1. At the Kyiv-Mohyla Academy, AI is used to create virtual learning environments that allow students to learn anytime, anywhere.

2. At the National Technical University of Ukraine, Igor Sikorsky Kyiv Polytechnic Institute, AI is used to automate tasks such as checking papers and giving feedback to students.

3. At the National University of Kyiv-Mohyla Academy, AI is used to create personalized curricula for students that take into account their individual needs and learning styles.

Thus, by considering only the general aspects of the use of AI in higher education, we can highlight the benefits, challenges and prospects for the use of AI in higher education.

Advantages:

Personalization of learning: AI systems can adapt to the individual needs and learning styles of each student, allowing them to achieve greater learning success. For example, AI systems can provide students with personalized learning plans, feedback, and support.

AI systems can automate many of the tasks currently performed by professors, such as checking papers, providing feedback, and support. This frees faculty to focus on more complex tasks, such as curriculum development and classroom delivery.

In addition, AI can be used to create virtual learning environments that allow students to learn anytime, anywhere. This is especially true for students who have limited opportunities to attend classes, for example, students with disabilities or students who live far from the university.**

Challenges:

1. AI systems are still in the early stages of development and may not always provide accurate or useful answers.
2. Some academics are concerned that AI could replace teachers and make learning less personal.
3. AI can be used to create virtual learning environments that can lead to social isolation of students.
4. AI can be used to manipulate students and monitor their behavior.

Prospects

1. AI can make learning more effective, personalized, and accessible.
2. AI can help students develop critical thinking and problem-solving skills.
3. AI can help students adapt to a changing labor market.
4. AI can help students become more creative and innovative.

We only looked at general trends and examples of how AI is already being used in universities. Over time, it is likely that the use of AI in education will only grow, and AI will have the potential to make education more accessible, effective and personalized, while at the same time it is necessary to understand and minimize the possible problems and risks associated with it.

Conclusions

The use of AI in education is a complex and multifaceted problem.

AI is a complex system that can be used for various purposes, including education. AI can help teachers personalize learning for each student, provide an opportunity for more interaction and exchange of ideas between students and teachers, and help students learn new skills and knowledge.

However, the use of AI in education is also associated with some ethical and social risks. One risk is that AI could be used to discriminate against students based on their characteristics, such as race, gender, religion, or social status. Another risk is that AI can be used to monitor and track students without their knowledge or consent. In addition, AI can be used to create fake news and misinformation that can negatively impact education.

It is important to consider these risks when using AI in education. It is also important to develop ethical principles that will govern the use of AI in education. These principles should include provisions such as respecting student confidentiality, preventing discrimination, and ensuring that AI is used for the benefit of students.

It is necessary to take into account both the positive and negative consequences of the use of AI in education. It is important to develop an ethical framework that will regulate the use of AI in education to ensure that AI is used for the benefit of all.

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WOJCIECH WALAT

Homo interneticus – a challenge for modern education[1,2]

ORCID: 0000-0002-3158-1923, Ph.D., Professor UR, University of Rzeszow, Faculty of Pedagogy, Department of General Didactics and Educational Systems, Poland

Abstract

This paper presents the three characteristics that constitute the modern type of Internet man – homo interneticus – easily lead to the rapid development of functional illiteracy. Therefore, education faces a great challenge in the era of dominant and widely accepted functional illiteracy.

Keywords: education, homo interneticus, literacy, functional illiteracy

Introduction

On a daily basis, we have a great tendency to take advantage of everything that concerns education, especially education. In the media information stream, one can often hear that things are bad with modern schools, that thousands or even millions of "educated" people, despite the completion of formal education,

[1] This research was carried out within the framework of the statutory work of the Department of General Didactics and Educational Systems of the Faculty of Pedagogy and the research program of the Lifelong Learning Laboratory at the Centre for Innovation and Knowledge Transfer of the University of Rzeszow.

[2] The article is a revised and supplemented version of the publication in the journal *Education – Technology – Information Technology* No. 4/18/2016 and thematically similar articles: Walat, W. (2016). Three degrees to functional illiteracy of homo interneticus. In: *New Horizons of Education. Modern Education, Science, Technology, Innovation. Via Ferrata Publishers*, *1*(14), 22–30; Walat, W. (2017). Homo interneticus – functional illiteracy of contemporary man. In: E. Smyrnova-Trybulska (Ed.), *Effective Development of Teachers' Skills in the Area of ICT and E-learning. E-learning.* Vol. 9 (pp. 13–22). Katowice, Cieszyn: University of Silesia; Walat, W. (2019). Homo interneticus as functional illiterate in the field of human rights. *Politics and Society*, *1*(17), 1–22; Walat, W. (2020). Homo interneticus – problems of education in times of functional illiteracy. In: M. Tanaś, S. Galanciak (Eds.), *Cyberspace human education. Open educational resources from a pedagogical point of view* (pp. 181–194). Kraków: Impuls Publishers;

remain illiterate in the strict sense of the word, and above all functionally illiterate. In practice, this means that they cannot make rational use of the knowledge they have acquired. It seems that the reasons for this state of affairs can be found primarily in the dominant modern network communication. Probably this is the reason for the description of modern man as a man connected to the Internet, that is: *homo interneticus(internetus)*[3].

Today, in a computerized world, traditional literacy is far from sufficient and there is an urgent need for universal functional literacy[4].

Cognitive distraction of homo interneticus

Hearing the term Internet man (homo interneticus), one may smile at first, as it is a fairly new term for classifying humans from a sociobiological point of view. In fact, homo interneticus means, in the shortest terms, a person connected to the global social network.

Based on available written and electronic sources, it can be assumed that the term first appeared on the BBC Two portal in a tab run by Krotoski (2010). Analysis of the terms appearing mainly in popular science publications leads to the conclusion that the Internet man is a new form of human evolution, the basis of which is the high state of his communication abilities, and the basis for the implementation of life functions is the connection to the network. The occurring lack of connection not only hinders, but even prevents his functioning in every dimension: personal, social, and professional.

Taking an evolutionary point of view and emphasizing the exceptional communication abilities of thinking man (homo sapiens), it is legitimate to distinguish four terms classifying his development as: speaking man (homo oralis), writing man (homo literalis), printing man (homo typographicus) and internet man (homo interneticus).

The term "thinking man", which is basic here, refers to humans who appeared more than 1.4 million years ago and, with the help of handmade tools, including communication tools, were able to record the course of events, e.g. with the help of cave drawings, ornaments that distinguish and distinguish objects according to their purpose and their social status – but without the accompanying narrative (story) they were and are completely illegible (we can only guess at their meaning). Talking man is defined as a human species with a narrative (story) communicative mode, actually developing concurrently since the

[3] The names homo interetus and homo interenticus appear interchangeably in the relevant literature. For the purposes of this publication, I have decided to consistently use the term homo intrenticus, which is much more common in Polish and foreign literature.

[4] "Alphabetization – pedagogical educational activity aimed at the acquisition of literacy and numeracy skills by illiterates". "Functional literacy – a method of literacy that combines learning to read and write with the acquisition by learners of knowledge directly needed in life and work". Retrieved from: http://encyklopedia.pwn.pl/haslo/3867725/alfa-betyzacja.html (12.2023).

emergence of homo sapiens. It was linguistic communication that was probably the only mode of cultural transmission until around 4000–3000 BC. That's when writing man appeared, i.e., humans efficiently communicating through writing. Printing man, on the other hand, refers to people using the modern mode of mass communication fully formed over the past 150 years[5].

The Internet man of today came to us with the invention of the World Wide Web[6].On a daily basis, people still speak, write, and use printed works, but the transmission and creation of culture has fundamentally changed and moved to the virtual world.

From early childhood, the man in print had to deal with a never-ending string of printed, admittedly symbolically coded, but nevertheless realistically existing works. His life began in a world that was realistically determined: every event, every action, every war and its outcome, every accident, every crime, mistake or misjudgment, and even every thought (state of mind) had definite causes that could be calmly traced back and forth. Thanks to this constancy of the world's narrative, education has always been built – hence, for literacy, the basis was learning to read, write, and count – today for functional literacy this is only of causal importance. Likewise, an earlier oral man had every reason to believe in destiny, to think that every story has a certain form and only that one certain form, even though in oral culture there is less constancy in the story telling and less complex causality – one follows from one instance to another (Goldhaber).

Implementation and with it the ability to communicate is always a key component of culture, and when the mode of communication changes, the culture changes as well. Today, the interent man always does everything he has to do with ten fingers on the keyboard. At the same time, he has a sense of unlimited knowledge, memory, time and space, and this is because the Internet knows no distance – there are no spatial relations on the Web. Another important point is that modern man is mainly guided by mimic free attention, because in the virtual

[5] Certainly, the invention and use of movable printing type by Gutenberg in 1450 can be considered the initial date of the emergence of homo typographicus. However, it took another nearly 500 years for printed materials to become the basis of mass communication. It was not until the second half of the 19th century, with the spread of magazines and primary education based on school books printed for this purpose, that writing became the basis of human communication: man both read and transferred his speech to paper.

[6] TT. Berners-Lee came up with a project proposal in 1989 to build a worldwide computer network based on hypertext – called the World Wide Web. It was to allow collaboration by combining information from multiple authors into a network of hypertext documents. T. Berners-Lee also developed his first server, called simply HTTPD, and the first "World Wide Web" client application – a WYSIWYG hypertext viewer and editor running in the NeXTStep environment. The "World Wide Web" program was made available on the CERN network in October 1990, and on the Internet in general in the summer of 1991. The first WWW site published by T. Berners-Lee was http://info.cern.ch/ (the first WWW site in the world, stillis still active – it contains information about the computer on which it was written and pictures of the PC, the first "surfer" and the WWW creator himself. Retrieved from: https://pl.wikipedia.org/wiki/ Tim_Berners-Lee (12.2023).

world people are placed in personal perspectives, which are often radically different from each other. The knowledge of modern man is indeterminate, because in the virtual world information is updated on an ongoing basis (continuously and permanently), so there appears the so-called appearance of knowledge, which is the basis of the posited culture. The prevailing belief is that what I know today may change tomorrow. The basis for the establishment of identity is the indeterminacy resulting from the constant variability of time and place of my being.

Today's electronized culture is institutionally immaterialized because people can manage it via the Internet. Therefore, it is no longer necessary to take notes, printouts, and in-person meetings (in the real world) are unnecessary. Such a culture of virtual communication affects human interaction, po- stances towards objects and living organisms become very different. Moreover, in the world of the Internet, gender and ethnicity are not distinguished, as they are also changeable, human senses change with cultural changes. Internet man is sensually distracted, as his bodily functions are realized only in appearance – after all, Internet communication does not reveal facial expressions when interacting with other people.

Cognitive distraction – the first principle of homo interneticus

On a daily basis, an online person is afraid of missing out on something, accompanied by a constant sense of discomfort due to the fear of overlooking an important piece of information, a chance to have an interesting experience or engage in social interaction. This is directly related to the spread of mobile devices and the development of social networks. Researchers of this phenomenon estimate that up to 70% of adults from developed countries who are constantly using, i.e. connected to the network, may suffer from it. The phenomenon was first named and described in 2010. D. Herman in his article The Fear of Missing Out (FOMO). The prevalence of the phenomenon is evidenced by the fact that the term "OMO" was added to the renowned Oxford Dictionary in 2013: "Anxiety, of knowing that an exciting and interesting event may be currently happening somewhere else where I am not, a common phenomenon in social media". The primary reasons for the FOMO phenomenon are:

– social networks (e.g. Facebook) flattering the ego of the Internet user, who feels that he is among his own – nice and intelligent people,

– on the Internet is the willingness to answer any questions,

– and if one does not look at the Internet, there is a great longing and all thoughts and actions go to check the Internet account, after checking again and again… and so on ad infinitum.

The Internet man is constantly checking something on his phone or laptop and cannot focus on his work – this wears him out and depresses him – eventually neurosis and depression sets in.

It seems that from today's point of view, prospectively, this will cause some significant changes in our culture, and to a special degree, it may change today's

common sense perspective on the world. In the future, there will be even more changes in human cognitive abilities, progressing in the wake of cultural changes. And for this we must be prepared, including for this situation, the school must be prepared.

"I am not thinking and yet I am" – the second characteristic of homo interneticus

Cognitive distraction leads to the disappearance of the value of knowledge sensu stricto, and thus the disappearance of understanding, the ability to relate facts, to build an individualized and internally and externally coherent narrative of the world – what matters is the literalness and attractiveness of the message of information measured by the number of clicks (so-called "likes"). Homo interneticus is convinced that information (equated with knowledge) is something naturally present in the environment and does not need to be sought, acquired, and nurtured – there is simply no need to learn.

Examples of this are plentiful, for example, the online channel "Matura to nonsense" (MTB) provides "hits" showing deficiencies in elementary knowledge and the ability to use it: "What is inflation? – The title of a movie with Leonardo Di Caprio" (presumably, the caller confused "inflation" with "infiltration" – such is the title of a famous film starring the aforementioned actor). Another example: "On whose side did the Americans fight at Grunwald? – On ours" (film adaptations appearing on the Internet show a distortion of the time and place of the events taking place – any historical event can be set in any time and place).

In modern school, learning facts, acquiring the basics of knowledge has become extremely difficult due to the fact that for students the primary source of knowledge – and the oracle as to its veracity – has become the Internet. There, everything is arranged not according to logical relationships, hierarchical structures, but on the basis of free hypertext associations.

Functional illiteracy – the third trait of homo interneticus

Philosophical illiteracy is embedded in a person's "readership", and it is not about reading paper books, but books in general, not just blogs and online hypertext, because the latter without knowledge of the reading canon leads to chaotic thinking. This is clearly evidenced by research conducted by the National Library, and concerning the state of reading in Poland in 2015 (Rakoski). They show that up to 63% of Poles have not had any contact with a book, and 37% of their compatriots have read only one reading.

"People who are completely sane, less educated or have a college education, cannot cope with the reality around us. Small problems, which can be solved on the fly with a minimum of resources, grow exponentially to the size of a massive tsunami of life. The person is incompetent, unmanageable, confused, but… often after

frustration sets in, he or she becomes demanding, impulsive, postulatory and increasingly seething with aggression. Such functional and life illiterates are unable to articulate what the problem they face is, do not understand it, and look everywhere a'la help, displaying aggression with demandingness" (*Functional Illiteracy*…).

Economic illiteracy – in a study conducted by Millward Brown for the Liberty Institute and Raiffeisen Bank in 2014. (Report: Polakom brakuje podstawowej wiedzy ekonomicznej – rp.p) is surprising not only for its belief in the power of sevens and thirteens, which is intertwined with the Polish borrower's failure to distinguish between a percentage and a percentage point (and this applies to 92% of those surveyed). Only one in three Poles knew that there are currently two tax thresholds in our country, and barely one in five grasps the principle that entering a higher threshold does not mean a change in tax assessment for all income earned in a given year. The level of inflation last year was rightly reported by one in four respondents.

There are already social problems arising from economic illiteracy, for example, the Spanish Entrepreneurs' Association proposes that unskilled workers be paid below the minimum acceptable wage. In Spain, one million people have no training for a profession, yet they must be paid like skilled people. During the years of the economic boom, thousands of students dropped out of school to work in construction or services and earn up to two thousand euros a month. Now they belong to the so-called "neither-neither generation" – young people who neither work nor study. Among other things, it is due to them that the youth unemployment rate has exceeded 50% in Spain. The Entrepreneurs' Association proposes that they be paid the lowest of all. "If people who are now 25–30 years old did not finish school as children, they cannot be paid at the same level as those prepared for a profession" – believes Monica de Oriol, president of the Entrepreneurs' Association (Spain's way out of the crisis…). Almost every area of life today involves some kind of illiteracy. We are dealing with political illiteracy (Maciejewski, 2010), social illiteracy (Rymszewicz, 2013), health illiteracy (Olejniczak, 2016), and technical illiteracy (Wincza, 2008).

Summary

Nowadays, the source of functional illiteracy is primarily the cyberspace of the virtual world, which gives people the illusion of interacting with the real world – the illusion of learning this world – not only writing, reading, counting, but the illusion of understanding and living in this – supposedly – real world.

As the most common indicators of functional illiteracy can be mentioned after Rymszewicz (2013):

- reading less than a few dozen books a year,
- not knowing any foreign language,
- inability to write precise, concise e-mails, reports and reports,

– preaching arguments full of aggression and personal attacks instead of substantive discussions,

– ignorance regarding cultural and substantive commenting on texts and statements,

– failure to understand written texts: instead of sound analysis and drawing conclusions, conducting pseudo-interpretations lined with the immortal statement "because it seems so to me" or "because I think so".

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MARIA MITROULIA[1], **STEFANOS ARMAKOLAS**[2], **JAN KROTKÝ**[3]

An Analysis on Research Trends of Distance Education

[1] ORCID: 0009-0007-4829-9792, MSc, University of Patras, Department of Business Administration, Greece
[2] ORCID: 0000-0003-1264-7066, Ph.D., University of Patras, Department of Educational Sciences and Social, Greece
[3] ORCID: 0000-0002-0601-5612, Ph.D., University of West Bohemia in Pilsen, Faculty of Education, Departament of Mathematics, Physics and Technical Education, Czech Republic

Abstract

The term "Distance Education" (hereafter DE) is gaining popularity amid new global trends in cross-cultural studies of transnational education. The main objective of this article is to identify the academic research development and future research goals in the Distance Education domain using the Scopus database in the last decade (2012–2022). To this end, a bibliometric analysis was performed examining the distribution of publications, the most influential scientific publication venues, the most productive authors, and regions and concluding with an explanation of the keywords co-occurrence in line with the VOSviewer program. The outcomes revealed that the most frequently examined topics in the field of DE can be detected, which focused on distance learning, online teaching, online education, moocs, ICT, and constitute subgenres of the literature under consideration. All in all, the paper can help scholars understand and decipher current trends, keep up with DE research directions, and finally enable them to conduct their future research more effectively.

Keywords: Distance Education, Bibliometric Analysis, Review, Research Evaluation, VOSviewer

Introduction

Online teaching is already being used in education learning environments around the world for teacher development and training, to meet the needs of entering the profession, and for their lifelong learning. Teleconferencing can be

the most appropriate tool for updating knowledge, acquiring professional skills, and modernizing teaching methods, according to new scientific techniques for organized, qualitative, scientifically consistent, and continuous teacher training (Armakolas, Panagiotakopoulos, Karatrantou, 2022). According to the literature review, a variety of technological, pedagogical, psychological, and social factors influence the teleconferencing environment. The effectiveness of a teleconferencing session mainly depends on the "lesson plan" and the teacher's coordination of collaborative/interactive activities and communication (Alqurashi, 2017; Taskiran, 2020). However, in terms of variables that significantly influence the effectiveness, privacy preference in online communication and procrastination tendency was identified as relevant. In light of this, the need for appropriate pedagogical design and thorough research in distance learning is imperative (Kohout et al., 2022).

Literature Review

In recent years, several studies have been conducted to examine the evolution process of DE and address new research directions. One of the first surveys was performed by Berge and Mrozowski (2001), who reviewed the scientific literature on DE for a decade (1990–1999). Lee, Driscoll and Nelson (2004) dealt with issues related to DE, and compiled studies published in the following four journals: "the American Journal of Distance Education" (AJDE), "the Journal of Distance Education" (JDE), "Distance Education" (DE) and "Open Learning: The Journal of Open, Distance and e-Learning" (OL). Zawacki-Richter has explored the DE research field in depth by conducting a considerable number of studies. In his first scientific attempt, Zawacki-Richter (2009) applied the Delphi method to classify the research directions. The second study (Zawacki-Richter, Bäcker, Vogt, 2009), analyzed 695 documents published in five leading German journals between 2000 and 2008 to uncover research gaps. In the third study, Zawacki-Richter and Von Prümmer explored the interrelationships between gender, collaboration, and research methods in DE (Zawacki-Richter, von Prümmer, 2010).

Bozkurt et al. (2015) examined trends in distance education research from 2009 to 2013, using an in-depth analysis of seven peer-reviewed scholarly journals. Amoozegar Khodabandelou nad Ale Ebrahim (2018) processed the data they extracted from the Web of Science platform (WoS) to determine current trends in distance education research for the period 1980 to 2016. Literature review and social network analysis were used primarily to examine the structure and patterns of information sharing in distance education research and to interpret the associations between keywords mentioned in the articles. An aggregate of 500 of the most cited papers was examined to probe the influence of factors such as journal DOI number and keywords according to the number of reports they got.

Hebebci (2021) carried out a bibliometric study using WoS to determine trends in scholarly research on DE during the outbreak of COVID-19 crisis and to suggest guidelines for further analysis on this topic. Following the filtering process of WoS, 767 scholarly articles were included in the study. Data analysis encompassed all the articles by year, country, journal, publication language, citation, co-author, co-occurrence, and co-citation. The study showed that the articles were published within a short span of two years (2020-2021), and were mainly written in English. The majority of the articles were published in the "Journal of Chemical Education". Also, this journal emerged as the most frequently cited and co-cited.

According to the literature, during the period of the COVID-19 lockdowns, studies on the bibliometric analysis of DE decreased significantly (Karakose, Demirkol, 2021; Sweileh, 2021; Yavuz, Kayali, Tutal, 2021). A study by Aggarwal, Aggarwal, Robles, Depasquale and Auseon (2020), which analyzed 3,641 documents, found that the proportion of educational research was less than 1%. Given the impact of the COVID-19 outbreak on education, it is critical to increase the quality and quantity of studies in this area to contribute to future literature and academic research.

In this study, a bibliometric analysis was performed to demonstrate the development path of DE philosophy and to trace the transfer of research directions, and seek new uncharted research opportunities, as this topic is becoming increasingly important. Questions to be addressed are as follows:

Question 1: How is research on DE evolving by the number of publications per year?

Question 2: In which journals have the most articles on DE been published?

Question 3: Which authors have contributed most to the publication of DE research results?

Question 4: Which author's countries contribute most to the publication of DE? Question 5: What are the key areas of research on DE?

Question 6: What are the limitations of current research?

To answer the above questions, the study was divided into five parts. Sections 1 and 2 introduce the concept of DE and argues the significance of understanding recent trend and the development of DE research. Section 3 describes the research methodology used for data extraction and preparation. The bibliometric analysis and results are interpreted in section 4, while section 5 summarizes the findings and confirms the limitations of this work.

Research Methodology

1. Method

To gain a thorough understanding of the research landscape in DE, this article employs bibliometric analysis. Alongside, it uses the VOSviewer application

(van Eck, Waltman, 2020) to analyze and visualize the dataset, and attain the research objectives, following similar methods employed in other articles (Das, 2021; Ghani et al., 2022; Prahani et al., 2022).

2. Selection of data

It is very often observed that scholars when they want to conduct a bibliometric review use one of the three platforms: Scopus (Elsevier), Web of Science (Thomson), and Google Scholar (Google). The Scopus database was used to search the scientific literature from the perspective of DE. This database offers many advantages over WoS, such as a wide range of papers and faster citation analysis (Joshi, 2016). It also allows easy data export without manual intervention and covers several business, financial, and management documents (Aksnes, Sivertsen, 2019). On the day of analysis January 5, 2022, the search term "Distance Education" [TITLE-ABS-KEY] contained 23,488 documents. The search was further refined using the following limitations. To ensure quality, only articles published in journals were included. Also, English-language documents within the field of "social sciences" were considered for a better understanding of the researchers. The period was limited to the last decade (2012–2022), and all open-access articles were added too.

After the extraction and cleaning process of the data, the final sample included 954 articles which was extracted in CSV format and imported into VOSviewer for more elaboration. Table 1 tabulates the research process.

Table 1. Data extraction & cleaning process

Data Query	Data Filtering	Data Export
1. Scopus 2. Title, Abstract, Keyword: "Distance Education" 3. Result: 23,488 documents	4. Subject Area: "Social Science" 5. Document Type: Articles 6. Language: English 7. Timespan:2012-2022 8. Source: Journals 9. Results: 954 documents for bibliometric analysis	10. Article data 11. Author data 12. Keywords 13. Citations 14. References 15. CSV Excel file 16. VOSviewer

Source: Authors computation.

3. Results and Discussion

3.1. Publication trend – Q1

Figure 2 displays the large academic interest in distance education as it has been shaped in the decade we are interested in. An overall increasing trend can be observed, especially from 2018 onwards. It is interesting to note that the highest production of articles occurred in 2022, demonstrating a surge in research activity. Specifically, the number of articles published in the first three years of the 2020s is

almost half the number of articles published in all previous years. The research trend in terms of the number of publications continues to develop. The data of the above figure reveals that DE as a subject of study is an expanding field that is constantly changing and gaining the attention of scholars. The upward trend of publications reflects the increasing efforts to comprehend different aspects of DE in order to meet the evolving needs of both educators and learners.

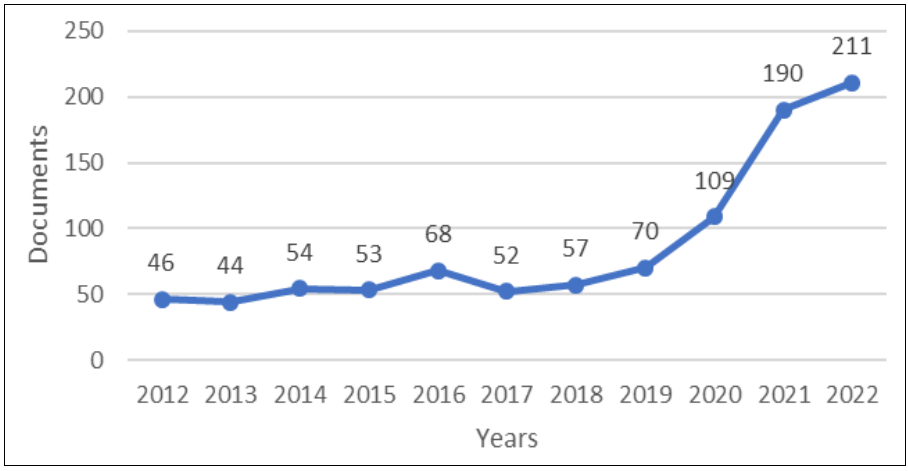

Figure 2. The annual scientific production of publications on DE

Source: Prepared by authors based on VOSviewer.

3.2. Most Productive and Influential Journals – Q2

Table 2 tabulates the top ten peer-reviewed journals with the most publications in DE research. Regarding contributing journals, the journal with the highest productivity is the "Turkish Online Journal of Distance Education" (TOJDE), with 101 articles published by Anadolu University.

Table 2. Ten Most Productive and Influential Journals

Sources	Documents	Citations
Turkish Online Journal of Distance Education	101	612
International Journal of Emerging Technologies in Learning	97	408
International Review of Research in Open and Distance Learning	81	1,867
World Journal on Educational Technology: current issues	30	47
Online Learning Journal	25	294
IEEE Transactions on Learning Technologies	21	769
Computers and Education	20	1,762
Cypriot Journal of Educational Sciences	19	12
Sustainability (Switzerland)	18	53
Education and Information Technologies	16	208

Source: Prepared by authors based on VOSviewer.

In second place is the "International Journal of Emerging Technologies in Learning" (iJET) with 97 articles. "International Review of Research in Open and Distance Learning" (IRRODL) is third in line but excels in terms of citations. Also, "Computers and Education" (C&E) journal occupies the second place as it has received a high rate of citations for its published articles.

The bibliometric method can serve as a tool that facilitates authors to select journals for possible publication of their articles. The presence of IRRODL and C&E in the top ranking suggests that both journals provide a combination of productivity and quality, making them a right choice for scholars seeking to contribute to DE literature and obtain visibility for their article.

3.3. Most Productive and Cited Authors – Q3

This section presents the top ten authors who contributed the most to DE literature. Using the publications as a proxy for productivity, the most active and prominent authors are listed in Figure 3 and meticulously in Table 3.

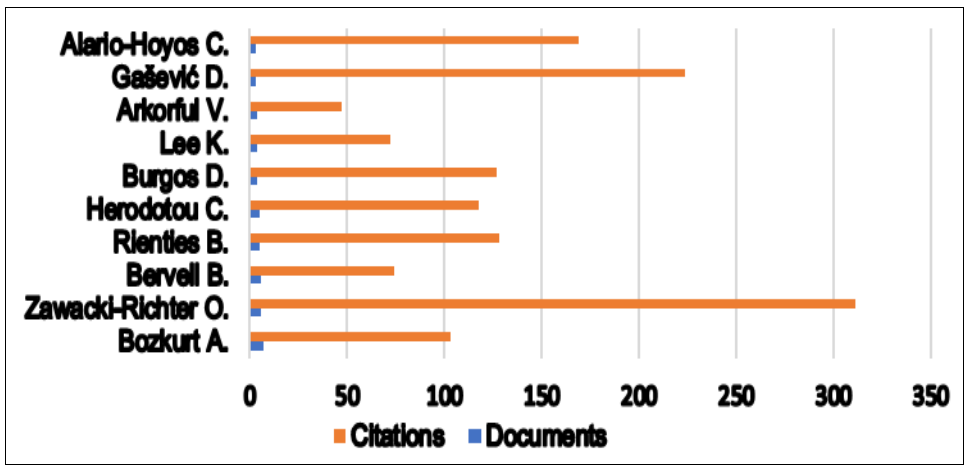

Figure 3. Ten most productive authors and their citations

Source: Prepared by authors based on VOSviewer.

A perusal of this table reveals that Bozkurt A. has seven articles in his credit, proving that he is the most prolific author. His scientific work revolves around identifying and mapping patterns in research on MOOCs. One of his distinguished articles is "What Research Says About MOOCs – An Explorative Content Analysis" (Zawacki-Richter, Bozkurt, Alturki, Aldraiweesh, 2018), and was published in the "International Review of Research in Open and Distributed Learning" in 2018. It is worth noting that in a short span of three years, this paper garnered significant attention.

Table 3. Number of Publications and Citations by Author

Rank	Author	Documents	Citations
1	Bozkurt A.	7	103
2	Zawacki-Richter O.	6	311
3	Bervell B.	6	74
4	Rienties B.	5	128
5	Herodotou C.	5	118
6	Burgos D.	4	127
7	Lee K.	4	72
8	Arkorful V.	4	47
9	Gašević D.	3	224
10	Alario-Hoyos C.	3	169

Source: Prepared by authors based on VOSviewer.

The second influential and well-known author is Zawacki-Richter O. with a record of six related publications and 311 citations. His paper "Mapping research trends from 35 years of publications in Distance Education" (Zawacki--Richter, Naidu, 2016) published in the "Distance Education" journal in 2016. In terms of citation, Scopus classifies this paper in the first place as it has been cited 95 times. He has focused his research on mapping out trends in distance education research and scholarship over a significant period (1980–2014). These results show that both the above authors are having high recognition in the academic field. Many other scholars often rely on their publications as a foundation for elaborating their own scientific work.

Among the authors who have written about DE, Gašević and Alario-Hoyos. have published three papers each and were cited 224 and 169 times, respectively. Bervell published six documents and received 74 citations. This suggests that while productivity plays an important role, it is not correlated with influence.

3.4. The most contributing countries – Q4

In this section, we identify the productivity and influence of different countries in terms of the number of documents and citations, providing information on the geographical distribution of the research we are interested in. Out of the 103 countries around the globe that have demonstrated high influence and productivity in the field of DE research, the top 10 are depicted in Table 4.

The list includes both developed and developing countries. The United States leads the list in publications and follows closely behind Turkey, the United Kingdom, China, and Russian Federation, indicating their active presence in DE literature. The result of a combined analysis of the number of documents and the citation per document are impressive. It highlights that among these ten nations, the UK, Australia, and Spain stand out particularly active and exhibit great influence. Although these three countries have a lower productivity compared to other countries, their scientific papers are frequently cited, showcasing strong impact and better quality. It is worth noting that dynamic productivity may not

be translated to higher influence. For example, Turkey shows high publication (140 documents), but its impact is relatively low (826 citations), as gauged by the citation count. In addition, Australia and Spain have low productivity but their research outputs receive frequent citations.

Table 4. Ten most productive and influential countries

Rank	Country	Documents	Citations	AC/D
1	United States	156	2,973	19,06
2	Turkey	140	826	5,90
3	United Kingdom	85	2,585	30,41
4	China	60	481	8,02
5	Russian Federation	46	149	3,24
6	Kazakhstan	46	40	0,87
7	Australia	44	1,476	33,55
8	Spain	40	1,043	26,08
9	Brazil	39	213	5,46
10	Canada	30	660	22,00

Source: Prepared by authors based on VOSviewer.

3.5. Main Research Topic in DE Performance – Q5

A visual representation of the keyword analysis performed on the most frequently discussed themes in DE publications is depicted in the following Figure 5. In more detail, the network visualization was completed by using a co-occurrence analysis, specifically based on the author's keywords. Using VOSviewer application we set a minimum occurrence number of 10, resulting in approximately 30 representative keywords related to temporary studies in the DE academic field. After evaluating the result, 7 distinct clusters were formed, denoted by various colors, reflecting trends and fields of exploration. Figure 5 presents the topics utilizing dots and labels. The size of the dot indicates the level of research carried out for each subject, while big dots showcase terms that have received more attention and analysis.

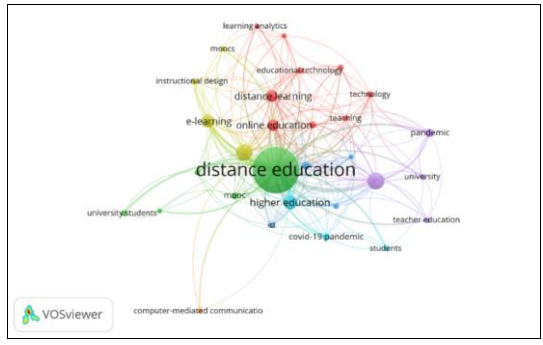

Figure 5. Network visualizations of the Scopus database

Source: VOSviewer.

The network visualization in Figure 5, presents that the first cluster in green, focusing on DE, becomes the main research topic of this study, evident by its big dot on the picture. Moreover, every cluster in the map corresponds to a specific scientific area. For example, the second cluster (red) shows distance learning and online education as its main topics, representing the largest constituency of this group. The third cluster (blue) is centered on online teaching and ICT. The fourth group (yellow) revolves around e-learning/online learning and moocs. Topics in cluster five (purple) focused primarily on teacher education and COVID-19. There are two more themes: one in light blue related to higher education and one in orange related to computer-mediated communication, which are subgenres within literature.

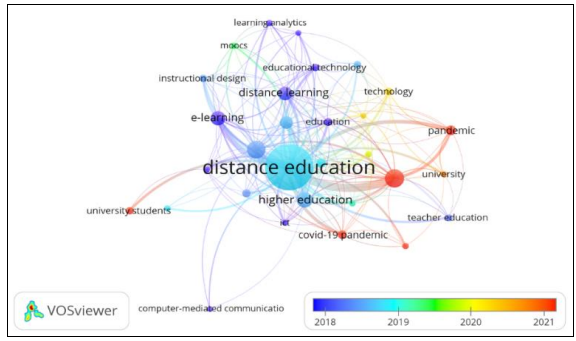

Figure 6. Overlay Visualization of Scopus database

Source: VOSviewer.

Figure 6 provides a closer look at research on DE conducted over a ten-year period. The above picture illustrates that the highest occurrence of keywords appeared from 2018 until 2021. Research topics such as technology, COVID-19, and pedagogy were relatively new (around 2021) compared to other topics like distance education and ICT which began to attract research interest in about 2018. It is clear that both Figure 5 and Figure 6 offer useful insights and temporal trends in the field under investigation.

3.6 Future Topics in the Field of DE – Q6

Figure 7 shows a density visualization created by VOSviewer, which captures the depth of research conducted in specific fields of DE. The following map illustrates the density of the topics by representing keywords in different colors based on their frequency. More intense and bright colors indicate an advanced number of academic papers on a particular keyword. Therefore, keywords with a less frequent occurrence are represented by a blurred color, which means limited research in those areas, signaling the need for more exploration. Such keywords could serve as potential research subjects.

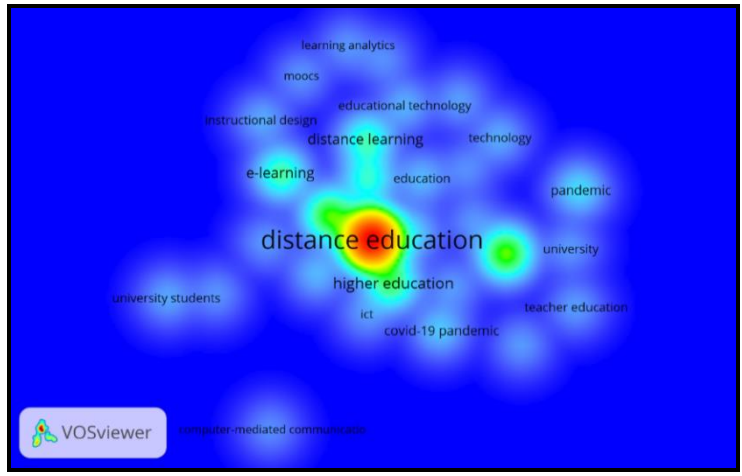

Figure 7. Density visualizations of Scopus database

Source: VOSviewer.

Some other examples of these keywords are learning analytics, educational technology, ICT, and computer-mediated communication. By identifying these emerging themes, scientific researchers can contribute to the area of DE studies and make new advances.

Conclusion

This paper uses bibliometric analysis to screen all literature in the Scopus platform in the distance education scientific field. The literature on distance education has grown gradually, as evidenced by the number of publications in recent years. According to the results, up to 954 records were pulled from the Scopus database in the initial phase. Also, the findings of this study show the trends in DE studies, publishers, contributors, and countries. An analysis of less common keywords outlines some promising areas for future research. Therefore, this study aimed to identify research developments and predict potential advances in future research through bibliometric tools as field research in the DE has increased significantly. The VOSviewer application has been successfully demonstrated in the mapping and visualizing bibliometric data. A limitation of this study is that the records are gathered only from the Scopus database, specifically journals as resources and articles published in the English language. It is therefore recommended to use a range of various electronic platforms (e.g. Web of Science, Springer, IEEE Xplore, Google Scholar) to ensure in-depth coverage of the survey. Additionally, it is advisable to obtain data from varied periods, as this can yield diverse findings and lead to a nuanced understanding of the subject.

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HELENA MIČKOVÁ[1], **JANA MIKOVÁ**[2], **ZDENKA NOVÁKOVÁ**[3], **JAN ŠMIDA**[4]

Pupils' Risky Behavior in the Cyberspace During the Transition to Distance Education

[1] ORCID: 0000-0002-8235-9599, JUDr. Mgr. Helena Mičková, Palacký University Olomouc, Faculty of Education, The Institute of Education and Social Studies, Czech Republic.
[2] ORCID: 0000-0001-5322-1876, Mgr. Jana Miková, Palacký University Olomouc, Faculty of Education, The Institute of Education and Social Studies, Czech Republic.
[3] ORCID: 0000-0002-3867-8314, JUDr. Zdenka Nováková, Ph.D., Palacký University Olomouc, Faculty of Education, The Institute of Education and Social Studies, Czech Republic.
[4] ORCID: 0000-0002-1807-2884, Bc. Jan Šmída, Palacký University Olomouc, Faculty of Education, The Institute of Education and Social Studies, Czech Republic.

Abstract

In connection with the covid pandemic and the closing of schools as anti-covid emergency measures in many countries, face-to-face teaching has moved to an online environment.

The Ministry of Education, Youth and Sports of the Czech Republic has issued Methodological Recommendations for distance education realized online using software tools, the Internet, and digital technologies. The presented pilot study brought disturbing findings about online teaching, namely that respondents experienced threats during distance education, with some even being blackmailed. Three hundred fifteen respondents from elementary and secondary schools in the Czech Republic took part in the pilot study, which was realized via a questionnaire survey.

At the same time, the pilot study points to other risks of online learning when transitioning to a distance form of education, which also presents several other risks in cyberspace.

Keywords: distance learning, online learning, blackmail, threats, cyberspace risks

Research subject

Like many other European countries, the Czech Republic was forced to adopt anti-covid measures in connection with the education of primary and secondary school pupils when teaching moved to cyberspace. Primary and second-

dary schools had to adapt to the current situation and, with the help of information and communication technologies (ICT), educate students at a distance. Until then, online or distance education had been used for lifelong adult education.

Piotrowski and Sliwa (2015) perceive today's world from a two-dimensional point of view, where real and cyber worlds are interconnected and interdependdent. This also characterizes the realization of the educational process, which was forced to move from the known real world to the unknown cyber world during the covid era.

Cyberspace can be characterized as a dynamically developing medium with many opportunities and threats that can attract various individuals aiming to exploit other people's vulnerability, unawareness, and trust. According to Kopecký and Krejčí (2010), the risks of virtual communication (communication in cyberspace) include, among others, cyberbullying, cyber grooming, stalking, and cyberstalking.

Distance education and online teaching, implemented through information and communication technologies in the cyberspace environment, represent possible risks and security threats during online teaching itself, which can interfere with the privacy of teachers and students. Over the past two years, primary and secondary school students and their teachers have been exposed to the digital environment many times more during the implementation of online teaching in connection with distance education.

With the increasing use of information and communication technologies in education, cybercrimes against children have also increased simultaneously (Prajapati, Kumar, 2022). Risky behavior not only in cyberspace is defined by Ostaszewski (2005) as behavior contrary to social norms and the legal order, which at the same time threatens human health and development. Online risky behavior can take many forms: making personal information available to others (Livingstone, Helsper, 2007, 2010), sharing visual material with the general public (Marcum, Ricketts, Higgins, 2010), engaging in online discussions with sexual overtones and vulgar comments (Ybarra, Mitchell, Finkelhor, Wolak, 2007), or establishing new friendships with unknown people (Livingstone, Helsper, 2007; Ybarra et al., 2007; Kopecký, Szotkowski, Krejčí, 2021). Adamski (2013) mentions anonymity, an unlimited range of users, and the universality of internet access as risky factors of behavior on the Internet with the possible development of cybercrime. Kopecký, Szotkowski and Krejčí (2021) consider, among other things, the use of fictitious identities, so-called equality of status, synchronous and asynchronous online communication, and social multiplicity in communication with an undetermined number of users to be risky.

Based on the initial questioning, threats, blackmail, and mockery during online teaching were found to be possible risky phenomena. We perceive those as possible threats during the implementation of online teaching.

Methodology

The introductory survey entitled "Selected risks of cyberspace during the transition of pupils to distance learning" focused on naming the possible risks of cyberspace that pupils of lower secondary schools, secondary schools, conservatories, and other schools of the Olomouc Region encountered during distance learning. As part of this research, we also found out what proportion of pupils encountered risky situations, such as blackmail or threats in cyberspace. The age range of the respondents varied between 13 and 19 years.

The initial questioning was implemented based on a ~~e~~quantitative research strategy. Data collection took place from 05/2022 to 07/2022 through a questionnaire survey, when online Google Forms questionnaires were used and shared among pupils of lower secondary and secondary schools. The obtained data were subsequently analyzed by statistical methods using MS Excel.

Research method:	Quantitative research method
Research tool:	Questionnaire survey
Research sample:	Lower secondary and secondary schools' pupils
Data analysis:	Statistical data analysis

Research results analysis

It can be seen from the first graph that a large part (41.9%) of the pupils were not instructed in any way before or during online teaching about the risks that may exist in cyberspace. This can also be one of the factors behind the dangerous behavior of pupils on the Internet, as well as the high numbers in the field of cyberbullying, which the pupils themselves have experienced. If there was any instruction about safe behavior on the Internet, it was primarily provided by the school (32.1%), parents (22.9%), or the students' teachers themselves (20.6%).

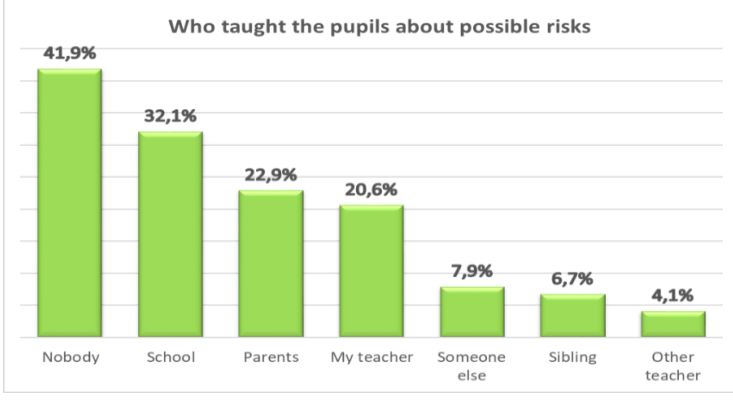

Figure 1

Source: our own research investigation.

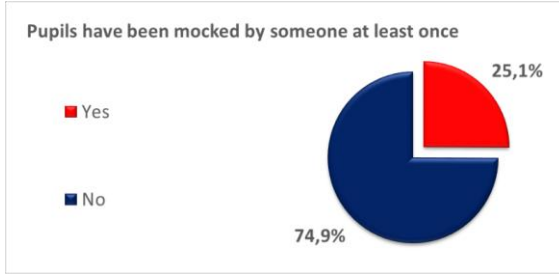

Figure 2

Source: our own research investigation.

Ridicule or mockery, which troubled pupils the most during distance learning, has long been the most widespread form of cyberbullying. This is also confirmed by Figure 2, which shows that up to 25.1% of pupils were mocked in some way during distance learning. That is, every fourth pupil.

However, risky behavior in cyberspace was not limited to ridicule. Figure 3 informs that during distance learning. Students also experienced hacking into their accounts (17.1%), misuse of their accounts (11.4%), or theft of personal data (8.6%). It is also quite alarming that 9.2% of pupils experienced threats during distance education, and even 9.5% were blackmailed. Of these, 3.8% of pupils experienced threats more than once, and 3.5% experienced blackmail more than once. Thus, almost every tenth student has become a victim of one or both forms of virtual attack. The question remains whether these percentages would be lower if the pupils were taught more, as described in Figure 1.

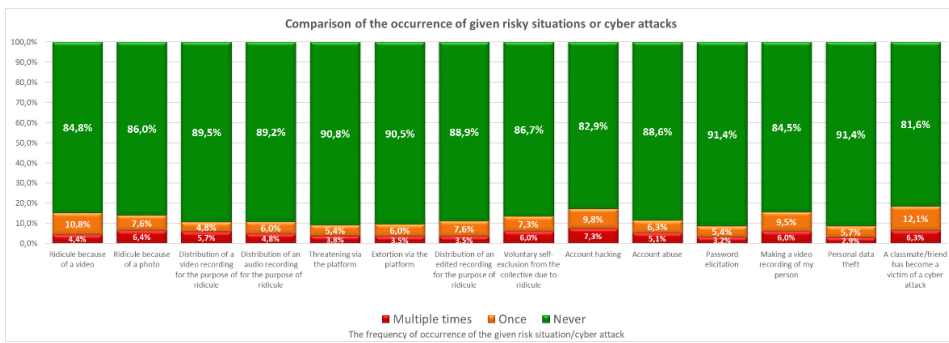

Figure 3

Source: our own research investigation.

Pupils were not only exposed to risky behavior but also behaved very risky themselves. This can be seen in chart No. 4. A relatively high percentage of pu-

pils deliberately disrupted lessons in the online environment in various ways. For example, 17.8% of pupils (11.4% once, 6.4% multiple times) turned off their teacher's camera, and 16.2% (12.1% once, 4.1% multiple times) even disconnected the teacher himself from the lesson. If we focus on mockery, 8.9% of pupils (5.4% once, 3.5% more than once) admit to having shared mocking photos or videos of a teacher. Pupils are, therefore, the most frequent perpetrators of various cyberattacks or forms of cyberbullying.

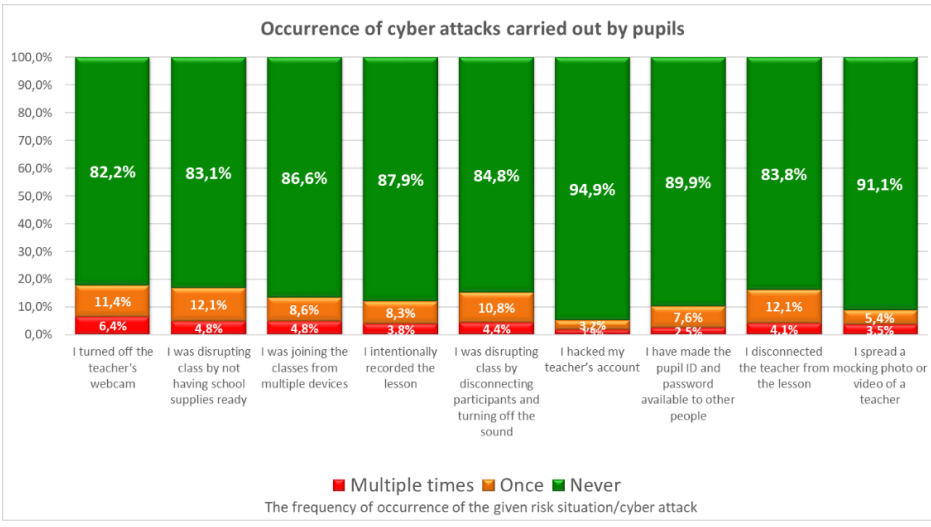

Figure 4

Source: our own research investigation.

Conclusions

The collected data represented by the charts clearly show that the pupils needed to be sufficiently instructed about safe behavior on the Internet, which could – and did – manifest itself in the frequency of various risky behaviors.

The following facts emerge from the data:

– 41.9% of pupils were not sufficiently trained in safe behavior on the Internet;

– 25.1% of pupils experienced ridicule or mockery at least once during distance education;

– 9.2% of pupils were threatened at least once, and 9.5% of pupils were even blackmailed online.

The preparation of pupils for online teaching should have been more sufficient. The low level of digital literacy and the ability to behave safely in cyberspace undoubtedly contributed to the intensity of various risky situations that

students had to face during distance education, but also to how students dealt with non-standard situations.

From a long-term perspective and several contemporary pieces of research, it is evident that mockery is one of the most widespread forms of cyberbullying. This also follows from our research. However, special attention should also be paid to the other risks that cyberspace brings, such as the risk of blackmail or threats, as well as hackers breaking into someone's account and stealing personal and login data. According to research, the percentage of occurrences of risky behavior and risky situations among pupils is still very high, so it is necessary to constantly strengthen the digital competencies of pupils and teachers. The school and the parents, who allow their children to access various content on digital devices such as mobile phones or computers, should participate in this.

Security and especially prevention in cyberspace have been priorities of the 2030+ educational strategy in the Czech Republic (Fryč et al., 2020), in the context of digital literacy, digital competencies, and related educational goals. Thanks to technological trends, emphasis is simultaneously placed on improving quality, efficiency, and innovation in teaching. In contrast, a greater emphasis is placed on individualizing teaching and communicating with pupils through digital technologies.

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JACEK JĘDRYCZKOWSKI

Didactic Film in Computer-Aided Education of People with Visual and Hearing Impairments

ORCID: 0000-0001-6707-263X, Ph.D., University of Zielona Góra, Faculty of Social Sciences, Institute of Pedagogy, Department of Media and Information Technology, Poland

Abstract

Artificial intelligence mechanisms enable fast speech transcription and printed text recognition (Optical Character Recognition). Speech synthesizers for reading any digital documents have also become popular. In most cases, these are free solutions that can significantly support the education and functioning of people with visual and hearing impairments. Unfortunately, the knowledge of parents and caregivers on this subject is insufficient. Bearing this in mind, a suitable series of educational videos was prepared and published on YouTube. Subsequently, research was conducted to determine whether and to what extent there is a demand for video materials on this topic. For this purpose, the method of implicit observation was used, carried out using YouTube Analytics mechanisms. Its results are available in the form of numerous reports and summaries. Based on the collected materials, a considerable interest in the study was found. It was possible to determine which issues are of particular interest to the recipients. The obtained results will allow for further development of the educational offer.

Keywords: didactic film, YouTube Analytics, e-learning, educational process, deaf people, blind people

Introduction

The dynamic development of artificial intelligence tools has made it possible to improve speech recognition and transcription solutions in a way that was not possible before. This is possible both for dictating to a computer and for processing existing audio-video recordings. Similarly, free tools for recognizing text directly from photos or scans and programs that allow the computer to read it aloud have developed. Unfortunately, few teachers, parents and caregivers have the IT skills to use these solutions. Bearing in mind the need to popularize this type of information, the author of the article prepared and posted a series of

educational videos on YouTube. The aim of the study was to determine whether there is a demand for this type of topic and to find out which issues interest the recipients. The information on this was obtained through YouTube Analytics reports.

The subject matter of the study

The article discusses the procedure and results of the evaluation of the didactic usefulness of the author's video materials. The subjects of the study are the recipients of educational videos who help people with visual and hearing impairments. It was assumed that these are teachers preparing teaching aids and parents and caregivers supporting their wards in the learning process and in using cultural goods available in electronic form. The condition for conducting the research was to develop a series of videos and publish them on a playlist on YouTube. This solution made it possible to evaluate the viewership of the published materials and the covert observation of the viewers' interaction with the video material (watching time of individual parts; scrolling and re-watching and pausing). Based on the research material collected in the form of YouTube Analytics reports, it can be stated which parts of the material aroused the most interest. The conclusions from the research allow for modifying educational activities and improving or modifying the films made.

Research methodologies and tools

The ways of using the videos were analyzed using the research tools offered by YouTube Analytics. This is a reporting system that provides information on the viewership and all interactions of the recipients with the published video materials. YouTube Analytics does not allow assigning the observational material to a specific viewer. However, the quantitative nature of this type of research is their advantage. If the research problem is general, allowing for the development of video material on a topic of interest to a wider audience, then the research sample can include thousands of people. This makes it possible to generalize the results with a high degree of probability. Łobocki (2000, p. 46; 1999, pp. 48–51) defines observation as a method of scientific research and distinguishes its types: direct and indirect; standardized and non-standardized; overt and covert. YouTube Analytics reports can be considered as an equivalent of documentation prepared during indirect observation. However, it should be noted that the monitoring system operates covertly as in direct observation.

When planning research using YouTube Analytics tools, you can specify the variables very precisely. We then have a typical standardized observation. However, the ability to combine the data collected by YouTube Analytics with the observed variable means that their review can lead to a number of unexpected conclusions, similar to the case of non-standardized observation.

YouTube Analytics reports provide information, among others, on: number of views, watch time, average watch time; average percentage viewed and traffic sources, i.e. the ways in which Internet users found a given video. All data can be assigned to a specific time period and to the source of visits. The most valuable from the point of view of analyzing the learning process are the audience retention reports. They inform about the interactions of the recipients with the video material. These are two charts: "Absolute audience retention" and "Relative audience retention". In both cases, the tool allows you to simultaneously track the content of the video and the vertical axis moving along the chart. This allows you to correlate specific content with the range of interactions.

The parameter defined as "Absolute audience retention" informs how many percent of the total number of views of the video are the playback of individual parts. This means that values greater than 100% may appear. If the chart is flat and indicates a low level of engagement of the recipients, you should use the second chart. It informs about the level of attention determined on the basis of the activity of the recipients of a given video in comparison with all videos from YouTube of a similar length. This solution allows you to determine whether there were content that engaged the attention of the recipients. The cognitive aim of the research was to determine the scale of interest in educational materials illustrating the use of information and communication technologies supporting the education process of people with visual and hearing impairments. The contents that aroused the most interest of the recipients were also sought, taking into account the practical purpose, which was to develop the concept of subsequent videos.

The formulated research problems were questions about: number of views; watch time; average watch time; average percentage viewed and parts of the videos that aroused the most interest. The researcher was also interested in the sources of visits corresponding to the highest viewership.

Educational YouTube channel in the education process

Based on the research on the educational impact of multimedia messages and the research on the difficulties related to understanding laboratory instructions, on June 7, 2015, the author of the study launched the YouTube channel "JJ Kursy" offering educational videos related to broadly understood information and communication technologies (Jędryczkowski, 2015). The "JJ Kursy" channel currently offers 257 original videos, supplementing the content of laboratory classes and lectures. These videos are also available on websites dedicated to individual laboratory groups at the University of Zielona Góra. This solution allows for collecting detailed statistics informing about the learning process. To date, the video materials have been viewed 1 465 901 times and watched for 50 825 hours (5 years and 292 days). Only 21 468 views (2.9%) correspond to

the students of the university, which corresponds to 1615 hours of watching (over 67 days). This means that the YouTube channel currently serves as a Massive Open Online Course (MOOC), which is used by Internet users in the country and abroad (Jędryczkowski, 2019a, pp. 167–180).

Results of analyzes of the possibilities of using didactic films to support the education of people with visual and hearing impairments

The educational videos were published on the "JJ Kursy" channel on YouTube on the playlist "Supporting the education of people with visual and hearing impairments" (Jędryczkowski, 2023). The data on the viewership are from November 23, 2023. The following materials were posted:

1. Converting speech to text in Windows 10 and 11.
2. How to use free cloud-based office suites?
3. Clipchamp – automatic creation of subtitles for videos for the deaf.
4. Converting text to speech in Windows.
5. OCR in Google Docs. Recognizing text from photos and locked PDF files.

The first three videos present solutions useful in the education process of people with hearing impairments. The mechanisms that convert speech to text in real time and the programs for transcription, obtaining text from audio and video files, including for automatic generation of subtitles for videos, are discussed. The fourth and fifth videos focus on tools designed for people with visual impairments. Numerous solutions that convert text to speech were discussed. Free Google Docs mechanisms for recognizing text from photos and scans were also analyzed. This information may be useful for teachers and parents preparing educational materials for blind people. The text obtained in this way can be automatically converted to speech.

The video "Converting speech to text in Windows 10 and 11" was published on December 14, 2023. The material lasting 06:33 min was viewed 4234 times and watched for 133.8 hours. The average watch time of the video is 1:53 min, and the average percentage viewed is 28.9%. The video received 29 likes and contributed to gaining 17 subscribers. The most popular sources of visits are: Google search (2250 views with 71.1 hours of watching) and YouTube search (823 views with 24.3 hours of watching).

Analyzing the absolute audience retention of the recipients (Figure 1), it was found that the most interest was aroused by the fragment from 0:16 to 0:30. It was repeatedly scrolled to re-analyze, which made it longer watched than the rest of the content. The highest value of audience retention in this case reached 96.5%. It was found that at this point the keyboard shortcut for dictating in Windows 11 is discussed. On this chart, it is difficult to indicate other fragments that attract attention, so the values of the relative audience retention (Figure 2) were

analyzed. A value above the average was observed in the ranges from: 00:00 to 01:08 and from 05:06 to 05:26. The first fragment is the full procedure for configuring dictation in Windows 11, and the second is the way of dictating to Google Docs. It should be noted that almost all the time (except for the last 20 seconds) the level of attention does not fall below the average value, which means the involvement of the viewers expressed by numerous interactions.

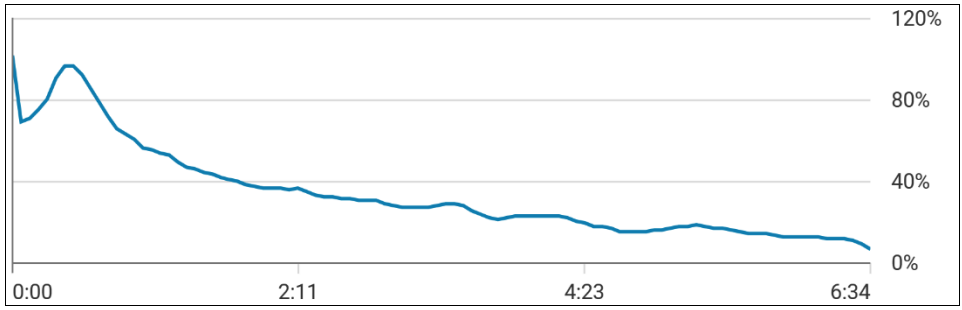
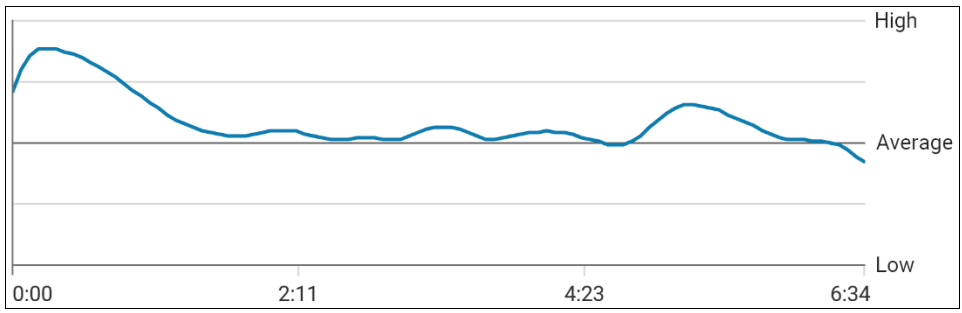


Figure 1. Absolute audience retention while watching the video "Converting speech to text in Windows 10 and 11"



Fogure 2. Relative audience retention while watching the video "Converting speech to text in Windows 10 and 11"

The video "How to use free cloud-based office suites?" was published on August 25, 2023. The material lasting 08:55 min was viewed 122 times and watched for 6.1 hours. In this case, only the part dedicated to text transcription in Microsoft Word 365 (online version), which is in the range from 01:17 to 02:20, was analyzed. The video received 7 likes and did not contribute to gaining subscribers. The most important sources of visits are: playlists (35 views with 1.4 hours of watching); suggested videos (24 views with 1.4 hours of watching) and browsing features (23 views with 0.8 hours of watching). Based on the analysis of the absolute audience retention referring to the analyzed fragment, attention engagement at the level of 52.6% was found (Figure 3). However, in the case of

the relative indicator, values above the average were observed, the highest in relation to the rest of the video (Figure 4). This suggests that some viewers watched only this part of the video. This could happen because the link leading to the discussed fragment was also posted in the description directly under the video.

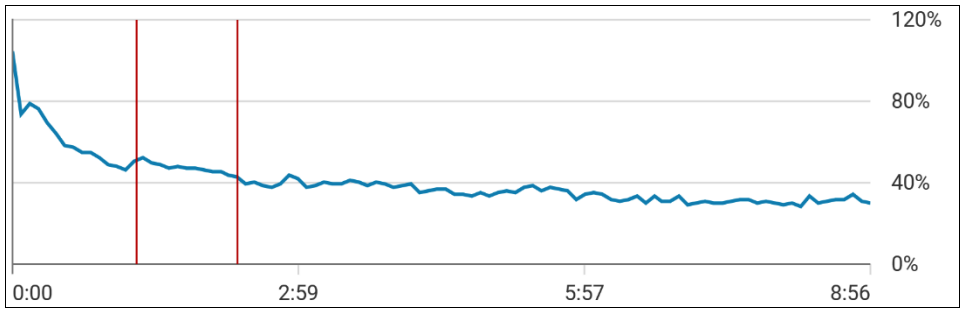


Figure 3. Absolute audience retention while watching the video "How to use free cloud-based office suites?"

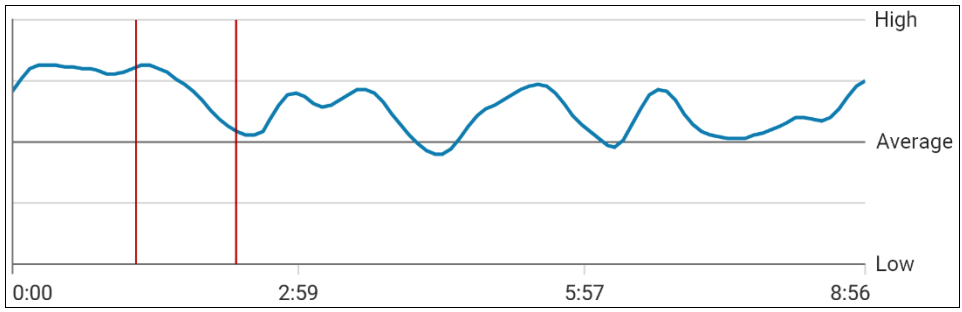


Figure 4. Relative audience retention while watching the video "How to use free cloud-based office suites?"

The video "Clipchamp – automatic creation of subtitles for videos for the deaf" was published on July 12, 2023. The material lasting 03:03 min was viewed 227 times and watched for 4.7 hours. The average watch time of the video is 1:14 min, and the average percentage viewed is 40.6% (a very high indicator on YouTube). The video received 5 likes and contributed to gaining 1 subscriber. The most popular sources of visits are: Google search (80 views with 1.5 hours of watching) and YouTube search (36 views with 0.8 hours of watching). Analyzing the absolute audience retention of the recipients (Figure 5), it was found that the most interest was aroused by the fragment from 00:00 to 01:24, taking values above 50%. In the case of the relative indicator (Figure 6), values above the average were found in the ranges from 00:17 to 01:40 – laun-

ching the program and automatically generating subtitles (transcription) and from 02:25 to 02:45 – starting to watch the video from its end. This is a cognitive strategy based on scrolling the video to the end and checking what the effect of the actions will be. If it is satisfactory, the viewer returns to the moment where the important procedures are demonstrated, usually skipping the introduction and theory (Jędryczkowski, 2019b, pp. 41–50).

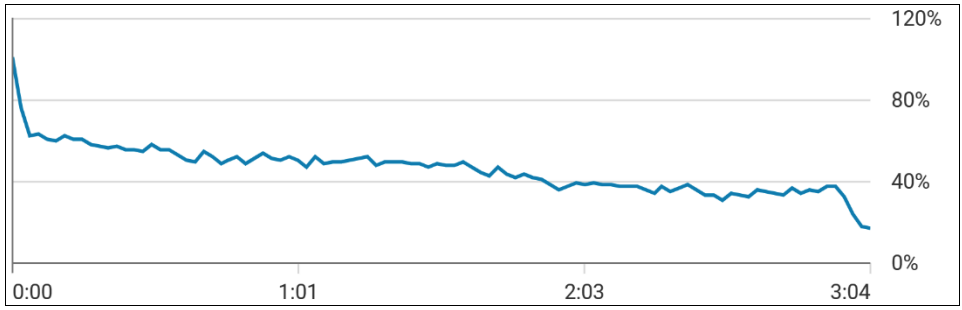


Figure 5. Absolute audience retention while watching the video "Clipchamp – automatic creation of subtitles for videos for the deaf"

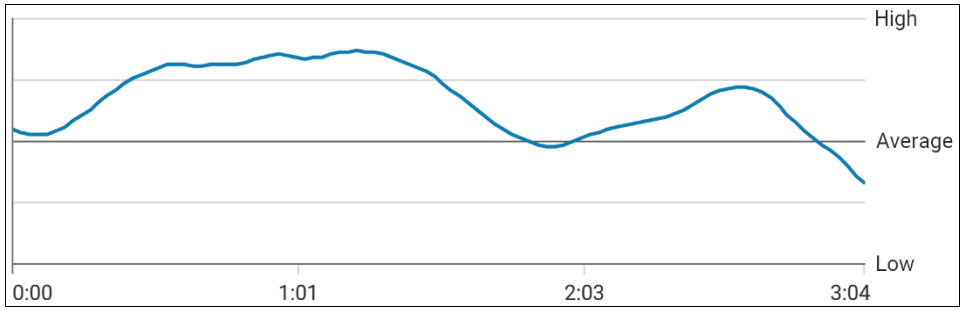


Figure 6. Relative audience retention while watching the video "Clipchamp – automatic creation of subtitles for videos for the deaf"

The video "Converting text to speech in Windows" was published on March 28, 2023. The material lasting 19:19 min was viewed 1526 times and watched for 58.6 hours. The average watch time of the video is 2:17 min, and the average percentage viewed is 11.9%. The video received 18 likes and contributed to gaining 4 subscribers. The most popular sources of visits are: Google search (629 views with 25.8 hours of watching); suggested videos (344 views with 17.2 hours of watching) and YouTube search (258 views with 9.2 hours of watching). The absolute audience retention chart does not clearly show the content that particularly interested the recipients (Figure 7). However, in the range from 00:11 to 01:10, values above 50% were recorded. At this time, the work with the

"Narrator" of Windows 11 was discussed. The interest in this topic is also confirmed by the relative audience retention (Figure 8). On this chart, you can also observe that other issues caught the attention of the viewers. An increase in interest, to the average level, was found in the range from 06:50 to 09:46 min. This is a fragment dedicated to e-book readers reading aloud the text of books. The range from 10:33 to 13:28 min corresponds to an increase in interest to average values. Then, the configuration and possibilities of the QTranslate program were discussed. In the range from 11:54 to 17:46, interactions were observed at the average level up to the level above the average. This fragment concerned the ways of installing extensions for loud reading of text in the Google Chrome browser.

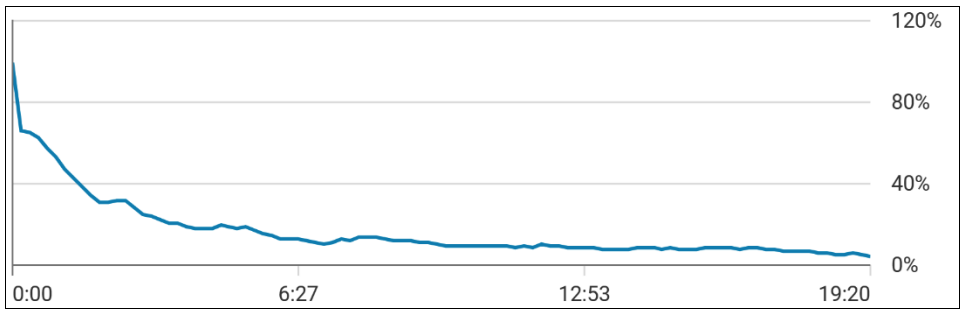


Figure 7. Absolute audience retention while watching the video "Converting text to speech in Windows"

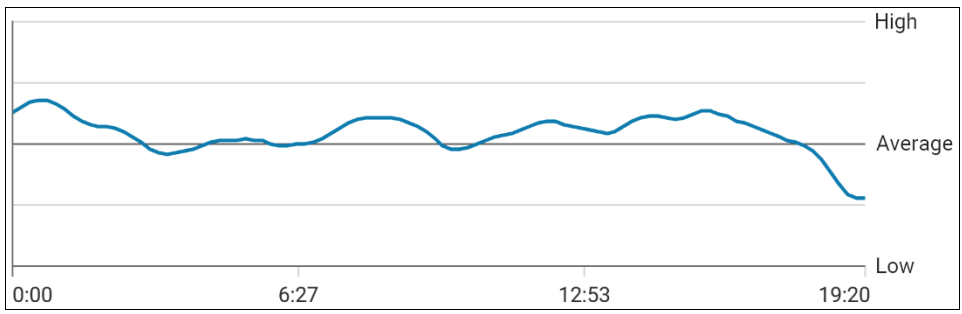


Figure 8. Relative audience retention while watching the video "Converting text to speech in Windows"

The video "OCR in Google Docs. Recognizing text from photos and locked PDF files" was published on November 26, 2022. The material lasting 07:33 min was viewed 1596 times and watched for 65.8 hours. The average watch time of the video is 2:27 min, and the average percentage viewed is 32.4%. The material received 22 likes and contributed to gaining 6 subscribers. The most popular

sources of visits are: Google search (662 views with 25.7 hours of watching) and YouTube search (354 views with 15.7 hours of watching). The absolute audience retention chart showed only one very clear increase in audience retention in the range from 02:50 to 3:20 min (Figure 9). It reached a value of 69.4%. At this time, the procedure for obtaining text from a photo using Google Docs was discussed. The relative audience retention indicator (Figure 10) showed interest above the average in the range from: 00:05 to 03:13 min (photographing and uploading photos to Google Drive and the entire OCR procedure), i.e. obtaining text from an image. Another increase in interest was noted in the range from 05:53 to 6:48 min (the procedure for obtaining text from a secured PDF document).

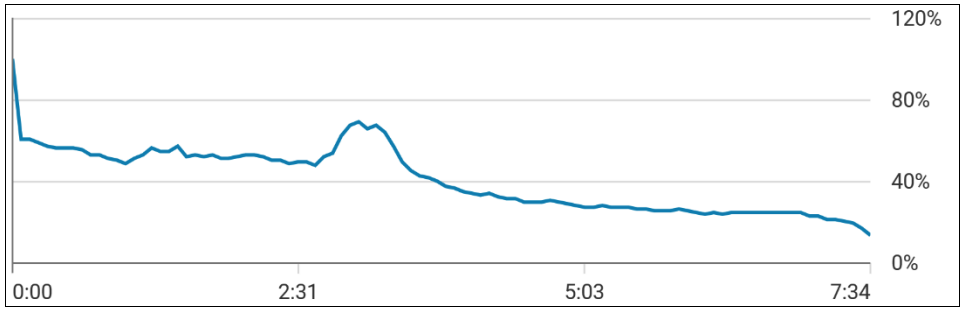


Figure 9. Absolute audience retention while watching the video "OCR in Google Docs. Recognizing text from photos and locked PDF files"

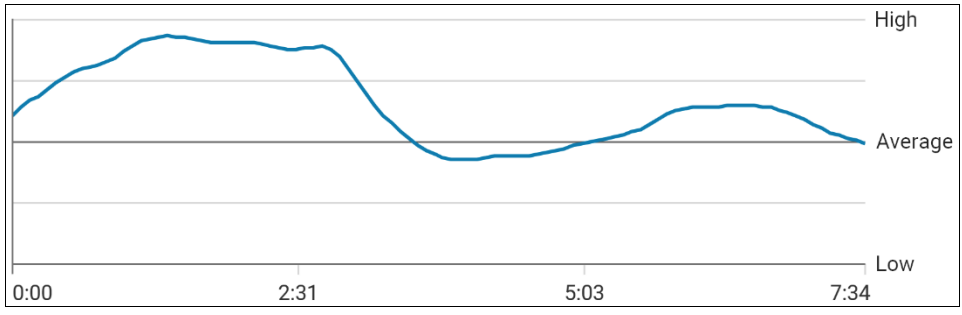


Figure 10. Relative audience retention while watching the video "OCR in Google Docs. Recognizing text from photos and locked PDF files"

Conclusion

The analyzed video materials with a total time of 35 min 25 sec. They were viewed 7705 times and watched for 269 hours. It was found that the videos were used by people interested in specific topics. Such a conclusion could be reached by analyzing the sources of visits. Most often it was searching in Google and

directly on YouTube. This is also confirmed by the likes (81) and the number of subscriptions obtained (28). Content that particularly interested Internet users was also found. These were most often technical solutions that facilitate the conversion of voice to text, transcription of text from audio and video files, and obtaining text from photos and locked PDF documents. The scale of interest in the published videos indicates that there is a demand for this type of content. The ease with which modern digital technologies transform speech into text has made it possible to meet the expectations of people with hearing impairments without incurring financial costs. Adding subtitles to videos becomes not only an expression of care for diversity and accessibility of content, ensuring equal access to culture and education. In the case of educational impacts, subtitles will facilitate full understanding of the content, which in turn translates into efficiency and equalization of educational opportunities (Domagała-Zyśk, 2017, pp. 41–53).

From the point of view of digital typhlopedagogy, speech recognition tools are an indispensable element of functioning of people with visual impairments in modern society (Pawłowska-Cyprysiak, Hildt-Ciupińska, 2022, pp. 18–22). There are a number of free solutions that allow parents and caregivers to independently process paper publications into digital form, and then read them by speech synthesizers. The ability of a blind person to communicate with a computer using speech is not insignificant. Copilot, an artificial intelligence that, in addition to answering very complex questions, is intended to enable computer control, is currently reaching computers with Windows. In a similar way, you can now control devices in the "digital home". Due to the great interest in this topic, it will be included in the implementation of subsequent video materials.

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JULIÁNA LITECKÁ[1], **ZUZANA MITAĽOVÁ**[2]

The Importance of the Multimedia Cognitive Learning Theory for Teaching of Technical Subjects

[1] ORCID: 0000-0002-1577-3140, Assistant Professor, University of Presov in Presov, Faculty of Humanities and Natural Sciences, Department of Physics, Mathematics and Technology, Slovak Republic
[2] ORCID: 0000-0002-2546-4640, Associate Professor, Technical university of Kosice, Faculty of Manufacturing Technologies with Seat in Presov, Slovak Republic

Abstract

The paper deals with the current requirements and direction of technical education within the framework of the curricular reform in Slovakia and its transition from education to student learning. The theoretical study approximates Mayer's theory of multimedia education in relation to the causes of cognitive overload, on the basis of which the principles of multimedia design were specified, which we consider crucial for the effective starter of changes in technical education.

Keywords: multimedia cognitive learning theory, multimedia design, technical education

Introduction. Technical education in Slovakia

Every advanced society considers it necessary to participate in technical and technological progress. The basic pillar for securing human resources can be considered technical education, which is included in the educational system of each country, while each country, as pointed out by Dostál (2023), has a curriculum specifically adapted to the economic and cultural-social conditions in which the country is located. The Slovak Republic (SR) places emphasis, even in the currently ongoing education reform, on technical education from an early age of the child, appropriate to his level of development. As part of pre-primary education – ISCED 0, the Slovak curriculum incorporates technical education into the thematic area "I am" in the form of the development of the perceptual-motor area of the individual, which is focused on fine motor skills, work with various

materials, work techniques, technical creativity, and elementary basics of work with a computer.

On a relatively wider scale in the Slovak Republic, technical education is defined within primary education – ISCED 1 and lower secondary education – ISCED 2 in elementary schools. Technical education is implemented through the educational field Man and the world of work, the basic building blocks of which are three components: Technology, Entrepreneurship and initiative, Career education. All three components are interconnected so that emphasis is placed on the development of technical, creative, and critical thinking in the educational field. Emphasis is placed on developing technical and professional literacy among pupils. The term technical literacy refers to the ability of pupils to use, manage, evaluate, and understand technology. To become a technically literate individual, the student should understand what technology and technology are, how they work, how they shape society and how they are shaped by society. In addition, a technically literate student has certain abilities to think technically and work with technical devices, which allow him to use their ingenuity in designing and building things, in solving practical problems of a technological nature.

Secondary vocational education is divided into 27 groups of branches. The outcome of technical education at secondary vocational schools is a qualification in the fields of mechanical engineering, construction, electrical engineering, etc. This also includes qualifications in the field of crafts or in the production or repair of various technical equipment. A student acquires a technical education by teaching and subsequently mastering technical subjects. (Kučerka, Kmec, 2017).

According to the Act on Universities, the Ministry of Education of the Slovak Republic publishes and administers the system of study fields of the Slovak Republic, based on which universities can only admit students to accredited study programs, i.e., j. programs that meet the standards of study programs in the fields of study included in the system. The study program clearly specifies and communicates the level of qualification that students acquire by successfully completing it, while the qualification corresponds to the relevant level of education according to the European qualification framework. Graduates of technical fields are therefore highly specialized professional employees who have highly specialized knowledge, skills, and abilities for the performance of a given technical profession.

In all these levels, an important role is played by the teacher and his forms and means of education, which he uses to achieve the set educational goals. Multimedia education, especially due to the development of digital technologies, has become very popular and is often used in the teaching of technical subjects. Although most models of multimedia learning focus on cognitive factors, as reported by Um, Plass, Hayward and Homer (2012), this form of learning can also influence positive emotions and attitude towards learning.

The subject matter of the study. Multimedia cognitive learning theory

The main representative of multimedia cognitive theory learning is Mayer, he is an American educational psychologist and professor of psychology at the University of California, Santa Barbara (UCSB), where he has been working since 1975. The multimedia cognitive theory learning tries to explain the processes that occur in the minds of students during meaningful learning from multimedia teaching. Mayer and Moreno (2003) define multimedia as the use of words and images (verbal and visual). The theory has clear implications for the design of teaching to facilitate multimedia learning, especially for how to cognitive apparatus. Mayer's cognitive theory of multimedia learning is based on three assumptions about how people process information: the dual-channel assumption, the limited-capacity assumption, and the active processing assumption.

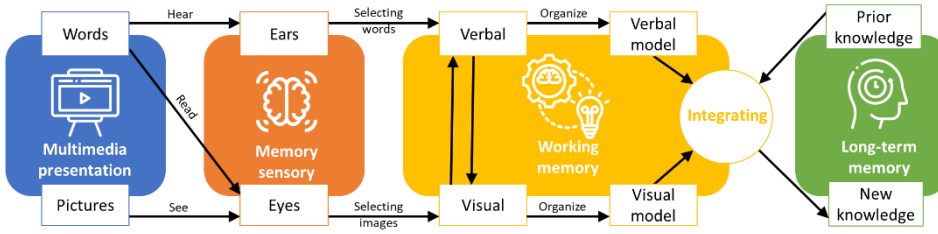

Figure 1. Diagram of Mayer's cognitive processing events

According to Mayer (2009a, p. 63), the dual-channel assumption dictates that "people have separate channels for processing visual and auditory information". The first is the visual-image channel, which processes images seen by the eyes (including words displayed on the screen). The second channel is the auditory-verbal channel, which processes spoken words. The limited-capacity assumption suggests that people have a fixed limit to the amount of information they can process at any given moment. The active processing hypothesis states that people do not learn by passively absorbing information. Instead, they must engage in active cognitive processes, namely identifying and selecting relevant material, organizing it into visual and/or verbal models, and integrating these new models with prior knowledge. The multimedia cognitive theory learning fundamentally argues against a "knowledge transfer" approach to learning in favor of a learner-centered "knowledge construction" model. He argues that students are not "empty vessels" waiting to be filled with information but must instead work to synthesize words and images into meaningful information that is stored in long-term memory.

Research methodologies and tools. Cognitive load

Mayer's overarching thesis is that people learn better when they use pictures and words together. An important question remains how to maximize the effec-

tiveness of multimedia messages based on the specifics of how people process information during learning. Mayer's theories reject multimedia learning as knowledge transfer (transplantation of information from instructor to student) and response reinforcement (enhancement of memorization through practice and hands-on methods). Instead, the theory embraces a knowledge-building perspective: "that multimedia learning is a sensory activity in which the learner tries to construct a coherent mental representation from the material presented" (Mayer, 2009a, p. 17). The focus of education, not only on technical subjects, is shifting from memorizing lessons and memorizing isolated facts to the systematic and deliberate development of versatile and functional literacy in accordance with the demands of society, which can be applied in everyday personal and social life and in fulfilling one's personal, educational, cultural, and social needs. The reason is that the breadth of acquired knowledge is no longer enough. Both the teacher and the student face more demanding goals: it is about the depth of learning, the ability to put things in context.

In connection with multimedia cognitive theory learning, it is also necessary to point out its limits, which are associated with cognitive overload. According to cognitive load theory, short-term or working memory has a limited capacity and can only efficiently process a few pieces of information at a time. If a person's working memory is overloaded, that person may not be able to process anything well, leading to poor comprehension, retention, and learning. (Sweller, 2011) One should be aware of three types of cognitive load: internal (related to the teaching content); germane (related to the activities students do); and external (everything else) (Nguyen, Clark, 2005). In each of these areas, the load on working memory needs to be minimized so that people can process information more efficiently and learn better. A closer examination of these theories and their interrelationship can be used to search for and determine the key principles of multimedia learning.

Development (analysis of research results) Principles of multimedia learning with overload limitation

Researcher Mayer in his review of thirty years of online education research (2018) states that students will be increasingly exposed to online learning, in formal and informal contexts, so the design of online teaching and multimedia learning will continue to be an important practical and theoretical challenge. This brief history review provides an example of applied cognitive psychology by focusing on the application of learning science to the practical problem of online instruction. Based on cognitive learning theories relevant to multimedia learning, such as cognitive load theory (Paas, Sweller, 2014; Sweller et al., 2011) and the multimedia cognitive theory learning (Mayer, 2009b, 2014), Mayer states three goals of instructional design for online and multimedia education:

1. Reduce extraneous processing – eliminate aspects of a lesson that prime the learner to engage in cognitive processing that does not serve the learning objective.

2. Manage essential processing – scaffold the lesson in ways that ensure the learner can process the relevant material.

3. Foster generative processing – include features in a lesson that prime the learner to exert effort to make sense of the material.

As can be seen in the overview mentioned above, Mayer's 30 years of research into techniques to reduce extraneous processing has created a substantial research base and yielded several research-based design principles relevant to online and multimedia learning:

1. Principle of coherence – states that people learn best when extraneous, distracting material is not included. It is necessary to use only the information that the student needs. And most often that means simple text and simple visuals that are directly related to the learning topic.

2. Signalling principle – basically means that people learn best when they are shown exactly what to pay attention to on the screen. If there is a lot of information on the screen, the student cannot distinguish which is the most important.

3. Redundancy principle – this principle suggests that people learn best with narration and graphics, as opposed to narration, graphics, and text. The theory is that if you already have narration and graphics, the text on top is just redundant information. And that can be overwhelming for a student.

4. Principle of spatial contiguity – this is about the actual space between text and visuals on the screen and states that people learn best when the relevant text and visuals are physically close together.

5. Principle of temporal contiguity – states that people learn best when matching words and visuals are presented together rather than sequentially.

6. Segmentation principle – states that people learn best when information is presented in segments rather than in one long continuous stream. Mayer found that when students could control the pace of their learning, they performed better on memorization tests.

7. Pre-training principle – states that people learn more effectively if they already know some of the basics. This often means understanding basic definitions, terms, or concepts before starting to teach. And that makes intuitive sense.

8. Modality principle – states that people learn better from visuals and spoken words than from visuals and printed words. It simply means that if there are visuals and too much text, students will be overwhelmed. The

9. Multimedia principle – states that people learn better from words and pictures than from words alone. This principle is kind of the basis of all of Mayer's principles, that images and words are more effective than words alone.

10. The voice principle – states that people learn better from a human voice than from a computer voice. While Siri and Alexa are close, there is no substitute for the human voice. It is important to note that the studies are still rather preliminary for the voice principle. But it still makes sense to use a human for your voiceover.

Conclusions

To be able to introduce effective curricular reforms in technical education, it is necessary to bear in mind that not only content changes are sufficient, but also changes connected with the forms and methods of teaching. Multimedia for learning refers to the process of building a mental representation from words and images in different contexts. They are designed to aid learning with tools that can be used in presentations, classroom or laboratory instruction, simulations, e-learning, computer games, and virtual reality, allowing students to process information in both verbal and visual form. For their effectiveness to be effective, it is necessary to eliminate possible aspects of cognitive overload in their design in the form of a design of multimedia teaching aids, to which specified design principles are applied, so that the student can independently acquire the knowledge he needs to acquire.

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MILAN KLEMENT[1], **LUCIE BRYNDOVÁ**[2]

Possibilities of Development of Informatics Thinking of Pupils and Students Using the Model of Subject-Didactic Competences of Teachers

[1] ORCID: 0000-0001-9964-4057, Professor, Head of the Center of the Information and Education Technology, Palacký University Olomouc, Department of Technical Education and Information Technology, Czech Republic
[2] ORCID: 0000-0003-3534-7621, Ph.D. student, Head of the Center of the Information and Education Technology, Palacký University Olomouc, Department of Technical Education and Information Technology, Czech Republic

Abstract

The development and incorporation of the concept of the development of computational thinking into the curriculum of computing subjects is currently one of the major challenges facing the Czech school system. However, such a concept of teaching presupposes a targeted development of content-subject and didactic- pedagogical competencies of teachers necessary for the development of computational thinking in their pupils and students. Thus, the present paper deals with the possibility of defining a general model of subject-matter and didactic competences of teachers supporting the development of computational thinking in pupils and students.

Keywords: computational thinking, content-subject competences, teachers, model of competences

Introduction

The accelerating development of technology has brought about many dramatic changes in all aspects of life over the last decades and has undoubtedly affected the functioning of our society. The expansion of the digital space, technological innovations leading to the modernisation of industry, commerce and households have given rise to a plethora of new concepts relating to digital and information technologies and their use.

One of them was Computational Thinking, introduced in 2006 by Jeannette Wing as an inevitable skill of a modern person who is able to fully use digital

technologies and computer methods to solve everyday problems. According to Wing, Computational Thinking is a thought process that allows one to formulate a problem and describe its solution in a way that can be effectively processed by a computer, machine, or even a human (Wing, 2014). Thus, it can be said that in general terms, it is a way of solving a problem that focuses on describing, analyzing, and finding an effective way to solve it, emphasizing systematicity and the use of concepts known in the field of computer science. It is important to emphasize that the development of computational thinking does not only mean programming, the related competences can be applied by anyone, not only by a professional computer scientist, and thus contributes to the holistic development of the pupil or student with an overlap into the development of his/her digital competences.

Informatics thinking and its implementation

Since the first introduction of the concept of Computational Thinking (hereafter abbreviated as CT), there has been a great deal of international discussion regarding its precise definition, the specification of its components, and also efforts to integrate the development of CT into curricula within school systems virtually worldwide. The introduction of the concept of computational thinking into academic discourse has fostered a pedagogical discourse regarding the role of digital technologies in education and the potential of introducing computer science and programming education into national curricula that has existed since almost the beginning of the millennium (Tran, 2017; Klement, 2018). Although computer literacy instruction and the targeted development of digital and communication competencies are still of considerable importance, there is a tendency to move the targeted development of these competencies to the cross-curricular domain as part of the modernization of the whole school system (Balanskat, 2018).

Practically since the beginning of the international discussion on the integration of the development of computational thinking into education, attempts have been made to define specific sub-areas of CT. The primary goal of this process is to specify an otherwise very general definition of the phenomenon of computational thinking, which is not suitable for the practical implementation of CT in the school system. Currently, most state curricular definitions of computational thinking are based on, or largely coincide with, the 2011 CSTA and ISTE definitions of the characteristics and competencies associated with CT use.

Also for pedagogical and didactic purposes, the specification of the areas defining CT is usually done by a detailed analysis of the formulations of the CSTA & ISTE document. The following comparative Table 1 lists the subcomponents of the informatics according to the CSTA & ISTE definition and the key words and phrases used in this definition according to Chen (2017), on the basis

of which we define the corresponding CT skills (Angeli, Nicos, 2020, Bocconi, Chioccariello, Dettori, Ferrari, Engelhardt, 2016; Wing, 2014; Selby, 2012) that are related to these concepts and that the informatics-minded learner should acquire.

Table 1. Definition of areas for the development of computational thinking

CSTA & ISTE definition	Keywords	Matching CT skill
Problem formulation for machine solutions	Formulation	Syntax, programming
Logically organize and analyze data	Data	Data processing
Represent data using abstractions	Representation	Modelling
Automating solutions using algorithmic thinking	Algorithmic thinking	Algorithmization, automation

At present, the vast majority of countries are still in the process of implementing the development of computational thinking in school curricula, and for many of them this is a very challenging to radical change. Implementation of the revision is particularly problematic in states that do not have an established tradition of teaching programming in schools and thus must revise virtually all areas of instructional management. The practical integration of CT development into school curricula usually depends on individual schools, their technological and economic background, resources, time availability, the qualifications of individual teachers, and other circumstances. It is these circumstances that often make implementation difficult because schools do not have sufficient support to facilitate curriculum revision.

The lack of support for educators is highlighted by virtually all states that have moved to implement CT in curricula in the last decade. Yet, the experience of many states that have already successfully implemented CT development in their public school systems suggests that an important aspect of implementing any form of IT curriculum revision is the preparation of detailed teacher support materials.

Difficulties accompanying the implementation of informatic thinking in educational practice

The main problem, apart from economic and organizational aspects, is the increased demands on the qualifications and competences of teachers brought by the integration of programming into schools. It is programming, regardless of the global conception and definition of the term computational thinking, that is considered the most effective tool for the development of computational thinking (Román-González, Pérez-González, Jiménez-Fernández, 2017).

From a didactic and pedagogical point of view, the practical application of its concepts such as algorithmization, decomposition, generalization, evaluation and abstraction is essential for the development of CT (Angeli et al., 2016). If the goal of curriculum revision and the development of computational thinking in schools is to prepare graduates to use information technology in life and in the

labour market, it is crucial that they are able to use their skills and abilities. However, such a design of teaching presupposes a targeted development of content-subject and didactic-pedagogical competencies of teachers necessary for the development of computational thinking in their pupils and students. Thus, it is not only about content competences, focused on the knowledge of algorithmization, decomposition, generalization, evaluation and abstraction, but also about didactic competences, enabling the development of cognitive, affective and psychomotor components of students' personality.

Therefore, continuous research on material conditions, analysis of educational content, forms and methods of teaching, as well as the readiness of teachers, including the necessary competences for the development of computational thinking in their pupils and students, is a necessity. In Europe, for example, European Schoolnet has been mapping the problems of implementing CT development in schools. According to the results of this research, the most important shortcoming is precisely the insufficient qualification of teachers, especially for teachers of lower grades (Balanskat, 2018). Many research activities in this area can be noted, which deal with the definition of CT content (e.g. Brennan, 2012; Kanemune, 2017; Moller, Crick, 2018, etc.), methods of teaching CT (e.g. Rubio, Romero-Zaliz, Mañoso, de Madrid, 2015; So, Jong, Liu, 2020, etc.), forms of CT teaching (Román-Gonzáles et al., 2017; Tran, 2017; Tang, Yue, Lin, Hadad, Zhai, 2020, etc.). Even less research focuses on teachers themselves and their level of preparedness for teaching CT in terms of content-subject and didactic-pedagogical competencies (e.g. Rambousek, 2013; Cheng, 2019; Klement, Dragon, Bryndová, 2020).

Our contribution in the area of describing content-subject competences of teachers for the implementation of CT development teaching was research (Klement et al., 2020), which, at least in the case of the Czech Republic, analysed this issue. Our aim was to identify different groups of respondents within the research sample (a total of 123 teachers of computer science subjects at the second level of primary schools) who declared the same or similar level of evaluation of the importance of individual subject units of computer science, and to describe their characteristics and, if necessary, to correct the negative impact of certain groups of respondents on the results of the research. This was achieved by using cluster analysis, which in this case analysed the clusters within the group of teachers to see if there were groups of teachers who reported similar levels of importance attached to each thematic unit in ICT education.

In this way, the computer science teachers were also divided into groups that showed similar variance in ratings. Simply put, if there were several thematic units that the respondents evaluated mostly in the same way in terms of their importance, these teachers formed a separate cluster (the essence, course and results of the survey are described in detail in the publication: Klement et al., 2020).

Methodology. Teachers and theirreadiness to implement computational thinking in teaching

On the basis of the analyses conducted, it can be concluded that the assumption we made about the possibility of typology is confirmed and that there is evidence of common sorting variables that can divide different groups of computer science subject teachers into separate groups according to their preferences for specific subject units. That is, a model has been found that characterizes the different subgroups within the group of teachers of computer science subjects in primary 2. Based on the identified model, different groups of respondents in the research sample were identified that show the same or similar level of evaluation of each thematic unit of computer science according to their degree of importance for teaching, so that it is also possible to describe their characteristics in more detail, as shown in Table 2.

Table 2. Groups of teachers according to the level of importance they place on the selected IT thematic units

Group of teachers	Typical thematic units preferred by the group of teachers	Overall characteristics of the group
1 – teachers preferring the development of students' computational thinking	Algorithmization and programming Working with databases Robotics and el. kits Administration and operation of computer networks	A group of teachers is interested in implementing teaching "non-traditional" thematic units, focused on the most challenging tasks related to the operation of information systems.
2 – teachers preferring to develop students' interaction skills	Working with touch devices Working with sound and video Creating web pages	A group of teachers are interested in implementing training in web services and social networking, for communication or information sharing purposes.
3 – teachers preferring to develop students' digital literacy	Computer hardware and software Work with spreadsheet calculator Working with the text editor Searching for information on the Internet Work with presentation applications	The group of teachers is interested in teaching in purely "traditional" thematic units consisting mainly in the creation and editing of documents, presentations, tables or simple graphics.
4 – teachers preferring to develop students' visualisation skills	Work with computer graphics Work with technical graphic systems Manage files and folders	A group of teachers is interested in implementing training in the use of IT tools for presentation or self--presentation in graphic form.

The above model of groups of teachers of IT subjects at the second level of primary schools can be interpreted in such a way that there is a significant group of teachers who prefer educational content focused on the development of digital literacy, i.e. on "traditional" thematic units (42.5% of teachers of IT subjects). There is also a group of pupils who prefer educational content focused on the development of computational thinking (26.8% of teachers of computing subjects). Thus, these two groups of teachers perceive the use of IT resources as a necessary condition for the further professional development of their pupils, as they attach the highest importance to those IT units that enable

productive use to perform either purely "professional" tasks or tasks related to "user" use.

Furthermore, it is possible to identify a group of teachers who prefer to use IT resources more for personal development within the social interaction of their students, as they prefer thematic units, their knowledge can now also be used in the field of information sharing or establishing and maintaining personal contacts and connections using social networks or related web services (26.8% of teachers of computer science subjects). The relatively smallest group of teachers are those who prefer thematic units focused on static or dynamic graphics (4.9% of IT teachers).

The descriptions of the individual groups and their intentions may be interpreted in different ways, which we fully admit, and it would be necessary to obtain further data on the basis of which these facts could be examined more closely. It is also necessary to emphasize that the developed model dealt only with a part of the content-subject competences of teachers, for the implementation of teaching aimed at the development of CT, and did not deal with the issue of equally important didactic-pedagogical competencies of teachers. Again, this is also the intention of our further scientific work in this area.

Results. A theoretical model of teacher preparation for the development of computational thinking

In the Czech Republic alone, there are more than 7,000 teachers of informatics at the primary and secondary level, representing 8.9% of the total number of teachers (see the document of the Ministry of Education and Science, Zprava_MiS3, 2020), while according to the statistics available to us, the situation in other European countries is similar (see European Schoolnet). In the context of innovative trends in computer science education based on the development of computational thinking, which presuppose a different approach not only to educational content (hard skills) but also to the methods of teaching it (soft skills), there is a need for international comparative research on this issue. Considering the fact that only a quarter of existing IT teachers are implementing or are ready to implement teaching aimed at CT development (see Table 2), there is a clear society-wide demand for an analysis of the causes of this situation and the creation of a suitable model and tool for diagnosing their competences in this area. Such a model would not only allow for the diagnosis of the level of competences needed, but would also allow for the targeted development of the knowledge and pedagogical potential of CT teachers in the necessary areas in undergraduate, postgraduate or continuing education.

The proposed model is based on the basic five domains of CT, which generally describe the definition of CT and are most often found in pedagogical, didactic and legislative documents (Klement et al., 2020):

1. Abstraction is considered to be the most important component of computational thinking (Wing, 2014). In the context of CT, it is the ability to simplify a problem to its basic form so that essential information is not lost, and then to work with the schematic form of that problem. They work with defining patterns, generalization, representation, simulation, implementation, parameterization, optimization, and other skills necessary to successfully solve complex problems.

2. Algorithmic thinking is the ability and skill to find efficient and economical solutions to a problem and to formulate these solutions in an adequate way. It is a matter of debate whether, in the context of CT, it is the formulation of a solution in a formal programming language, or whether it is a concept completely independent of practical programming. Sometimes a separate component of Automation is defined from this area, i.e. simplifying the process to save time and energy. More often, however, it is understood as one of the principles of algorithmization (Angeli, 2016).

3. Decomposition, associated by some authors or directly identified with modularization, is the ability to divide the whole into subcomponents and to work with these components. It is closely related to abstraction because it involves solving the subparts of a problem. In the pedagogical area of CT development, it is typically associated with working with the subparts of a sequence and optimizing them through the use of functions.

4. Systematic evaluation, which includes concepts such as analysis, debugging, and analysis, is reasoning that allows predicting the outcome of a situation and the operation of an algorithm based on a critical analysis of the situation. It works with testing, analytical and logical thinking, variation and evaluation.

5. Generalization is the identification of similarities and connections between problems, which should result in the design of a universal solution to the problem, applicable to multiple situations. It is the ability to solve multiple problems based on similarities, as well as the use of learning based on the similarity of a problem to a previous one.

The theoretical design of the model includes not only the subject-subject dimension, i.e. the content component of competences, but also includes the didactic-pedagogical dimension, which allows the study and derivation of the relationship between knowledge and the ability of targeted CT development, which forms the integrating dimension of the model. Both dimensions contain identically five CT domains each, from the perspective of application within the content-subject focus and from the perspective of application from the didactic--pedagogical focus. The integrative dimension allows to understand the links between the content and the level of competences aimed at factual knowledge and orientation in CT issues on the one hand, and on the other hand the level of competences aimed at the ability to convey CT issues to pupils and students.

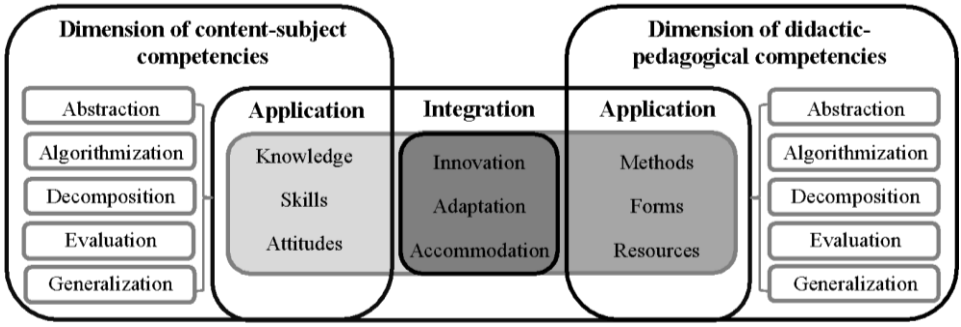

Figure 1. Proposed model of subject-didactic competences of teachers reflecting the development of students' computational thinking

Procedure for further verification of the theoretical model

The described model of subject-didactic competences of teachers reflecting the development of computer thinking of pupils and students will have to be specified in the first phase and filled with specific items of the CT domains, which will be developed on the basis of the discussion of the involved experts from the four countries, taking into account regional specificities and needs. The items will be defined both for the vocational-subject dimension, in each of the five domains, and for the didactic-pedagogical dimension, again in all five domains of this dimension.

These items and their arrangement will be verified in the first phase on the basis of qualitative-quantitative methods of pedagogical research, i.e. using Q-methodology. The Q-methodology, or also Q-sorting, works with a set of statements (in our case, the items of the dimensions of the model) that represent possible answers to the specific content of the subdomains (abstraction, algorithmization, etc.). Respondents, thus, will have the opportunity to express their level of agreement with the importance of each item within the CT domains, but also within the whole dimension. An analogous procedure will be followed within both dimensions and all five CT domains.

Respondents will compare the statements to each other and will assign levels of importance from highest to lowest, with each level of importance occupied by a completely defined number of statements. The sorting at the domain level will be adapted to this number so that the edges always contain fewer statements than the middle (the sorting follows a Gaussian curve). This procedure will force respondents to really think about priorities and identify those items that are most important for a given CT domain.

The model thus created and filled with content will be further validated using advanced non-parametric statistical methods of factor and cluster analysis. The aim of this phase of the research will be to validate the structure of each dimen-

sion of the module and its CT domains and to identify the preferred specific applications (Knowledge, Skills, Attitudes vs. Methods, Forms and Resources) of each dimension in the form of evaluation factors/criteria. For these purposes, a research instrument in the form of a questionnaire will be constructed and redistributed to respondents in all participating countries.

The initial research method used was factor analysis (McDonald, 1991, p. 230), which is a statistical method used to extract important combinations of factors with a high degree of correlation from a large data set. Thus, factor analysis allows finding latent (indirectly observed) causes of variability in the data. By finding the latent variables (factors), the number of variables can be reduced while retaining the maximum information, and it is also possible to find relationships between the observed variables and the derived factors. Factor analysis is one of the multivariate statistical methods (nowadays rather a group of methods) that originally originated in the evaluation of psychological test results. Later it was also applied in many other fields - technology, economics, anthropology, etc. It belongs, like principal component analysis, to the so- called variable reduction methods. In factor analysis, we assume that each input variable can be expressed as a linear function of a small number of common (hidden) factors and a single error factor.

In addition to nonparametric tests for dependent samples, which are designed for ordinal variables and require specifying the similarity of the variables to be surveyed, there are clustering methods. Since the dissimilarity of groups of variables is simultaneously detected, these tasks are referred to as segmentation in the current literature (especially in the context of the term "data mining") (Řezanková, 2010, p. 188).

Thus, by applying this procedure we verify not only the statistical validity of the individual dimensions of the theoretically proposed model, but also its specific items and their importance. On the basis of the cluster analysis it will also be possible to verify and prove statistically erasure factors and links integrating the dimensions when the necessary blending of the content-subject dimension and the didactic-pedagogical dimension occurs. On the basis of this fact it will also be possible to construct an evaluation tool with the help of which it will be possible to realize the diagnosis or self-diagnosis of the level of teachers' competences for the development of CT.

Conclusion

The current trend of implementing the development of computational thinking in national curricula is necessary to modernize the school systems of developed countries and to respond to accelerating technology and labor market developments. In many countries, this implementation builds on the long-heralded integration of programming into national curricula, or extends on the already

established tradition of such teaching. These renovations are intended to ensure equity in basic computer science education, which in the past has been tied only to leisure activities or electives, and thus has not led to the formal development of computer literacy for the entire population.

It was the need for widespread formal development of the population in computer science and programming that helped popularise the concept of computational thinking and the associated renovation of the state curriculum. Informatics thinking, although still not precisely defined, is generally understood as a set of cognitive processes that lead to the solution of a problem in such a way that this solution is machine-processable and feasible. It is therefore a prerequisite for further education and development in computer science and programming, and a competence that is becoming indispensable as technology is gradually integrated into everyday life. The specific definition of computational thinking and its subcomponents for state education is regulated by the legislation of the state and is therefore completely individual for each education system.

From the point of view of the development of computer thinking in schools, its greatest contribution can be seen in the education of the general population in the field of programming and the principles of modern technology, facilitating adaptation to the new technologies coming and in supporting their creative use at work and in everyday life. Although the concept of computational thinking is not necessarily tied to programming, when its development is implemented in the classroom for practical application reasons, programming is appropriate. In this practical implementation, the use of specialized teaching aids and tools is suggested among which online tools are highlighted which will be discussed in detail in the following chapters, propaedeutic programming environments and educational robotics.

Despite the fact that the concept of computational thinking has an irrefutable interdisciplinary potential, its implementation in cross-curricular teaching is currently impossible in many systems due to the lack of teacher qualifications, lack of subject-specific materials and often economic support. However, in many countries, despite these difficulties, the interdisciplinary potential of developing computational thinking is supported by legislation. It is therefore highly likely that in the future there will be efforts to integrate the development of computational thinking and programming interdisciplinarily into public schools, and these tendencies are already evident, especially in the Nordic countries of Europe.

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MILAN KLEMENT

Possibilities of Digitalization of the Qualification Thesis Topic Submission Process

ORCID: 0000-0001-9964-4057, Professor, Head of the Center of the Information and Education Technology, Palacký University Olomouc, Department of Technical Education and Information Technology, Czech Republic

Abstract

The challenges associated with the process of awarding and processing qualification work can be traced both in the area of efforts to improve the quality of this specific process and in the area of supporting the digitisation of the study agenda in general. Given that the core processes at the university rely on highly skilled professionals, digitising processes is not as straightforward as it would be for more mechanical work. Although universities have a long tradition of organising work, they have not yet paid much attention to digitised processes.

For this reason, we developed and piloted a flexible electronic workflow for digitizing a selected process and tested it under real-life conditions, including the implementation of qualitative research. The results show the usefulness and adaptability of the proposed electronic workflow from the perspective of its users.

Keywords: digitization of processes, approval workflow, university qualification papers

Introduction

The progress of digitisation of higher education in European countries has significantly accelerated the onset of the COVID-19 pandemic in the early 2020s. Such an intensive and massive transition to distance forms of education required an active digitization of the educational process, which took place in parallel with traditional pedagogical techniques (Ostapenko, 2022). The conducted research shows positive results (Kuzmina, 2020), where digitalization of educational processes improves relevant skills for the modern labor market and opens new horizons of knowledge and skills for the needs of the development of the information society. Thus, research on issues related to socio-cultural peda-

gogical impacts on the educational process remains relevant and open in the research space. In this context, several studies have also addressed the use of modern digital technologies as a means of reducing the costs associated with the implementation of educational activities. This is a serious topic, where, on the one hand, there is a prevalence of opinions pointing to the need to incur relatively high costs associated with the need to employ experts in this field (Alfarwan, 2019). Another group points to facts that emphasize the high added value of digitalization (Haneem, 2019). This is a relevant research problem here, which focuses on balancing the positives and negatives of implementing digitalization in the educational process.

As a consequence of digitisation, information systems have therefore increased in importance even in areas of education that are not usually considered to be primarily IT-oriented (Lagstedt, Lindstedt, Kauppinen, 2020). Universities are no exception, although some processes have a long and relatively unchanging tradition over several centuries. Although long traditions may be a barrier to digitizing these processes, there are other barriers as well. The core educational processes of universities rely heavily on highly technical work, and the proportion of purely mechanical tasks is rather minimal. In cases of digitisation of processes in higher education institutions, experts with strong opinions and expertise combined with a high degree of autonomy must be counted on.

That is why we have chosen one of the key processes of each university in our implementation, i.e. the process of assigning and elaborating the topic of the qualification paper. Although crucial for universities and their students, the process of specifying a qualification topic is not usually considered systematic. Rather, it is often seen as a repetition of a unique craft that is carried out using the best skills of the students and the will of the supervisors of these papers (Karunaratne, 2018).

Challenges associated with the process of assigning and processing qualification papers can be traced both in the area of efforts to improve the quality of this specific process and in the area of supporting the digitisation of the study agenda in general (Aghaee, 2015; Karunaratne, 2018; Klement, Kotouč, 2020). Currently, there are a number of systems for digitising the study agenda of higher education institutions that cover the area of assigning and processing qualification paper topics. One of these systems, which is used in more than 50 higher education institutions in the country, is the System of Study Agents (hereafter referred to as STAG), which has been investigated in terms of the interaction between the student and his/her supervisor in terms of the efficiency of processes (Keyte, Locher, 2004) related to the assignment and processing of qualification thesis topics. The scaling of these processes has also been examined in terms of its quality (Khalid, 2010) and resource management (Hansson, 2014; Haneem, 2019).

Specifics of the development of information systems for the digitalization of processes at universities

When digitizing processes and creating approval workflows, it is important to understand the capabilities and limitations of different IS development methods (ISDMs). Another important consideration is how ISDMs can be combined to enable the development of the desired processes and their workflows. From a management perspective, ISDM methods can be loosely divided into two methodological categories: plan-driven and change-driven methods (Moe et al. 2012). Plan-driven IS development methods were dominant in the late twentieth century, while change-driven ISDM has increased in popularity over the last two decades and is now the preferred method (Theocharis, Kuhrmann, Münch, J. & P. Diebold, 2015; Lagstedt et al., 2020). In plan-driven IS development, planning and development are divided into separate phases. This is based on the assumption that every aspect of the development work, i.e. the goals and their required metrics, tasks and resources, can be planned thoroughly and in advance. Development begins immediately after the planning phase is completed. Plan-driven methods such as the waterfall method (Page, 2016) are a straightforward way to develop software, but there are many known problems (e.g., initial bugs are discovered late and are difficult and costly to resolve). It is assumed that no changes will occur during software development, and what is defined at the beginning will be implemented in later phases. Even if all the initial operating assumptions are formulated correctly, this does not guarantee the overall success of IS development as circumstances may change during the development process (Lagstedt et al., 2020).

In change-driven development, such as agile methods (Singh, 2019), the idea is that the whole IS is not planned at once, but planning and development are done in small steps. After each step, the situation is reassessed and necessary changes are made to the goals. Each step of development results in a new version of the IS. Even a change-driven approach is not seamless. Due to its nature, it is highly likely that radical, unplanned changes in the code will occur during development, causing inconsistencies in the software architecture. Because these inconsistencies are usually not resolved during the agile development step (called sprint), they become technical debt (Cunningham, 1992), causing further development and maintenance problems in the long run. Furthermore, if the user does not have a clear vision and priorities are constantly changing, or if there is no shared understanding of what is to be delivered, the scope of development becomes unclear and quality assurance challenging (Moe, Aurum, Dybå, 2012; Klement, Kotouč, 2020). Despite the relatively high success rate of projects delivered using agile methods, 61% are still not considered successful (Hastie, Wojewoda, 2015; Lagstedt et al., 2020).

One alternative is to use a hybrid approach, combining parts of plan-driven and change-driven development (Cobb, 2015). As no one method is suitable for all cases, it is important to constantly consider situations and select the appropriate method on a case-by-case basis (Harned, 2018).

The process of assigning the topic of the qualification thesis

The process of commissioning and producing a qualification thesis (Hansson, 2014) is often considered relatively straightforward, with the supervisor as the expert advising and the student producing the thesis according to the supervisor's instructions (Karunaratne, 2018). In practice, however, the process is more complex (Klement, Kotouč, 2020). For example, in our case, the process involved other professionals such as the department head (organising information sessions, checking students' thesis ideas and assigning supervisors), curriculum supervisors (overseeing the workload of supervisors and coordinators) and administrative staff (publishing the final thesis and recording assessments). The process of assigning and developing qualification thesis topics was selected for digitization based on the decision of the faculty management, the approval of the administration, the study programme guarantors, the student curia of the academic senate and the qualification thesis supervisors.

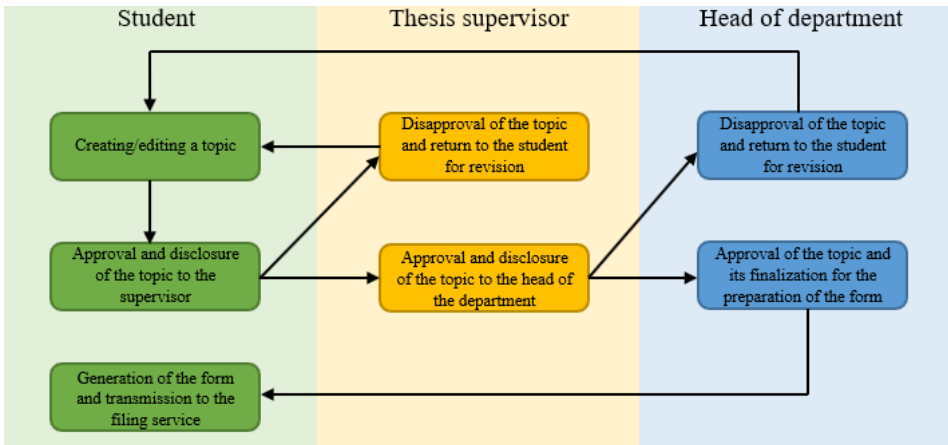

Figure 1. Basic life cycle of a qualification topic

In the initiation step (prior to 2022), the basic processes were described, and the process of specifying qualifying thesis topics proved to be one of the most complex. Various communication techniques and tools were used in the initial contact and between the student and the thesis supervisor, such as email, personal consultation, as well as various e-learning platforms (Moodle, MS Teams, Zoom, Big Blue Button, etc.), but these were not considered very useful when it

came to project-oriented personalized communication. However, the benefits of digitization, using a single system and a single approval workflow, were evident, and therefore work on the implementation of a digitized process was initiated in the period 2022–2023. The main requirements for this process were integration with existing data sources, automatic data transfer and that it be a modern platform supporting mobile devices.

The result was the introduction of a new digitised process for the submission and approval of qualification thesis topics, see Figure 1. The main advantages of digitising the process in this way are, for example, the automatic real-time monitoring of the progress of the work (deadlines and alerts, integrated automatic monitoring bar), notes and comments, visualisation of acceptances at each stage, integrated evaluation and a full log of the actions taken. One of the great advantages is the existence of different levels of reporting and different levels of transparency (according to user groups: 1 student, 2 work leaders, 3 department heads).

Verification methodology

In the research carried out to verify the usefulness of the implemented digitized process of assigning and approving qualification thesis topics, we relied on the four sources of data collection recommended by Sanchez (2013): documentation, archival records, participant observation and interviews. In the analysis, the main focus was on interviews; the other sources were considered complementary. The following research questions were formulated to validate the developed digital approval process:

Q1: What was the experience of the digital approval process?

Q2: How did users perceive the digitized process when it was implemented?

As the author of the present paper was responsible for the development and implementation of the digital process for the approval of qualification thesis topics, as well as for the operation of the STAG IS that supports it, there was thus a consistent approach to all documentation of the STAG module development (process models, notes, product backlogs, version histories, plans, emails and instructions). We also used STAG logs and registers as supporting data to understand the actual usage of the qualification work module under review. In addition, from the position of implementation guarantor, it was possible to manage the digitized process and make participant observations during the process.

The interviews followed the protocol developed by Dahlberg, Hokkanen and Newman (2016). Questions were presented to the interviewees either face-to-face or via video call.

A total of 29 respondents were interviewed. The respondents were selected on the basis of their above-average activity in various stages of the development and implementation of the qualification thesis topics module. Given that the

interviewees had extensive experience of the work and the roles they represented, the interviews can be described as expert (Bogner, Littig, Menz, 2009). The experts interviewed included study department staff (3), programme guarantors (2), thesis supervisors (8), department secretaries (4) and students (12).

The interview had two parts: the first part was about the digitisation process (O1) and the second part focused on the resulting process in STAG (O2). Of the total number of interviewees, 13 answered the first part and 27 answered the second part, with 11 being able to answer both parts.

Results

The first part of the interview consisted of identifying the role of the interviewees and answering four open-ended questions. This also included the opportunity to provide open-ended comments. Responses were coded under each of the themes of the research questions (expectations, experiences and implementation of engagement). One code (service promise) was created based on the responses. In this section, 10 of the 13 respondents acted in one role, two in two roles and one in three roles. Areas of responsibility included administration (3), curriculum guarantee (2), and thesis supervision (8).

Table 1. Summary of respondents' answers in the area of O1 – experience with digitisation processes

Question	Positive	Negative	Total
Meeting expectations	10	3	13
Deepening the experience	12	7	19*
Implementation of engagement	8	6	14*
Promise of service	12	1	13

* accumulation of positive and negative reviews

In terms of experience, the majority of respondents (10 out of 13) set expectations early on, immediately after engaging with digital. From the administrative, managerial and guarantor perspectives expressed in the interviews, the following were considered particularly important: visibility of processes (at all levels of the organisation), automation of processes (automating parts of processes) and recording of statistics (getting rid of manual monitoring of supervisors and their resources). Managers and guarantors emphasised the change in communication, the usefulness of a single platform (fewer emails when communicating; materials are in the same place) and transparency (supervision is visible). Of the 13 respondents, 6 reported only positive experiences, 6 reported both positive and negative experiences, and 1 reported only negative experiences. Experiences with management, guarantee and supervision were more numerous and detailed, while experiences with administration and management were fewer and more general. Positive experiences were related to the characte-

ristics of the digitized process (extremely useful, agile model that makes good use of internal competencies and is generalizable to similar, well-designed development efforts), involvement (it was valuable to be able to participate and try things out, which also helps in commitment to the outcome), and influencing the outcome (user needs were considered).

Positive experiences of being involved in the digitisation process were noted by 7 respondents, and negative experiences (5 of 13) related to doubts about the extent of involvement (the pilot phase could have been longer and more people involved) and coping with incompleteness (some may have felt insecure about the changes). One respondent declared both negative and positive experiences of engagement (novelty of the solution and the need for change, the benefit of engaging in other activities). The service promise was viewed positively by 12 respondents (improved processes, motivation to continue working; positivity of the impact of the solution). It is worth noting that the respondent who stated that they had only had a negative experience still viewed the engagement itself as positive and found the associated work on the service promise useful.

Table 2. Summary of respondents' answers in the area of O2 – perception of the digitalisation process

Question	Positive	Negative	Total
Process clarity	24	3	27
Process improvement	20	7	27
Process automation	23	4	27
Process usability	19	8	27
Process transparency	18	29	27
Process interactivity	20	11	31*
Absence of process features	9	18	27

* accumulation of positive and negative reviews

The most positive characteristics were the visual clarity and the holistic view of the process (24 responses, everything related to the process was in the same view). Twenty respondents cited improvements to the process either as a whole or as a specific detail or phase of the operation (fewer emails to send; assessment in the same system). The positive impact of automating the process was mentioned in twenty-three responses (topics were stored in the student's agenda system). Six respondents also cited the following characteristics: streamlining the process, guiding the process (forcing the user to take certain steps), easier communication (connecting the student and the supervisor), and ease of use.

There were 19 positive comments about the appearance and usability and the following adjectives were used: clear, simple, easy, logical, fast, light, easy to understand, and convenient. Six users also made negative comments. Five of them used the word "boring" when describing the appearance, and the terms

"old-fashioned" and "Windows-like" also appeared in the descriptions. Some respondents referred to specific features they did not like or found confusing. Eleven users wanted to suggest improvements they would like to see in the future. One feature that students would like to see added is a preview feature that would allow them to review the content of subsequent stages of the process. Work leaders would like to see the activities during the phases in more detail, especially in the final phase which contains many small steps. Eighteen users felt that the process has improved and is now more transparent (the student has to remember many things in the final stage of the process; tracking student processes was more difficult without STAG). Twenty respondents thought that the interaction between students and thesis supervisors had improved (interaction is now more organized), but ten respondents said there had been no change. One student pointed out a negative aspect (a student who does not use a university email address does not receive notification at the beginning of the process). One supervisor complained about the word processor (not on par with the bulk email editor).

Users cited the clarity of the digitised process and the fact that everything is in one place as reasons for the improved usability of the digitised process (11 responses). Five users stated that the overall manageability of the process had improved due to digitisation. There were individual views that the process was more manageable due to streamlining, enforced steps and record keeping. Four respondents also mentioned improved communication.

Of the negative features, most responses (18) culminated in the view that the system did not have a certain desired feature or did not work as the user expected. Seven respondents felt confusion at some point, which was usually related to a technical issue (do topics really transfer automatically and according to instructions?). However, only two users mentioned that the instructions were insufficient. Eleven respondents, including three students, identified some kind of resistance to change or to using STAG and its module for creating and approving thesis topics (many students still send emails). Nine users had some specific features in mind that they would like to see in a digitised process (text proofreading would be useful; group mail for students is needed).

Reliability of research findings

Interviews were conducted either face-to-face or via Big Blue Button (again, interviewees were able to monitor responses). Sessions were pre-arranged and took place in a quiet environment free from distractions. Data processing was carried out in Excel using standard content analysis techniques - i.e. coding and summarising. During the interviews, the questions appeared clear and the interviewees were able to answer fluently. Conceptual and construct validity was therefore at an appropriate level.

The empirical data used in this paper is based on interviews with a relatively small sample of individuals who are referred to as stakeholders due to their different roles and activities during the use of the digitisation process. Therefore, the interviews were considered expert interviews (Bogner et al., 2009) rather than standard research interviews. Given that full use of the Qualification Thesis Topic Approval module has only recently begun (early 2023), stakeholder interviews were limited to staff involved in the planning and trial use phase in the autumn of 2022. Students were selected randomly from STAG and from those who had either completed or were in the process of completing the assignment of Qualification Thesis Topics. Thus, they did not include all degree programs in the faculty, and therefore the results obtained are questionable because the sample consisted of rather pioneering users and may be slightly biased compared to the base population (all faculty staff and students). However, other available data, such as discussions and emails with a more representative, larger number of users, are consistent with the data from the research sample used.

Conclusions

Interview data, STAG protocols, documentation and observations confirmed that the digital process performed reasonably well in the development and approval of qualification thesis topics. The findings met the objectives set out for the digitised process: students felt they were listened to, the implemented digital process reduced the workload of thesis supervisors, was easy to use from the perspective of programme supervisors and departmental managers, and ensured "unification of activities" (see e.g. Davenport, 2010). The level of development of the digitised process was meaningful and therefore provides a suitable basis for the next steps in the digitisation of the curriculum. In addition, the implemented digitised process is visually clear, allowing for seamless control of all its functions and visualisation of the different stages of the development and approval of the qualification topic. This supports the understanding of the process and refers to the ease of use (Sarkar, 2007). The above feedback suggests that the process of entering and approving qualification thesis topics has improved, i.e. the implemented workflow is perceived as useful.

There is always room for improvement, as some students and thesis supervisors perceive the changing IS as confusing, hence more emphasis could be placed on planned development. In addition, some felt that the pilot validation was short and therefore feedback should be collected over a longer period of time and from a larger group of users. In addition, in some cases, users claimed to be following the delivered procedures, but analysis of their activities showed that this was not in fact the case. Interestingly, the implemented workflow seems to have created so-called "engaged change agents" (Lagstedt et al. 2020), alt-

hough this was not the observed goal. This effect should be investigated and further developed, which is also an intention for our further development and research work in this area.

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PAWEŁ DYMORA[1], **MIROSŁAW MAZUREK**[2], **MARIUSZ NYCZ**[3]

Comparison of Angular, React, and Vue Technologies in the Process of Creating Web Applications on the User Interface Side

[1] ORCID: 0000-0002-4473-823X, Ph.D. Eng., Rzeszów University of Technology, Faculty of Electrical, and Computer Engineering, Department of Complex Systems, Poland
[2] ORCID: 0000-0002-4366-1701, Ph.D. Eng., Rzeszów University of Technology, Faculty of Electrical, and Computer Engineering, Department of Complex Systems, Poland
[3] ORCID: 0000-0002-6297-5730, Ph.D. Eng., Rzeszów University of Technology, Faculty of Electrical, and Computer Engineering, Department of Complex Systems, Poland

Abstract

This paper presents a comparative analysis of three programming technologies and their application in building a web application, taking into account the code on the server-side and the user interface side. Three equivalent applications Angular, Vue, and React were analyzed. The needs for web applications are described, the implementation of particular functionalities in all technologies is presented together with the programming of database functionalities. The article is aimed at helping students of computer science faculties to make an informed choice of a framework or library for a specific project, taking into account the differences between these popular solutions.

Keywords: web applications, design process

Introduction

A WEB application is an interactive program that runs on a server accessible from any browser. To use a web application you don't need to install anything, but you do need a browser and access to the Internet. Continuous development of web technologies has made the applications less and less scalable, therefore developers found it useful to separate the front-end and back-end of the application (Molina-Ríos, Pedreira-Souto, 2020; Technical Documentation in Software Development: Types and Best Practices, 2; Kaluža, Vukelić, 2018).

The first part is responsible for what the user sees, it makes up the visible interface, while the second part is responsible for the layer that is invisible to the user, it is responsible for the operation of the site from the "inside". The server part communicates with the interface part and is responsible for the functionalities. With each user action, the browser sends a request to the server which returns information in the form of client layer code. In turn, the browser interprets the code and displays it in a user-friendly form (Kaluža, Vukelić, 2018; Current browser market share, 2021; Dymora, Paszkiewicz, 2020).

The main tools without which the compilation of script code into an actual page would not succeed are browser engines. They are used to render web pages, mainly used by web browsers. It is software that is responsible for processing the content of web pages and their formatting elements and then rendering them in a user-friendly manner . On the user interface side, there are three main types of technologies: HTML, CSS, JavaScript. On the server-side of the application, the database system can be separated - this is the place where data is stored. The programmer defines their structure and describes them. The most popular databases are MySQL, PostgreSQL, Firebird (Current browser market share, 2021; Dymora, Paszkiewicz, 2020; Dymora, Mazurek, Mroczka, 2021; https://www.postgresql.org/; https://firebirdsql.org/). The programming language used is important. The server-side programmer has a choice of many programming languages, and the most popular are Python, Java, C#. In Java, servlets can be distinguished as a basic element of business applications, they are used both in Java EE applications and those developed in Spring MVC. The most complex applications nowadays also need highly developed tools, so the article focuses on comparing the three most popular solutions: Angular, Vue, React (Dymora, Paszkiewicz, 2020; Flanagan, 2021; https://www.javascript.com/; Freeman, 2018).

This paper presents a simplified methodology and description of the application development process. The presented approach shows in detail what stages the entire web application development process consists of and what influences its efficiency. The presented cycle of creation of a new IT product allows one to properly understand the project process, as the knowledge gained is crucial from the business point of view of the work on a given IT project. In particular, novice developers as well as IT students can compare the essential properties of popular web application programming technologies and use the corresponding one in the process of web application development. This is achievable through a rather in-depth comparison of Angular, React, and Vue technologies in the process of creating web applications on the user interface side.

The paper is divided into five sections. The introduction provides a review of the literature and recent trends in technologies used in the development of

user interfaces in web-based applications. Chapter 2 characterizes the test environment and methods selected for the study. Chapter 3 presents selected research technologies used and their main characteristics. Chapter 4 presents a description of the experiments and a comparative analysis of the results obtained. Summary, conclusion, and scope of future research are presented in Chapter 5.

Test application design

In order to make an objective comparison of the discussed technologies, a web application "Car Seller" was designed. The main function of the application is to enable the user to buy a car in an online car shop. Each user, to use the store, has to register. After registration, the user can choose from over 1700 cars, a model that interests him. The data about the cars, such as price and condition, are selected according to a proprietary algorithm based data on from an open API. The user can filter the cars by 3 features. After selecting cars or a car, the user is able to add it to his/her cart and then purchase it. The data from the purchase is stored in the Firebase database. The structure of the application is shown in Figure 1.

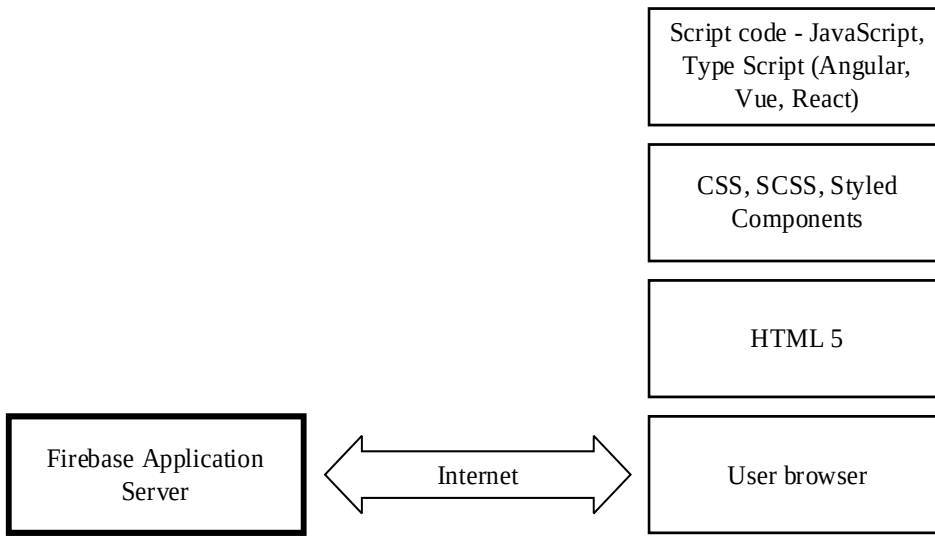

Figure 1. Structure of the application "Car Seller"

Description of selected technologies

Three applications identical in terms of functionality were prepared for testing using different technologies and programming environments. The detailed implementation is shown in Table 1.

Table 1. Summary of implementation details of developed applications and used technologies

	Application #1	Application #2	Application #3
Script Language	TypeScript	JavaScript	JavaScript
Technology	Angular	React	Vue
Page Styles	Pre-processor SCSS	Styled Components Library	CSS
Used environment	PHP Storm	Visual Studio Code	Visual Studio Code
Hypertext Markup Language	HTML 5	HTML 5	HTML 5

JavaScript Language

The JavaScript language is a dynamically typed, high-level programming language. It is most commonly used for web programming where it provides interactivity and event handling. This language has many libraries that make it easier to work with one of the first was the jQuery library. This language has gained enormous popularity, especially among web developers on the user interface side, but this language is also used on the server-side. An environment that helps you run JavaScript code directly on your computer without any browser involvement is Node.js. According to the Tiobe index, the language is ranked as the seventh most popular language (Flanagan, 2021; https://www.javascript.com/).

Angular programming technology

Angular is a comprehensive development tool for creating SPA (Single Page Ap-plication) applications that are loaded dynamically in the browser. This technology does not need to download the page from the server the user goes through the individual tabs. Angular has been developed by the Google team and community and is an open-source project. Angular as technology provides all the tools to create a SPA, it does not need to download other libraries like HTTP library which other technologies need. Angular is fully written in TypeScript which allows for greater scalability of any project (Freeman, 2018; https://angular.io/features).

React programming technology

React is a JavaScript programming language library that is used to create user interfaces for various types of applications and is available to the general public because it is open-source. React was created by one of Facebook employees Jordan Walke. The React library, like Angular, allows you to create interactive SPA-type pages. React by itself does not provide all the tools you need to create SPA-type applications, many additional features need to be downloaded, but when a developer plans to make a smaller application and cares about its smaller size it can be considered a plus. An additional advantage that can be given to React is the documentation in Polish (https://pl.reactjs.org/; Chinnathambi, 2019).

Comparative analysis of study results

Depending on the technology, components are written in different ways. In an application written in Angular technology one component is contained in three files: CSS, HTML, TypeScript. When components written in React and Vue technologies are contained in a single file, in React technology these are files with .js extensions, in turn, components written in Vue technology are components with .vue extension (Hanchett i Listwon, 2020). In each application one file is responsible for configuration settings, in each of them it is a package.json file. It contains, among others, information on how to run the application, the version number of the application, or installed dependencies. Additionally, in an application written in Angular technology, there is an angular.json file that has information about the configuration of Angular CLI which makes it easier for the developer to develop the application. An overview of the application structures can be seen in Figure 2.

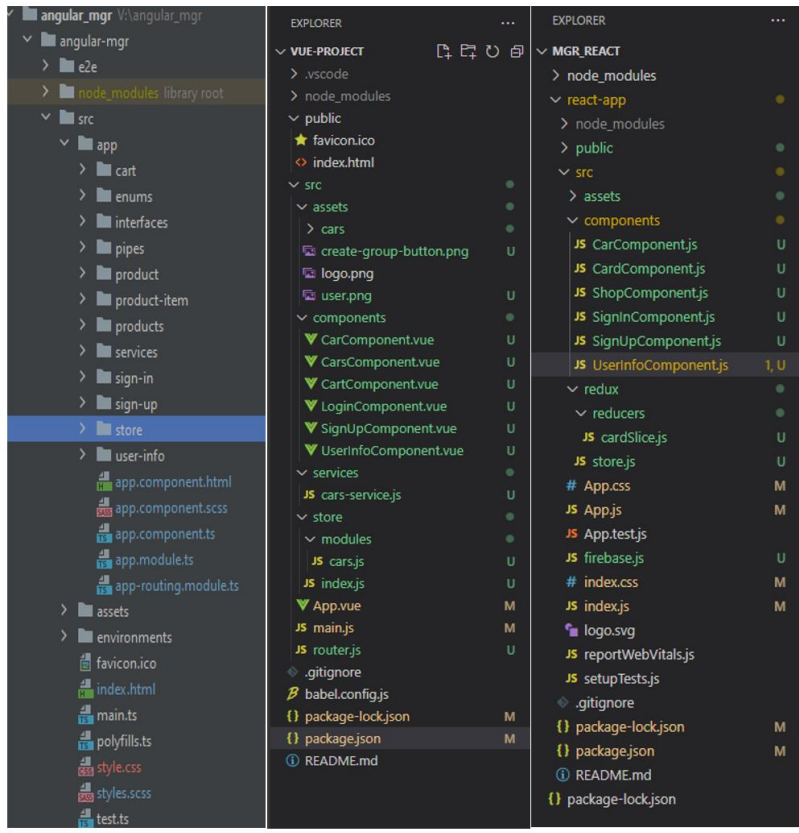

Figure 2. File and directory structure of the application written in three technologies: Angular (left), Vue, React (right)

An identical mechanism for adding cars to the list was used in the three applications. It was implemented differently depending on the application, but the algorithm works the same way. The data to be processed in the application was taken from an open API. They were created in 1997. There are 1728 rows of data in 7 columns in the downloaded data.

The comparison scenario involved listing each component in each application, listing selected parts of the implementation, and then comparing components written in three different technologies and development tools. The application is written in Angular technology used: TypeScript scripting language, SCSS Preprocessor in page styling. It was written in the PHPStorm environment. It used HTML 5 as a hypertext markup language.

The next application written in React technology used JavaScript scripting language, Styled Component library in page styling, Visual Studio Code environment, HTML 5. The last application written used Vue technology and also used JavaScript scripting language, CSS for page styling, and Visual Studio Code and HTML5.

The comparison scenario also included a list of runtimes for each component in the applications, as well as the time period needed to write a given component and the number of lines of code needed to implement a given functionality separately for the code responsible for the hypertext markup language, the code responsible for the scripting language, and the code responsible for view styling. The rendering time studies for a given component will be recalculated thanks to the add-ons: Vue Devtools for an application written in Vue, React Developer Tools for an application written in React, and Angular DevTools for an application written in Angular.

Comparison of login function implementations

The codes responsible for hypertext markup languages differed very little. In React technology, after using the Styled Component library, each component that was styled separately was assigned to JavaScript const variables. Components written in Vue and Angular technologies were tagged with ordinary HTML code tags, which can be seen in Figure 3.

```html
<section class="login-box">
  <h1 class="login-box__title">Zaloguj się do platformy</h1>

  <div class="login-box__wrapper">
    <div class="login-box__icon-wrapper">
      <img class="login-box__icon" src="assets/layouts/user.png" alt="">
    </div>

    <form class="login-box__form" [formGroup]="userForm">
      <input placeholder="Login" class="login-box__input" type="text" formControlName="login">

      <input placeholder="Hasło" class="login-box__input"  type="text" formControlName="password">
      <button class="login-box__button-login" (click)="loginUser()">Zaloguj się</button>
      <span (click)="goToSignUp()" class="login-box__button-create-account">Załóż konto</span>
    </form>
  </div>

</section>
```

```vue
<template>
  <section class="login-box">
    <h1 class="login-box__title">Zaloguj się do platformy</h1>

    <div class="login-box__wrapper">
      <div class="login-box__icon-wrapper">
        <img class="login-box__icon" src="../assets/user.png" alt="" />
      </div>

      <div class="login-box__form">
        <input v-model="email" placeholder="Login" class="login-box__input" type="text" />

        <input v-model="password" placeholder="Hasło" class="login-box__input" type="text" />
        <button class="login-box__button-login" @click="loginUser()">
          Zaloguj się
        </button>
        <span @click="goToSignUp()" class="login-box__button-create-account"
          >Załóż konto</span
        >
      </div>
    </div>
    )
  </section>
</template>
```

```jsx
<>
<StyledLoginBox>
    <StyledTitle>Zaloguj się do platformy</StyledTitle>
    <StyledWrapper>
        <StyledIconWrapper>
            <StyledIcon />
        </StyledIconWrapper>
        <StyledForm>
            <StyledInput onChange={event => setLogin(event.target.value)}  placeholder="Login"></StyledInput>
            <StyledInput onChange={event => setPassword(event.target.value)} placeholder="Hasło" ></StyledInput>
            <StyledButtonCreateAccount onClick={handleChange}>Zaloguj się</StyledButtonCreateAccount>
            <StyledButtonLogin onClick={handleChangeSignIn}>Załóż konto</StyledButtonLogin>
        </StyledForm>
    </StyledWrapper>
</StyledLoginBox>
</>
```

Figure 3. HTML code of applications written in Angular, Vue and React

As we can see in Figure 4, most codes appeared in the application written in Vue technology.

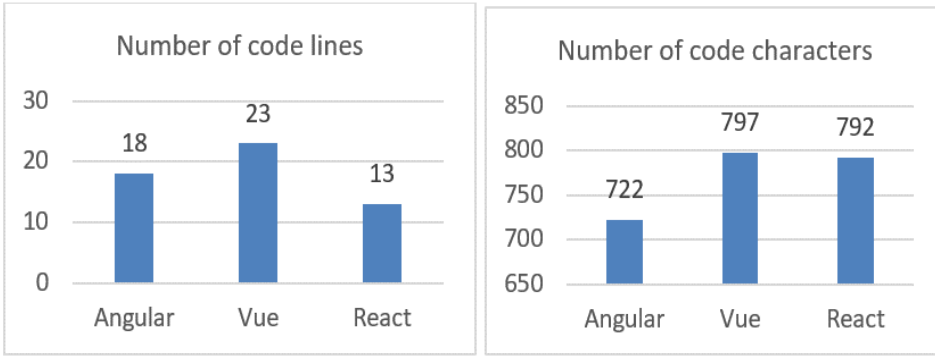

Figure 4. The number of code lines (left) and code characters count (right) responsible for HTML

Cascading Style Sheets Implementation

The technique for styling the view responsible for logging in all three applications differed. In the application written in Vue technology, the styling was contained in .css files. When styling in Angular, the application was supported by SCSS preprocessor. On the other hand, the styling of elements in the React application differed the most from the others. In this case, the styled-components library was used. In this library, each element that was styled had a separate entity and was separately assigned to a variable. Sample style codes are shown in Figure 5.

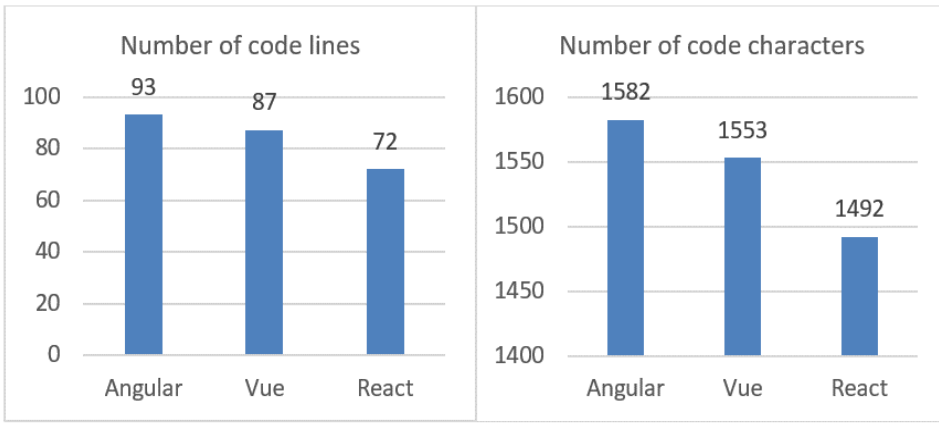

Figure 5. Comparison of the number of code lines (left) and code characters count (right) responsible for styling

Script Language

In the application written in Angular technology, Typescript was the scripting language, while in the Vue and React applications, Javascript was the scripting language. Figure 6 illustrates that most codes appeared in the application written in Angular technology. On the other hand, the script code of the application written in Vue technology had the most lines.

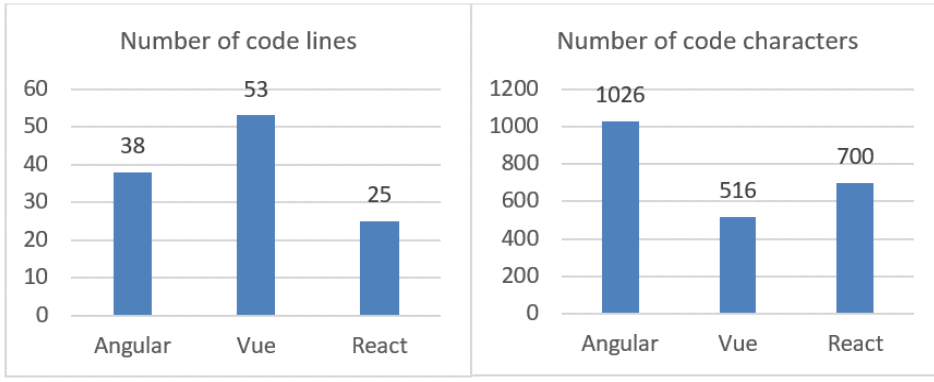

Figure 6. Comparison of the number of code lines (left) and code characters count (right) in the script language

The time required to create a given component

Due to the different types of language, a different amount of time is needed for software development. The calculation of programming time is not reliable, however, it was observed that it did not take long to write each component. The first component written in Angular technology took by far the longest due to the fact that TypeScript language was used. The comparison of workloads is shown in Figure 7.

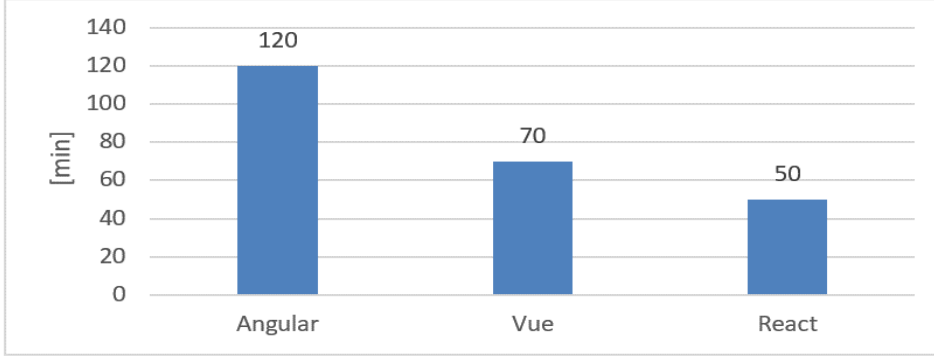

Figure 7. The time required to write the login component in three applications

Comparison of browser login component creation time

The next test analyzed the time it takes to create a component in a browser. Each browser has different rendering times, but the browser used for testing was Chrome, which has the most facilities for a web developer. In Figures 8 and 9, you can see that the component created in Vue technology took the longest time to create.

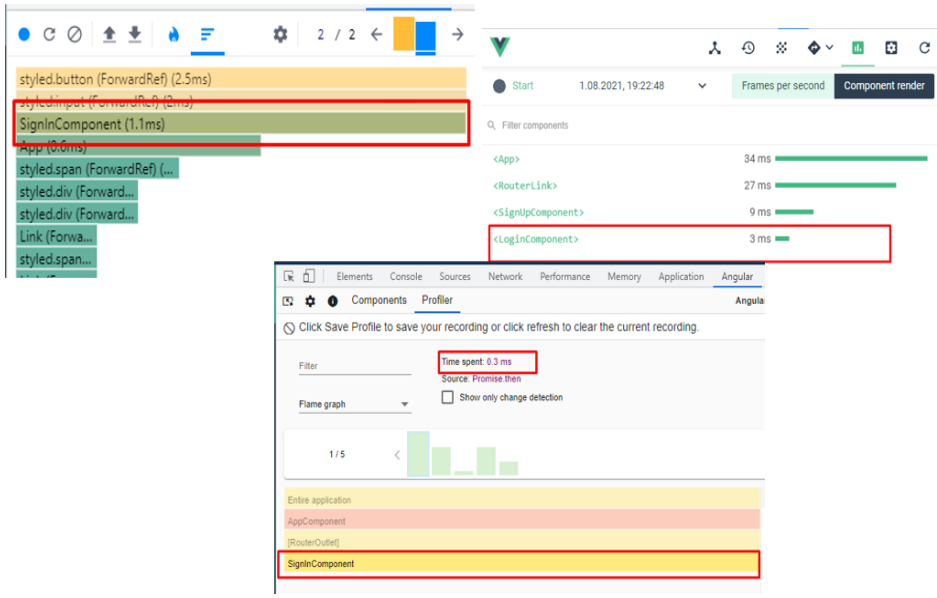

Figure 8. Rendering times of individual components in React, Vue, Angular applications in add-ons installed in Google Chrome

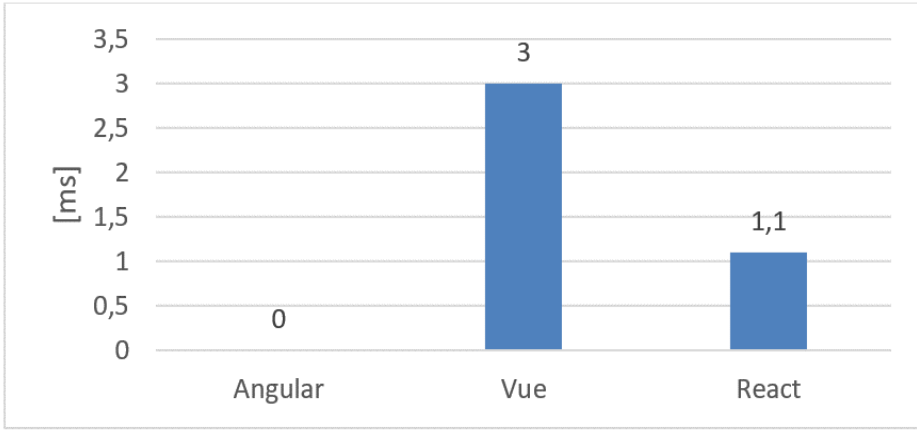

Figure 9. The time required for the browser to generate the components

A comparative analysis of the entire application

The overall results of the tests are shown in Table 2. The time needed to compile each application, as well as the number of lines of code and characters were analyzed in turn. In the time analysis test, the Windows stopwatch was started after running the command responsible for compiling the application (for the Vue application npm run serve, for the React application npm start, for the Angular application ng serve).

The time required to compile the React application was 15 seconds, in Vue similarly 12 seconds. The longest application was compiled in Angular (25 seconds). The total number of lines of code in each application, as well as the total number of characters in each application depending on the HTML code, code responsible for styling and scripting code in each component, showed that Angular is the most demanding. The lowest values were obtained for React. The compiled sums of the number responsible for the script code in applications showed that the number of lines of script code in all cases was close to 600, and the number of script characters, as before, was the highest for Angular.

Table 2. Comparison of key application features

	React	**Vue**	**Angular**
Complication time [s]	15	12	25
Number of code lines in HTML	150	213	216
Characters number in HTML	6430	7843	9218
Number of code lines in CSS	585	537	545
Characters number in CSS	10122	10416	10758
Number of code lines in the script language	566	619	600
Characters number in the script language	17421	15487	19075

Conclusion

This paper provides a detailed comparative analysis of the most popular techniques and technologies used in programming web applications on the user interface side. Three applications written specifically for testing in Angular, Vue, and React technologies were used to compare the tools. In addition to the various scripting language technologies, JavaScript and TypeScript were used in the applications. Styling in the applications was implemented in different ways. SCSS preprocessor, ordinary CSS, and styled-components library were used. Applications using different technologies had the same functions. The comparisons showed that most of the markup language code appeared in the application written in Angular technology.

In the case of styling the application, most codes appeared in React technology. Influence on this definitely had to use the library Styled-Component, which makes that each element that we want to style should be assigned to a variable. This solution makes the code definitely more, but it is more scalable and easier to develop. Using SCSS preprocessor in the application written in

Angular technology made the code the least. You can feel that by doing so the code is the least readable, but the syntax of the preprocessor promotes intuitiveness and scalability of the code.

Analysis of the amount of code responsible for the scripting language showed that the most appeared in the application written in React. However, if the .ts files responsible for the service interfaces or "pips" were added to the scripting code of all the components in Angular, by far the most scripting code appears in Angular. This technology favors scalability, for example, the user may be forced to specify the type of a newly defined variable or the type of the returned element from a function. This situation is conducive to the development of projects with greater complexity and on which more developers work.

The analysis of the time needed to implement particular components showed interesting results. The Angular application took the most time, which was due to the fact that it was the first application that was written, a lot of functionality had to be designed, and the complexity of the technology, resulted from the need to use a TypeScript scripting language, which differs from JavaScript. To sum up, the application written in Angular technology turned out to be the most complex and time-consuming, so definitely this type of technology has the highest thresh-old of entry for young developers. The application written in Vue took second place. It took relatively the least time to implement an application written in React. The complexity of this application is also the lowest, as evidenced by the amount of code that is written intuitively.

The functionality of the application was chosen because currently e-commerce applications are by far the most developed in the Polish market. A great advantage of such applications is the ability to implement additional elements such as product details and the implementation of a more complex user page. By far the most needed functionality in applications is the mobile view. The application can be further developed and, most importantly, it has met the user's expectations.

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PAWEŁ DYMORA[1], **MIROSŁAW MAZUREK**[2], **MARIUSZ NYCZ**[3]

Modeling and Statistical Analysis of Data Breach Problems in Python

[1] ORCID: 0000-0002-4473-823X, Ph.D. Eng., Rzeszów University of Technology, Faculty of Electrical, and Computer Engineering, Department of Complex Systems, Poland
[2] ORCID: 0000-0002-4366-1701, Ph.D. Eng., Rzeszów University of Technology, Faculty of Electrical, and Computer Engineering, Department of Complex Systems, Poland
[3] ORCID: 0000-0002-6297-5730, Ph.D. Eng., Rzeszów University of Technology, Faculty of Electrical, and Computer Engineering, Department of Complex Systems, Poland

Abstract

The subject of the work is electronic medical record linkage threat analysis and modeling with the use of the submitted data breaches list published by the U.S. Department of Health and Human Services. Multipronged data analysis with the use of statistics utilities and data visualization has been conducted. The model forecasting the number of data breaches based on a time series mathematical model has also been built. The article reviews the tools and techniques used in data security analysis and presents practical examples of modeling and analysis that can be used in practice to improve data protection. It was shown how important it is to protect personal data, especially medical data, and what tools can be used in the educational process of data analytics for students to effect data analysis, trend assessment, and data prediction.

Keywords: Data Breach, Data Analysis, Cybersecurity, Electronic Health Record, Time Series, Statistical analysis, Forecasts

Introduction

One of the duties of healthcare providers is to keep medical records. Such records contain information on the examination and treatment of the patient, such as symptoms, staff observations, diagnoses, treatment plans, and course of treatment. It may contain information about the patient's private life, such as lifestyle, habits, or recreational activities (Beltran-Aroca, Girela-Lopez, Collazo-Chao, Montero-Pérez-Barquero, Muñoz-Villanueva, 1992). Medical services

have a duty of confidentiality regarding the information provided by their clients - this is the foundation of trust in the doctor-patient relationship (Boyd, 1992; Kleinman, Baylis, Singer, 1997).

The progressive development of information technology has also affected the medical industry. It is becoming increasingly common to replace traditional paper medical records with systems such as Electronic Health Record – HER (Benefits of EHRs, 2022; Seh et al., 2020). Data security consists of confidentiality, integrity, and availability. According to the European Union, a data breach occurs when any of these three components is compromised as a result of an incident (What is a data breach and what do we have to do in case of a data breach? 2022). According to the US Department of Health and Human Services, a data breach is an unauthorized access or disclosure of data, as defined by the Privacy Rule set of standards, that compromises the security and privacy of protected (medical) information (Breach Notification Rule, 2022; Schlackl, Link, Hoehle, 2022).

Between 2005 and 2019, 249.09 million people were affected by health data leaks (Seh et al., 2020). For example, in 2018, there were 2216 data leaks in 65 countries, of which health services were affected by 536 leaks; this means that, of all the industries included in the study, the medical industry was the most affected (2018 Data Breach Investigations Report, 2022). As the study shows, the cost per such spill is calculated in millions of dollars. The subject of the study is the analysis and modeling of threats to medical records, i.e. data (often sensitive) stored by entities in the medical industry, such as hospitals, outpatient clinics, and medical networks, but also entities related to the business medical industry, such as health insurances, companies offering medical care. The analysis was based on a U.S. data source - lists of reported leaks published by the U.S. Department of Health and Human Services (Breach Portal: Notice to the Secretary of HHS Breach of Unsecured Protected Health Information, 2022).

The security of electronic data in healthcare and beyond has been the subject of many scientific studies in recent years. A study (Ayyagari, 2014) analyzed 2,633 leaks in the medical and other industries, which resulted in data breaches of more than 500 million people. The results show the significant contribution of hacking attacks to these breaches but at the same time the increasing importance of leaks based on the "hu-man element". In contrast, the paper (Angst, Block, D'Arcy, Kelley, 2017) analyzed data leaks in healthcare, focusing on the evaluation of the implementation of IT security measures.

The authors of the paper (Schlackl, Link, Hoehle, 2022) highlighted the multitude of different studies and approaches developed in different environments and the need to integrate the knowledge gained on this topic. They performed a systematic search of the scientific literature on the causes and consequences of breaches of information confidentiality and integrity. The paper (Seh et al., 2020)

analyzed data on data leaks in healthcare. The data for the analysis came from multiple sources, such as the PRC database, HIPAA, and OCR reports.

In the paper, the authors (McLeod, Dolezel, 2018) aimed to build a model that is a profile of factors related to data leakage in healthcare. The theoretical basis was the Swiss Cheese Model. Backward stepwise logistic regression models were built – as output, the models estimated the probability that data leakage would occur in a given healthcare unit. The paper, therefore, seeks to attempt to draw constructive conclusions for healthcare entities on how to improve the level of security of their data.

In the educational process in the faculty of data analysis, a particularly important issue is the selection and use of appropriate IT tools based on the theory of mathematical statistics, and multidimensional data analysis as well as areas of data mining. The article reviews the tools and techniques that can be used in the training process of future data analysts, and analytical system architects that can be used in data security analysis and presents practical examples of modeling and analysis that can be used in practice to improve data protection. It is shown how important it is to protect personal data in particular medical data. The main threats, selected methods, and measures to counter such threats and errors are indicated, pointing out the low level of user education and awareness as the main problem. This study presents compelling social indicators of such magnitude that they cannot be ignored. The following paper attempts to fit a model to a time series of the number of data leaks and a time series of the number of leaks of each type. The modeling aimed to obtain a model capable of producing reliable predictions of the number of data leaks in the future.

Time series modeling

The model fits the time series of the number of data leaks and the time series of the number of leaks of each type were carried out based on the number of leaks, which were counted monthly. The period considered was the time segment from the beginning of 2010 to the end of 2022. A tool was prepared for the automatic retrieval and aggregation of data. A modeling scheme based on autocorrelation and development trend extraction was developed. The model was implemented. A simulation was run, the results were presented in a graph and the model was validated.

Mathematical model

The model for the total number of leaks was built from smaller models - sub-series, i.e. series denoting the number of leaks of one particular type (e.g. monthly numbers of leaks due to an IT/hacking incident). The sub-series were divided into two groups: group I and group II. Group I included those series showing signs of non-random trends (e.g. a trend). On the other hand, group II included those series that did not show any non-random features (so-called noise).

The partial series in the two groups were modeled in a slightly different way. It was assumed that X(t) is the actual number of leaks of a given type per month t, and x(t) is the model–predicted number of leaks per month t. Group I series was modeled using the sum of linear regression and the moving average error of this regression last in the month (1), (2), (3).

$$\varepsilon_j(t) = (at + b) - X_j(t) \quad (1)$$

$$\underline{\varepsilon}_j(t) = \frac{\varepsilon_j(t-w)+\varepsilon_j(t-w+1)+\cdots+\varepsilon_j(t-1)}{w} \quad (2)$$

$$x_j(t) = max\,(at + b + \underline{\varepsilon_j}(t), 0) \quad (3)$$

For moments of time t, where we are unable to calculate the ε(t) due to the fact that we do not know X(t-1) (future values), values ε(t) we calculate from the equation (1), by replacing unknown values X values calculated from the model x.

We model the Group II sub-series using only a moving average. The model's prediction of total leakage for month t is obtained by summing the predicted values for each subseries.

Modeling framework

An ACF autocorrelation function plot was used to investigate non--coincidental patterns in the series. Modeling involves the following steps:

- Determination of model parameters and learning and forecasting intervals.
- Aggregation of data into monthly time series of counts.
- Dividing the sub-series into groups based on autocorrelation plots.
- Simulation of sub-series models.
- Aggregation of the sub-series forecasts, obtaining a summary forecast of the number of leakages.
- Visualize the results, and compare the modeling results with real values.
- Model validation.

A computational environment with the necessary tools was created for computer data analysis and numerical model building. The Python programming language was used (with additional libraries). Analysis and modeling were carried out in the JupyterLab environment.

Data analysis

The data used for the analysis cover several years. They show the changes that have taken place during this time, including the laws governing the phenomena under study. A set divided into three parts according to the date the leakages were reported was used for the analyses:

- concerning leakages reported from the beginning of 2010 until the end of 2014;

– on leakages reported from the beginning of 2015 until the end of 2019;
– on leakages reported in 2020 and beyond.

For these periods, the abundance of individual values for the features stored in the data was examined. A series of leakage counts of each type and for each data storage location in consecutive months was created. Correlations between them and between each of them and changes in selected macroeconomic values related to health care in the United States were examined.

Analysis of the number of data breaches victims

In order to examine the distribution of the number of affected people, basic statistical indicators were calculated for the sample described; these are presented in Table 1.

Table 1. Statistical measure values for the number of leakage victims

Examined period	2010–2014	2015–2019	2020–present	Summary
Number of leaks	1207	1838	2072	5135
Average	39 802,28	105 369,8	65 489,32	73 522,81
Standard deviation	311 450,7	1 915 294	251 748,1	1 166 876
Minimum	500	500	500	500
1st quartile	1 000	1 016,5	1 450,25	1 125,5
Median	2 365	2 675	5 000	3 116
3rd quartile	7 461	10 865	28 768,5	13 734
Maximum	6 121 158	78 800 000	4 142 440	78 800 000

Since the beginning of 2020 (i.e. in three years), approximately 72% more spills have been reported than from the beginning of 2010 to the end of 2014 (four years) and approximately 13% more spills than from the beginning of 2015 to the end of 2019 (also four years). The analysis shows how the mean and median have changed. It can be seen that, in both cases, the smallest values are for the years 2010–2014. However, the mean reached its highest value for the years 2015–2019. The median, on the other hand, reaches its highest value for the most recent period – from 2020 onwards. This discrepancy may be due to the fact that in the period 2015–2019, one of the spills involved a number of over 78 million victims – the maximum value number of victims for this period. Anomalies such as this may overstate the average. This conjecture is confirmed by the very high standard deviation for the period 2015–2019.

Categorical features analysis

In the next step, the values taken by the categorical characteristics available in the data were examined, i.e.: type of entity (institution) affected, type of leakage, and storage location of the data affected by the incident.

The study was conducted by visualizing the distribution of values in a bar chart for each characteristic and for each of the three periods into which the data

were divided (Figure 1, 2, 3). Healthcare clearinghouses account for a negligible proportion of incidents in each period. It is noteworthy that there is an increasing number of spills where the healthcare provider is affected. For the characteristic "type of spill", significant changes were observed over the three periods studied. In the first period – 2010 to 2014, the leading type of data leakage was theft (theft), and a significant proportion was loss (loss) – these are categories whose representatives often have little to do with IT. An IT or hacking incident in this period was a phenomenon comparable in scale to leaks due to loss. The following two periods show a large increase in the number of leaks due to an IT or hacking incident. Interestingly, the number of leaks due to theft decreases. In the first of the periods studied, the counts for each location of information were most evenly distributed, the slight leader being data stored in paper form. In the following two periods, a large increase in the counts of two categories was observed: web server and email, i.e. digital form. It is worth noting the decreasing number of data leaks stored on a desktop computer (PC).

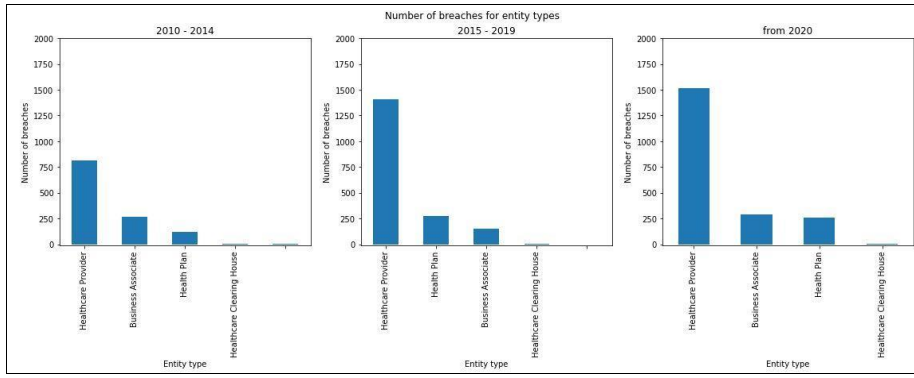

Figure 1. Number of breaches for entity types

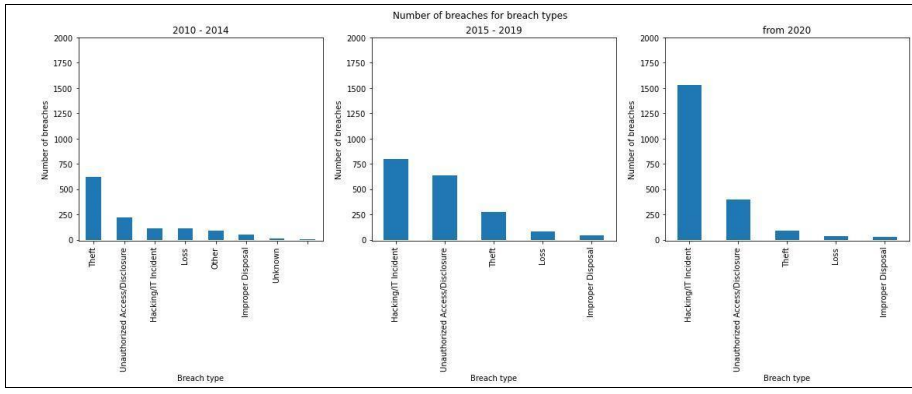

Figure 2. Number of breaches for breach types

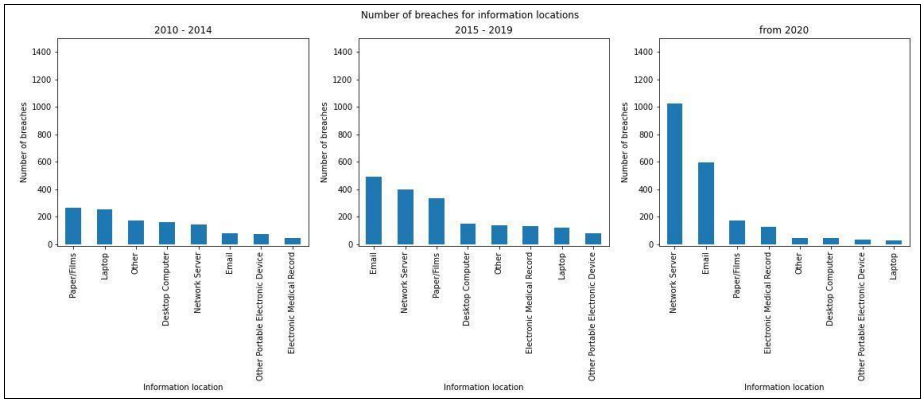

Figure 3. Number of breaches for information location

Correlation coefficient analysis

For each type of spill and each type of data location, a time series was created, being the number of reports of a given type of spill in consecutive months, as well as all reports in total, from the month in which the first spill was reported that is reported in the data, to the last month from which a spill was reported. Pearson's linear correlation coefficient was calculated for each pair of the resulting series. Two additional series were included in the analysis: the monthly change in the number of people employed in health care in thousands and the change in total profit from health and social care activities (both for the United States). For each coefficient, a statistical significance test was performed on the value of that coefficient with a significance coefficient of 0.01. The results are shown in Figure 4.

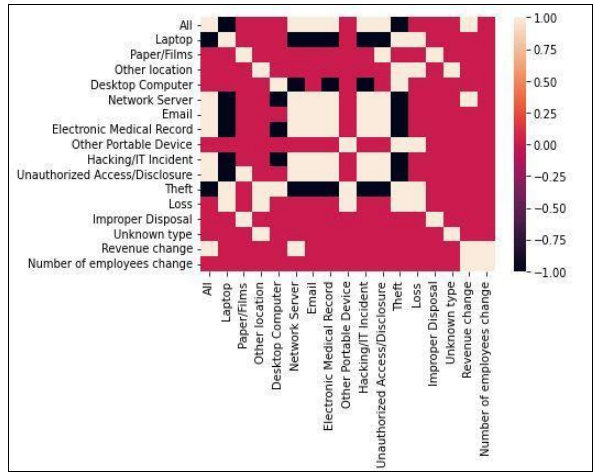

Figure 4. Map of the results of the Pearson correlation coefficient significance test (including the sign of the coefficient if the coefficient is significant)

Both negative and positive correlations were observed, as well as quite a few cases where the test showed no statistically significant correlation. It was observed that the total number of leaks per month is correlated with the monthly numbers of leaks: from a web server, from an email, from an EMR record, from a hacking/IT incident, from unauthorized access, as well as with the monthly change in total healthcare gain.

Models simulation

In the analyses, 12 (corresponding to 12 months) was used as the window length (number of observations in the window) for the moving averages. The autocorrelation analysis in the sub-series was performed for the 2010–2013 model, the 2014–2017 model, and the 2018–2021 model, respectively. Figure 5 shows the results for the 2018–2021 model.

Based on the ACF, the series for the leakage types were classified as series with non-random trends:

- 2010–2013: Other, Unauthorized Access/Disclosure.
- 2014–2017: Other, Hacking/IT Incidents.
- 2018–2021: Hacking/IT Incident.

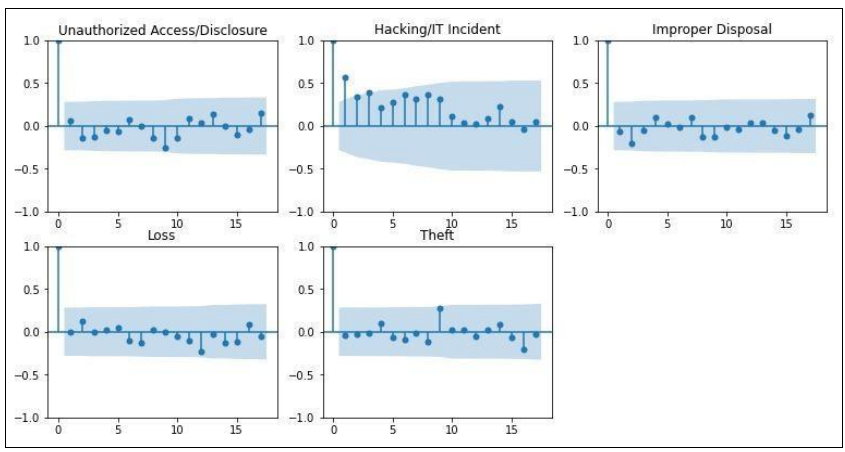

Figure 5. Autocorrelations for 2018–2021

The unspecified series for each modeled period were classified as noise. Each of the three models was simulated over a period of 48 months (4 years), including the 36 months at the values from which it was learned, and the 12 months immediately following that period (forecast).

Figure 6 shows graphs of the actual monthly number of leakages and the predictions of the individual models. The vertical lines separate the learning periods of the models.

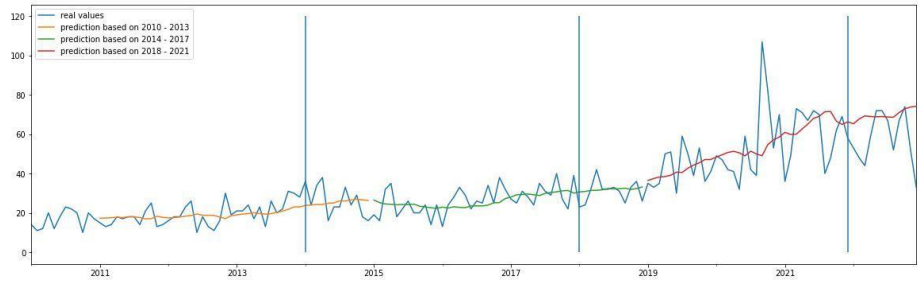

Figure 6. Autocorrelations for 2018–2021

Models validation

The first type of validation performed was a visual-informal validation, based on Figure 6. For the first two models (learned in the years periods: 2010–2013, and 2014–2017 respectively), a good fit to the learning data was observed in terms of mean value and trend, but the actual data has a much higher variability – the error changes its sign, but is rarely close to zero. The behavior of the model for the values in the months on which it performed the forecast was similar in each of the two cases to the behavior of the data used for learning – which should be read as a positive sign. For the most recent period, the model looks like a poor fit for the learning data, and the forecast is mostly overestimated. Perhaps this behavior is to some extent due to the anomaly seen in one of the months towards the end of 2020.

Table 2 presents the error measures of each of the three models, calculated for the months where each model performed forecasts (i.e. months not involved in learning).

Table 2. Calculated error measures for leakage number models

Learning range	2010–2013	2014–2017	2018–2021
Forecast period	2014	2018	2022
ME (Mean Error)	–0,77	1,16	12,13
MAE (Mean Absolute Error)	6,68	3,99	13,34
MPE (Mean Percentage Error)	6.13%	6,76%	28,03%
MAPE (Mean Absolute Percentage Error)	27,29%	14,07%	29,70%

The numerical error measures largely confirm the previously made observations in the graph. The first two models have MPEs in the order of a few percent, meaning that the forecast was not significantly under or overestimated overall. The difference is in the MAPE values, with the first model being wrong by an average of around 27.29 percent (excluding the sign), while the second model was only wrong by 14.07 percent (excluding the sign). However, the large ME and MPE clearly indicate that the model is more likely to predict values that are too large than too small.

Conclusion

In this paper, a multifaceted analysis of data on data leakage in healthcare-related institutions in the United States was performed, and a predictive model of the number of leakages was built based on these data. The data came from one of the websites belonging to the US Department of Health and Human Services. The data consisted of several thousand records from 2009 to 2023, where each record described one reported spill.

The analyses showed several clear patterns, as well as changes in the risk profile over the years. A clear change was observed regarding the types of leaks and the types of the location of the affected data. Back in the early years of the second decade of the 21st century, theft was the dominant category. Data leaked was mainly stored on laptops or in non-computerized form. Over the decade, hacking and other IT incidents have clearly become the dominant category of leaks, with data leaking mainly from web servers and emails. A significant positive correlation was observed between the counts for leak categories for which similar long-term trends were previously observed in the graph (e.g. for Email and Hacking/IT Incident, for Theft and Laptop, for Hacking/IT Incident, and Network Server).

A model was built to predict the monthly leakage rate for a selected point in time. In order to build it, the learning data was partitioned based on an autocorrelation function. The model uses a least-squares linear trend approximation and moving averages. For the temporally earliest and middle periods of the three modeled terms, the model fitted the learning data well, with the forecast trend close to that of the true data. Good results were recorded especially for the middle period, where the absolute forecast error averaged about 14 %, which was considered a satisfactory result given the large variance in the data. Worse results were obtained for the last period, where the leakage forecast tended to be significantly overestimated. This result can be interpreted to mean that towards the end of the learning period of the last model (i.e. around 2021), there was a change in the growth rate of the monthly number of leaks.

In this study, statistical evidence has been presented that shows health data breaches occurring at an unprecedented level. Preventing illegal breaches of EHR, currently taking place at such a level, is no longer possible by technology alone, and a wider discussion is needed, with relevant stakeholders involved, including patients and the public at large (patient public involvement, PPI)

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