ISSN 2719-6550
ISSN 2719-7417 online

JOURNAL OF EDUCATION, TECHNOLOGY AND COMPUTER SCIENCE

No. 3(33)/2022

Journal of Education, Technology and Computer Science is a continuation of
“Edukacja – Technika – Informatyka. Education – Technology – Computer Science” Journal

Publishing Office
University of Rzeszow
Rzeszow 2022

JOURNAL OF EDUCATION, TECHNOLOGY AND COMPUTER SCIENCE
No. 3(33)/2022

ADDRESS OF EDITORIAL OFFICE
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

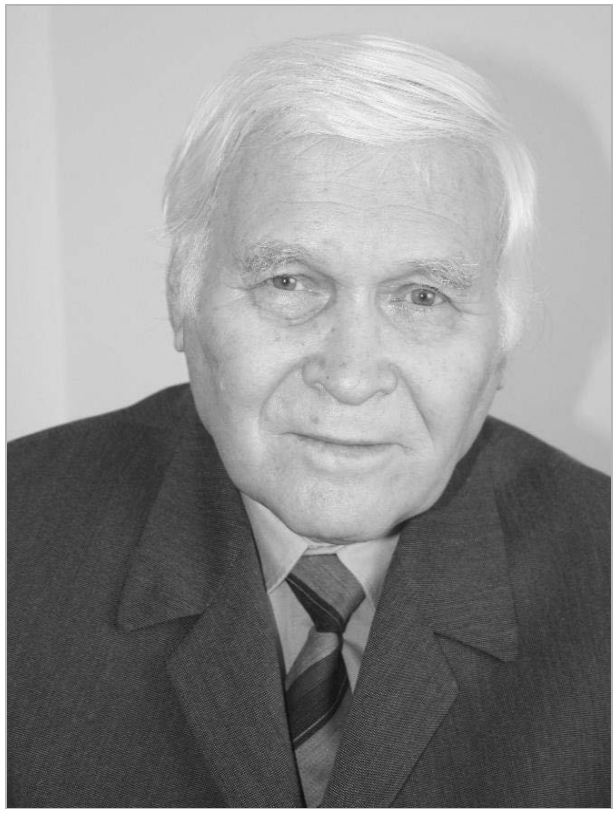
tel. +48 17 872 1833, e-mail: keti@ur.edu.pl

ISSN 2719-6550
ISSN 2719-7417 online

DOI: 10.15584/jetacomps

ADDRESS OF PUBLISHER
PUBLISHING OFFICE UR
prof. S. Pigonia 6 Street, 35-959 Rzeszów, tel. 17 872 13 69, tel./faks 17 872 14 26
e-mail: wydaw@ur.edu.pl; https://wydawnictwo.ur.edu.pl
Issue I; size B5; publisher's sheet 10,5; signature 11; editor's contract 110/2022

Printing and binding: Printing house University of Rzeszów



We dedicate this publication to the late Professor Ján Stoffa (1937–2022) a Slovak, Czech, but also Polish engineer and humanist, who in his scientific work combined the development of technology with the development of education in the periodic DIDMATTECH conferences.
We are grateful that his chief idea was to build scientific bridges between researchers not only from European countries but also from around the world.

Editors and Authors

Professor Ing. Ján Stoffa, DrSc.
(*11 July, 1937, †20 July, 2022)

Prof. Ing. Ján Stoffa, DrSc., born on July 11, 1937 in the village of Šamudovce (Michalovce district).

Prof. Ján Stoffa's professional career began to take shape at the Electrical Faculty of the Slovak Technical University in Bratislava, and in 1967 he successfully defended his doctoral thesis at the same faculty and received the degree of candidate of technical sciences. In 1970, he successfully habilitated in the field of electrical engineering, and in 1979, he completed his scientific development with the DrSc degree of Doctor of Technical Sciences. In 1980, at the age of 43, he was appointed professor of electrical engineering, which was the first time in Czechoslovakia that he was awarded the title of professor of electrical engineering. He worked at universities in both the Czech Republic and Slovakia, including their immediate leadership. He was the first professor in the history of the CSSP Military Technical School in Liptovsky Mikulash.

His influence has been significantly applied in the development of the current shape of the Department of Technical and Information Education of the Faculty of Education at Olomouc University, with which he has been associated as a professor since 1995, and has also served as head of the department since 1996. He has contributed significantly to changing the profile of the faculty and to the overall increase in its prestige, making the department one of the recognized places of work at home and abroad. In addition to the traditional combinations of disciplines in the teaching process, he is also credited with expanding the number of dual-discipline combinations in the UP Department of Philosophy. He participated in the teaching of many subjects and also invented and introduced new subjects into the curriculum, such as Electrical Engineering, Technical Terminology and Scientific and Technical Information. Under his leadership, by the decision of the Accreditation Commission, the name of the field of study Technical Education was changed to Technical and Information Technology Education, which ushered in a new era of technical and information technology education at the Faculty of Philosophy of UP in Olomouc. Under his leadership, the faculty's scientific activities underwent a fundamental change in the number and level of grants and projects, which began to focus on solving current scientific problems, including projects of the General Council for Science. The level of presentation of scientific results has also improved, especially in the form of publications and conferences organized by the faculty. He was instrumental in establishing three international scientific conferences, DIDMATTECH, Trends in Education, and Modernization of Teaching in Technically Oriented Disciplines and Subjects, and contributed to a significant deepening of the Department's cooperation with sister departments at home and especially abroad.

He has also published a remarkable number of scientific and professional papers that are thematically related to the directions of his scientific interests. Prof. Stoff's activities and results have been the subject of recognition and awards, and many of his papers have been cited by other authors in the Czech Republic and abroad. After his retirement, he was appointed Professor Emeritus of UP in 2009 and continued to work very closely with the UP Pedagogical Department, especially the Department of Technical and Computer Education.

Prof. Ing. Ján Stoffa, Ph.D., created an indelible and important mark not only in his original field of electrical engineering, but was also one of the prominent figures in the fields of technical education didactics, material science, and technical terminology. Prof. Ján Stoff's career, way of working, and achievements were, and certainly still are, in many ways stimulating and inspiring, not only in the technosphere.

Doc. PhDr. Miroslav Chráska, Ph.D.

CONTENTS

EDITORIAL

The current issue of the quarterly scientific journal Education – Technology – Computer Science in 2022 consists of four main thematic parts.

Part one, entitled *Selected Problems of School Education*, features articles presenting, among other things, research on mapping pedagogical patterns that can be applied to the teaching of computational thinking, and teacher preparation in mathematics and ecological education.

The second part, titled *Selected Problems of Using Information Technology in Education*, consists of papers presenting, among other things, the concept of applying QEEG research in evaluating teaching activities in technical education; the interdisciplinary nature of augmented reality; a research- and problem--solving-oriented model for educating students in technical education in a general education school; and the possibilities of applying new 3D printing technologies in education.

The third part, entitled *Selected Problems of Professional Education*, describes in three articles the experimental verification of a model for the organization of professional education of communication management specialists in higher education institutions; the assessment of the compatibility of the professional competencies of graduate-ecologists with the needs of the labor market; and the need to find a balance between the protection of the fundamental rights of individual patients to privacy and dignity and the need for research by the pharmaceutical industry.

The fourth part, entitled *Selected Problems of Educational Research Conducted in the Doctoral Seminar*, describes here, among other things, the practical requirements for an educator as a diagnostician in an attempt to respond to the ever-changing regulations on organizing and providing psychological and pedagogical assistance in public schools; the use of mediation in the educational space of the teacher's work; and examples of the use of information and communication technology (ICT) tools in physics lessons.

Readers are encouraged to critically analyze and prepare polemical texts with regard to the various topics of educational research discussed in the pages of the quarterly.

PART ONE

SELECTED PROBLEMS OF SCHOOL EDUCATION

©University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 6.10.2022
Accepted for printing: 10.11.2022
Published: 22.12.2022
License: CC BY-SA 4.0

DOI: 10.15584/jetacomps.2022.3.1

LOICE VICTORINE ATIENO[1], **MÁRTA TURCSÁNYI SZABÓ**[2]

Enhancing Teaching Computational Thinking: a Systematic Mapping of Pedagogical Patterns

[1] ORCID: 0000-0002-4697-2900, MA, Eötvös Loránd University, Faculty of Informatics, Department of Media & Educational Informatics, Hungary
[2] ORCID: 0000-0002-8962-1959, Ph.D, Associate professor, vice-dean for Educational Innovation, Eötvös Loránd University, Faculty of Informatics, Department of Media & Educational Informatics, Hungary

Abstract

Efforts to enhance understanding Computational thinking (CT) are curtailed by: (i) problem solving complexity linked to implementing a new subject; and (ii) teaching CT for problem solving is a new field. Unfortunately, the only support available are pedagogic theories and anecdotal explaining other's practice. Implementing these theories can be challenging, hence continuous research on realistic methods of sharing successful and commendable practice amongst educators, necessitating this study. Systematic Mapping (SM) was used with the following steps: research questions formulation; identifying keywords; identifying source databases; defining inclusion and exclusion criteria; constructing the search string; conduct the search; data extraction; and presentation of results. 22 studies were selected with the majority being solution proposal research. The identified pedagogical patterns were mapped to the 5Es of Framework of Action. Several patterns for solving assessment related problems were also identified hence the inclusion of the 6th E (Evaluation).

Keywords: pedagogical patterns, systematic mapping, computational thinking, teaching computational thinking, framework of action

Introduction

Recently, researchers have progressively reviewed matters related to teaching and learning (Fioravanti, Barbosa, 2016), with computational learning applications, playing a vital role in teaching and training activities, displaying growing significance (Svetlana, Yoon, 2009). This includes teaching and learning CT. Developing CT education necessitates teachers to be methodically prepared as

regards to designing CT learning activities, teaching and assessing CT, and teaching CT concepts using technologies (Angeli, Giannakos, 2019). Although significant attempts have been made in improving the conceptualization of CT, teaching CT for problem solving is a new domain for most teachers coupled with complexity of problem solving resulting from executing new subject matter (Cooper, Gunckel, 2019). There are also challenges resulting from existing and emerging learning designs as a result of new ideas augmented by utilization of new technologies (Laurillard, Derntl, 2014).

Despite the challenges, teachers are required to equip themselves with new subject knowledge (Brown et al., 2013; Sentance et al., 2013; Thompson, Bell, 2013), and embrace new suitable subject delivery pedagogies more so, those associated with algorithms, programming and development of CT (Sentance, Csizmadia, 2017). Unfortunately the only support available are the pedagogical theories and anecdotal explanations of other's practice (Laurillard, Derntl, 2014). The implementation of these theories and research can be challenging, hence the continuous research on realistic methods of sharing successful and commendable practice amongst educators (Philip, 2018).

This paper investigates the existing research on pedagogical patterns, with the aim of establishing their suitability in enhancing teaching CT. To achieve our aim, a systematic mapping was performed by analysing scientific papers from various sources. The results are relevant as more studies on improving the conceptualisation of CT are still underway. CT teachers just like other teachers require well documented pedagogical practices that could help enhance their teaching.

The subject matter of the study. Related Studies

Teaching CT has conventionally been perceived as predominantly a constructionism undertaking (Bers et al., 2014; Buss, Gamboa, 2017). Constructionism posits that by constructing significant projects in a community of learners and carefully reflecting on the process, deep learning can take place among the learners (Bers et al., 2014). Thus learners, through technology are accorded autonomy to discover their own interests (Bers, 2008) while exploring domain-specific content learning and applying metacognitive, problem-solving, and reasoning skills (Bers et al., 2014; Papert, 1980). Constructionism is based on the view that the most effective learning experiences stem from four core activities: designing, personalizing (Bruckman, 2006; Papert, 1980), sharing (Papert, 1980), and reflecting (Kolodner et al., 2003; Papert, 1980).

As teachers embrace the teaching of CT, novice teachers find it hard and time consuming matching existing pedagogical practices to existing pedagogical theories while depending on their insight or pedagogies observed when students (Maher et al., 2020). Teachers require strategies and supporting documentation that would enhance the teaching of CT and this include pedagogical patterns. This study explored the existing pedagogical patterns to identify the relevant

pedagogical patterns and map them to the 5Es (**E**xplore, **E**nvisage, **E**xplain, **E**xchange and bridg**E**) of Framework of Action. The *Framework of Action* by (Benton et al., 2016, 2017), comprising five unordered components dubbed 5Es that present a guide for establishing the right levels of intervention with the desire to design a constructionist approach to learning (Benton et al., 2017). With the 5Es giving the intervention points, teachers need a guide on how to implement the interventions hence the need for relevant pedagogical patterns.

Research methodologies and tools. Systematic Mapping

Studies involving pedagogical pattern, resulting from architectural patterns (Alexander et al., 1977; Alexander, 1979), have evolved from the building of patterns and pattern languages (Bergin et al., 2002), to refined studies that looked at how the existing patterns can be mapped to the problems that they can solve (Köppe, 2015; Fioravanti, Barbosa, 2016, 2018). Teaching CT for problem solving has elicited several challenges, provoking the need for accessible, easy to use, and adaptable contextualised models and representations (Bennett et al., 2007; Bower, 2017; Goodyear, Retalis, 2010) such as pedagogical patterns. The main contribution of this study is to identify the relevant pedagogical patterns and systematically map them to the 5Es to facilitate the implementation of interventions required to develop CT among learners.

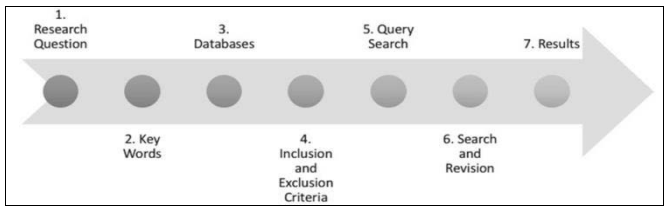


Figure 1. The Systematic Mapping Process (Ramirez et al., 2017)

The following steps (Figure 1) were performed in the systematic mapping (SM) process: (i) three research questions were formulated, (ii) identifying keywords for the searches in English (iii) the source databases defined, (iv) the paper inclusion and exclusion criteria and time range defined, (v) defining the search string, (vi) conduct the search, (vii) Data extraction, (viii) presentation of results.

Analysis of research results

1. *Defining Research Questions*

In this study, the aim of the SM was to conduct a review on the existing pedagogical patterns with emphasis on: (i) establishing the patterns that can be used to teach CT and (ii) map them to the learning activities based on the problems they can solve. The following questions were raised to guide the study:

Q1: What existing pedagogical patterns can be deployed in teaching CT?

Q2: What problems do the identified pedagogical patterns aim at solving or mitigating while teaching CT?

Q3: Where can the pedagogical patterns be applied to enhance teaching CT?

2. *Identifying Keywords for the Search*

The following keywords in English were used to obtain better results of the searches and enable a more comprehensive review in the databases: pedagogical pattern(s), educational pattern(s), teaching pattern(s) and learning pattern(s).

3. *The Source Databases*

It is recommended searching several electronic sources (Brereton et al., 2007). The search was conducted in the following databases: Google Scholar, ACM, Scopus, Springer Link, Web of Science and ScienceDirect. The databases are internationally recognised in engineering, computer science and education research (Ramirez et al., 2017). A generic search string was deployed realising 6,291 hits as distributed in Table 1, out of which 2956 were identified as duplicates and excluded. The remaining 3,335 articles were explored further in the screening step.

Table 1. Articles per Database Searched

Database	URL	Acronym	Total Studies
Google Scholar	<scholar.google.com>	GS	2,304
ACM Digital library	<dl.acm.org>	ACM	289
Web of Science	<webofknowledge.com>	WoS	554
Springer	<link.springer.com>	Springer	1,514
SCOPUS	<scopus.com>	SCOPUS	712
Science direct	<sciencedirect.com>	ScienceDirect	918
Total			**6,291**

4. *Screening the Articles for Inclusion and Exclusion*

To avoid missing out on important studies the time range of the studies was undefined. Inclusion and exclusion criteria were applied to establish the studies that possess the potential of answering the research questions.

Inclusion: Primary studies that: (i) contain at least one full pedagogical pattern that can be used in teaching CT; (ii) papers published in journal, conferences, books, book chapters; (iii) papers written in English; and (iv) papers found in the databases listed and can be downloaded.

Exclusion: Studies that: (i) cannot be downloaded; (ii) not written in English; and (iii) Gray literature.

Out of the 3,335 studies evaluated, 25 were selected for the next step. This was arrived at by reading the paper to establish if it can help answer the research questions.

5. *Defining the Search String*

The search does not involve all the existing pedagogical patterns, but only those relevant to the teaching of CT. Considering that there are no pedagogical patterns for teaching CT in particular, search string shown in Table 2 was formed using generic but relevant terms.

Table 2. Generic Search String

("pedagogical pattern" OR "pedagogical patterns" OR "teaching pattern" OR "teaching patterns" OR "educational pattern" OR "educational patterns")

6. *Search Process*

The abstracts were read in search for the keywords and concepts that reflect the contributions of the paper to identify the relevant articles. The classification was done using two main facets:

Pattern category: used to group the patterns based on their application towards the development and enhancement of CT. The patterns were organised according to the 5Es of *Framework of Action* (Benton et al., 2016, 2017) summarised in Table 3, that acted as a guide in establishing the right levels of intervention coupled with the desire to design a constructionist approach to learning (Benton et al., 2017).

Table 3. 5Es of Framework of Action

Component	Description
Explore	Learners requirechances to investigate concepts by attempting issues on their own and correcting errors (Benton et al., 2016, 2017).
Envisage	Learners should be inspired to project the results before creating the projects and then reflect on the real result.
Explain	Teacher as well as peer facilitated opportunities should be availed to the learners using reflective questioning (Benton et al., 2017).
Exchange	Inclusion of significant possibilities for sharing and building on others' ideas (Benton et al., 2017).
BridgE:	Ideas are perceived as influential partly due to their link to other fields for example mathematics (Papert, 1980).

Research type: reflects the research approach employed in the articles. An existing classification of research approaches by Wieringa et al. (2006), summarised in Table 4 was used (Wieringa et al., 2006).

Table 4. Research Type Facet

Category	Description
Validation Research	Investigate novel techniques for example experiments.
Evaluation Research	Evaluation of already implemented techniques.
Solution Proposal	A proposed problem solution that can be either novel or a significant extension of an existing technique.
Philosophical Papers	Draw a new way of viewing existing things by organizing the study in the form of a taxonomy or conceptual framework.
Opinion Papers	Express personal opinion and do not rely on related work and research methodologies.
Experience Papers	Explain what and how something has been accomplished in practice, giving the author's own experience.

7. *Data Extraction and Mapping process*

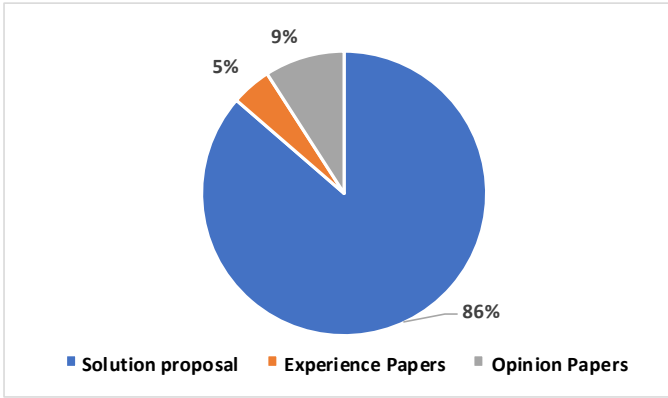
Data was extracted from the studies using a data extraction template in Table 5 and the results summarised to answer the research questions.

Table 5. Data Extraction Template

Field Name	Description	RQ to be Answered
Research ID	Comprising letter 'R' and an integer	
Research Title	Title of the research	
Author(s) & Pub Year	Name of the author(s) & year of publication	
Research Type	Research classification (Table 3)	
Pattern ID	Comprising letter 'P' and an integer	
Pattern Name	Name of the pattern	RQ1
Application Problem	Problem where the pattern is applied	RQ2
Pattern Category	Pattern application area	RQ3

8. *Results of the Systematic Mapping*

In this step, the summary of the selected articles is presented with the articles categorised using the research type as shown in Graph 1.



Graph 1. Distribution of Selected Studies based on Research type

Solution proposal studies formed most of the selected studies (84%), with opinion and experience papers constituting 12% and 4% respectively. Validation research, evaluation research or philosophical papers were missing among the selected studies. This is evident that even though pedagogical patterns for various solutions have been proposed, their validation and evaluation is still lacking. The selected studies and their information are initially presented in summary form as shown in Table 6.

The patterns selected were based on the 5Es of *Framework of Action* (Benton et al., 2016, 2017) summarised in Table 3, guided by the core learning activities: designing and creating, personalisation, sharing and reflecting (Brennan, 2015).

Table 6. Selected Articles

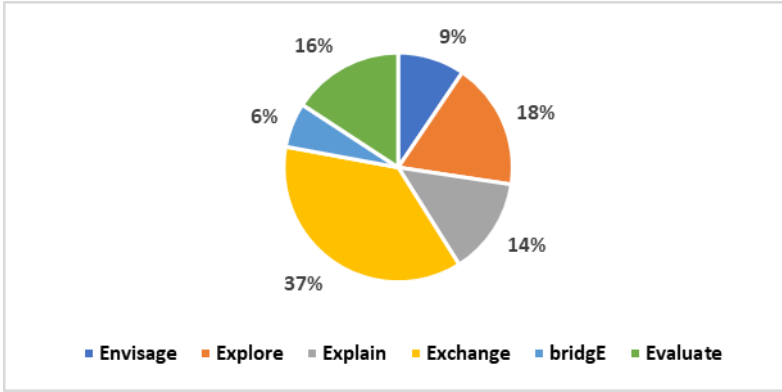
ID	Title of the Study	Author(s) & Year
R01	Pedagogical Patterns for Creative Learning	Iba et al., 2011
R02	Learning Patterns III: A Pattern Language for Creative Learning	Iba, Sakamoto, 2011
R03	Learning Patterns: A Pattern Language for Creative Learners II	Iba, Miyake, 2010
R04	Educational Patterns for Generative Participants: Designing for Creative Learning	Shibuya et al., 2013
R05	Educational Design Patterns for Student-centred Assessments	Köppe et al., 2020
R06	Lecture Design Patterns: Improving Interactivity	Köppe, Schalken--Pinkster, 2013
R07	Assessment-Driven Course Design – Fair Play Patterns	Bergin et al., 2015
R08	Flipped Classroom Patterns – Designing Valuable In-Class Meetings	Köppe et al., 2015
R09	Patterns for Gaining Different Perspectives	Bergin et al., 2001
R10	Continuous Feedback Pedagogical Patterns	Larson et al., 2008
R11	Learning Patterns for Group Assignments – Part 1	Köppe, 2012
R12	Learning Patterns for Group Assignments – Part 2	Cortie et al., 2013
R13	Improving Student Group Work with Collaboration Patterns: A Case Study	Köppe, Eekelen et al., 2015
R14	Patterns of Active Learning	Eckstein et al., 2002
R15	Applying and Developing Patterns in Teaching	Bennedsen, Eriksen, 2003
R16	Pedagogical Patterns Successes in Teaching Object Technology A Workshop from OOPSLA '96	Sharp et al., 1996
R17	Active Learning and Feedback Patterns Version 4	Bergin, 2006
R18	Interaction Design Patterns for Classroom Environments	Breuer et al., 2007
R19	Patterns for the creation of e-learning content and activities in a university setting	Holden et al., 2010
R20	Design and Communication Patterns Observed in an eLearning Design Team: A Case-Study	Rapanta et al., 2010
R21	A Pedagogical Pattern Language for Mobile Learning Applications	Fioravanti, Barbosa, 2017
R22	Guess my X and other techno-pedagogical patterns: Toward a language of patterns for teaching and learning mathematics	Mor, 2010

A total of 73 patterns were extracted and summarised as shown in the excerpt in Table 7. The table shows the pattern ID, name and problem the pattern is supposed to solve. The patterns were further categorized according to the teacher interventions guided by the 5Es of Framework of Action as shown in *Graph 2*. Exchanges that cover collaboration, group work and even sharing have the highest number of patterns with 37%. This shows how much collaboration has been prominent in learner-centred learning. Evaluation, which was not one of the 5Es also had higher % hence forming the 6th E in the study.

Table 7. Excerpt of Patterns and the Application Problems

Pattern ID	Pattern name	Problem
1	***2***	***3***
P01	Discovery-Driven Expanding	Suddenly introducing collaborative learning (learner-centred learning) creates difficult for learners to perform and learn from their experience effectively.

1	*2*	*3*
P02	Generative Participant	Communication for the collaboration doesn't always go smoothly and often stops and sometimes falls into the situation where a very few members control and others follow it
P14	Student Miners (Collaborative Knowledge Construction)	Just presenting a new concept makes it hard for students to relate this new knowledge to their existing knowledge and keeps them in an undesired passive role.
P15	Question Parking Space	Handling learners' questions that do not directly relate to the content or require a longer or very specific answer.
P16	Collaborative Summary	It keeps learners passive if you just present the list of content covered to the students and run through all the bullets.
P23	Every Student Solution Counts	Students may feel that their work is not considered relevant and stop handing it in.
P25	Explore For Yourself	You want to give your learners the ability to learn in the future and to communicate their wisdom, but students are often afraid of taking responsibility for their own learning.
P30	Think...Pair...Share	Students' focus is not on the lesson.
P37	Share Expectations	Students might have different expectations of the results and the way of working on the assignment. This often leads to conflicts or an inefficient way of working.
P41	Mediate the Dispute	There is a dispute between group members, which has a negative impact on the motivation and the participation. There might be negative consequences on the project results.
P42	Keep Motivated	During the execution of a group assignment, insufficient participation, bad quality deliverables or simply not getting satisfaction from the given tasks can be the result of decreased motivation.
P44	Regularly Check Requirements Fulfilment	A group assignment is given to a group of students. The project consists of single or multiple deliverables and the quality requirements for both intermediate and final goals are determined, either by the teacher or the students. You are at the beginning, middle or final phase of the project.
P49	Invisible Teacher	Usually, the teacher is the central point of a training environment. Often the students only trust the teacher and (maybe) themselves, However, in the work environment the teacher will not be around.
P50	Study Groups	Your best students may often be bored, because they have finished a task quickly while the poorest struggle constantly.
P52	Real World Experience	A lot of concepts are too abstract for students to conceive their value and learners often doubt the viability of these concepts
P55	Nobody is Perfect	Learners expect only one right solution to a problem from the instructor. However, there is no single answer, but many equally correct answers.
P56	Explore-Present-Interact--Critique (EPIC)	Allows learners to learn new material efficiently and share the knowledge with peers by forcing them into being the teacher for themselves.
P58	Play, Reflect, Jump	How to kick-start the learning design process, create a shared vision for the aims of the course and ensure the overall vision for the course is reflected in its detailed learning design plan.
P73	Soft scaffolding	Providing direction and support while maintaining the learners' freedom, autonomy and sense of self as well as the teachers' flexibility to adapt.



Graph 2. Pattern Categorised According to the Application Areas

Conclusions and Way Forward

This study presented a mapping of pedagogical patterns to be deployed in the teaching of CT. The motivation towards pedagogical patterns approach is necessitated by the need for sharing knowledge and good practices between research literature and the real world, for facilitation and communication purposes between stakeholders. A systematic mapping methodology was deployed with the aim of conducting an impartial assessment of the literature. It is worth noting that the study concentrated in establishing the pedagogical patterns that can be used by teachers while executing the interventions at the various intervention points guided by the 5Es of the Framework of Action (Envisage, Explore, Explain, Exchange and bridgE) in learner-centred learning. Assessment patterns contributed to 16% of the patterns identified hence necessitating the inclusion of a new component – Evaluation) forming the 6th E. This study is part of the study to develop a comprehensive and flexible framework for developing and enhancing CT among learners in different learning levels and different learning contexts.

References

Alexander, C. (1979). *The Timeless Way of Building*. Oxford: Oxford University Press.

Alexander, C., Ishikawa, S., Silverstein, M., Jacobson, M., Fiksdahl-King, I., Angel, S. (1977). *A Pattern Language: Towns, Buildings, Construction*. Oxford: Oxford University Press.

Angeli, C., Giannakos, M. (2019). Computational thinking education: Issues and challenges. *Computers in Human Behavior*. https://doi.org/10.1016/j.chb.2019.106185.

Bennedsen, J., Eriksen, O. (2003). Applying and Developing Patterns in Teaching. *Frontier in Education, FIE 33rd Annual*, *1*(T4A-2), 4–9.

Bennett, S., Agostinho, S., Lockyer, L., Kosta, L., Jones, J., Koper, R., Harper, B. (2007). Learning designs: Bridging the gap between theory and practice. In: *ICT: Providing Choices for Learners and Learning. Proceedings Ascilite Singapore 2007.*, 51–60.

Benton, L., Hoyles, C., Kalas, I., Noss, R. (2016). Building mathematical knowledge with programming : insights from the Scratch Maths project. *Constructionism 2016 Conference Proceedings*.

Benton, L., Hoyles, C., Kalas, I., Noss, R. (2017). Bridging Primary Programming and Mathematics: Some Findings of Design Research in England. *Digital Experiences in Mathematics Education*, *3*(2), 115–138. https://doi.org/10.1007/s40751-017-0028-x.

Bergin, J. (2006). Active learning and feedback patterns: Version 4. *Proceedings of the 2006 Conference on Pattern Languages of Programs, PLoP'06*. https://doi.org/http://doi.acm.org/10.1145/1415472.1415479.

Bergin, J., Eckstein, J., Manns, M. L., Sharp, H., Sipos, M. (2002). *Teaching from Different Perspectives*. Create Space. Retrieved from: http://www.pedagogicalpatterns.org/current/FromDifferentPerspectives.pdf (10.09.2022).

Bergin, J., Eckstein, J., Wallingford, M.L.M.E. (2001). Patterns for Gaining Different Perspectives. *Proceedings of PLoP'01*, 1–17.

Bergin, J., Kohls, C., Köppe, C., Mor, Y., Portier, M., Schümmer, T., Warburton, S. (2015). Assessment-Driven Course Design – Fair Play Patterns. *Proceedings of the 20th European Conference on Pattern Languages of Programs, EuroPLoP'15*.

Bers, M. (2008). *Blocks to Robots: Learning with Technology in the Early Childhood Classroom*. Teachers College Press.

Bers, M., Flannery, L., Kazakoff, E.R., Sullivan, A. (2014). Computational thinking and tinkering : Exploration of an early childhood robotics curriculum. *Computers & Education*, *72*, 145–157. https://doi.org/10.1016/j.compedu.2013.10.020.

Bower, M. (2017). Design Thinking and Learning Design. In *In Design of Technology-Enhanced Learning Integrating* (pp. 121–158). Bingley: Emerald Publishing.

Brennan, K. (2015). Beyond Technocentrism Supporting Constructionism in the Classroom. *Constructivist Foundations*, *10*(3), 289–304.

Brereton, P., Kitchenham, B.A., Budgen, D., Turner, M., Khalil, M. (2007). Lessons from applying the systematic literature review process within the software engineering domain. *The Journal of Systems and Software*, *80*(4), 571–583. https://doi.org/10.1016/j.jss.2006.07.009.

Breuer, H., Baloian, N., Sousa, C., Matsumoto, M. (2007). Interaction Design Patterns for Classroom Environments. *Human Computer Interaction, HCL Applications and Services*, 163–172.

Brown, N.C.C., Kölling, M., Crick, T., Jones, S.P., Humphreys, S., Sentance, S. (2013). Bringing computer science back into schools: Lessons from the UK. *Proceedings of the 44th ACM Technical Symposium on Computer Science Education (SIGCSE 2013)*, 269–274.

Bruckman, A. (2006). Learning in online communities. In: K.R. Sawyer (ed.), *Cambridge handbook of the learning sciences* (pp. 461–472). Cambridge: Cambridge University Press.

Buss, A., Gamboa, R. (2017). Teacher Transformations in Developing Computational Thinking : Gaming and Robotics Use in After-School Settings. In: P.J. Rich, C.B. Hodges (eds.), *Emerging Research, Practice, and Policy on Computational Thinking* (pp. 189–203). https://doi.org/10.1007/978-3-319-52691-1.

Cooper, J.A., Gunckel, K.L. (2019). *Teacher Perspectives of Teaching Computational Thinking* (Issue April).

Cortie, T.D.E., Broeckhuijsen, R.V.A.N., Bosma, G., Köppe, C. (2013). Learning Patterns for Group Assignments – Part 2 Learning Patterns for Group Assignments – Part 2. *Proceedings of the 20th Conference on Pattern Languages of Programs, PLoP '13*, 18 pages.

Eckstein, J., Bergin, J., Manns, M.L., Sharp, H. (2002). Patterns for Active Learning. *Proceeding of PLoP'2*.

Fioravanti, M.L., Barbosa, E. (2017). A Pedagogical Pattern Language for Mobile Learning Applications. *Proceedings of the 24th Conference on Pattern Languages of Programs (PLoP 2017)*, 22 pages.

Fioravanti, M.L., Barbosa, E.F. (2018). A Catalog of Pedagogical Patterns for Learning Applications. *Proceedings of the 48th Annual Frontiers in Education Conference (FIE 2018)*. https://doi.org/10.1109/FIE.2018.8658904.

Fioravanti, M.L., Barbosa, E.F. (2016). A systematic mapping on pedagogical patterns. *Proceedings of the 46th Annual Frontiers in Education Conference (FIE 2016)*, 1–9. https://doi.org/10.1109/FIE.2016.7757407.

Goodyear, P., Retalis, S. (2010). Learning, Technology and Design. In: P. Goodyear, S. Retalis (eds.), *Technology-Enhanced Learning: Design Patterns and Pattern Languages* (2nd ed., pp. 1–27). Sense Publishers.

Holden, G., Schadewitz, N., Rapanta, C. (2010). Patterns for the creation of e-learning content and activities in a university setting. *Proceedings of the 15th European Conference on Pattern Languages of Programs, PLoP'15*. https://doi.org/10.1145/2328909.2328922.

Iba, T., Ichikawa, C., Sakamoto, M., Yamazaki, T. (2011). Pedagogical Patterns for Creative Learning. *Proceedings of the 18th Conference on Pattern Languages of Programs*. https://doi.org/10.1145/2578903.2579165.

Iba, T., Miyake, T. (2010). Learning Patterns : A Pattern Language for Creative Learners II. *Proceedings of the 1st Asian Conference on Pattern Languages of Programs (AsianPLoP2010)*, 4:1–4:6.

Iba, T., Sakamoto, M. (2011). Learning Patterns III: A Pattern Language for Creative Learning. *Proceedings of the 18th Conference on Pattern Languages of Programs, Ser. PLoP '11.*, 29:1–29:8.

Kolodner, J.L., Camp, P.J., Crismond, D., Fasse, B., Gray, J., Holbrook, J., Puntambekar, S., Ryan, M. (2003). Problem-Based Learning Meets Case-Based Reasoning in the Middle--School Science Classroom: Putting Learning by Design™ into Practice. *Journal of the Learning Sciences*, *12*(4), 495–547. https://doi.org/10.1207/S15327809JLS1204_2.

Köppe, C. (2011). Continuous Activity – A Pedagogical Pattern for Active Learning Continuous Activity – A Pedagogical Pattern for Active Learning. *Proceedings of the 16th European Conference on Pattern Languages of Programs (EuroPLoP'11*. https://doi.org/10.1145/2396716.2396719.

Köppe, C. (2015). Towards a Pattern Language for Lecture Design : An inventory and categorization of existing lecture-relevant patterns. *Proceedings of the 18th European Conference on the Pattern Languages of Program, Ser.EoroPLoP'13*. https://doi.org/10.1145/2739011.2739014.

Köppe, C. (2012). Learning Patterns for Group Assignments – Part 1. In ACM (Ed.), *Proceedings of the 19th Conference on Pattern Languages of Programs, PLoP '12* (p. 12 pages).

Köppe, C., Eekelen van, M., Hoppenbrouwers, S. (2015). Improving Student Group Work with Collaboration Patterns : A Case Study. *EEE/ACM 37th IEEE International Conference on Software Engineering*. https://doi.org/doi:10.1109/icse.2015.160.

Köppe, C., Manns, M.L., Middelkoop, R. (2020). Educational Design Patterns for Student--Centered Assessments. *26th Conference on Pattern Languages of Programs, PLoP'19*. https://www.researchgate.net/publication/339362456.

Köppe, C., Niels, R., Bakker, R., Stijn, H. (2016). Flipped Classroom Patterns – Controlling the Pace. *Proceedings of the 10th Travelling Conference on Pattern Languages of Programs, Viking PLoP'16*. https://doi.org/10.1145/3022636.3022637.

Köppe, C., Niels, R., Holwerda, R., Lars, T., Niek, V.D., Turnhout, K. Van, Bakker, R. (2015). Flipped Classroom Patterns -Designing Valuable In-Class Meetings. *Proceedings of the 20th European Conference on Pattern Languages of Programs, EuroPLoP'15, August*. https://doi.org/10.1145/2855321.2855348.

Köppe, C., Schalken-Pinkster, J.H. (2013). Lecture Design Patterns : Improving Interactivity. *Proceedings of the 20th Conference on Pattern Languages of Programs, PLoP'13.*, 15.

Larson, K.A., Trees, F.P., Weaver, D.S. (2008). Continuous Feedback Pedagogical Patterns. *Proceedings of the 15th Conference on Pattern Languages of Programs, PLoP '08.*

Laurillard, D., Derntl, M. (2014). Learner Centred Design – Overview. In *Practical Design Patterns for Teaching and Learning with Technology* (Yishay Mor, pp. 13–16). Sense Publishers.

Maher, M.L., Dehbozorgi, N., Dorodchi, M., Macneil, S., Diego, S. (2020). Design Patterns for Active Learning. In: M.J.A. Keith-Le, P. Morgan (eds.), *Faculty Experiences in Active Learning: A Collection of Strategies for Implementing Active Learning Across Disciplines* (Issues 130–158). University of North Carolina Press.

Mor, Y. (2010). Guess my X and other techno-pedagogical patterns Toward a language of patterns for teaching and learning mathematics. *Proceedings for 13th European Conference on Pattern Languages of Programs (EuroPLoP'08)*, 348–384.

Papert, S. (1980). *Mindstorms: Children, computers and powerful ideas. New York: Basic Books*. Basic Books, Inc.

Philip, R. (2018). Finding creative processes in learning design patterns. *Australasian Journal of Educational Technology*, *34*(2), 78–94. https://doi.org/10.14742/ajet.3787.

Ramirez, G.M., Collazos, C.A., Moreira, F. (2017). A Systematic Mapping Review of All--Learning Model of Integration of Educational Methodologies in the ICT. In: Á. Rocha, A. Correia, H. Adeli, L. Reis, S. Costanzo (eds.), *Recent Advances in Information Systems and Technologies. World CIST 2017. Advances in Intelligent Systems and Computing* (vol. 570). Springer. https://doi.org/https://doi.org/10.1007/978-3-319-56538-5_89.

Rapanta, C., Schadewitz, N., Holden, G. (2010). Design and Communication Patterns Observed in an e-Learning Design Team : A Case-Study. *Proceedings of ED-MEDIA 2010-World Conference on Educational Multimedia, Hypermedia & Telecommunications*, 356–365.

Sentance, S., Csizmadia, A. (2017). Computing in the curriculum: Challenges and strategies from a teacher's perspective. *Education and Information Technologies*, *22*(2), 469–495. https://doi.org/10.1007/s10639-016-9482-0.

Sentance, S., Dorling, M., McNicol, A. (2013). Computer science in secondary schools in the UK: Ways to empower teachers. In: I. Diethelm, R. Mittermeir (eds.), *Informatics in schools: Sustainable informatics education for pupils of all ages. Lecture notes in computer science* (pp. 15–30). Springer. https://doi.org/10.1007/978-3-642-36617-8_2.

Sharp, H., Manns, M.L., Mclaughlin, P., Prieto, M., Dodani, M. (1996). Pedagogical Patterns Successes in Teaching Object Technology A Workshop from OOPSLA '96. *ACM SIGPLAN Notices*, *31*(12), 18–21.

Shibuya, T., Seshimo, S., Harashima, Y., Kubota, T., Iba, T. (2013). Educational Patterns for Generative Participants : Designing for Creative Learning. *Proceedings of the 2013 Conference on Pattern Languages of Programs*, 13pages.

Svetlana, K., Yoon, Y.I. (2009). Adaptation E-Learning contents in mobile environment. *Proceedings of the 2nd International Conference on Interaction Sciences: Information Technology, Culture and Human*, 474–479. https://doi.org/10.1145/1655925.1656012.

Thompson, D., Bell, T. (2013). Adoption of new computer science high school standards by New Zealand teachers. *ACM International Conference Proceeding Series*, 87–90. https://doi.org/10.1145/2532748.2532759.

Wieringa, R., Maiden, N., Mead, N., Rolland, C. (2006). Requirements engineering paper classification and evaluation criteria : a proposal and a discussion. *Requirement Engineering*, *11*(1), 102–107. https://doi.org/10.1007/s00766-005-0021-6.

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 29.10.2022
Accepted for printing: 24.11.2022
Published: 22.12.2022
License: CC BY-SA 4.0

DOI: 10.15584/jetacomps.2022.3.2

JOANNA KANDZIA

Math Teacher and e-Learning Courses. Report on the Project "Modern Mathematics Teacher"

ORCID: 0000-0001-6660-8527, Doctor, Cardinal Stefan Wyszyński University, Institute of Pedagogy, Poland

Abstract

The article is a report on the project conducted by the author, co-financed by the National Center for Research and Development from European funds POWR.03.01.00-IP.08-00-MOC/18 entitled: A modern mathematics teacher. It was dedicated to teachers of mathematics from all over the country, teaching in primary and secondary schools, and future mathematics teachers – gaining qualifications to teach mathematics. The project aimed to improve the quality and efficiency of mathematics teachers' work through active participation in innovative e-learning courses – offered on the navoica.pl platform, concerning new teaching methods based on information technologies. A short description of the four proposed e-learning courses is presented, as well as an analysis of the choices made by the participants depending on the subject[1].

Keywords: algebra, competition tasks, e-learning, mathematical education, mathematical modeling, mathematics teacher, multimedia

Introduction

Cyberspace is remote work, cyber manager – middle and senior management. Engineering offices, tax advisers, lawyers, publishing consultants, and advertising agents are institutions that operate without offices and desks. A huge disproportion has arisen between the rate of human brain development and technological progress. In contrast, the biological, behavioral – reactions, and physiological or emotional needs remained at the same level as several thousand years ago. The enormous progress of civilization and the development of technology

[1] The author was the project coordinator and the main contractor, so some of the wording used in the descriptions are similar to those on the WMPSNŚ UKSW website both as well as to the courses on the navoica.pl platform (Kandzia, 2019). https://wmp.uksw.edu.pl/pl/node/525 (2.01.2019).

forces a specific lifestyle. We are bombarded with an enormous amount of information at a tremendous pace. Our life can be compared to a train traveling at high speed (Kandzia, 2016, p. 124).

The rapidly changing reality forces the educational system and management to change. It also influences the methods and forms of work used by teachers. It requires them to know constructivism as a knowledge, cognition, and learning theory. Appropriate skills, acquired by educators using new technologies are: effective contact with learners, arrangement of virtual problem situations that fully meet the criterion of linking with real life and practice, and finally a reliable evaluation of the achievements of each student (Szafraniec, 2013).

The emergence of the media in human life, and thus in education, changed the privileged position of the teacher in transferring knowledge. There is no longer an impeccable expert who wields power over the students. Every teacher should be prepared to use information technology in their daily work. The computer must be a tool used by all educators. Society demands and needs a new role model of a teacher. A creative, imaginative, competent, effective teacher, looking for new constructive and unconventional solutions tinged with humanism, able to apply and use information techniques. It cannot be a person with computer phobia, (Siemieniecki, 2016), technology related anxiety, and resistance to new challenges. The teacher and educator must adapt his habits and patterns and be a conscious director of the play entitled *Teaching* (Kandzia, 2016, p. 74).

The subject matter of the study. Project description

The implemented project (2019–2021) "A modern mathematics teacher" consists of two editions of four thematic courses each (four of the same). The courses were aimed at mathematics teachers and future teachers – students of teaching specialization from all over Poland as well as mathematics enthusiasts (which happened). They were available on the navoica.pl platform. Participants could train in the following areas:

1. Multimedia in the work of a math teacher.
2. Mathematical modeling.
3. Competition and Olympic tasks.
4. School algebra in a new version.

One or more courses could be selected. Each of the subjects is 23 lessons based on didactic lectures and associated exercises for 8/9 weeks. The lectures were recorded and tagged. The materials for each module were available immediately after the beginning of the course and were active until it ended. Participants could work at their own pace. The obtained messages were verified by short tests after each module and an exam at the end of the course. Each participant had the opportunity to share his observations and impressions on the topics

proposed by the lecturer in the related forums and during discussions. Completing the course was conditional on giving 65% correct answers in all tests (including the exam) and resulted in receipt of a certificate. There was no grading applied. It was possible to attempt the individual tests twice while there was only one attempt for passing the final exam (UKSW, 2019).

Analysis of research results. Characteristics of the courses offered on navoica.pl platform

Multimedia in the work of a mathematics teacher (MPNM, 2020)

The course was created and performed by the author. The main goal of the course was to get acquainted with the methodological workshop of a mathematics teacher using digital media while encouraging the application of several information technology tools. The following issues were considered:

– using application programs to present mathematical problems, with particular emphasis on heuristic methods,

– lessons using the educational resources of websites dedicated to mathematics,

– creating math quizzes,

– geometric constructions using the interactive mathematical program GeoGebra,

– new basic skills for online learning, including teacher and student competencies.

The author coordinated the remaining courses and conducted the second edition.

Mathematical modeling (MM, 2020)

The main goal of the course was to discuss the basic tools needed for mathematical modeling of linear problems. Mathematical modeling is a very extensive topic. Hence, the focus during the course relied on discussion of linear problems. The participants gained the ability to calculate the maximization of profits in production plants and the ability to solve further basic mathematical problems such as backpack problem, and transport problem. In addition they learned how the Google search engine sorts results and how to measure popularity on social networks.

The presented issues are:

– introduction to linear programming, presentation of necessary tools,

– discussion of the graphic method,

– discussion of the simplex method with solutions,

– application of the simplex method in Excel, introduction to the Solver add-in,

– using vectors and eigenvalues, using the Google.com search engine.

Competition and Olympic tasks (ZKO, 2020)

The main goal of the course was to get acquainted with the mathematical competition/Olympic tasks of various categories at the level of primary and secondary schools. The presented material in each of the sections provides basic information on a given scope of the material and the analysis of selected tasks that appeared at provincial competitions, Olympic tasks, or more difficult tasks from textbooks. The issues discussed are:

- equations and systems of equations,
- in-plane geometry,
- combinatorics,
- finite probability of events and independent events,
- sequences, arithmetic, and geometric sequence,
- polynomials and algebraic expressions.

School algebra in a new version (ASNO, 2020)

The main goal of this course was to acquire the skills needed to solve tasks in this field and to consolidate the knowledge of school algebra and the content slightly beyond the degree of difficulty applied by current curriculum. Evidence for the claims could be found. The course covered topics such as:

- arithmetic of polynomials,
- Bézout theorem,
- numerical sets and equations, number field,
- complex numbers and operations on complex numbers,
- vectors, operations on vectors, dot product and vector norm, basis vectors,
- numerical sets and equations – operations on matrices, matrix determinants, inverse matrix,
- matrices and systems of equations – matrix form of a system of equations, solving matrix equations.

Analysis of the research results

The study used reports on logins into the platform and a register of issued course completion certificates. The analysis was made based on four courses for two editions. This allowed us to verify the research problems posed:

1. What is the relation between the number of math teachers enrolled in e-learning courses and the number of those completing this form of self-study?

2. Are female math teachers more consistent in achieving goals than male teachers?

Tables 1 and 2 compare the number of participants with the number of certificates issued, split by women and men, and the ratio of obtained certificates to the number of participants, for two editions.

I edition

Table 1. Comparison of the number of participants with the number of obtained certificates, divided into female and male participants

Name of the course	Number of participants		Together	Number of obtained certificates		Total	Percentage of certificates
	F	M	%	F	M		%
Multimedia in the work of a math teacher	59	8	**67**	44	4	**48**	71.6
Mathematical modeling	62	20	**82**	35	8	**43**	52.4
Competition and Olympic tasks	86	21	**107**	50	15	**65**	60.7
School algebra in a new version	55	8	**63**	43	4	**47**	74.6
Total	262	57	**319**	172	31	**203**	63.6

By analyzing Table 1 it can be stated that most people were interested in the course – Competition and Olympic tasks – as many as 107 participants, whereas 82 people chose mathematical modeling. The other two courses had the smaller number of participants – 67 and 63. The percentage ratio of obtained certificates to the number of participants is slightly different. The most persistent and consistent were Students of school algebra in a new version – 74.6% and multimedia in the work of a math teacher – 71.6% of the obtained certificates in relation to registered persons. Participants of the course – Competition and Olympic tasks obtained fewer certificates, which constitutes – 60.7%; the fewest certificates – 54.2% were completed in the course mathematical modeling. It is worth paying attention to the ratio of the participants' genders: 262 women and 57 men were enrolled. Overall, 172 women – 84.7% and 31 men – 15.3% passed the course.

II edition

Table 2. Comparison of the number of participants and the number of obtained certificates

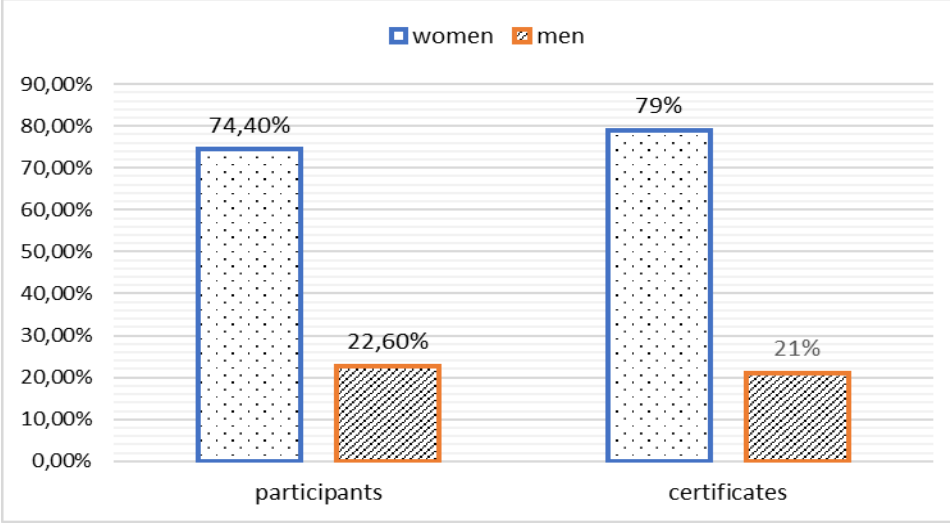
Name of the course	Number of participants		Total	Number of certificates obtained		Total	Percentage of certificates
	F	M		F	M		
Multimedia in the work of a math teacher	33	8	**41**	19	5	**24**	58.5
Mathematical modeling	41	20	**61**	23	12	**35**	55.6
Competition and Olympic tasks	59	22	**81**	23	9	**32**	39.5
School algebra in a new version	39	20	**59**	23	12	**35**	59.3
Total	172	70	**242**	88	38	**126**	52.1

In the second edition, the interest in the courses was much lower, although the course – Competition and Olympic tasks attracted the greatest number of students, as many as 81. In the remaining three courses, the number of students enrolled was comparable. Also, the number of obtained certificates was similar. The highest percentage of obtained certificates was in the course – School Algebra in the new version – 59.3%; Multimedia in the work of a mathematics teacher – 58.5%; Mathematical modeling – 55.6% and Competition and Olympic tasks only 39.5%. In this edition, the training was completed by 88 women, which constitutes 69.8%, and 38 men, which constitutes 30.2% of the total number of participants.

Table 3. Comparison of participation in the courses with the obtained certificates, divided into women and men in the 1st and 2nd editions

Edition	Number of participants				Number of certificates obtained			
	F	%	M	%	F	%	M	%
I	262	82.1	57	17.9	172	84.7	31	15.3
II	172	71.1	70	28.9	88	69.8	38	30.2
Total	434	77.4	127	22.6	260	79.0	69	21.0

Definitely more women continued their self-education compared to men – 434 (74.4%) women and 127 (22.6%) men. 260 (79%) women and 69 (21%) men finished the courses and obtained certificates. The teaching profession is extremely feminized, therefore it is a pleasingfact that so many men have faced the courses. However, the differences between the number of participants and the number of obtained certificates for both women and men are similar and hence comparable.

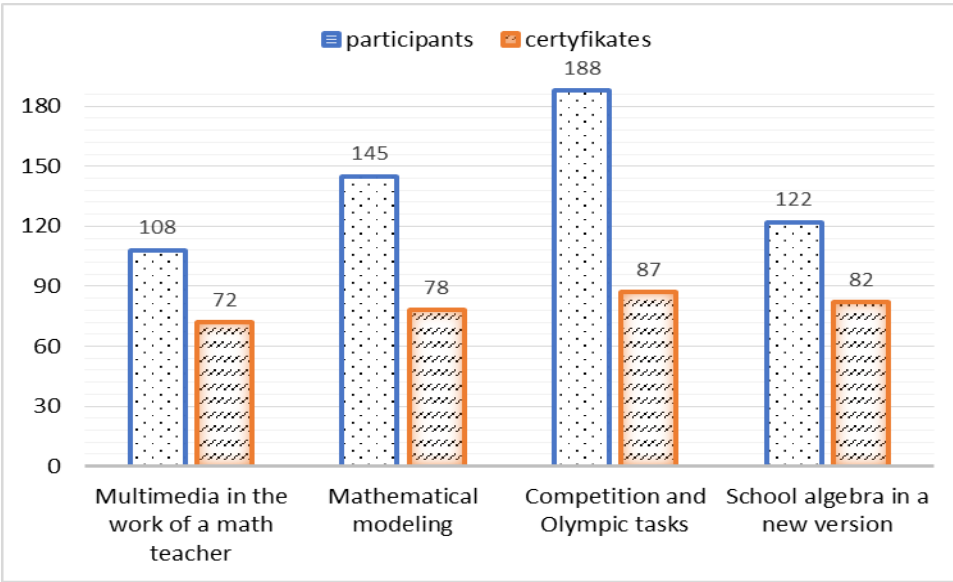


Graph 1. Percentage comparison of participation in the courses with the obtained certificates, divided into women and men in the 1st and 2nd editions

Table 4. Comparison of the number of participants in relation to the number of certificates obtained during the entire project

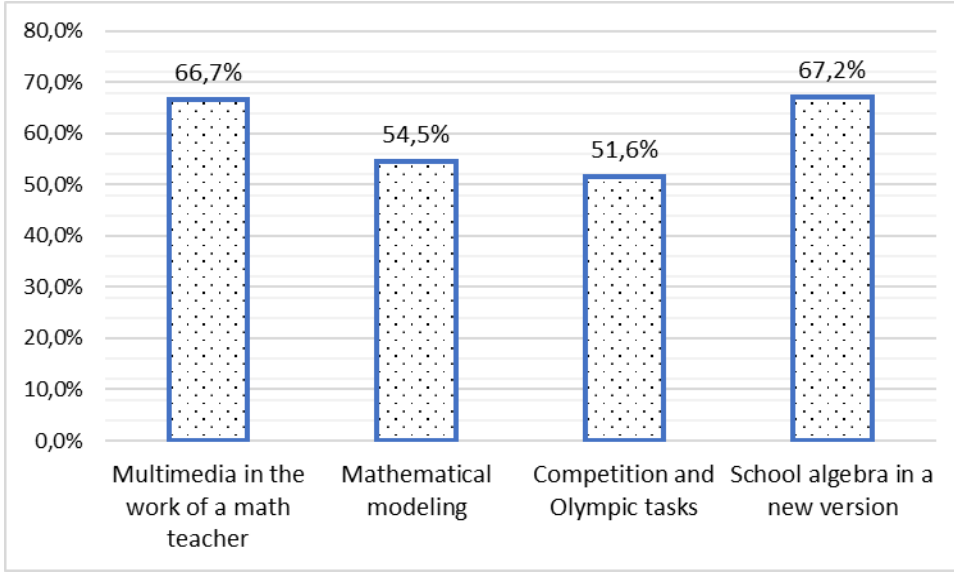
Name of the course	Number of participants	Number of certificates obtained	Percentage of certificates
Multimedia in the work of a math teacher	108	72	66.7
Mathematical modeling	143	78	54.5
Competition and Olympic tasks	188	97	51.6
School algebra in a new version	122	82	67.2
Total	**561**	**329**	56.9

The most popular course was Competition and Olympic tasks which gathered 188 people and graduated 97. Next: Mathematical modeling – 143 people, 78 graduated; The new version of school algebra – 122 people, 82 graduated and Multimedia in the work of a mathematics teacher – 108 people, 72 graduated. 561 people participated in the entire project, and 329 certificates were obtained, which is a ratio of 56.9% graduates.



Graph 2. Quantitative comparison of the number of participants and the number of obtained certificates in the entire project

When comparing the number of students enrolled in the course to the number of obtained certificates, the order is opposite to that in the case of participation. The lowest percentage is: Competition and Olympic tasks only 51.6%; Mathematical modeling – 54.5%; Multimedia in the work of a mathematics teacher – 66.7%; The new version of school algebra was in the first position – 67.2%.



Graph 3. Percentage of the number of participants in particular courses which obtained certificates

Conclusions

The presented analysis allows us to answer the research problems provided:

1. What is the relation between the number of math teachers enrolled in e-learning courses and the number of those completing this type of self-study?

2. Are female math teachers more consistent in achieving goals than male teachers?

Ad. 1

Math teachers prepare students for competitions. Therefore it is not surprising that 188 people signed up for the course on competition and Olympic tasks. Unfortunately, only 96 of them completed the course and obtained certificates, which is 51.6%. The situation was similar during the mathematical modeling course – 143 participants and only 73 exams passed (54.5%). In the other two courses the discrepancy is smaller, but the tendency is similar. A relatively large number of enrolled participants certificates. In the first edition, there is observation made of 319 registered participants resulting in only 103 certificates. In edition II – 242 participants but only 126 certificates. Was it fatigue and aversion to taking tests and exams? Was it discouragement and reluctance to take tests and exams? It can be assumed that there were only people who wanted to check what remote teaching looks like in the university edition or compare it to their actual work and what how they potentially could improve. As a result, even without finishing the course by passing the exam, they got acquainted with the materials and this can be regarded as a positive aspect.

Ad. 2

The analysis of the collected data shows that the majority of participants of all courses, both in the 1st and 2nd edition, were women, which also translates into the number of certificates obtained. Furthermore it can be unequivocally stated that both teachers and mathematics teachers were determined to a similar degree when it comes to achieving goals. There were 77.4% of women enrolled, 79% completed it; there were 22.6% of enrolled men, and 21% completed it. The definite difference between the first and second edition shows that there is less interest in the topic in each of the groups.

Summary

The learning comfort obtained by participants of e-learning courses is very useful in self-education. The main advantages are:

- work at your own pace,
- refill in the gaps of your knowledge,
- expand knowledge with new content,
- meet your own cognitive needs,
- better prepare for classes, credits, exams, self-education, systematics and creativity,
- independence in acquiring knowledge,
- self-responsibility of your education process,
- learn to respect the opinions and views of other participants in distance learning.

Remote learning, despite many advantages, requires self-discipline, motivation (although it was here – obtaining a certificate), consistency, concentration, good organization, and creativity.

The courses and certification were completely voluntary. They were not a ticket to further stages of education. The obtained results are not surprising. When preparing the project application, the author assumed that the course would be completed by at least 50% of the participants. Initial euphoria and then work. Successful participation in e-learning courses requires appropriate competencies on the part of the students. Not everyone can participate in this form of education.

In online learning, an e-tutor takes a very important, if not the most important role. The quality of the didactic process and who the student will become in adulthood depend on his or her competencies and knowledge. Information and communication competencies constitute an inseparable link in remote education. Basic skills in this area are necessary for obtaining, evaluating, storing, creating, presenting, and exchanging information as well as for communication and participation in networks, and cooperation via the Internet (Kandzia, 2016, p. 72).

When talking about e-mathematics teachers and e-learners in mathematics education, one should remember about mathematical competencies necessary in mathematics education. Teaching mathematics is not only substantive and pedagogical knowledge. It is based on: concept formation, motivations, emotions (psychology); communication, language in learning and teaching mathematics, creating symbols, and understanding them (linguistics); equality and diversity (socio-cultural theories); development of mathematical concepts, historical obstacles to understanding mathematical concepts (history and epistemology); the use of technology in mathematics, the use of computers in teaching mathematics (technology) (Kandzia, 2016, p. 136).

It is not enough to place computers "next to" the student or recommend their use in textbooks. It is necessary to link curricula, teaching aids (textbooks, computers and software) and the methods of their use in teaching mathematics. The condition for achieving success resulting from the use of computers in education is full interdisciplinary integration, i.e., the link of information technology considering every sphere of learning and teaching related to mathematics, in combination with the ability to work with information.

Among the general tasks of the school in the core curriculum, the following statement was included: "Teachers create conditions for students to acquire the following skills: (…) search, organize and use information from various sources, and use information technology effectively" (Fundamental Program, 2014).

References

(ASNO)School algebra in a new version. Retrieved from: https://navoica.pl/courses/course-v1:UKSW+ASNO04+2020_02/course/, https://navoica.pl/courses/course-v1:UKSW+ASNO+2021--2/course/ (10.09.2022).

Fundamental Program. Retrieved from: http://www.bip.men.gov.pl/?s=podstawa+programowa (2.06.2021).

Kandzia, J. (2016). *Edukacja matematyczna a cywilizacja cyfrowa. Podmioty kształcenia wobec wyzwań technologii informacyjnej*. Warszawa: Wyd. UKSW.

Kandzia, J. (2019). *Project description.* Retrieved from: https://wmp.uksw.edu.pl/pl/node/525 (1.02.2019).

(MM)Mathematical modeling. Retrieved from: https://navoica.pl/courses/course-v1:UKSW+ZKiO+2021-2/course/, https://navoica.pl/courses/course-v1:UKSW+MM+2021_2/course/ (10.09.2022).

(MPNM) Multimedia in the work of a math teacher. Retrieved from: https://navoica.pl/courses/course-v1:UKSW+MPNM-2+2021-2/course/, https://navoica.pl/courses/course-v1:UKSW+MPNM01+2020_01/course/ (10.09.2022).

Siemieniecki, B. (2016). *Komputerofobia – negatywna reakcja na technologię komputerową*. Retrieved from: www.edukacja.torun.pl.pdf (10.10.2022).

Szafraniec, M. (2013). *Based: Some Thoughts About WebQuest by B. Dodge*. Retrieved from: http://www.intereol.net (10.03.2013).

(ZKO) Competition and Olympic tasks. Retrieved from: https://navoica.pl/courses/course-v1:Uniwersytet_Kardynala_Stefana_Wyszynskiego+ZKO02+2020_01/course/, https://navoica.pl/courses/course-v1:UKSW+ZKiO+2021-2/course/, (10.09.2022).

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 11.07.2022
Accepted for printing: 10.11.2021
Published: 22.12.2022

DOI: 10.15584/jetacomps.2022.3.3

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

Learning Mathematics Through the Modern Didactic Principle of Polyformity

[1] ORCID: 0000-0001-9632-2458, College of Vocational Studies for Educationof Preschool Teachers and Sport Trainers, Serbia
[2] ORCID: 0000-0003-2123-6285, Ph.D., College of Vocational Studies for Educationof Preschool Teachers and Sport Trainers, Serbia

Abstract

Modern teaching of mathematics tries to eliminate the mechanical memorization of a large amount of knowledge, and also tends to avoid the formal development of students' psychological abilities. It is normal that such teaching implies the development of student abilities, not on worthless mathematical material, but on content that is of high quality in terms of education and training. Solving problems, which arouses students' interest and triggers ingenuity, producing experiences of the tension of self-engagement, as a result, necessarily has the triumph of the inventor. Such experiences can create a tendency for mental work, making an indelible mark on the spirit and character of a young person.

Keywords: goal of learning mathematics, didactic principle of polyformity, teacher's role

Introduction

The very conceptof mathematics is in frequent use in various social spheres. As a teaching subject, it activates logical thinking in students and thereby contributes to the development of their competences. In this way it prepares them for certain life vocations and choosing their future occupations. Mathematics teaches us to be wise and to solve problems step by step. It should be loved, because it is logically tangled and as such presents a challenge to many people andencourages their readiness to deal with it in different ways. Each of us can learn math. There is no human activity that does not depend on mathematics. All secondary schools, and many faculties have mathematics as a subject. The importance of mathematics is enormous, not only as an educational subject, but also something that contributes to the development of per-

sonality. The goals and tasks of the teaching subject are strictly defined, and in elementary school they are intended for the acquiring of basic linguistic and mathematical literacy. During schooling, 15% of students express a greater or lesser need for private mathematics lessons by the time they enter the fifth grade of elementary school, 25% by the time they enter high school, 40% by the time they enter college, and up to 90% at the faculties where they study, or more precisely, listen to this subject. Many researches conducted in Serbia in the last few years point to a high level of mathematical anxiety among students. More than half of students worry that they will have difficulties in maths classes and that they will get bad grades. Indifference, if not resistance to mathematics is, in essence, a fundamental trait of human beings. That limitation should be taken into account and adapted to, instead of teachers deluding themselves that a suitable presentation will make mathematics interesting. Mathematics is a science that was created by studying figures and calculating with numbers. It is a science that studies structures that it creates itself or which originate from other sciences (most often physics, but also other natural and social sciences) and describes the properties of those structures. However, mathematics can tell us many things. There are many prejudices about mathematics. Unlike other subjects, in school mathematicscontinuity is necessary, it is necessary to work constantly. Today's students, unfortunately, are generally not inclined to work constantly, they are not persistent enough. The role of teachers is also important here,their readiness to help and their knowledge, ability and talent to do it in the right way. A large part of the material will never be used by most students, although some students will use it all the time. No one can predict exactly how useful knowledge of the square root algorithm will be in the future. It will probably be unnecessary, but what if it inspires someone for some future projects? The number of good ideas is surprisingly small and most of them, after failing in one form, reappear in new forms. "Unnecessary" ideas that are on the decline today may be a hit again when today's students are at the peak of their careers. And all of them can feel the consequences of the hasty reduction of materials due to someone's illusion that the future can be reliably predicted.

The subject matter of the study. The Goal of Learning Mathematics

What distinguishes mathematical thinking from social and natural sciences is not its flexibility, activity, orientation, economy, depth, breadth, originality, laconicism, etc., but its characteristic operation with abstractions, i.e. mathematical phenomena, objects, which are devoid of any materiality, and which we can present in various ways, while only the relations between them are immutable, i.e. invariant. Of course, those relations are described by mathematical axiomatics. However, if we keep part of the mathematical phenomena (objects) and add to them either real or some other abstract objects and apply to them that

characteristic operation with abstractions, whereby the relations between them remain invariant, and which we define partly by mathematical and partly by painting rules, then we get a complete a new mathematical expression, i.e. polyform mathematical style (Nikolic, Lipovac, Medic, 2022). As we have already mentioned, knowledge of mathematics does not improve thinking, although people who think precisely are usually good at mathematics. But that connection is a result of an innate tendency for math/precision thinking, not an effect of math knowledge on thinking. This idea, about the global effects of mathematical knowledge on other areas of knowledge and life, is part of the discredited doctrine of "knowledge transfer", which assumes that acquired knowledge is easily generalized and transferred from domain to domain, so for example when a person has mastered the material of formal logic well, that person becomes a master in logical reasoning on every topic. People think concretely, not abstractly, and it is very difficult for them to apply acquired knowledge to new contexts. Depending on the school's goal for students to learn the application of mathematics, in most cases this application must be specially practiced, because it cannot be assumed that it arises spontaneously from the knowledge of mathematics. This also means that students should be specially prepared for all international mathematics tests based on the application of mathematics and not for dealing with mathematical concepts. However, the application of mathematics must not replace knowledge of mathematics, in the sense of dealing with mathematical concepts and techniques, because the purpose of knowledge of mathematics is only that knowledge, which is a necessary condition for all engineering, a large number of natural and increasingly social sciences. For example, one who does not know algebra cannot master differential calculus, and one who cannot master it, can, for the beginning, say goodbye with practically all engineering professions, a great number of natural sciences and economics. It also permanently limits his understanding of any field that uses statistics. Mathematical literacy is one of the key competencies for lifelong learning, defined as the ability to develop and apply mathematical thinking in order to solve a series of problems in everyday situations (Anić, Pavlović-Babić, 2011) and to ensure that all students acquire basic language and mathematical literacy and progress towards the realization of the appropriate Educational Achievement Standards, as well as to:

– enable students to solve problems and tasks in new and unfamiliar situations,

– enable students to express and justify their opinion and discuss with others,

– develops motivation for learning and interest in subject contents,

– ensure that students acquire elementary mathematical knowledge that is necessary for understanding phenomena and laws in nature and society,

– train students to apply acquired mathematical knowledge in solving various tasks from life practice,

– represents the basis for successful continuation of mathematics education and for self-education,

– contributes to the development of mental abilities, the formation of a scientific view of the world and the all-round development of the student's personality.

In the Republic of Serbia, basic education and upbringing is acquired at school through the implementation of a curriculum lasting eight years. Classroom teaching is organized for students from I to IV grades, and subject teaching is organized for students from V to VIII grades. Teaching subjects in the curriculum are distributed during schooling by classes, and they can be compulsory or optional. Mathematics as a teaching subject appears in ancient Greek schools under the name *logistica numerosa*. Children in age of today's primary school age learned, with the help of an abacus, to count with numbers, which was useful in their everyday life. Geometry was then a scientific discipline that was studied in classical schools of philosophy and mathematics. Therefore, in the teaching of mathematics, the principle of polyformity should have a universal role, which would be presented by enriching the teaching with various contents, means, procedures and methods (Marković, 2012). Today, mathematics is a compulsory general educational subject, whose position in relation to other subjects is indicated by the fact that from I to IV grades, mathematics is offered five hours a week, while in higher grades the number of hours is reduced to four hours a week. If we look at the upper grades of elementary school, except for Serbian language classes in the fifth grade, which is represented by five classes a week, mathematics together with the Serbian language has the maximum number of classes. Mathematics in elementary school is determined by contents, goals and tasks that are determined by the age and psychophysical capabilities of the students. The transfer of knowledge in class was created with the aim of leading the student to the correct conclusion and knowledge through the application of appropriate teaching forms, methods and tools. As mathematics is increasingly applied in everyday life, its successful application requires a general mathematical education. The new principle of polyformity of school organization is based on global requirements for effective pedagogical standards, which enable lifelong learning. Traditional value systems, which, until recently, reflected different patterns of living environments, are increasingly being imposed by a globally acceptable standard of education in modern schools (Nikolić, Hilčenko, 2021).

Research methodologies and tools. Didactic Principle of Polyformity

The didactic principle of polyformity is not encountered at all as a didactic peculiarity, and if it is applied in some places, then it is very rare, intuitive, spontaneous, singular and accidental in the teaching of mathematics in primary

school, high school and colleges. The essence of the application of this principle consists in the permanent insistence on the integral consideration of various approaches to the comprehension and understanding of the studied teaching phenomena, therefore its exploitation in practice requires from the teacher excellent knowledge and the skill of applying the most diverse professional-didactic-methodical possibilities, and induces intensive thinking activity of students expressed in high-quality self-exalting work and greater motivation. (Marković, 2008). The effectiveness of the principle of polyformity is based on the evident psychological fact that changes and diversity in work refreshes teaching, and monotony generally induces a weakening of interest and the appearance of passivity and boredom. The principle of polyformity, due to the mentioned peculiarities, represents a universal scientific and teaching principle, whose epistemological basis is identical to that of the principle of permanence, the law of negation of negation, whereby the principle of polyformity takes on the characteristics of a dialectical law. As the principle of polyformity includes all existing didactic principles, it elevates this principle to the pedestal of universality. That is why the principle of polyformity should play a universal role in teaching mathematics, which would be presented by enriching the teaching with various contents, means, procedures and methods. When we talk about content, we mean the selection of such tasks that allow for a greater number of diverse approaches to solving them and using obvious means. However, organizing such classes requires an adequate application of the polyformity of methodical forms and methodical details of teaching, i.e. their variations in the same lesson (Nikolić, 2021).

Analysis of research results. Application of the Principle of Polyformity in Mathematics Teaching

The essence of the didactic principle of polyformity is reflected in the permanent insistence on the integral consideration of diverse approaches to comprehension and understanding of the studied teaching phenomena. Its exploitation in practice requires the teacher to have excellent knowledge and the ability to perceive the most diverse professional-didactic-methodical possibilities, and it induces an intensive thinking activity of the students made by high-quality self-examination work and greater motivation. That is why the principle of polyformity should have a universal role in teaching mathematics, which would be presented by enriching the teaching with various contents, means, procedures and methods (Penavin, 1971). When we talk about content, we mean the selection of such tasks that allow for a greater number of diverse approaches to their solution and the use of obvious means. However, the organization of such classes requires an adequate application of the polyformity of methodical forms and methodical details of teaching, i.e. Their variations, even methodological innovations in the same lesson. The methodical forms and methodical details that

the teacher plans and observes during the lesson are based on the timely pulsation of didactic principles, which is manifested in their simultaneous polyform-cohesion effect, i.e. integral dialectical unity.

The Role of the Teacher

Learning math is not fun for many people. Mathematics for children of early age was "fun because they added numbers". It was also interesting "when we drew some boots and then added them together", as the children say. The reason why math is boring is, basically, that humans didn't evolve in modern cities but rather in small, technologically primitive groups. As a result, natural selection favored those traits that provided an evolutionary advantage in that environment – traits that may or may not be adaptive today. For example: for someone living in a small group of people, knowing information about who did what to whom is of fundamental importance, and this is the root of the universal human need for gossip (in the modern environment, this instinct has the unusual consequence that people collect information about celebrities – people with whom they have no connection, but who are perceptibly constantly present, which once upon a time meant really relevant). Thus, indifference if not resistance to mathematics is, in essence, a fundamental trait of human beings. And that limitation should be taken into account and adapted to, instead of deluding yourself that mathematics can become interesting with a suitable presentation. Like writing, mathematics is a laboriously devised cultural product rather than a matter of natural instinct. Except in the case of rare individuals, it will not inspire enthusiasm, although long, regular and thorough work can make its learning less painful. All this doesn't mean that the way mathematics is taught is completely irrelevant. There are good and bad math teachers, but the quality of a teacher is not how well he is able to entertain the student, but how well he is able to teach him math.

The basic conditions for this are that:

- the teacher himself is good at mathematics,
- the teacher is able to understand what the students do not understand.

The problem in mathematics arises primarily due to omissions in the previous school material. In an ideal case, the teacher is able to identify the specific failure, separate the student's knowledge from ignorance, and using the student's islands of knowledge (which, as a rule, exist even in the worst students) repair the damaged foundations and gradually incorporate new school material.

Problems in Training Procedures

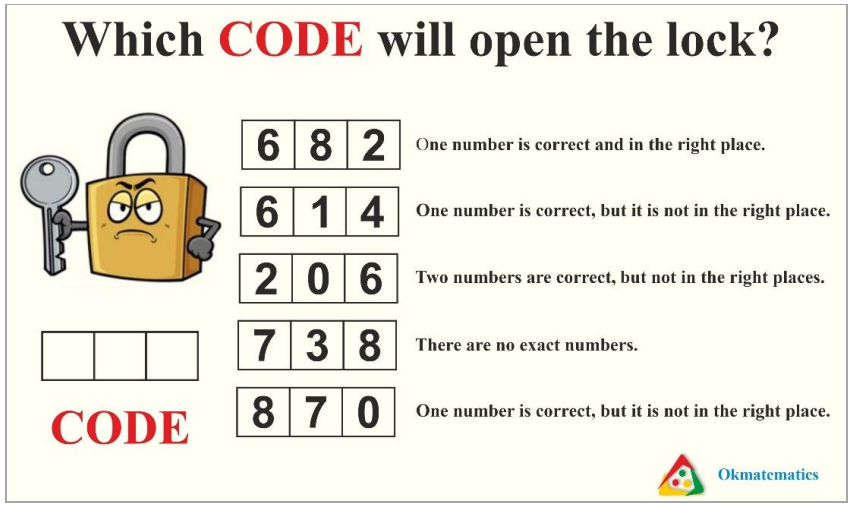
Problems in the training process have a special importance for the teacher himself. They are mainly related to the simultaneous speed and the large number of demands placed on the student. According to Vladisavljević (1986), this procedure contains processes of analysis and synthesis. In the physiological

sense, both processes are very complicated and the transformation of one process into another, then into a third, is carried out gradually, all the more slowly if the child is younger. For example, when reading, there must be compatibility of visual, acoustic and articulatory processes. In this complex integrated circuit with a large number of functions, errors may occur in certain parts of the system when transmitting a message. It can be wrongly seen, or if the visual representation is well transferred to the auditory one, the auditory process can make a mistake in perception, and therefore gives a wrong command to the speech organs (or hand), etc. This is why mistakes occur. In order to reduce the possible or resulting difficulties, it is necessary to simplify and slow down the training process as much as possible, remove the multitude of impressions and the multitude of requirements, in order to create a single, but clean and safe engram (a hypothetical permanent change that occurs on the tissue of living organisms as a result of the action of external impact). Teaching mathematics has always been problematic. This applies to students in the classroom as well. Problems arise at the moment when abstraction exceeds the ability of students to understand the problem, that is, to move from manipulative/concrete thinking to abstract thinking. This happens because the transition in content and work methodology is too fast and unadjusted with the pace of development in students' learning from visual/motor to abstract thinking. These problems manifest in content such as units of measure, inequalities, fractions or word problems. Problems of this type can be greatly overcome if we present dry word problems in a more interesting way. When learning by way of self-aware polyform heuristics, as a dominant method within the polyform principles of interactive teaching, the content that students should learn is not presented in a finished form, but must be discovered, preferably in different ways. Then the students' intellectual power, motivation, activity in learning increases, and, due to the completed work,the feeling of satisfaction appears. Learning through the method of self-aware polyform heuristics has greater effects in terms of the acquiring of content knowledge, and especially process, i.e. applicable knowledge in the sense of modern taxonomies of knowledge, because the student makes his own efforts to organize newly acquired information, in his own information system, and to find the entire range of information he needs, which increases his ability to organize and arrange data, using deductive, analytical-synthetic approaches and the application of the same in various problematic and life situations (Nikolić, 2016). According to numerous researchers, modern teaching, which is a combination of principled and methodical "knitting", with the help of computers, and which is not known or recognized by traditional teaching, contains new qualities of diverse teaching work, increases the activity of students in the process of teaching and acquiring knowledge, affects their greater motivation, initiative, creativity and applicability of acquired knowledge in everyday life, which are the main goals of modern mathematics teaching.

The essence of this significant didactic principle is reflected in the permanent insistence on the integral consideration of various approaches to comprehensing and understanding the studied teaching phenomena.

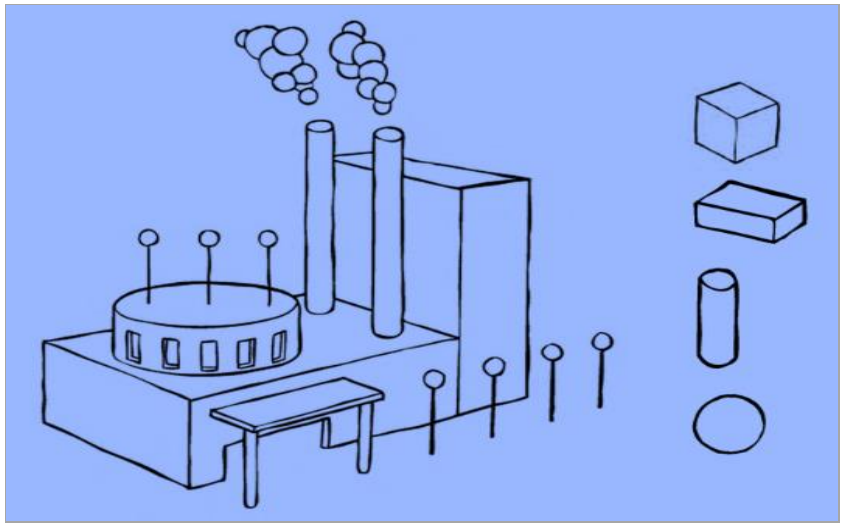
Examples of interesting problems in mathematics

1) Task:

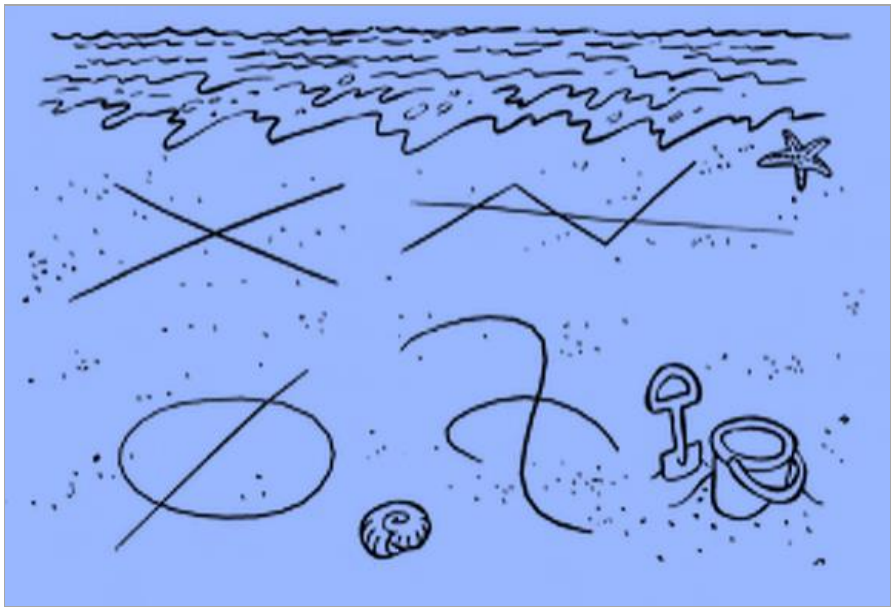


Solution: 042

2) Task: circle the geometric bodies seen in the picture



3) Task – mark the places where the lines intersect



4) Task – let the skier connect these three flags with straight lines

5) Task – There are 15 apples in a large basket

Conclusion

The acquisition of mathematical contents by some students is accompanied by discomfort and fear. For many of them, mathematics is one of their least favorite subjects. Math anxiety can be defined as a feeling of tension or fear that interferes with operating and manipulating mathematical facts, numbers or solving mathematical problems. It manifests itself as a negative emotional response to the contents of mathematics. Highly anxious people avoid mathematics content and have negative attitudes towards mathematics, as well as a negative perception of their mathematical abilities. Negative math experience is a key factor in the development of math anxiety. Children are essentially motivated to overcome mathematical concepts, however negative attitudes of the environment, fear of failure, as well as comparison with peers escalate into negative feelings. Fear can appear when solving one or more mathematical concepts. Math anxiety in school-age students is considered a prerequisite stage of math anxiety in adulthood. Students with math anxiety avoid math and learn less than students who do not have math anxiety (Ashcraft, 2002). As a result, they show lower math achievement. Their poor results are due to low competence and achievement, not increased math anxiety. Therefore, it is very important to examine math anxiety on different math tasks. Students with a high level of math anxiety do not have a global deficit in math, they can be successful on one or more types of math tasks that do not cause them discomfort and fear. Although,

based on all of the above, mathematics can be experienced as a ghost and an insurmountable obstacle for most students, it can be overcome with a lot of work and effort. Both teachers and people involved in educational reforms in Serbia should contribute to this, as well as students who should understand and accept that mathematics is a subject that is learned continuously and that it is a long but rewarding process. Examining the relationship between math anxiety and achievement on the math literacy scale, Videnović and Radišić (2011) believe that math anxiety includes feeling pressure, inadequacy, and anxiety during solving tasks that involve manipulating numbers and solving math problems, citing PISA test data.

References

Anić, I., Pavlović-Babić, D. (2011). Solving Mathematical Problems in a Real Context – qualitative and quantitative analysis of achievements. *Teaching and Education*, *60*(2), 193–205.

Ashcraft, M.H. (2002). Math Anxiety: Personal, Educational, and Cognitive Consequences. *Current Directions in Psychological Science*, *11*, 181–185. https://doi.org/10.1111/1467--8721.00196.

Jenkins, N. (2006). *Factors That Influence Mathematics Attitudes*. Nebraska: Department of Teaching, Learning and Teacher Education University of Nebraska-Lincoln.

Easy Math – Mechanical Memory or Logical Thinking? Retrieved from: https://www.intelektualnevestine.rs/blog-detail/laka-matematika-mehanicko-pamcenje-ili-logicko-misljenje.html (1.07.2022).

Mathematics is not a Ghost. Retrieved from: https://www.politika.rs/scc/clanak/14735/Matematika--nije-bauk (6.09.2006).

Videnović, M., Radišić, J. (2011). Anxiety Related to Learning Mathematics, Mathematics – Ghost or not? *Psihološka istraživanica*, *14*(2), 157–177. doi: 10.5937/PsIstra1102157V.

Vladisavljević, S. (1986). *Reading and Writing Disorders: speech therapy IV*. Belgrade: Institute for textbooks and teaching aids.

Ok Maths – how long does it take you to "crack" the code that will unlock the lock. Retrieved from: https://www.matematika.edu.rs/koliko-ti-je-vremena-potrebno-da-provalis-kod-koji-otkljucava-bravu/ (25.06.2022).

Marković, Đ. (2008). *New Views on Mathematics Teaching Methodology, "3M Makarije"*. Podgorica.

Marković, Đ. (2012). *What Kind of Mathematics Teaching Methodology Does the School of the 21st Century Need? Education and Training 3*. Podgorica.

Nikolic, S., Lipovac, V., Medic, B. (2022). Advantages of Applying the Method of Self-aware Polyform Heuristics in Mathematics Teaching. *Journal of Algebraic Statistics*, *13*(2), 2197–2208.

Nikolić, S., Hilcenko, S. (2021). *Application of the Principle of Polyformity of Digital Competence of Teachers Caused by Covid, 19*. 12. International interdisciplinary conference "Horizons 2021" (pp. 331–340). Subotica 14–15.05.2021.

Nikolić, S., (2021). Innovation in Mathematics Teaching as the Basis of Polyform Self-awareness Heuristics. Education and Training. *Journal of Pedagogical Theory and Practice*, *1*, 101–116.

Nikolić, S. (2016). *Method of Self-aware Polyform Heuristics in Teaching Mathematics* (doctoral dissertation). Novi Pazar.

Penavin, V. (1971). Structure *and Classification of Methods in the Teaching of Arithmetic and Algebra*. Belgrade: Zavod za izdava Čuubenika.

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 10.09.2022
Accepted for printing: 10.11.2022
Published: 22.12.2022

DOI: 10.15584/jetacomps.2022.3.4

MACIEJ CIEPIELA[1], **OKSANA NAGORNIUK**[2], **WIKTORIA SOBCZYK**[3]

Ecological Education as a Function of the International Idea of Sustainable Development

[1] ORCID: 0000-0003-0362-8461, M.Eng., AGH University of Science & Technology, Dept. of Environmental Engineering, AGH Doctoral School, Poland
[2] ORCID: 0000-0002-6694-9142, Ph.D., Department of Agricultural Economics in the Agrosphere of the Institute of Agroecology and Environmental Management of NAAS, Kyiv, Ukraine
[3] ORCID: 0000-0003-2082-9644, Prof. Ph.D., Eng., AGH University of Science & Technology, Dept. of Fuel Technology, Poland

Abstract

An indispensable element of the social and economic programme aimed at realising the new environmentally friendly era is environmental education. The leading principle of the National Environmental Policy is the principle of sustainable development, implemented through effective educational, informational and promotional activities. They consist in changing the environmental awareness of the society and in shaping proper human attitudes towards nature. The idea of sustainable development is understood as socio-economic development that takes into account the rights of nature and a dignified life for future generations. The functioning of this global concept is based on reconciling environmental, economic and social rationales. As a global trend, it ensures peace and a decent standard of living for all countries of the world. Education emphasises the need to respect human dignity, to respect diversity, to protect the environment and the resources of our planet.

Keywords: education, goals of sustainable development, environment

Introduction. The role of education in raising environmental awareness

Education is the transmission and acquisition of knowledge, the formation of skills and values. Education enables us to understand ourselves, those close to us, and the world we live in. Through education, people all over the world have the chance for a better future. The International Strategy for Environmental Education assumes that environmental education is an open-ended process during which

society acquires experience, forms the will to act to solve environmental problems (Wiatr, Marczak, 2004). In environmental education, it is necessary to understand the interdependence between ecology and economics, to learn about the consequences of environmental degradation, to represent a lifestyle that respects the environment. Environmental education is a component of the multifaceted development of the human personality, the formation of a pro-environmental attitude, an understanding of the threats to the environment, sensitivity and activity in responding to its degradation (Buchcic, 2009).

Educational establishments at all levels implement teaching and education in the spirit of respect for nature. In practice, environmental education is a form of activity aimed at and for the public. In education today, more and more attention is being paid to practical knowledge, which manifests itself in activating young people and involving them in solving environmental problems. These activities help to shape pupils' sensitivity and responsibility for the environment from an early age.

The subject matter of the study. Principles of the National Environmental Policy

The principles of the National Environmental Policy determine how it is shaped and implemented. They depend on the general policy of the country, the state of the natural environment, the level of development and condition of the economy, the public mood, international obligations. The leading principle of the National Environmental Policy is the principle of sustainable development (http://www.mos.gov.pl). It is enshrined in Art. 5 of the Basic Law of the Constitution of the Republic of Poland, thus gaining constitutional status. In this article we can read that: "The Republic of Poland shall safeguard the independence and inviolability of its territory, ensure the freedom and rights of man and citizen and the security of citizens, protect the national heritage and ensure the protection of the environment, guided by the principle of sustainable development".

There are several sectors in the Environmental Policy, dealing with specific aspects. For example, the Nature Protection and Biodiversity Conservation Policy is based on the Nature Protection Act of 16 April 2004, which sets out the following objectives: maintaining the stability of ecosystems, protecting landscape values, preserving geological and palaeontological heritage and shaping appropriate human attitudes towards nature through educational, informational and promotional activities (Ustawa, 2004). An efficient system for disseminating information and enabling effective public participation in environmental protection enables the public to access information and environmental education. Popularising environmental issues among children and young people, and shaping pro-ecological attitudes is the guiding principle of the national environmental policy.

Analysis of research results

Education for sustainable development

Sustainable development is understood as socio-economic development that takes into account the laws of nature and a dignified life for future generations. The functioning of this global concept is based on reconciling environmental, economic and social rationales. As a global trend, it ensures peace and a decent standard of living for all countries of the world. As we know, there are currently 17 Sustainable Development Goals (SDGs) with 169 Intermediate Goals and 232 Sustainable Development Indicators (SDIs), and the range of goals and indicators is constantly being updated and newly designed (Steward, 2015).

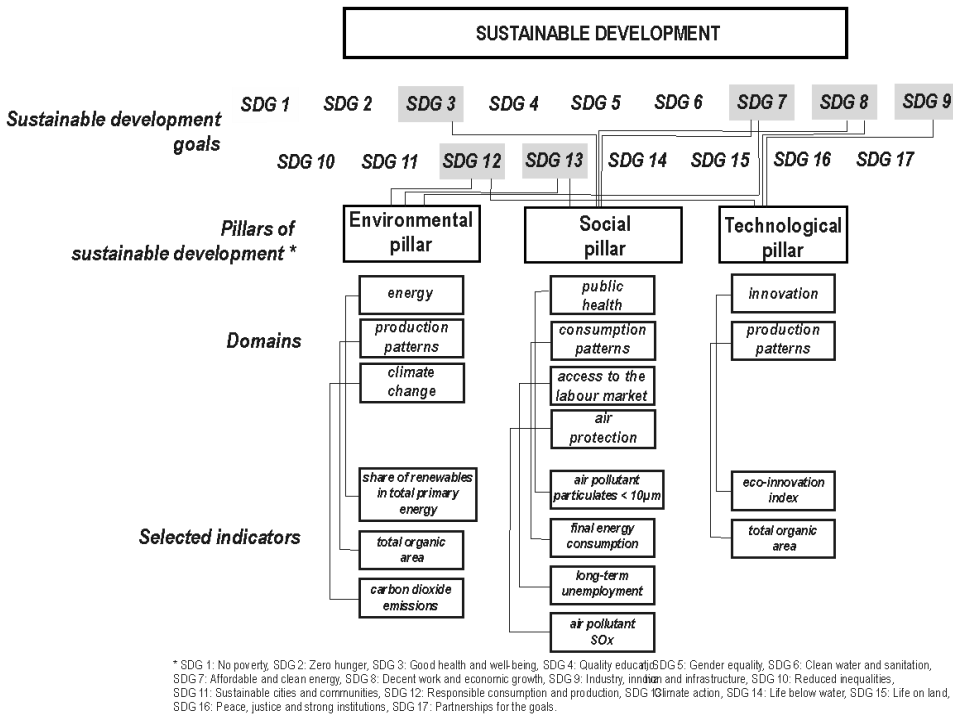


Figure 1. A flow chart showing the pursuit of sustainable development through the implementation of selected indicators in the context of diversification of energy sources (Sobczyk, Sobczyk, 2021)

Sustainable development indicators are an essential monitoring tool, representing in a measurable way the essence of this development concept. They make it possible to create a statistical picture of a country from the point of view of implementing the new development paradigm. The most important feature of an indicator is the comparability of its values, making it possible to determine the position of an object/country in relation to other objects/countries. In this

sense, an indicator is a function of one or more characteristics. Indicators are implemented within areas (domain), and these in turn form pillars (deals): green, economic and social. The introduction of eco-development is based on the realisation of the individual deals and the degree of their integrity (interference) (Sobczyk, Biedrawa, Kowalska, Pawul, 2010). For example, Picture 1 shows a flow chart illustrating the pursuit of sustainable development through the implementation of selected indicators in the context of energy diversification.

The aim of education for sustainable development is to strive for a balance between social and economic well-being and the Earth's culture, traditions and conservation of natural resources. Education emphasises the need to respect human dignity, to respect diversity, to protect the environment and the resources of our planet. Efforts should be made to provide each person with educational opportunities in accordance with their abilities. The learning process should instill values without which social sustainability would be impossible. Continuous monitoring of the quality of the education process is a prerequisite.

The implementation of the idea of sustainable development is aided by educational tools aimed at increasing the public's knowledge of environmental processes and human-environment interactions. Formal education (curricular and extracurricular) can take place in national parks, landscape parks, botanical gardens. Informal education takes place through mass media, local environment, NGOs.

Level of environmental awareness among Poles

Can we speak of a high level of environmental awareness among Poles? Environmental awareness is the area of social consciousness directed towards the relationship between man and the natural environment. The elements of environmental awareness are: knowledge, eco-friendly imagination, and a value system. Let us look into our household. Almost every Pole declares to sort their waste. But what does it look like in practice? Are we responsible for the state of our environment?

Legislative changes introduced 10 years ago are extremely slow to produce results (Ustawa, 2012). Gradually, individual environmental goals are being achieved, but the process of improving the functioning of waste management is proceeding lazily and sluggishly, and its effects will only become apparent in the future. Long-term observations of the behaviour of a housing estate community in a large Polish city confirm a sad reality: the awareness of the inhabitants is very low and the unwillingness to segregate waste is widespread. The containers for segregated waste contain raw materials that should not be there. Bags of waste are thrown thoughtlessly anywhere. Waste segregation is a fairy tale from another world. Society has not been prepared to implement the principles of the new Waste Act. In the face of the Covid pandemic, the Russian-Ukrainian war,

the energy crisis, the political situation in the country, the fall of the zloty and the deterioration of living conditions, the issue of saving the planet has receded into the background.

Conclusions

The transformation of acquired environmental knowledge into norms for everyday life, into habits resulting from a natural relationship to the surrounding nature, is the formation of personality and ethics. Everyday behaviour and actions should go in harmony with beliefs, and should flow from them. It is not an easy thing to do. Our attitudes and habits need to be critically evaluated. The way to do this is through environmental education: creating sensitivity and developing environmental awareness, creating ethics and self-criticism. Systematic educational measures must be taken in this regard. In a few years it will be too late to shape attitudes. Efforts should be made now to do sound educational work with young people.

Some believe that acting locally has a negligible impact on the future of our planet. Being aware of being integrated into the environment will allow an emotional approach to environmental issues. An individual should feel part of the environment and society. Through their everyday behaviour they can do something good for themselves and for future generations. Each of us should, on a small scale, take action to minimise our harmful impact on the environment (Kowalska, Sobczyk, Korzec, 2020). Each of us can make a difference in the world. The effects of these actions, multiplied on a regional, national or continental scale, will have a tangible impact.

References

Buchcic, E. (2009). Edukacja ekologiczna priorytetem wykształcenia współczesnego człowieka. *Studia Ecologiae et bioethicae*, *7*(1), 203–211.

http://www.mos.gov.pl/artykul/329_polityka_ekologiczna/340_zalozenia.html (4.08.2022).

Kowalska, A., Sobczyk, W., Korzec, K. (2020). The role of society education in the concept of circular economy. *Journal of the Polish Mineral Engineering Society*, *22*(1), 113–118.

Sobczyk, W., Biedrawa, A., Kowalska, A., Pawul, M. (2010). Education – ecology – sustainable development. About implementing the principles of sustainable development. *Education – Technology – Computer Science*, *1*, 265–270.

Sobczyk, W. , Sobczyk, E.J. (2021). Varying the energy mix in the EU-28 and in Poland as a step towards sustainable development. *Energies*, *14*(5), 1–19.

Stewart, F. (2015). The Sustainable Development Goals: a comment. *J Glob Ethics*, *11*, 288–293.

Ustawa z 16.04.2004 o ochronie przyrody. Dz.U. 2004, nr 92, poz. 880.

Ustawa z 14.12.2012 o odpadach. Dz.U. 2013, poz. 21.

Wiatr, I., Marczak, H. (2004). *Edukacja ekologiczna. Podstawy działań naprawczych w środowisku*. Nałęczów: Polskie Towarzystwo Inżynierii Ekologicznej.

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 11.07.2022
Accepted for printing: 10.11.2022
Published: 22.12.2022

DOI: 10.15584/jetacomps.2022.3.5

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

Approach to the Subject "DETE I EKOL⏲GIJA" by Applyingict at Preschool Institution

[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, College for Vocational Education of Preschool Teachers and Coaches, Subotica, Serbia

Abstract

This text represents working approach to the subject **"CHILD AND ECOLOGY"** = **„DETE I EKOL⏲GIJA"** by applying ICT at preschool institution. The work is reflected in a combination of discussions about ecology, practical presentation of rules in recycling and sorting of various waste, projection of the educational film **"EKOL⏲GIJA"** and individual solving of play sheets by children.

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: education, ecology, recycling, ICT, preschool institution

Introduction – "DETE I EKOL⏲GIJA"

Accelerated NEGATIVE environmental changes (*greenhouse effect, rising planetary temperature, melting glaciers and rising ocean and sea levels, pollution of water, air and land*…) that occur due to irresponsible behavior of mankind, have brought the planet Earth to a dead end.Environmentalists and scientists claim that it is the last moment for humanity to give up fossil fuels and general pollution that calls into question the survival of its living world on our "beautiful blue planet". In that sense, the recycling and selection of diverse waste plays a major role.Encouraged by the urgent environmental situation facing the whole world, and in accordance with the slogan "think globally, act locally", we wanted to give our contribution in educating the youngest about ecology, especially about recycling various waste.

EKOLOGIJA = ECOLOGY

„KO“ = „WHO“ „JA“ = “I”

Figure 1

For these needs, we have created an educational lecture entitled **“DETE I EKOL🕐GIJA”**, intended for children in preschool institutions using ICT (Hilčenko, 2003).

Lecture that lasts ≈ 35 minutes has the following contents and course:

1. Projection of animated educational film (Hilčenko, 2008) **“EKOL🕐GIJA”** (2 min.).
2. Discussion on the content of the animated film with a practical presentation of the rules in the process of recycling various waste (15-20 min).
3. Individual solving of play slips by children.

The subject matter of the study. Example of the approach to the subject: “DETE I EKOL🕐GIJA”by applying ICT in preschool institution

The animated educational film “EKOL🕐GIJA” has the following plot: The main “character”is a fish, that lives in a clean pond, but due to various sources of pollution that occur in its immediate natural environment, it gets sick. Those are:

– wastewater from sewage in the city ends up in the lake,

– air pollution from thermal power plants, traffic…,

– accumulation of waste in landfills causes pollution of the surrounding land, underwater waters and lakes, and

– excessive pollution of arable land with pesticides ends up in underwater waters.

In the film **“EKOL🕐GIJA”**, all the negative environmental influences are accompanied by a clock from the title of the film (Figure 1). When the pollution reaches its zenith, and the fish gets sick, clock hands (from position 11.55h) move in the opposite direction, in the direction of possible healing that depends only on man! This means an alternative to everything that led to the ecological catastrophe: filters on wastewater, factory chimneys, sorting and recycling of various waste, use of natural fertilizers in the fields, electric cars ...

The title of the animated film **“EKOL🕒GIJA”** (picture no. 1) symbolically contains or refers to “**WHO**” should be most directly involved in this process, **“I”**, ie. each of us ...

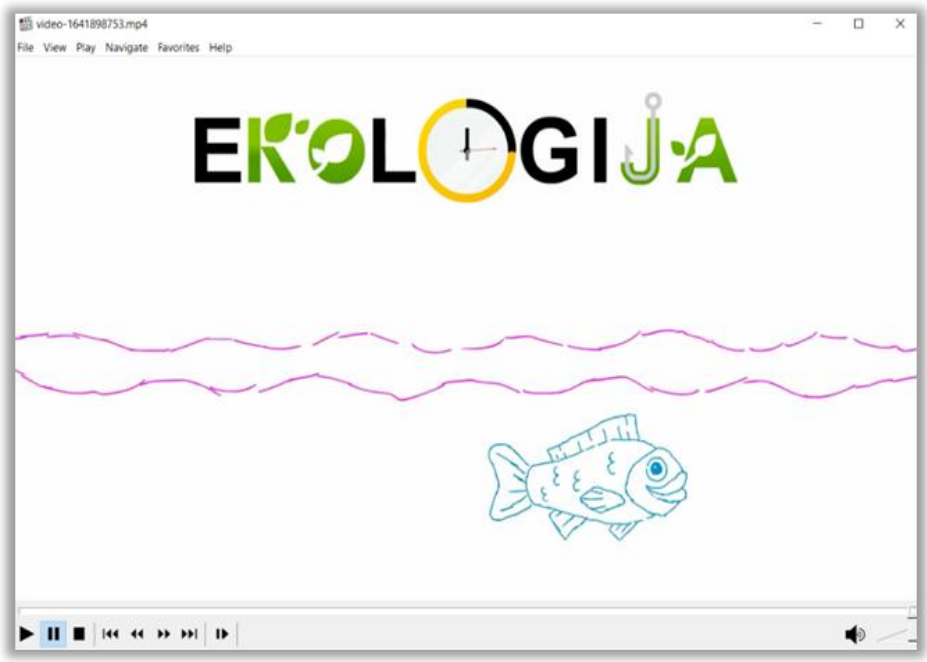
The film is a warning to all of us, but it also gives hope that we still have the opportunity to “heal the planet”.

Hardware-software requirements for the realization of the animated film were:

The basic (main) animation in “rough animation” and “clean up” was done in Adobe Animate (Hilčenko, 2004):

1. Effects and various animated objects were done in Adobe After Effects (Hilčenko, 2006).
2. Film length 1:30–2:00 minutes.
3. Resolution 1080 p.i.e., 1920:1080, i.e., Full HD (Hilčenko, 2009).
4. The project was implemented on the configuration of Intel i5, RAM 8GB, optimally Mac mini M1 computer.
5. Wacom Cintiq 16 graphics drawing board (also a monitor), minimum Wacom Intuos M. (Hilčenko, 2010).

On the pictures number 2 and 3, phases in the realization of the animated film **“EKOL🕒GIJA”** can be seen.



Figures 2

Figures 3

Research methodologies and tools

Discussion about the film with a practical presentation of the rules in the process of recycling various waste should provide educators with feedback on what children already know about the recycling of various waste, what they learned from the film, to know where to start upgrading their knowledge. Children need to understand the cause-and-effect relationshipsin environmental pollution and what needs to be done about it, in order to restore better environmental conditions (Hilčenko, 2011).

In this regard, educators should acquaint children with the process of recycling various waste and the containers in which it is disposed of. At the very end, children independently practice sorting and disposal of various waste with prepared didactic materials (various waste samples and pictures of containers in various colors) (Hilčenko, 2015a).

Individual solving of play sheets by children should enable children to confirm the adopted contents in which they participated, and educators to gain insight into the extent to which that knowledge has been improved, and which parts should be emphasized more in the future. From the prepared folder with 10 play sheets, the educator determines the number of worksheets and in which period he plans to offer them to the children to solve (Figure 4).

Figure 4. Folder layout and 10 play sheets

Analysisresearch results

After the lecture, we interviewed educators (15), asking them to express their views on the way of work. The answers of educators on the assessment scale are presented in Tables 1–5.

Table 1

Question 1	***Do you use ICT technologies in your work?***					
Answers	1 I never use ICT in my work	2 I rarely use ICT in my work	3 Sometimes I use ICT in my work	4 I often use ICT in my work	5 I regularly use ICT in my work	Σ
Σ	/	**9** 59,94%	4 26,64%	**2** 13,32%	/	15

Table 2

Question 2	***Would you use the presented mode in your work as well?***					
Answers	1	2	3	4	5	
	never	rarely	sometimes	often	always	∑
∑	/	/	**5** 33,3%	**8** 53,28%	**2** 13,32%	15

Table 3

Question 3	***Do you agree that the mode shown is suitable for children aged 4–6?***					
Answers	1	2	3	4	5	
	I don't agree at all	I mostly disagree	neither agree nor disagree	I mostly agree	I totally agree	∑
∑	/	/	/	**8** 53,28%	**7** 46,62%	15

Table 4

Question 4	***Do you agree that the presented example of work is sufficiently comprehensive processed topic?***					
Answers	1	2	3	4	5	
	I don't agree at all	I mostly disagree	neither agree nor disagree	I mostly agree	I totally agree	∑
∑	/	/	/	**8** 53,33%	**7** 46,62%	15

Table 5

Question 5	***Would you recommend the presented mode to a colleague?***					
Answers	1	2	3	4	5	
	I would never recommend	rarely I would recommend	sometimes I would recommend	Often I would recommend	I would regularly recommend	∑
∑	/	/	**5** 33,33%	**5** 33,33%	**5** 33,33%	15

From the answers of (representative number of interviewees) educators, we can see that 86,58% of them “rarely” or “sometimes” use ICT in their work. All this speaks of insufficient ICT competencies of educators (Nikolić, Hilčenko, 2021).

On the other hand, 66,6% of educators would “often” and “regularly” use presented example of the work by applying ICT (Hilčenko, 2017, 2019).

53,28% of tested educators “predominantly” think, and 46,62% of them “totally agree” that presented wa of the work is suitable for children between 4 and 6 years old.

53,33% of educators “predominantly think, and 46,62% of them “totally agree” that the presented example of the work sufficiently covered the processed topic.

33,33% of educators would “sometimes recommend”, or “often recommend” or “regularly recommend” presented example of the work.

Conclusion

The presented way of the work on the subject **“DETE I EKOL⏱GIJA”** represents combination of work using ICT and practical work of educators and children. According to a larger percentage of surveyed educators, it is a desirable approach to work that they would like to apply in their practice (Hilčenko, 2015b).

Our goal is to convince Ministry of Education to implement presented way of work in all preschool institutions, in order for children to get closer and in this way get acquainted with this urgent topic – such as **“DETE I EKOL⏱GIJA”** and recycling of various waste.

References

Hilčenko, S. (2003). *Multimedijalni nastavni model instrukcionog dizajna u radno orijentisanoj nastavi tehničkog obrazovanja.* Zrenjanin: Tehnički Fakultet Mihajlo Pupin, PhD thesis.

Hilčenko, S. (2004). Kognitivna psihologija i instrukcioni dizajn kao polazne osnove u razvoju obrazovno-računarskog softvera. *Pedagoška stvarnost, 1–2*, 84–10.

Hilčenko, S. (2006). Multimedijalni obrazovni softver: “Od igre do računara” (2). *Pedagoška stvarnost*, 9–10.

Hilčenko, S. (2008). *Obrazovni softver kao interaktivno manipulativno i motoričko podsticajno sredstvo u razrednoj nastavi. Pedagoška stvarnost, 1–2*, 69–78.

Hilčenko, S. (2009). *Two Examples of redloženi pristup for Working with Multi Media Educational Software in Primary School 1st Grade.* The University of Rzeszow, The Institute of Technology, Department of Didactics of Technology and Computer, The Seventh International Scientific Conference, Education – Technology – Computer Science, Iwonicz Zdroj, Anthology of Works.

Hilčenko, S. (2010). Model preventivno-korektivnog softvera na primjeru nepravilnosti i poremećaja u pisanju brojeva. *Informatologia, 43*(1), 63–67.

Hilčenko, S. (2011). Reflections of a Teacher about the Study of Geometrical Shapes Through an Animation Movie in Primary School (Year 1 to 4). International Year of Youth, May 5th and 6th.

Hilčenko, S. (2015a). A model: animated logical mathematical tasks for the younger elementary school children. *IOSR Journal of Research & Method in Education, 5*(4), 39–42.

Hilčenko, S. (2015b). An E-model of a Flipped & Heuristic and Functionally & Logical Learning for the Generation “Z” in the Classwork. *International Journal of Elementary Education, 4*(3), 65–79.

Hilčenko, S. (2017). *Metodika razvoja početnih matematičkih pojmova, udžbenik za studente vaspitačkih škola, Visoka škola strukovnih studija za obrazovanje vaspitača i trenera – Subotica.*

Hilčenko, S. (2019). IKT u vaspitno-obrazovnom radu, udžbenik za studente. Subotica: Visoka škola strukovnih studija za obrazovanje vaspitača i trenera.

Nikolić, S., Hilčenko, S. (2021). *Primena načela poliformnosti digitalne kompetencije nastavnika izazvane Kovidom 19, 12th International Interdisciplinary Scientific Conference “HORIZONS 2021”, “Quality of life in pandemic conditions”, Subotica, on 14th and 15th May* (pp. 331–339).

PART TWO

SELECTED PROBLEMS OF USING INFORMATION TECHNOLOGY IN EDUCATION

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 7.05.2022
Accepted for printing: 10.11.2022
Published: 22.12.2022

DOI: 10.15584/jetacomps.2022.3.6

TOMASZ PRAUZNER

The QEEG Research as an Example of an Alternative Method of Evaluation of Didactic Activity – Popularization of the Concept and Effects of Own Research

ORCID: 0000-0002-8792-7794, Doctor, Department of Pedagogy, Jan Dlugosz University in Czestochowa, Poland

Abstract

The article presents the concept of applying QEEG research in the assessment of didactic activity in polytechnic education. In addition, the promotion of EEG research in the field of therapeutic activities and as an innovative research method in didactics will be shown.

Keywords: simulation programs, electroencephalographic tests, QEEG, cognitive process, modeling, brain and education

Introduction

The concept of neuroeducation or neurodidactics is more and more often cited in the category of novelty in pedagogical literature. Neurodidactics seems to be a concept strictly related to didactics it self, soitcan be concluded that the area of its interest is not all education, but only refers to a narrower scope, didactics it self. Other concepts functioning in Polish and foreign literature are: *neuroedukacja*, *brain and education*, *educational neuroscience*. The thematic scope of these concepts is extremely extensive, but there is no doubt that it brings together knowledge from various fields of science, in this case neuroscience, cognitive psychology, pedagogy (didactics), and cognitive science. Neurodidactics, as a new trend in the development of the humanities, uses the known knowledge about the work of the brain in the teaching-learning process. It indicates the correlation of brain activity with the human cognitive process. Information processing processes that take place in the nervous system, consisting in receiving information from the environment, their storage and transformation, reflect the attitude of human behavior and its cog-

nitive activity. Simply put, the more we know about the activity of our brain, its activity under the influence of external stimuli, the greater our knowledge about the possibilities of organizing the educational process. With regard to teaching methodology, we have an impact on the targeted and individualized practice of upbringing and education. No wonder that the more and more frequently emerging possibilities of using specialized information technology encourage research on content. One of the possibilities offered by current technology is EEG electroencephalography. The idea of EEG research and its use in research on didactic effectiveness is one of the main activities to promote science. An exampleis the cyclical participation of the author in activities promoting the latest scientific achievements as part of the Silesian Science Festival Katowice (Figure 1, 2).

Figure 1. The place of promoting EEG research at the Laboratory of Experimental Research Biofeedback at Jan Dlugosz University in Częstochowa (own source)

Figure 2. The place of promoting QEEG research – a method of bioelectrical activity of the cerebral cortex (own source)

The subject matter of the study

In the Experimental Research Laboratory of Biofeedback in Jan Długosz University, EEG and QEEG research has been carried out for many years. QEEG tests (Quantitative electroencephalography) are a type of EEG tests that enable the so-called mapping brain activity (Prauzner, 2019–2021). For this purpose, specialized measuring equipment is used in the research, including a device called Mitsar 202. The operation of the apparatus consists largely in reading electrical impulses read on the scalp thanks to sensors placed in the so-called a bonnet (Figure 3). These are electrodes made of low impedance materials connected with recording equipment located on the head according to a specific pattern (Oostenveld, Praamstra, 2001; Olejniczak, 2006).

Figure 3. The QEEG research (own source)

Research methodologies and tools

In the years 2020–2022, complementary QEEG research was carried out among students in the field of engineering. A total of 34 people participated in the research, and their small number resulted from pandemic restrictions. The aim of the research was to evaluate the activity of the brain while working at the computer. Students were tasked with making a project in the form of a virtual model in a simulation program. During their work, brain activity was recorded.

The implementation of the engineering project was associated with several stages of work, such as: reading the documentation of the exercise, getting to know the software environment, developing the model in a simulation program, simulating the operation of the model, substantive evaluation of the work. At each of these stages of work, the activity of the brain was recorded and the results obtained in the form of frequency waveforms of the brain's work were used to perform the graphic activity of the brain's work QEEG. It is worth mentioning at this point that the activity of the brain is visualized in the form of specific frequencies of electrical potential impulses. In addition, the occurrence of these frequencies, the so-called waves of activity is related to their location, these are the waves: Alpha, Beta, Gamma and Theta. The most important in terms of didactic activity are Beta waves (Beta1 and Beta2, SMR). Beta1 waves with a waveform frequency of 16–20 Hz are associated with concentration on one issue, with an external orientation. If a person is faced with the need to solve, for example, a mathematical problem (intense mental effort), we will notice that first the amplitude of the activities will increase around 17 Hz and at exactly the same time the amplitude of Theta and Alpha (8–10 Hz) will decrease. This bandwidth correlates with the cognitive activity characteristic of active problem solving (intense mental effort). Low Beta1 level accompanies intellectual deficits as well as disturbances in concentration and attention. Too high Beta wave in the non-dominant (genetically non-dominant) hemisphere disturbs the emission of the SMR wave, which in turn is associated with emotional disturbance and attention deficit. Waves 18–36 Hz, the so-called Beta2 – a stressful wave of anxiety, accompanies us during intense mental work. It is associated with increased emotional tension, because its emission accompanies the release of adrenaline responsible for the state of readiness of the body. For the above studies, it was assessed as undesirable (Thompson, Thompson, 2012). The higher the frequency, the greater the creative stimulation and abstract thinking. We are aware of external stimuli. The main research goal was to determine the didactic activity among students of technical studies during practical work with the use of simulation software. The simulation software allows you to conduct classes in the IT laboratory thanks to the use of the most modern computer programs, in this case computer simulation determinists (abbr. DSK). The general (initial) hypothesis was with high probability that the use of DSK in the course of didactic activities increases the level of cognitive activity in the didactic process. Computer software was adopted as an independent variable, its features determining its attractiveness as a teaching means, while an increase in knowledge and skills of using this software in the implementation of an engineering project was assumed as a dependent variable. The method of the research was the ob-

servation and measurement of the results obtained from the Mitsar 202 research apparatus. The indicator of the dependent variable is the analysis of the occurrence of specific waves accompanying the activity of the brain during the student's work. The presence or absence of specific waves indicates a greater or lesser activity of specific brain structures characteristic of a human's creative work. The effects of individual work in the form of technical solutions in the construction and the course of simulating the operation of a virtual model were also assessed.

Review of author's research

In the course of the research, in each of the examined persons, a series of frequency wave forms, proving the activity of the brain, was recorded. Figure 4 shows an example of the course of one person at different stages of his work. Figure 5 shows a graphic illustration of the activity of the brain with the division into the activity of brainwaves. Due to the large number of such runs, the data of the entire group are presented in the form of Graph 1 and Table 1.

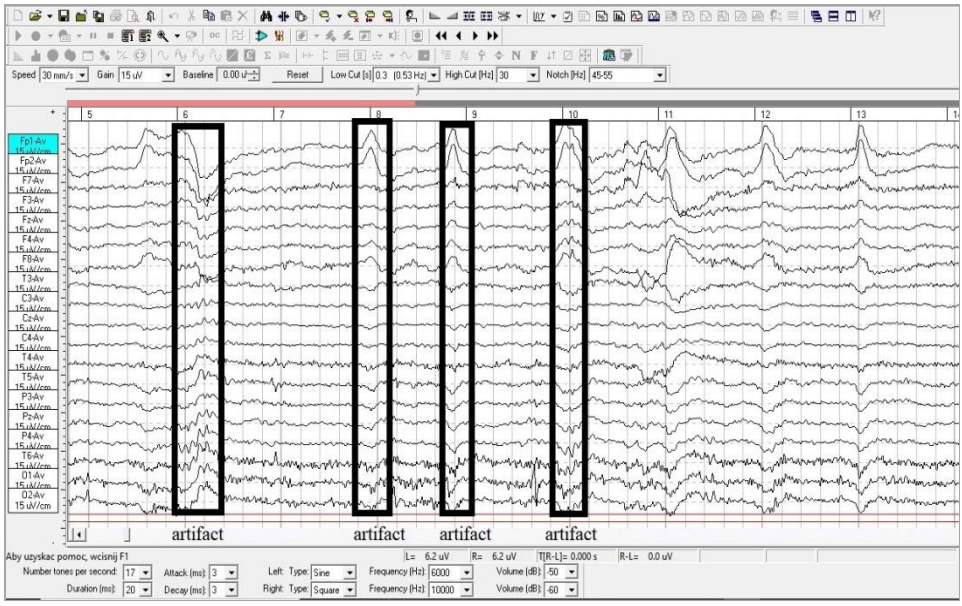


Figure 4. Frequency waveform of EEG waves

The figure also shows the so-called artifacts, i.e. disturbances in the operation of the apparatus, which should be removed after registration and then the results should be graphically interpreted (Figure 5) (Prauzner et al., 2019–2021; Robbins, Touryan, Mullen, Kothe, 2020)

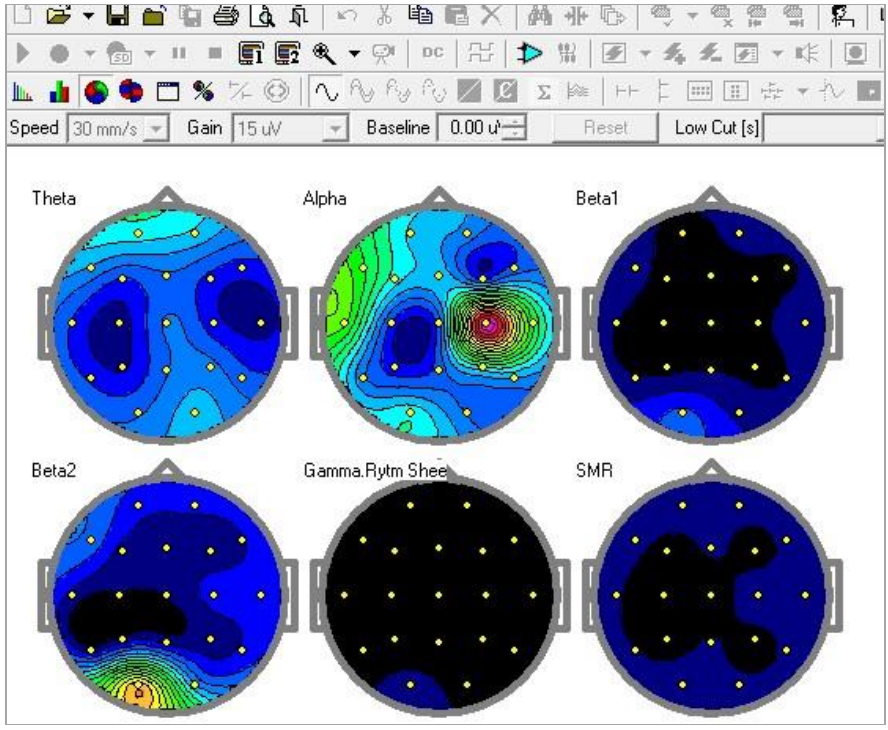
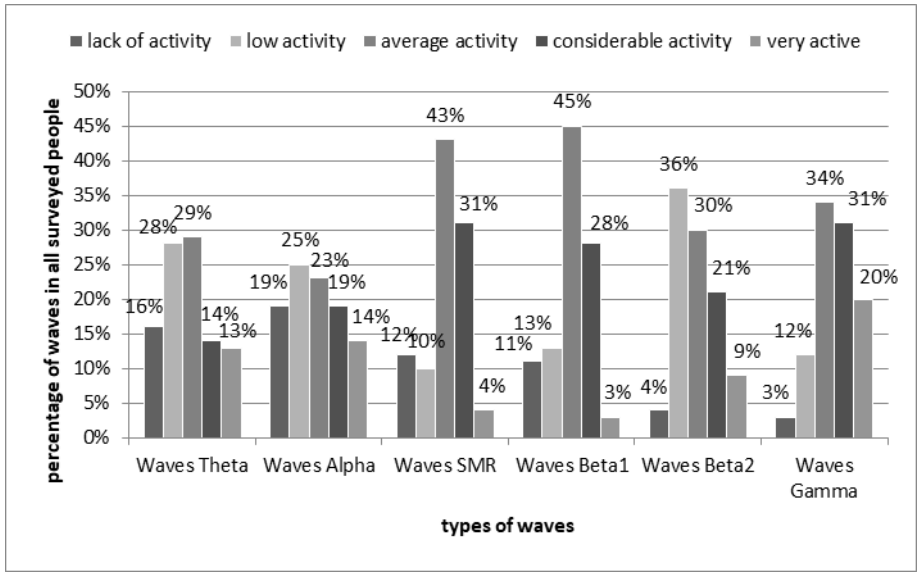


Figure 5. Graphical analysis of brain activity (own source)



Graph 1. Percentage of waves in all surveyed people (own source)

Table 1. Percentage share of individual waves and their intensity in the studied group (own source)

	lack of activity	lowactivity	averageactivity	considerableactivity	veryactive
WavesTheta	16%	28%	29%	14%	13%
WavesAlpha	19%	25%	23%	19%	14%
Waves SMR	12%	10%	43%	31%	4%
Waves Beta1	11%	13%	45%	28%	3%
Waves Beta2	4%	36%	30%	21%	9%
Waves Gamma	3%	12%	34%	31%	20%

Conclusions

The analysis of the results shows that all waves (Theta, Alpha, SMR, Beta1, Beta2, Gamma) occurred in 34 subjects. Of course, as expected, the percentage of dominant frequencies is different. This condition is influenced by many factors, including individual and biological predispositions, medical history, medications taken, etc. However, the quantitative analysis of the data shows that there is a significant correlation with the occurrence of certain waves (especially Beta1, Beta2, SMR) with mental activity in during work. The average and significant activity of Beta1 and SMR waves proves the involvement of all senses simultaneously and the state of attention, so in didactic terms it was the moment when the student was extremely focused on what he was doing. Beta1 waves appear very often when the student is doing mathematical or physical calculations. They are related to concentration on one issue, with an external orientation. Emotional states are related to arousal and alertness, the mind is focused on solving a task. Beta2 waves also occur frequently and are usually associated with Beta1 waves, but although they are characteristic of the active state of attention, they indicate increased emotional tension, and thus stress. Of course, stress accompanies creative work because it is often an experimental stage of work, the obtained results are not certain and raise concerns about their accuracy. They are related to the secretion of adrenaline in humans, so their excess determines the state of stress, which in didactic terms may be a destructive factor. Gamma waves are also frequently observed frequencies. Their occurrence is always related to the active and cognitive state in humans. It accompanies very active mental work of a person. We are dealing here with a high concentration in humans, creative work. The remaining types of waves, although their occurrence was also noticed, are dominant in a smaller number of people. They are associated with a state of calm, often lack of concentration and information processing, which does not mean that a person does not learn at this moment. However, they are not so important in active creative work at the computer. We must remember that working with a computer is primarily a static and moving image, so the organ of sight is the basic organ responsible for the information reaching the mind. Added to this is the problem of using software and computer skills. This conclusion can be

used for further research related to the usefulness of computer applications in didactics due to their architecture, data visualization side, difficulty in using software and many other factors. However, this is a topic for further research and joint discussion.

References

Olejniczak, P. (2006). Neurophysiologic Basis of EEG. *Journal of Clinical Neurophysiology*, *23*(3), 186–189.

Oostenveld, R., Praamstra, P. (2001). The five percent electrode system for high-resolution EEG and ERP measurements. *Clin Neurophysiol*, *12*, 713–719.

Prauzner, T. (2020). Innovativeness of didactic practice in the field of current pedagogical knowledge, *SOCIETY. INTEGRATION. EDUCATION. Proceedings of the International Scientific Conference*. Vol. II (pp. 247–255).

Prauzner, T. (2020). Didactic significance of modern simulation programs in vocational education – divagations from own research. (Zastosowanie założeń edukacyjnej analizy transakcyjnej w konstruktywistycznej teorii uczenia się). *Journal of Education, Technology and Computer Science*, *1*(31), 86–94

Prauzner, T. (2021). Progressive way of thinking about contemporary education – personal discussions. *SOCIETY. INTEGRATION. EDUCATION. Proceedings of the International Scientific Conference*. Vol. I (pp. 502–512).

Prauzner, T., Prauzner, K. (2020). Application of assumptions of educational transactional analysis in constructivist learning theory. *Edukacyjna Analiza Transakcyjna*, *9*, 71–78.

Prauzner, T., Prauzner, K. (2021). Dydaktyczny wymiar badań elektroencefalograficznych w ujęciu edukacyjnej analizy transakcyjnej. *Edukacyjna Analiza Transakcyjna*, *10*, 61–69.

Prauzner, T., Prauzner, M., Prauzner, K. (2019). Aktywność pracy mózgu w procesie dydaktycznym w ujęciu badań elektroencefalograficznych. *Edukacja – Technika – Informatyka*, *10*(2), 312–317.

Robbins, K., Touryan, J., Mullen, T., Kothe, C. (2020). How Sensitive Are EEG Results to Preprocessing Methods: A Benchmarking Study. *IEEE Trans Neural Syst Rehabil Eng*, *28*, 1081–1090.

Thompson, M., Thompson, L. (2012). *Neurofeedback, wprowadzenie do podstawowych koncepcji psychofizjologii stosowanej*. Wrocław: Biomed Neurotechnologie.

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 26.10.2022
Accepted for printing: 24.11.2022
Published: 22.12.2022

DOI: 10.15584/jetacomps.2022.3.7

SŁAWOMIR BŹDZIUCH

Interdisciplinary Take on Augmented Reality

ORCID: 0000-0002-4487-6835, MSc, University of Rzeszow, Institute of Sociological Sciences, Poland

Abstract

This publication attempts to show the interdisciplinary nature of augmented reality. With the development of technology and the widespread use of smartphones, there has been a great development of AR technology. This technology, due to its universal nature, is used in various spheres of everyday life. Discussing the interdisciplinary nature of this technology within the scope of this publication, the author focused on the possibilities of its use in education, medicine and marketing. By pointing out practical examples of the use of AR, the author will show how this technology is entering everyday life. The choice of the areas indicated is intended to show that AR technology will be used by the majority of society in the future. This is due to the fact that this technology has great prospects for development with particular emphasis on the areas mentioned.

Keywords: augmented reality, education, technology, AR in medicine, AR in marketing

Introduction

With the development of technology, particularly telecommunications technology, which uses increasingly modern devices no longer referred to as phones but as "smartphones", the use of augmented reality (AR) has entered everyday life with a "bang". The rise of AR and its practical use has certainly also been influenced by the popularity of the game Pokemon Go, which in 2016 became a global hit in the games market in less than a few weeks (Siwak, 2016, p. 365). The opportunity to use AR in this case is contained within the broader realm of entertainment. It is just one way of using this form of information sharing. For, in fact, AR technology has its applications in various areas of life. With this in mind, the main purpose of this publication is to review the possibilities of using AR technology in relation to education, medicine and marketing. These areas have been chosen because of the wide range of their impact on society.

The subject matter of the study

In the first part of the paper, the issue of augmented reality will be analysed, followed by the author's review of the possibilities of its use in order to emphasise the interdisciplinary nature of the technology in question. Particular emphasis will be placed on the role of AR in education, where the possibilities of using this technology are numerous. Whether we are dealing with primary or tertiary education, AR can be an interesting way to make the traditional learning process more attractive and quality enhancing. Next, the author discusses the possibilities of using HR in medicine, pointing out the possibility of using this technology in both theoretical and practical terms. In the last part of the paper, the author will characterise the possibilities of using AR in marketing.

Research methodologies and tools. Selection and characterisation of the research method or literature

The author will base his research in the context of reviewing the possibilities of using augmented reality technology on a literature search, during which he will focus on analysing available scientific publications and online sources.

Issues related to the use of AR are of interest to researchers all over the world, so the author will base his analysis on both Polish and foreign literature. Particularly important in the analyses conducted on the interdisciplinary nature of AR is the use of foreign literature. This is due to the fact that the use of AR technology in practical terms is definitely more developed in the USA. A corollary of this, is that there is a far more extensive literature that describes the use of AR.

The combination of foreign and Polish literature will allow the topic to be treated comprehensively, which will give the author a good overview of how AR is used in the areas discussed. It will also contribute to a better identification of the directions of development of the discussed technology in the future.

Results of analyses of the possibilities of interdisciplinary use of augmented reality

When considering the possibilities of using AR in an interdisciplinary manner, it is important to start by defining what the technology actually is. In the literature on virtual reality, the most commonly cited definition is the one developed by Pardel (2009, p. 35), who believes that AR is "an area of scientific research in computer science that deals with combining images of the real world with elements created using information technology. Augmented Reality does not create a virtual, complete, new 3D world (like virtual reality, Virtual Reality, VR), but extends and supplements the one we know".

From an analysis of the definition cited above, we can conclude that augmented reality is intended to complement the image of the real world around us

by a so-called information layer. This layer is superimposed on physically existing objects in the real world. These objects form the background for the message generated using virtual reality. It is worth emphasising at this point that the role of this background is crucial, as AR cannot exist without reference points in the real world. Also noteworthy is the fact that the literature emphasises that the information presented using this technology is close to the real world view of the presented world. This is undoubtedly a great advantage in that we do not treat AR as a "virtual world", but as a complement to reality, aimed at stimulating interest and curiosity. This advantage is very often emphasised in the literature on the subject; many authors, when attempting to define AR, refer to the "Mixed reality" diagram developed by Miligram and Kishino (1994, p. 1323).

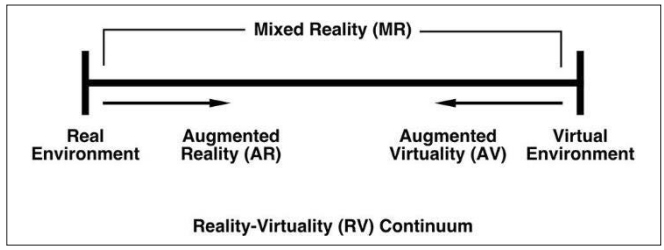


Figure 1. Milgram and Kishino's reality-virtuality continuum
(adapted from Milgram et al., 1994).

In this chart, physical reality is placed at one end of the scale, while virtual reality is placed at the opposite end, with AR and augmented virtuality marked in the middle of the chart. The positioning of the technology of interest in this article shows that it is definitely closer to the real world than virtual reality. Another aspect that distinguishes AR is the generation of an information layer in real time, a feature that distinguishes this technology from others. This approach can be found, among others, in the work of Carmigniani, according to whom AR is "a real-time direct or indirect view of a physical real-world environment that has been enhanced/augmented by adding virtual computergenerated information to it" (Carmigniani et al., 2011, p. 342). Another feature of augmented reality worth pointing out in the context of this publication is that, as discussed in Warchol's publication, defining AR as primarily the visualisation of objects is too narrow. This author points out that this technology is also the ability to perform activities previously designed by the designer (Warchol, 2016, p. 185).

AR in education

With the development of AR, more and more new application solutions are being created and used in various areas of human existence. The use of this technology in education is particularly interesting. According to Kęsy (2017,

p. 127), the increased interest in augmented reality as a supplement to the traditional educational process is due to its great visualisation possibilities. These possibilities can be used, among other things, in the study of human anatomy, the design of complex technical devices or even in spatial geometry. The learning process at each level should involve the use of a variety of teaching methods and resources. With help in this case comes AR, which can make education at each level more attractive by illustrating something that is not easily presented on the pages of a textbook. Such textbooks can contain "markers" that, when scanned by, for example, a smartphone with the appropriate software, will give us complementary multimedia information (Postawa, 2018, p. 114).

There are two forms of AR in education, one is information-locative and the other is vision-based. The former offers learners digital multimedia to navigate through a physical area using a smartphone equipped with GPS. Graphics, text, audio or 3D models are used to extend the physical area in order to narrate or provide scientific information about a location. Vision-based AR, on the other hand, presents learners with digital media only when the camera of their smartphone is pointed at an object with, for example, a QR code (Postawa, 2018, p. 114). The forms described take advantage of the several possibilities available through the use of a smartphone (camera, GPS, traceability) to supplement the real world with an additional layer of information, which creates a very attractive opportunity to provide content to support teaching and learning.

The use of AR in education, due to its unique nature, has interdisciplinary potential. The technology is already being used in teaching subjects such as mathematics, biology, physics, chemistry and astronomy as part of primary education (LEE, 2012, p. 14). Also in history education AR finds its application, in this case it can be used as a technology to develop content in a textbook and as a guide to historical cities and museums (Dejanka, 2012, p. 31). In addition, the mentioned technology can be used during field history lessons. An example of the aforementioned didactic intentions is the project "Warsaw 44 – tracing the Warsaw Uprising by mobile phone", which can link selected places in Warsaw to the events of that period. The project Guide. Lublin 2.0, which also plays an educational role (Laskowski, 2013, p. 39).

The use of AR technology is also finding its way into higher education, where students can improve their skills in complex theories or mechanisms thanks to this highly efficient technology. Liarokapis, for example, has shown that complex mechanisms and theory can be taught to students using AR technology by making them more understandable. He used AR technology when discussing the construction of a valve train, where, thanks to a contextually enriched presentation, he discussed a 3D model of the valve train using real engine components (Liarokapis, 2004, p. 13). Another translation of the use of AR in higher education is the teaching of human anatomy in medical science. An exam-

ple of a solution dedicated to medical science, among other things, is the augmented reality-based iSkull app. This application offers the possibility to study the structure of the human brain thanks to a so-called 360 view.

The use of AR technology in higher education is particularly evident in areas where it is important to combine both theoretical and practical knowledge. Technical and medical sciences are prime examples of this, and it is significant that AR technology can support both the learning process and the real world. This dual use of AR technology is particularly evident in the medical sciences, where it can also be used to guide surgical procedures or operations. The possibilities for the use of AR in medicine are extensive and therefore worth analysing in more depth.

AR in medicine

AR-based technology support in the medical professions is a very popular activity. Already at the level of medical studies, this technology for presenting content is being used, which is really only an introduction to the extensive use of AR in medicine. In addition to the education process and, later on, the training process of medical personnel, AR can have many important applications. The technology can be used to support or replace the senses of its users through the use of sensory substances. With its use, it is possible to assist visually impaired users or those with low vision based on the use of auditory cues. Similarly, it is possible to assist the deaf-blind, who can perceive the external world in a wider range thanks to visual cues (Carmigniani et al., 2010, 342).

AR technologies, due to the wide range of applications they offer, are also playing an increasingly important role in diagnostics and in supporting the healing process. According to Pereira (2019, p. 760), healthcare solutions that make use of AR have made significant advances in the context of providing high-quality diagnosis or treatment support. In addition, AR supports the development of preventive medicine, through the use of online consultations, the doctor is able to conduct real-time surveillance of the patient which, among other things, increases the possibility of detecting tumours (Omarov, 2022, p. 9854). The development of the use of AR in Poland is definitely still in its infancy and is definitely only gaining momentum. It is true that the Polish medical market and technology are catching up with solutions adopted in the West, although the prevalence of AR use is much lower. While Polish centres are tentatively starting to make use of AR, more than 200 hip and knee replacement surgeries have already been performed in the United States, using the ARVIS augmented reality--based orthopaedic navigation platform. This platform uses information that is collected by tracking cameras and presents it on a 3D display combined with a hands-free interface. This tool was recently approved for commercial use by the US Food and Drug Administration (Medicalpress, 2022). In addition, the

development of AR-based m-health services also supports the medication dosing process through greater supervision and supports rehabilitation processes, which has been improved through the use of this technology (Ara, 2021, p. 845).

Such a wide range of possibilities for the use of AR technology in medicine will certainly influence its use in the future, not only in the operating theatre but also in doctors' offices supporting the process of diagnosis or teleportation. Market Research Future analysts predict that the augmented reality market in healthcare will reach a value of more than $11.6 billion by 2030. The average annual growth rate in the coming years will remain at over 28 per cent (Medicalpress, 2022).

AR in marketing

The use of augmented reality also has significant business potential in the context of marketing activities. Companies using augmented reality in the promotion of their products can improve the quality of sales, both in relation to traditional sales channels and in e-Commerce. The increased interest in using AR technology to promote products is linked to the development of mobile marketing and the popularisation of the use of smartphones. This situation has created an environment in which AR applications can be freely created and developed (Gabajova, 2021, p. 42). The use of AR provides the opportunity to obtain more complete information about a product by using additional layers of data that can contain any useful information that can be read when viewing the product with a smartphone or other mobile device with an embedded camera. For e-Commerce, augmented reality can become a tool for detailed examination of goods by the potential buyer in terms of their usability (Vilikna, 2022, p. 58). A popular example of the use of augmented reality in e-commerce is IKEA's "IKEA Place" app. Using the camera on a smartphone to scan an area in a room, this app provides the opportunity to place the furniture offered by IKEA in the room. The user of this app will be able to see, free of charge, how the products offered by the aforementioned company fit into the layout of the flat (Delante, 2022).

Conclusions

In conclusion, the use of virtual reality in the areas of life cited in this publication has a great deal of potential for use. The use of AR in education is a solution that is increasingly boldly entering the teaching of various subjects at every level of education. There is great potential in the development of this technology in the context of education, which will influence its greater use in the teaching process. In the opinion of the author of this publication, the prospects for the development of AR in education are very high and this technology should be used more and more boldly in the teaching of more subjects.

Augmented reality in medicine is actually already a thriving industry, the development prospects of which are described in this publication. This technology will certainly become more popular in Poland in the future in line with trends in the United States. These trends in the use of AR accelerated during the COVID-19 outbreak, when there was a surge in demand for this technology in North America. As a result, the author predicts that the level of interest in the technology in question in the broader medical field will also increase significantly in the coming years.

In a highly competitive market, companies wishing to increase their sales and thus their profits must use ever more modern methods of reaching the customer's imagination. The answer to these needs is definitely the popularisation of the use of AR technology in marketing activities. Therefore, in the opinion of the author of this publication, the potential for the development of AR technology in marketing activities is also high, especially at a time when market saturation with this technology is not yet so high, and the need to stand out from competitors is constantly growing.

In conclusion, this publication presents the interdisciplinary nature of augmented reality technology, demonstrating that the technology has very high development potential. The projected development of AR technology in the sectors discussed will make the technology an indispensable element of human life in the future. This prediction is supported by the fact that the Augmented Reality (AR) Industry is already being talked about globally. And the interdisciplinary nature of this technology will be an advantage that will give AR the opportunity to grow in other fields.

References

Ara, J. et al. (2021) Comprehensive Analysis of Augmented Reality Technologyin Modern Healthcare System. *International Journal of Advanced Computer Science and Applications*, *12*(6), 845–854.

Augmented Reality (AR) Market by Application, Component, and Geography – Forecast and Analysis 2023–2027. Retrieved from: https://www.technavio.com/ (20.11.2022).

Carmigniani, J. et al. (2011). Augmented reality technologies, systems and applications. *Multimedia Tools and Applications*, *51*(1), 341–377.

Dejnaka, A. (2012). Rzeczywistość rozszerzona i jej zastosowanie w edukacji. *e-Mentor*, *2*(44), 30–36.

Gabajová, G., Krajčovič, M., Furmannová, B., Matys, M., Biňasová, V., Stárek, M. (2021). Augmented Reality as a Powerful Marketing Tool. *Proceedings of CBU in Economics and Business*, *2*, 41–47.

Kęsy, M. (2017). Poszerzona Rzeczywistość w Edukacji. *Dydaktyka Informatyki*, *12*, 124–131.

Laskowski, M., Rawski, M., Szadura, P. (2013). Wykorzystanie rzeczywistości rozszerzonej w życiu codziennym. *Informatyka, Automatyka, Pomiary w Gospodarce i Ochronie Środowiska*, 2, 37–40.

Lee, K. (2012). Augmented Reality in Education and Training, *TechTrends*, *56*(2), 13–21.

Liarokapis, F. et al. (2004). Web3D and augmented reality to support engineering education. *World Transactions on Engineering and Technology Education*, *3*(1), 11–14.

Miligram, P. Kishino, F. (1994) A Taxonomy of Mixed Reality Visual Displays. *IEICE Transactions on Information and Systems*, *E77-D*, *12*(12), 1321–1329.

Omarov, B., Doskarayev, B., Omarov, N., Kurmanbayev, B., Bitabarov, Y. (2022). Augmented reality in sport and healthcare sciences: A review. *International Journal of Health Sciences*, *6*(S6), 9847–9859.

Pereira, N., Kufeke, M., Parada, L., Troncoso, E., Bahamondes, J., Sanchez, L. (2019). Augmented reality microsurgical planning with a smartphone (ARMPS): a dissection route map in your pocket. *Journal of Plastic, Reconstructive & Aesthetic Surgery*, *72*(5), 759–762.

Postawa, A. (2018). Rzeczywistość rozszerzona w nauczaniu i uczeniu się. In: J. Kędzior (ed.), *Komunikacja a zmiana społeczna* (pp. 109–122). Wrocław: Wyd. Instytutu Pedagogiki UW.

Rozszerzona rzeczywistość w marketingu – jak ją wykorzystać? Retrieved from: https://delante.pl/ (20.11.2022).

Siwak, W. (2016). Matrix i pół-Matrix czyli rzeczywistość wirtualna i rzeczywistość rozszerzona jako wyzwania dla tożsamości, kultury, sztuki. *Rocznik Naukowy Kujawsko-Pomorskiej Szkoły Wyższej w Bydgoszczy. Transdyscyplinarne Studia o Kulturze (i) Edukacji*, *11*, 355–388.

Vilkina, M.V., Klimovets, O.V. (2020). Augmented Reality as Marketing Strategy in the Global Competition. In: Popkova, E., Sergi, B. (eds.), *The 21st Century from the Positions of Modern Science: Intellectual, Digital and Innovative Aspects* (pp. 54–60). Springer.

Warchoł, T. (2016). Technologia rozszerzonej rzeczywistości w rozwijaniu wyobraźni dzieci i młodzieży. *Edukacja – Technika – Informatyka*, *3*(17), 184–190.

Wójcik, M. (2018). *Rozszerzona rzeczywistość w usługach informacyjnych bibliotek*. Kraków: Wyd. UJ.

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 22.05.2022
Accepted for printing: 10.11.2022
Published: 22.12.2022

DOI: 10.15584/jetacomps.2022.3.8

MILAN ĎURIŠ[1], **PETRA KVASNOVÁ**[2]

Implementation of a Research-oriented Model of Learning in the Subject Technique in Lower Secondary Education with a Focus on the Cognitive Domain

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

Abstract

In this paper, attention is paid to the inquiry-oriented model of students' education in the subject Technique in lower secondary education. The proposed model reflects the long-term needs of students' education in the subject Technique, which, in spite of the updated content of the curriculum in the Educational Standard of the subject Technique, have not yet been fulfilled. These issues are addressed within the KEGA project No. 006UMB-4/2022 in the years 2022–2024. The project is funded by the Ministry of Education and Science of the Slovak Republic. In the article we present basic information about the background, objectives, about the research team and the planned outputs of the problem.

Keywords: elementary school, model of education, subject Technique, technical education, experiment

Introduction. Current state of the issues

One of the aims of education in primary and secondary schools is to prepare students for practical and real life so that every graduate has an equal opportunity to join the workforce in today's evolving information society, knowledge economy and globalisation. Currently, the still prevailing transmissive way of teaching and the assessment of students with a grade requires, due to the ongoing school reform from 2015 and the changes in the curriculum with a specific focus on the educational scope of Man and the World of Work, to implement elements of research-based learning and new assessment practices in the teaching process.

Based on the decision of the Ministry of Education, Science and Higher Education of the Slovak Republic, starting from the school year 2015/2016, the technical education began to be implemented from the 5th class of the primary school (PS) in line with the innovative State Educational Programme (iSEP) according to the innovative Educational Standard (iES) of the subject Technique. The subject Technique in lower secondary education has its firm, specific and irreplaceable place in the system of teaching subjects, which cannot be replaced by any other subject.

As stated in the iSEP, the subject Technique must be based not only on theoretical knowledge but above all on practical activities. Its content is targeted at skills and habits for students' employment and society further in life. It is based on students' creative participation and cooperation. It adds an important component to basic education by laying the foundations in technology that are essential for further study and for students' performance in real life. Students learn to plan, organise and evaluate work activities both independently and in groups. The content of the subject Technique continuously provides students with important information and helps them to make responsible decisions about their future career and life choices.

The objectives of the subject Technique formulated in the iSEP reflect the content of the subject in grades 5–9 of primary school. From the aspect of solving problems in the project, we are primarily interested in fulfilling the following objectives in the subject Technique:

- students experiment with ideas, materials, technologies and techniques,
- students distinguish and safely use natural and technical materials, instruments, equipment and tools,
- students apply creativity and their own ideas in work and experimental activities,
- students acquire the necessary knowledge and skills relevant to employment opportunities, the choice of their own professional direction and further professional and life orientation.

Innovative Educational Standard for the subject Technique in 5th–9th grades of PS within individual thematic units also includesso called Performance Standard, which formulates performances that determine what the student should know at the end of a given year within a given thematic unit should know and be able to perform.

Experience and our own knowledge from pedagogical practice, as well as the results of extensive research in the Slovak Republic (Ďuriš, Stadtrucker, Pandurović, 2019; Pavelka et al. 2020) lead us to a conclusion that the objectives of the subject Technique and the required performances formulated in the Performance Standard have not yet been met.

This state has not been significantly affected in a positive sense by the publication and commercial dispatch to PS (not to all PS in the Slovak Republic) of

the following methodological materials for the subject Technique (Workbook for 5th and 6th grades, 2015, Workbook for 7th, 8th and 9th grades, 2016 – from the publishing house Dr. Josef Raabe Slovensko, s.r.o. Workbook for 5th, 6th and 7th grades, 2017, Textbook for 5th and 6th grades – from the Taktik, s.r.o.).

Among the causes of thisstate,we can include mainly the unqualified teachers teaching the subject Technique, still prevailing transmissive method of teaching and evaluation of students with a grade, the absence of textbooks for the subject, insufficient material equipment for the subject and others.

In pedagogical practice, we most often encounter the application of summative assessment of students in the teaching process, which is usually associated with a classification. Students are often stressed by its application, they learn only for good grades, and they are often only passive objects of examination and evaluation. The aim of students' assessment cannot simply be to assess their performance at the moment, 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 students' self-activity and independence from the teacher.

Self-assessment and self-controlare the most important motivational means for the students. Formative assessment of students in the teaching process aims at obtaining feedback on the students' progress in learning, on shortcomings and mistakes, with the aim of their eliminating. As stated by several authors (Turek, 2014; Kalaš, 2013; Shute, Kim, 2014; Ďuriš, Stadtrucker, Pandurović, 2019), formative assessment of students should be used more extensively because it improves the quality of students' knowledge and skills.

Since the existing models of education in the subject of technology fail to meet the stated objectives of the subject, it is necessary to perform the teaching process not only in a demonstrative and age-appropriate way, but especially experientially with the application of creative thought participation and cooperation of students. This requires the need for active participation of students in the teaching process, which can be achieved, for example, by means of research-oriented teaching. Another need is to carry out activities of an experimental nature with use of available and unexpensive tools. We also propose to methodically process the proposed activities of an experimental nature with the application of formative assessment of students (self-assessment sheets for students) with a focus on comprehension and specific transfer of learning in the cognitive domain.

The subject matter of the study. Project focus and description

The project focuses on the design and implementation of students' experimental activities using formative assessment and students' self-assessment within a research-oriented model of learning in the subject Technique in lower secondary

education. The proposed experimental activities and their implementation will serve to improve and consolidate students' knowledge and skills (fixation phase) and application in practical tasks and life situations (application phase), thus emphasizing the integration of students' learning and self-evaluation. It also implies a "shift" from simply verifying the students' state of knowledge towards activating their higher cognitive abilities in solving tasks requiring creative thinking.

In the learning process of a student, feedback on what he/she has learned is very important for him/her. This information enables to regulate his/her own learning and, if obtained by the student him/herself, has a significant impact on his/her level of self-assessment and self-awareness. The implementation of a research-based model of learning in the subject Technique represents an innovation in the formal assessment of the student in the teaching process. On the one hand, the student applies his/her knowledge and skills from the exposure phase of teaching in practical situations, which is required of the student in the field of technical education and, on the other hand, the student receives immediate feedback on the success or failure of his/her learning. In this way, students' learning outcomes can be improved in synergy with the application of experiential learning. At the same time, students' experimental activities are aimed at promoting their key competences and 21st century skills (creativity and innovation, creative and critical thinking, problem solving, etc.).

The experimental activities will be focused on the thematic unit Technical materials and working procedures of their processing, which is included in the updated Educational Standard for the subject Technique in the 6th and 7th grade of PS. Emphasis will be placed primarily on the Performance Standard in which the performances are formulated in a given thematic unit, determining what the student should know and be able to do at the end of a given school year in a given thematic unit. Part of the formulated performances is also the implementation of simple experiments that should significantly influence the acquisition of knowledge and skills of students in the higher levels of the taxonomy of educational objectives, which are necessary for further education and life in the 21st century.

As this is applied research, the aim of its implementation within the project will be to verify the effectiveness and efficiency of the proposed research-oriented model of education, the proposed experimental-oriented practical activities and activities of students with the application of formative assessment of students, in selected fully organized urban and rural primary schools through the main research method - natural pedagogical experiment. The research will be carried out through partial research activities of the members of the research team.

Research methodologies, tools and research Team

The solution of the given problems in the project and the gradual fulfilment of the set objectives should also be applied in the undergraduate training of fu-

ture teachers of the subject Technique at the FE CFU in Nitra. Another reason is the implementation of the verification of the proposed research-oriented model of education in the subject Technique also in primary schools in the regions, for which the FE CFU in Nitra prepares their teachers for the subject Technique.

All members of the research team have recently published not only university textbooks, but also important scientific works (scientific monographs in domestic and foreign publishing houses), scientific studies at home and abroad in renowned journals, as well as in journals included in the scientific databases Web of Knowledge or Scopus. Numerous published outputs have been acclaimed at the national and international level.

The project team consists of teaching staff, experts in the field of didactics with a focus on didactics of scientific technical subjects (prof. PaedDr. M. Ďuriš, CSc., doc. PaedDr. J. Stebila, PhD., doc. PaedDr. V. Tomková, PhD., doc. PaedDr. J. Depesova, PhD.) and focusing on the field of scientific technical subjects (prof. Ing. A. Očkajová, PhD., Ing. P. Kvasnová, PhD., Ing. M. Kučerka, PhD.) from two departments (Department of Technology of the Faculty of Natural Sciences of Matej Bel University in BanskáBystrica, Department of Technique and Information Technologies of theFaculty of Education of Constantine the Philosopher Universityin Nitra). The need to involve the collaborating department (FE CFU in Nitra) into the research team results mainly from the fact that this department prepares students in the accredited study programmes Teacher of Technique (Bachelor and Master studies) for the position of teacher for teaching the subject Technique in lower secondary education.

Since the members of the research team have achieved excellent results in the KEGA and VEGA projects in recent years, there is a presumption that they are a guarantee of high expertise and quality of the project outputs and also, to achieve the set project objectives in the research area of Educational Sciences.

Within the framework of international cooperation, the research team will collaborate with foreign partners:

1. Prof. PaedDr. Jarmila Honzíková, Ph.D. (University of West Bohemia in Pilsen, Czech Republic).

Participation and assessment of research activity proposals including the application of formative assessment of students focusing on comprehension and specific transfer of learning in the cognitive domain, which will be included in the publication Workbook for the subject Technique with exemplification tasks. Expertise and assessment of the proposed scientific monograph aimed at defining the theoretical basis of experimental activities in the selected content of the curriculum and at interpreting the results of the experimental validation of the research-oriented model of education in the subject Technique.

2. Doc. PhDr. PaedDr. Jiří Dostál, Ph.D. (Palacký University in Olomouc, Czech Republic).

Participation and assessment of research activity proposals including the application of formative assessment of students focusing on comprehension and specific transfer of learning in the cognitive domain, which will be included in the publication Workbook for the subject Technique with exemplification tasks. Expertise and assessment of the proposed scientific monograph aimed at defining the theoretical basis of experimental activities in the selected content of the curriculum and at interpreting the results of the experimental validation of the research-oriented model of education in the subject Technique. Collaboration in publishing the results of the problem solving in the international journal JTIE – Journal of Technology and Information Education.

3. Dr hab. prof. Wojciech Walat (University of Rzeszów, Faculty of Mathematics and Natural Sciences, Department of Modern Educational Technologies, Rzeszów, PL).

The aim of the cooperation, apart from the mutual exchange of information on the latest developments in the field of didactics of technology focused on research activities in Polish primary and higher education institutions, will be the presentation of the achieved results at an international conference entitled *Education – Technology – Computer Science. Main Problems of Technology and Professional Educatin. Rzeszów*. Part of the cooperation will include the publication of outputs from the solution of the given problem in the international journal Education – Technology – Computer Science.

Analysis of research results. Objectives of the project

The main objective of the project is to design and validate experimental activities that will be part of a research-oriented model of students' education in the subject Technique in lower secondary education. Other important objectives of the project are the development of the methodology of the proposed exploratory activities with the application of formative assessment of students (students' self-assessment sheets) focusing on the understanding and specific transfer of the selected content of the curriculum in the cognitive domain. The experimental activities will involve the development of strategies for solving practical learning tasks that are aimed at promoting and developing key competences and skills of 21st century students (creativity and innovation, creative and critical thinking, problem solving, etc.).

Intangible objectives of the project

1. Development of theoretical basis for the design of research activities in the selected content of the subject Technique with emphasis on the development of competencies and skills of students in solving application and problem--solving tasks.

2. Creation and incorporation of selected chapters from didactics of technique focused on innovations in the assessment of students in the teaching process into the study in accredited study programs Teaching Technique, preparing future teachers of the subject Technique.

3. Creation of conditions in the undergraduate training of future teachers of subject Technique and for selected groups of teachers in the framework of life-long learning also in the form of conferences, methodological days, or professional seminars and workshops.

Tangible objectives of the project

1. Creation of a set of experimental activities, experiments focused on the selected content of the curriculum (thematic unit Technical materials and working procedures of their processing) in the subject Technique in lower secondary education with the application of formative assessment of students – Workbook for the subject Technique with exemplification tasks.

2. Creation of an information sheet for a compulsory elective course focusing on activities of an experimental nature for the field of technology and materials processing, which will form a part of the future accredited study programme Teaching Technique. The compulsory elective subject will complement the compulsory subject in its content.

3. Creation of a scientific monograph aimed at defining the theoretical foundations of experimental activities in the selected content of the curriculum in the subject Technique and the analysis and interpretation of the results of the experimental validation of the research-oriented model of education in the subject Technique.

Conclusions. Planned application of outputs

The application of the project outputs in practice is in the form of a publication entitled Workbook for subject technique with exemplification tasks. The publication will contain designed and methodically processed students' exploratory activities, experiments in the selected content of the curriculum with the application of formative assessment of students with a focus on understanding and specific transfer in the cognitive domain.

Another output will be the design and production of an information sheet for a compulsory elective course focusing on experimental activities for the field of technology and materials processing (wood, metal, plastics). The information sheet will form part of the future accredited study programme Teaching Technique.

The final output of the project will be the publication of a scientific monograph aimed at defining the theoretical foundations of research activities in the selected content of the curriculum in the subject Technique and at presenting the results of research aimed at experimental verification of the proposed research--oriented model of education in the subject Technique.

The publications produced will respect:

– requirements that are aimed at promoting and developing key competences and skills for 21st century learners (creativity and innovation, creative and critical thinking, problem solving, etc.),

– based on these requirements, didactic resources and teaching materials will include new modern teaching elements (formative assessment, problem tasks, PISA tasks, experimental support for teaching, etc.),

– the requirements of the guarantors of individual study programmes focused on the teaching of subject Technique and the current requirements of individual departments (FNSof Matej Bel University in Banská Bystrica, FHNS of University in Prešov, FEof Constantin the Philosopher University in Nitra),

– publications will take into account the impact of the school reforms of regional and higher education that have taken place in Slovakia in recent years.

The created publications will be used not only in the undergraduate training of future teachers of the subject Technique, but also in the framework of lifelong learning of teachers teaching the subject Technique, also in connection with the introduction of new content of the curriculum according to the updated Educational Standard of the subject Technique in lower secondary education.

The problem solved in the article is part of the KEGA project No. 006UMB-4/2022 and the VEGA project No. 1/0629/20.

References

Boocová, E. et al. (2015). *Technika. Od nápadu k výrobku.* Pracovný zošit pre 6. ročník ZŠ. Bratislava: Dr. Josef Raabe Slovensko, s.r.o.

Boocová, E. et al. (2016). *Technika. Poznať, rozumieť, vyriešiť.* Pracovný zošit pre 7. ročník ZŠ. Bratislava: Dr. Josef Raabe Slovensko, s.r.o.

Bogová, O. et al. (2016a). *Technika. Plánovať, konštuovať, opraviť.* Pracovný zošit pre 8. ročník ZŠ. Bratislava: Dr. Josef Raabe Slovensko, s.r.o.

Bogová, O. et al. (2016b). *Technika. Navrhnúť, zhotoviť, aplikovať.* Pracovný zošit pre 9. ročník ZŠ. Bratislava: Dr. Josef Raabe Slovensko, s.r.o.

Ďuriš, M., Stadtrucker, R., Pandurović, I. (2019). *Formatívne hodnotenie žiakov v kognitívnej oblasti v predmete technika*. Banská Bystrica: Belianum.

Ďuriš, M., Stadtrucker, R., Pandurović, I. (2019). *Stratégie a postupy vyučovania podporujúce formatívne hodnotenie žiakov v predmete technika*. Banská Bystrica: Belianum.

Fujas, A. et al. (2015). *Technika. Inšpirácia okolo nás.* Pracovný zošit pre 5. ročník ZŠ. Bratislava: Dr. Josef Raabe Slovensko, s.r.o.

Kalaš, I. et al. (2013). *Premeny školy v digitálnom veku.* Bratislava: SPN.

Pavelka, J. et al. (2020). *Záujem žiakov základných škôl o technické činnosti a technické vzdelávanie.* Prešov: Vydavateľstvo Prešovskej univerzity.

Shute, V.J., Kim, Y.J. (2014). Formative and stealth assessment. In: *Handbook of research on educational communications and technology* (pp. 311–321). New York: Springer.

ŠPÚ (2015). *Inovovaný ŠVP pre základné školy. Inovovaný vzdelávací standardpredmetu technika, nižšie stredné vzdelávanie.* Bratislava: ŠPÚ.

Turek, I. (2014). *Didaktika*. Bratislava: Iura Edition.

Žáčok, Ľ. (2017a). *Hravá technika*. Pracovný zošit pre 5. ročník ZŠ. Košice: Taktik, s.r.o.

Žáčok, Ľ. (2017b). *Hravá technika*. Pracovný zošit pre 6. ročník ZŠ. Košice: Taktik, s.r.o.

Žáčok, Ľ. (2017c). *Hravá technika*. Pracovný zošit pre 7. ročník ZŠ. Košice: Taktik, s.r.o.

Žáčok, Ľ. (2019a). *Technika.* Učebnica pre 5. ročník ZŠ. Košice: Taktik, s.r.o.

Žáčok, Ľ. (2019b). *Technika*. Učebnica pre 6. ročník ZŠ. Košice: Taktik, s.r.o.

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 10.11.2022
Accepted for printing: 17.12.2022
Published: 22.12.2022
License: CC BY-SA 4.0

DOI: 10.15584/jetacomps.2022.3.9

MIROSŁAW Z. BABIARZ[1], **JUSTYNA WCZEŚNIAK**[2]

Theoretical Aspects of Remote Learning in Grades I–III of the Primary School

[1] ORCID: 0000-0003-2229-767X, dr hab. prof. UJK, Institute of Pedagogy, Faculty of Pedagogy and Psychology, Jan Kochanowski University in Kielce, Poland
[2] MSc, Institute of Pedagogy, Faculty of Pedagogy and Psychology, Jan Kochanowski University in Kielce, Poland

Abstract

Early childhood education is an essential stage in the life of every child. Thanks to participation in lessons and school life, the child not only gains knowledge and various skills, but also shapes his personality, establishes bonds, and learns how to function in a social group. At the beginning of March 2020, the current order, also in the field of education, was disrupted by the outbreak of the Covid-19 pandemic. By decision of the state authorities, schools and many other public facilities were closed. Education has changed its current form by moving completely on the virtual plane, which has never happened before. The extremely fast turn of events caused huge chaos in both the pedagogical environment and among parents and their children. This has become a contribution to the theoretical and research considerations of many people.

Keywords: education, distance, learning, help, early education, student

General statement of the problem

The broadly understood concept of education is an extremely complex subject matter because it includes not only providing students with didactic materials from various fields necessary to acquire knowledge and skills in specific areas, but also affects the personality of each individual, taking into account their cognitive abilities, interests, attitudes, values, and generally speaking all-round intellectual development (Kupisiewicz, 2002, p. 28).

Subject of research

The subject of the research was the theoretical aspects of remote learning in grades I–III of primary school. Due to the outbreak of the Covid-19 pandemic,

schools and many other public facilities have been closed by the decision of the state authorities. Education has changed its current form by completely moving to the virtual plane, which has never happened before. The extremely fast turn of events caused huge chaos both in the pedagogical environment and among parents and their children. This has become a contribution to the theoretical and research considerations of many people, including ours. In this study, we have presented an initial outline of the studied phenomenon, focusing our considerations on the school, teacher, and student.

Publication analysis

Education understood in this way is usually implemented through institutional education, and while it is possible to implement it in stationary conditions, i.e., within the institution, it is necessary to reflect on the situation when such conditions cannot be met. Remote education, distance learning, e-learning or other terms meaning basically the same, i.e., teaching away from the institution using computer techniques and the Internet, or also supporting teaching with the use of computers, multimedia techniques, and the Internet. A very detailed definition of this process was proposed by Kubiak (2000, p. 34) who wrote that "distance learning is a method of conducting the didactic process in conditions when teachers and students (students) are distant from each other (sometimes significantly) and are not in the same place, using to transmit information – in addition to traditional means of communication – also modern, very modern telecommunications technologies, sending: voice, video image, computer data, and printed materials. Modern technologies also enable direct contact in real time between the teacher and the student by means of audio or videoconferencing, regardless of the distance that separates them". Until recently, this method of education was an additional element supporting the didactic process and was aimed at increasing its attractiveness for students or increasing their interest and motivation in relation to the content they are learning, or increasing their IT competences. Education ministers from countries of the European Union developed an educational strategy, the tool of which was to be distance education, and the implementation deadline was 2010, while the following goals were set:

- Improving the quality and efficiency of education systems in the EU;
- Widening access to the education system;
- Making education systems accessible to the wider community (Bednarek, 2008, p. 16).

Thus, it can be concluded that more than ten years ago the huge potential of distance learning was noticed. It is worth noting that it was supposed to be a tool to improve and broaden didactic horizons. There was no question of completely replacing the existing education with a remote form because there are diametrical differences between these types of education; for example, in terms of the

cognitive aspect, it is not difficult to see that in online education the role of the image received is increasing, while the position of handwriting, which is popular in the traditional model, in addition, providing ready-made images may somehow limit the recipient's imagination. In favor of distance education, however, there is the fact that the possibilities of supporting the memory process in all its phases are ensured. Distinctive features of distance education are:

– Maintaining the same objectives as in traditional education, but eliminating formal barriers to recruitment;
– Complementing the programs developed by the school;
– Using various information media and other possible methods of communication and transmission;
– Flexibility in the selection of methods, forms, and modes of education;
– Widely available selection of training materials;
– Adaptation to the individual needs and abilities of the student;
– Ability to contact the student with the teacher via the Internet, both in synchronous and asynchronous mode;
– Possibility of individualization of education;
– Time and place adapted to the needs and capabilities of both parties (Cęcelek, 210).

Over the years, distance learning has been developing, and the organization of didactic work has been carried out in various ways, thus taking the form of:

– Correspondence courses, which were based on training materials delivered by post;
– Teaching of correspondence based on specially prepared learning materials sent to students;
– Videoconferencing systems coupled with a computer network;
– Teaching via radio or television;
– Courses made available on the channels of the educational cable television network;
– Teaching via radio or television with additional telephone or other interaction (Bednarek, Lubina, 2008, p. 95).

Remote education used as an additional form to supplement traditional teaching has its advantages and disadvantages. Undoubtedly, they speak in their favour:

– High flexibility as to time, place, and pace of learning;
– Increasing the efficiency and effectiveness of education;
– Improving IT skills;
– Attractive form of classes.

However, there is also the "other side of the coin", because in addition to the positives, you can also see the negative aspects of distance education, which are undoubtedly:

– Lack of direct contact with the teacher and other students;
– Weakened emotional bonds with peers;
– Barriers related to lack of IT competence or technical problems.

Despite some of the above-mentioned inconveniences, many students willingly used the additional form of education that was distance learning to provide themselves with additional learning opportunities. This form seemed quite attractive as long as it was a voluntary choice of the student, did not limit his personal space, and did not disturb his current habits and basic development needs.

Presentation of the material

The beginning of 2020 brought with it difficult conditions for education and its participants. Due to the appearance and very rapid spread of the SARS-CoV-2 virus, the Ministry of National Education decided to introduce distance learning in order to prevent the development of the pandemic, therefore, the relevant regulations were issued:

– amending the regulation on the temporary limitation of the functioning of educational system units in connection with the prevention, counteraction, and combating of COVID-191
– on special solutions during the period of temporary limitation of the functioning of education system units in connection with preventing, counteracting, and combating COVID-192 (www.dziennikustaw.gov.pl).

The solutions proposed therein were to allow the organization and course of education to be carried out using distance learning methods and techniques so didactic and educational tasks could be performed and the core curriculum implemented despite the limitations resulting from the specificity of distance learning.

In addition, the Ministry of National Education has also created a guide addressed to all participants in remote education, i.e. headmasters, teaching staff, parents, and students. Each of the above-mentioned sides of education received appropriate advice and materials to positively influence the effectiveness of the didactic process. Initially, the responsibility for children's education fell on the shoulders of parents. Teachers were only supposed to be the initiators of certain activities by proposing activities and exercises to parents or by sending worksheets. The guardians, on the other hand, had to introduce their children to the current situation, explain all the unknowns, create conditions, and, of course, implement remote education into their lives so far (MEN, 2022).

Due to this situation, the entire educational system at all levels required a complete reorganization. Looking at the structure of education, it is obvious that many participants take part in it, and each of them should be perceived from a completely different perspective, because they have different rights, obligations, and points of view. The basic members of remote education are, of course, the student and the teacher, but speaking of the early school stage, the partici-

pants of this process are also parents or legal guardians, who play a huge role in education, especially those in the online form. Each of the parties mentioned above had to reorganize their lives as a result of the situation. It was necessary to adjust one's own lifestyle related to both the personal and personal sphere. Education has also different methods and techniques, which have also had to change because those used so far have ceased to be useful. Both teachers had to adapt to working with new tools, and students needed time to adjust to receiving knowledge and learning in a completely different way than before.

From the point of view of all participants in education, the prospect of online learning was a huge shock. Teachers who had no contact with this form of teaching or knew little about it had to do a lot of work to implement, at least to a small extent, the methods and tools for remote education. According to the reports on this subject, it can be safely stated that no detailed guidelines on how to organize remote learning have been provided by the government, and no support has been provided. As a result, some of the teaching staff tried to train on their own by participating in online training and webinars; there was also a group of teachers who did not take up the challenge and stopped teaching when schools were closed and switched to remote mode. Such activities had an impact on the recipients, i.e., students, and therefore in the first case, education could continue, although perhaps in a slightly reduced form, but it still occurred, students did not lose the chance and opportunity to acquire knowledge and skills, and in the second case, the echo of teacher training resulted in tragic consequences, pupils were left to fend for themselves, disoriented, and deprived of the possibility of further education in this situation. This image shows how important the teacher is in remote education. Much depends on his willingness and motivation to improve himself and overcoming obstacles encountered in his development path. Interestingly, many educators who wanted to meet the needs caused by the pandemic set up Facebook groups in which they shared with other teachers their ideas for working with students under current conditions, advised each other what tools could be used to make lessons interesting and effective, and provided each other with mutual mental support, which was also essential in such a difficult time (Buchner, Wierzbicka, 2020).

Another party involved in education is, of course, students who have been placed in a very difficult and incomprehensible situation. many questions and unknowns were born in their heads, as well as a lot of fear and anxiety related to the presence of a pandemic. They demanded explanations from teachers and parents; they could not understand and accept the situation in which they found themselves. It is worth noting an important issue, not only the way of education has changed for them, but also their relationships between peers, which at the early school stage are an extremely important element of the development of an individual, have been severely limited. It was also very difficult to adapt to les-

sons at home; many students did not want to show their surroundings in front of the camera or had to share the space with their siblings. A big barrier was also IT competences, which at this age, for obvious reasons, were not yet developed and the help of household members was necessary here. All these aspects make the education process very stressful and difficult for students to manage. The children were faced with quite a challenge – they had to assume the role of a fairly independent participant in education, responsible, caring for their educational path.

Early childhood education is a special stage, because students are already obliged to acquire knowledge, but they are just learning this process and need a lot of support. in "normal" conditions, it is given by the teacher who tries to observe the student's work on an ongoing basis and correct mistakes made; as a result of switching to remote mode, this task fell on the shoulders of parents and legal guardians, so it is worth mentioning how important they were in the process of remote education. Their tasks included not only reconciling professional life with remote teaching of their children. They had to organize a space at home adapted to learning, take care of the mental aspect of their charges, explain the situation to them, and, of course, help them get used to remote education. Often it was the parents, on their own, who first had to undergo training in the tools proposed by the school in order to be able to show their children how to use them (Plebańska, Szyller, Sieńczewska, 2020).

As you can see, all participants in remote education played essential roles and it would not have been possible without the participation of any of them. Everyone had to do a lot of work and adapt to existing conditions so that distance learning could function and bring about results. The cooperation of the above-mentioned parties is necessary for remote education to exist, despite their cooperation, there are still other barriers that need to be overcome so that students can learn from home; these include:

- access to technology,
- preparing teaching staff and students for virtual education;
- maintaining an appropriate level of communication and participation,
- student progress checks and exams (pie.net.pl, 2020).

Conclusion

For remote education to exist and bring effective achievement, three basic elements must be met:

- technical capabilities on both sides of the process, i.e., both the student and the teacher. These possibilities should be understood as access to equipment and the Internet, as well as remote education management software;
- educational resources;
- competences of teaching staff in the field of organizing education in a remote form (Pyżalski, 2020, p. 43).

Bearing in mind the above elements, the readiness of the current school and students for distance learning in each of the above-mentioned points should be considered, and if not, whether and what steps should be taken to achieve this readiness.

References

Bednarek, J., Lubina, E. (2008). *Kształcenie na odległość. Podstawy dydaktyki*. Warszawa: Wyd. Naukowe PWN.

Buchner, A., Wierzbicka, M. (2020). *Edukacja zdalna w czasie pandemii Raport*, Edycja II. Retrieved from: https://centrumcyfrowe.pl/wp-content/uploads/sites/16/2020/11/Raport_Edukacja-zdalna-w-czasie-pandemii.-Edycja-II.pdf (8.02.2022).

Cęcelek, G. (2010). *Kształcenie na odległość ważnym wyzwaniem dla edukacji w społeczeństwie informacyjnym*. Retrieved from: www.bazhum.muzhp.pl/media/files/Nauczyciel_i_Szkola/Nauczyciel_i_Szkola-r2010-t3_(48)/Nauczyciel_i_Szkola-r2010-t3_(48)-s63-72/Nauczyciel_i_Szkola-r2010-t3_(48)-s63-72.pdf (30.01.2022).

Gajderowicz, T., Jakubowski, M. (2020). *Cyfrowe wyzwanie stojące przed polską edukacją*. Warszawa: Polski Instytut Ekonomiczny. Retrieved from: https://pie.net.pl/wp-content/uploads/2021/02/Raport-PIE-cyfrowe_wyzwania.pdf (8.02.2022).

https://kometa.edu.pl/uploads/publication/941/24a2_A_a_nauczanie_zdalne_oczami_nauczycieli_i_uczniow_RAPORT.pdf?v2.8 (8.02.2020).

https://www.dziennikustaw.gov.pl/D2020000049201.pdf (30.01.2022).

https://www.dziennikustaw.gov.pl/D2020000049301.pdf (30.01.2022).

Kubiak, M.J. (2000). *Wirtualna edukacja*. Warszawa: Mikom.

Kupisiewicz, C. (2002). *Dydaktyka ogólna*. Warszawa: Graf-Punkt.

MEN (2022). *Kształcenie na odległość. Poradnik dla szkół*. Retrieved from: https://dokumenty.men.gov.pl/Ksztalcenie_na_odleglosc_%E2%80%93_poradnik_dla_szkol.pdf (30.01.2022).

Plebańska, M., Szyller, A., Sieńczewska, M. (2020). *Edukacja zdalna w czasach Covid-19 Raport z badania*. Warszawa: Wydział Pedagogiczny Uniwersytetu Warszawskiego.

Pyżalski, J. (red.) (2020). *Edukacja w czasach pandemii wirusa COVID-19. z dystansem o tym, co robimy obecnie jako nauczyciele*. Warszawa: EduAkcja.

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 22.06.2022
Accepted for printing: 10.11.2022
Published: 22.12.2022
License: CC BY-SA 4.0

DOI: 10.15584/jetacomps.2022.3.10

PETER KOVÁČIK

Possibilities of 3D Printing as Modern Technology Using at Education

ORCID: 0000-0002-0697-6499, doc. Ing., Ph.D., DTI University in Dubnica nad Váhom, Department of didactics and special subjects, Slovakia

Abstract

The article describes possibilities of 3D printing using at educational process. It focuses attention to alternative creation of new specific teaching aids as well as motivation of pupils and students towards study of: informatics, programming, using of CAD programs, design of new products, etc. Working principle of 3D printer and cardinal information concerned to successful using of new technology is described shortly.

Keywords: education, 3D printing, teaching aid, modern technology for education

Introduction

For the most effective educational process there is need to present knowledge to students by style, so as obtaining knowledge would be desire for students. High quality education is based on knowledge and using of different devices and teaching aids for teaching. Teachers employ didactic equipments and do not rely only to verbal and non verbal communication with students. Material tools and models are basic elements of didactics. It is integral part of teaching process and it has big influence to realization of educational aims. One of the most important didactic principles is principle of object teaching that is realised mostly by teaching aids and models.

An improvement of technologies makes it possible to use them in educational system. 3D printing is one of new methods that can be used to create different products. The technology of 3D printing offers efficient alternative of large amount of models creation by actual needs of education based on natural creative invention, hardware and in bounds of solid expense. An 3D model is

possible to use for assistance at active education with practical manipulation with models at standard teaching. It is possible to make easier learning for pupils with visual in sufficiency or reduced space orientation.

The subject matter of the study. Exploitation of 3D printing at school

3D printing is possible to use at educational system as teaching subject or as component of other related subjects (informatics, construction drawing, designing, engineering, etc.). But also as alternative of creation of teaching aids for teacher (for example for subject as: chemistry, physics, geometry, electrical engineering, etc.). Probably, the most suitable of 3D printing at school is creation of models with pupils that will be used as didactic aids at different study subjects.

It is possible, by 3D printing, to create basically any object. It is reason why different educational aids can be created for different study subjects for basic and secondary schools. There is possibility to teacher to create models that serve to purpose of student motivation. A teacher does not have to create models from the beginning. Today, there are lot of models that are ready. A model can be copied from source, adapted for specific type of 3D printer and printed. Some exhibits from museum can be copied for example by this way as well. There are some fields of learning topics that are not easy for students usually. Mostly it is: models and diagrams that are displayed by 2D version at text boxes. It is usually: different kind of mathematical and chemical models and diagrams. There is possibility for better understanding for students by the possibility of 3D printing and creation of three dimensional models. It brings motivation that is able to change dynamics of all class. It is not possible to avoid changes of size of some parts of models (for example to reduce size of machines or on other hand to expand models of atoms, molecules, etc.). Observations of students can be distorted by the change of dimensions. However, manipulation with model, it is lot of times the only way how to know presented object at least.

Research methodologies and tools

The research was carried out using the analysis of commonly available IT solutions regarding technology and software to support 3D printing. It is convenient to exploit for example projects that support introduction of 3D printing into schools, considering financial status of educational system. These projects are often financed by technological companies or dealers of technological equipment. They organise education for teachers moreover. There isn't obligation to buy expensive software to 3D printers within educational system. Software is oftentimes available to copy free, or there is possibility to use online CAD editors that is not obligation to install. Some producers of commercial software enable special educational editions by bargain prices of cost free.

Analysis of research results. The principle and basic characterization of 3D printing

3D printer uses X and Y axes on plane as standard printer, but adds third axis Z – height. Said very simply, complex future object is decomposed into horizontal slim measures (slices) that are during printing stocked at each other. Each of slices has outside contour in X–Y plane in shape of future object at corresponding height. Material object is created by process that particular segments are stocked on each other step by step. Different restrictions originate depending up used material and 3D printer and other factors. In spite of all restrictions, 3D printing has lot of advantages in comparison with standard methods of production of three dimensional models. Compared to casting – there is for example saving of time and financial resources needed for preparation of cast up, standard machining – saving of waste material. Lot of patterns is complicated to produce by standard methods and 3D printing offers proper alternative. 3D printing method is not universal of course. It is required to consider properly, what will be printed by 3D printer and what is expected from resultant printed models.

A material is supplied in the shape of printing filament. It is extruded by heated nozzle in head of 3D printer – it is the most common technology of 3D printing and also the most cheep alternative. The price of such 3D printers is from hundreds Euro (printers used at home)to tenths thousands Euro (professional). The technology of 3D printing is convenient for printing of functional models and prototypes that are after printing ready to be used immediately. A material for 3D printing is from thermoplastic, twisted in coil. Material is gradually supplied into extruder – printing head.

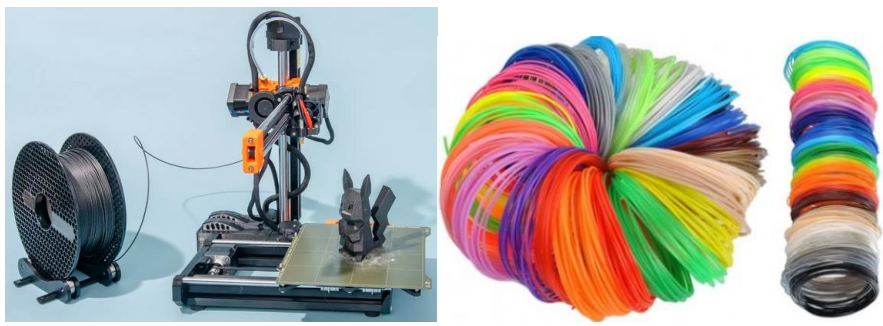


Figure 1. 3D printer and filament with different colours

A plastic is warmed to required temperature in printing head and coated on a base at axis X–Y. When one whole layer is deposited the system is shifted along axis Z and next whole layer is printed. This way of printing is not precise and separate layers are often visible. This can be adapted by adjusting of layer height or by treatment of completed model.

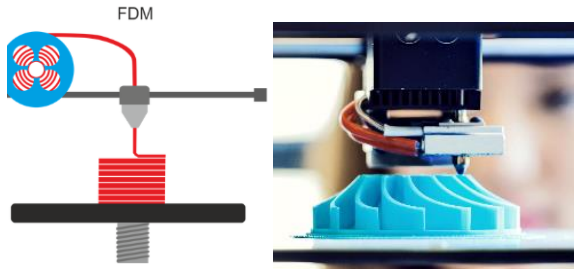


Figure 2. Basic principle of 3D printing (layer over layer)

Specific disadvantage is necessity to create supporting skeletons when plates that exceed fundament of printed model are printed. Advantages are price availability of printers and printing material, proportions of printers that is suitable for using at office or at home. There is possibility to print coloured models thanks to possibility to change filaments during printing. Changing of filament is possible to do by hands (printers of lower cost) or automatically (printers with more feed blocks). Materials for printing are more sorts at present. Materials for printing have different characteristics and are produced from: plastics, metals, alloys of metals, ceramics, concrete, paper, different sorts of bio materials, etc.

PLA is the most frequently used filament probably. Its popularity results not only from low cost but large assortment and good properties for printing moreover. It is efficient for printing of small and detailed objects. Considering small temperature expansion of this material, printed models do not screw, crack and come unstuck from plate. PLA is robust and breakable all at once. It has low temperature resistance – it comes plastic at 60°C. It is least long live material to weather conditions among the most used materials.

PETG combine properties of PLA and ABS properly and it is suitable for recycling. It has lower temperature expansion but it is more stabile to temperature and mechanical stress. Models are soft elastic this is why they do not crack immediately by mechanical impact. A model made from PETG has bright surface comparing to PLA.

The 3D printer is selected by more criteria:

- Technology of printing – what material is used for printed model,
- Largeness of printing plane,
- Speed of printing (mm/s) –it depends on resolution and other facts,
- Resolution – details on printed model makes printing longer,
- Proportions of printer,
- Possibility to print by more colours – usually in separate slices,
- Possibilities of printer connectivity (including connection to data network),
- Using of display to control of printer,

– Software and its upgrade,
– Price of printer, etc.

Process of 3D printing consists from three main steps that follow to each other:

1. Creation of model of printed object in digital shape – obtaining of model from internet, creation of 3D model by using CAD software, transformation of existing matter to digital version by 3D scan or by photogrammetry.

2. Conversion to format determined for printing – the object is represented in it by three dimensional networks of reciprocally interconnected points. The model can be modified and edited at any time. As many points are in the network, that represents object, thereby model is more precise, but resulted file is bigger and operation with it is more complicated and demanding to computer power. Consequently, the file is transformed into format generally used for programming of CNC machines (sequence of text instructions, printer use instructions to provide individual transactions). In the programme, that divide model into separate horizontal segments (slicer) it is possible to set lot of parameters that bear relation with printing. A printing can be modified in light of printing duration, cost, visage and robustness of model. Parameters are for example: temperature of printing head, speed of printing head, thickness of one layer, robustness of surface, format and thickness of filling, format and situation of supports, situation of model on plate, etc.

3. Printing:

– The temperature strait relates with speed of printing and diameter of jet and can be adapted to dimension of printed object. Small precise objects are preferable printed with lower speed and lower temperature then bigger objects that can be printed with higher speed and higher temperature.

– A layer height affects resolution in Z axes. As higher is height of one layer as more visible are separate layers. A height of 0,15mm is used usually, but different values can be used as well. The height of one layer influences time needed for printing significantly. As lower are layers as longer is time needed for printing of the some model. A width of layer relates with its height (100% = width of printing head). Higher robustness can be obtained by extension of width of layer.

– An infill influences speed of printing, filament consumption and robustness of resultant object. An infill density is usually 10–20% (0% is hollow object, 100% is solid object). As higher infill density is as heavy and robust against pressure object is. A shape of infill pattern: line, grid, honeycomb, etc. influences situation also.

– Supports uphold parts of models that without support would suspend in air.

Most of printed models are possible to be used directly after printing. Treatment of printed model makes it possible to improve mostly visual quality of product where are higher demands to this parameter. It is mostly: abrasion, cementing, gluing, smoothing by chemical process, colouring, etc.

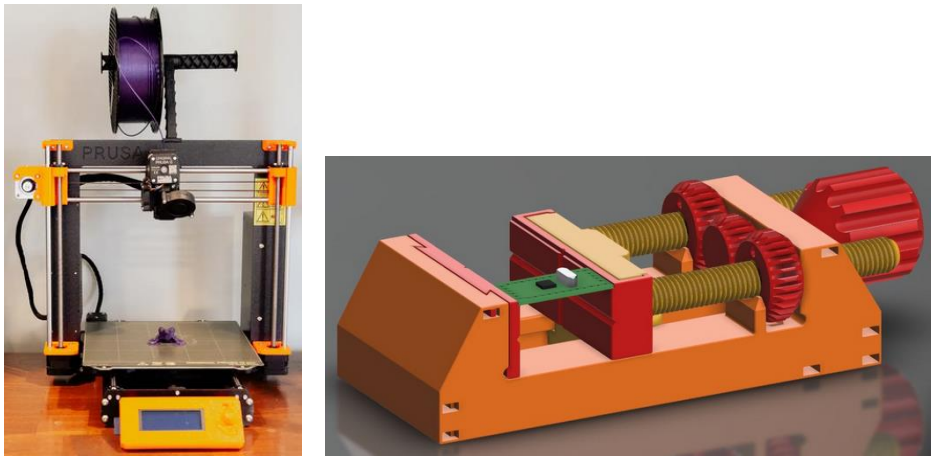


Figure 3. Printer and model after 3D printing

Advantages of 3D printing that are possible to exploit at educational system for preparation of teaching aid are: cheaper and mere quick production, local production by requirement, controllable quality, more clear presentation, competitive advantage, fast economic return of investment, care to environment, etc.

The exploitability of 3D printer at school relates with education, when a printer is didactic instrument studied by students as taught subject, eventually as device used at after school activities to produce different kind of objects. Exploitation of modern technologies increases prestige of the school as an institution, what can be positive at recruitment of new students and pedagogues.

An application of didactic aids is integral component of effective and qualitative process of education. School surrounding should educate modern technologies as much as possible with aim: to prepare students for life in reality of accelerated technological improvement of society.3D printing has its future. It is one of new, useful technologies suitable for using at school. An improvement of educational process on the base of results reached at science, research, advancement and application of effective modern pedagogical approach should be one of basic principles of education.

Conclusion

Basic purpose of the article is to inform pedagogues about possibility to use 3D printing as new dynamically unroll technology in favour of education. There are two basic possibilities – production of new teaching aids and education of students at field of software creation by using CAD programs, principles of CNC machines programming and creation of new design models. Focus is orientated to practical creation and by that motivation to active performance.

References

https://www.darcekovy-raj.sk/netradicne-vychytavky/3144-nahradna-pla-napln-do-3d-pera-rp100a--suprava-30ks-x-5m- (20.05.2022).
https://www.fabbaloo.com/2017/02/design-of-the-week-yet- (5.06.2022).
https://www.nytimes.com/wirecutter/reviews/best-home-3d-printer/ (10.06.2022).
https://3dsolutions.sk/co-je-to-3d-tlac-a-ako-funguje/ (8.06.2022).
https://www.onsitegas.com/industrial-nitrogen-generators-3d-printing/ (25.05.2022).

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 13.07.2022
Accepted for printing: 10.11.2022
Published: 22.12.2022

DOI: 10.15584/jetacomps.2022.3.11

PETER KOVÁČIK

ORCID: 0000-0002-0697-6499, doc. Ing., Ph.D., DTI University in Dubnica nad Váhom, Department of didactics and special subjects, Slovakia

The Alternative Model of Simplified Estimation of Measured Variables

Abstract

The article analyse errors which occur when airborne instruments are used and it creates basic idea about a chance of a man (pilot) to receive correct indication to his activity. The article introduces simplified model of numbers of measured values perception at short time and some possibilities of activity simplification which can lead to bigger lucidity and efficiency of measured values using. As a result is an alternative design of optimization of measured values estimation by a man who is influenced by stress situation, mostly by time.

Keywords: measurement, airborne instrument, probability, optimization

Introduction Educational merit of the article

The analysis in this article can improve communication between teacher and pilot student. In the beginning of pilot study, a student has not optimal idea about processing of lot of dates at short time and stress situation. A student has to understand what is important – he has to have sense (even though not exact) about complex situation at each moment. When he has enough time, he can solve different situations more precisely. The analysis shows complexity of decision making and its phases from very simplified version to more complex and more natural (fuzzy) view. Student can see, and understand at one place, conversion from simplified problem solving to more natural solving by estimation (but estimation needs experience). This analysis shows to student how estimation and experience are connected. As soon as possible student penetrates this fact, as better for his progress.

A cooperation of pilots or a pilot with pilot student is based on effective, strict and clear verbal communication. Any bigger size misunderstandings and

inaccuracies can conduce not only to troubles from human point of view (influence of an overload which can tend up to the senselessness, jumps of the movement and impacts or injury resulting from it) and technical also (aeroplane particular parts damage as for possibility of air crash with all fatal effects). Pilots and air traffic control personnel are using human language, not exact number values, not only for communication but also at thinking and solving of different situations. This is a reason why lot of estimations and predictions of variables values, which do not have exact value but use some degree of precision, are at their thinking. These values are changing continuously at the time in addition.

The subject matter of the study. Causality of measurement errors of airborne instruments

An example: pilot is using deflections of elevator to control aeroplane flight at longitudinal plane and control of aeroplane altitude at specific situation. As input variables can be used values from aerometric altimeter and vertical speed meter. Both measuring instruments, in form of pressure sensors frequently at present time, measure barometric pressure at relevant place of aeroplane surroundings. Pressure sensing is influenced by errors which are originated by:

1. Changes of an air flow round pressure sensing place influenced by changes of velocity, temperature and pressure of air flow.
2. Changes of atmospheric moisture and water vapour condensation, eventually icing formation.
3. An angle of air flow stream is not constant round pressure sensor in dependence of aeroplane manoeuvring.
4. Location of pressure sensing places is not identical on different types of aeroplanes which induce variation even though the same sensors are used.
5. Pipes between place of pressure sensing and aerometric instruments influence a measurement when classic instruments concept is used.
6. When classic concept of aerometric instruments is used, there has to be specific pressure change to deform barometric boxes which induce position change of indicator pointers by transmission mechanism.
7. When electronic principle of instruments is used, indicated value is influenced by exactness of computing algorithm and tempo of computing system (time delay of computed value indication).

Inherent instruments involve errors and sense with specific accuracy. Measured values are influenced by errors resulting not only from principle of measurement and instruments construction, but additional occasions influence measurement on a board of an aeroplane moreover:

1. A temperature is changing depending up altitude of flight which causes changes of mechanical characteristics of particular instruments parts (expansion, elasticity, etc.).

2. Condensation of air humidity, caused by intense changes of temperature depending up flight altitude, produces surface moisture which influences function of instrument in light of short and long time moreover.

3. Different values of overload affect to all parts of instruments during flight. That mean, forces affect measured values, because forces influence during different time periods to not absolutely compensated parts of instruments at three dimensions.

4. It is similarly with influence of vibrations which are originated by turbulent atmosphere but also by all technical systems of an aeroplane. Frequencies of vibrations are important in respect of natural resonant frequencies of separate parts of instruments but instrument as a unit also.

5. Significant influence has electric and magnetic fields generated by all electric and electronic equipment including generation and distribution of electric energy on aeroplane board.

It is well known, man is bringing biggest errors to measurement outcomes by his inaccurate performance:

1. Man read out measured value inaccurately.
2. Man estimates value between number representations inaccurately.
3. Man do not observe an instrument from reasonable position.
4. Man estimates a position of instrument pointer when it is not stabilized, etc.

There are facts which make pilot activity difficult:

1. Pilot has usually short time to read up value shown by instrument.
2. Illumination of instruments is changing.
3. Sun blindness of pilot eyes is changing.
4. Vision of pilot is changing by overload influence:

– Visual angle width is on decrease

– A competence to discriminate colours is on decrease until total vision end in dependence of very small or lot of blood in pilot brain caused by overload.

5. There are changes of quality of seen information performance by pilot brain caused by influence of different stress factors:

– Coldness,
– Heat,
– Big amount of tasks,
– Threat of life:
  - Crash,
  - Impact during flight in: clouds, at night, above sea when pilot has not visual contact with ground,
– Down shoot, etc.

6. Degradation of brain oxygenation in dependence of smaller oxygen concentration when air pressure is smaller.

7. An implementation of completely digital indicators was not successful, because a pilot needs to have schematic idea about complex actual situation. Creation of this idea is strongly supported by an analogue presentation of situation by indicators, which is supplemented by precise numeric data, that a pilot can see when he has time enough.

Research methodologies and tools

By given analysis, a pilot can differentiate whole scale span of instrument into certain number of sectors, which pilot is using when he analyses actual situation and he do approximate calculations of particular flight parameters by his brain. Very approximately said, whole scale span of instrument is represented by rectangles and one of them represents an input variable into pilot reflection at actual situation.

Analysis of research results. The simplified model of measured values perception by a pilot

A centre of a specific rectangle is at position of instrument pointer and measured value is plus minus round this centre. Rectangle length is caused by negative influences to measurement mentioned above. That would means, rectangles are moving according to actual situation which would think and real activity of pilot considerably embarrass.

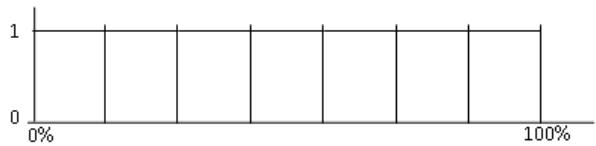


Figure 1. Division of a whole scale span of an instrument into certain number of sectors

A pilot needs sophisticated and well trained reactions to basic situations in advance, which can help to evaluate input data from instruments to him. That means, what are actual positions of instruments pointers (at least approximately) which indicate particular parameters of flight. This is a reason, why it is preferable when centres of relevant sectors of particular instruments (situated only in pilot brain) are stable and relevant value is situated insight of relevant rectangle. A probability of relevant value is lower in the direction out from the centre of sector that means probability of problem solving by corresponding value is lower. Probability, that measured variable is assuming value of adjacent sector, is increasing continuously which tends to idea that situation should be solved by another plan sophisticated in advance. Such arrangement of thinking about measurement is possible to express highly simplified by triangular shape with peaks of triangles at centres of sectors.

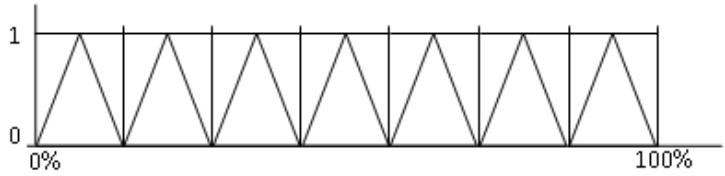


Figure 2. Substitution of rectangular shape sectors by triangle shape as expression of value truth

Decrease of probability measure of specific value is not linear and equal triangle. This fact results from analyse of negative effects to measurement which are additively and multiplicatively combined, and from which producer specifies instrument accuracy for predetermined conditions, for example ±1%. However, this condition is not possible to keep whenever which is a reason why tolerance of measurement can be bigger. Within the tolerance frame is needed to consider truth of variable at level 1. That means the peak of a triangle is not a point but certain sector, which is reason for trapezoid probability function of measured variable creation.

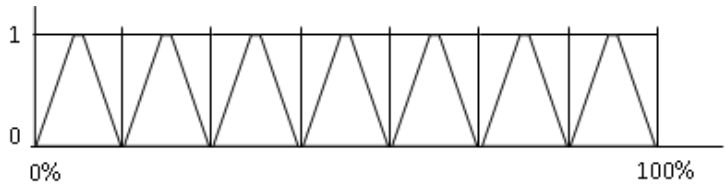


Figure 3. Decomposition of truth probability of instrument value

A number of considered instrument scale sectors affect problem solving expressively. If there are only two input variables and instrument scales are divided into five sectors there is $5 \times 5 = 25$ possible solutions. If there are more sectors $7 \times 7 = 49$; $9 \times 9 = 81$; $11 \times 11 = 121$, the number of solutions increases radically and there is a question: how many solutions pilot can have prepared in advance. Situation, when there are only two input variables is considerably simple. Decision making of pilot is influenced by more input variables usually. For example, if there are three input variables: $5 \times 5 \times 5 = 125$; $7 \times 7 \times 7 = 343$; $9 \times 9 \times 9 = 729$; $11 \times 11 \times 11 = 1331$. By given analysis, there exists an obligation to select appropriate number of sectors of measured variable and by this way reasonable sensitivity and preciseness of variable determination for standard solution:

1. 5 sectors mean one central and two towards higher and lower values. Such decomposition of instrument scale is relatively coarse and resulting solution will probably be fairly distant from optimal activity.

2. 11 sectors mean one central and five towards higher and lower values. It asks relatively large demands for estimations which are done at high speed activities and relatively big number of solutions for decision making at short time.

3. 9 sectors mean one central and four towards higher and lower values. Four sectors towards centre are possible to estimate really, but number of possible solutions is relatively large for decision making.

4. Adequate optimum is 7 sectors probably, which mean one central and three towards higher and lower values. This is possible to estimate really and resulting number of solutions is 49, which is approaching to abilities of trained pilot.

If 100% of measuring range is divided into 7 sectors, then one sector is 14% of measuring range. If top of trapezium is ±2% and it is subtracted from 14% of sector that results in ±5% for side part of trapezium from measuring range. Aforementioned alternative optimization of simplified sensing model could be accepted in the case, when trapeziums do not overlap. However it is convenient, when probability of one variable decrease then probability of neighbouring variable increase. That mean: 90% of particular value and 10% of neighbouring value, 50% of particular value and 50% of neighbouring value, etc. It results in side part of a trapezium is 10% of measuring range for probability change from 1 to 0.

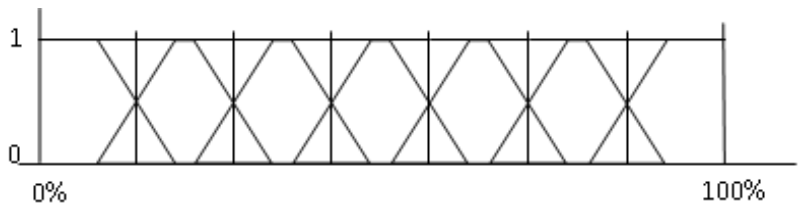


Figure 4. More real decomposition of truth probability of instrument value

A number and variety of negative effects to measurement preciseness indicate that mentioned shape of a trapezium is not kept from point of view of measurement errors distribution probability. From theory of measurement and probability used for measurement evaluation results, the most probable distribution of one sector is in the shape of the Gaussian curve.

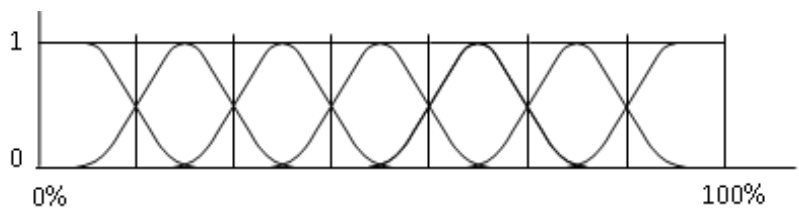


Figure 5. Decomposition of truth probability of indicated variable

However, the Gaussian curve shape is difficult for evaluation and technical realization in term of computation. This is a reason why it is preferable to substitute it by a trapezium again. But shape of a trapezium should be modified so, that difference of the trapezium to the Gaussian curve is minimal along whole curve.

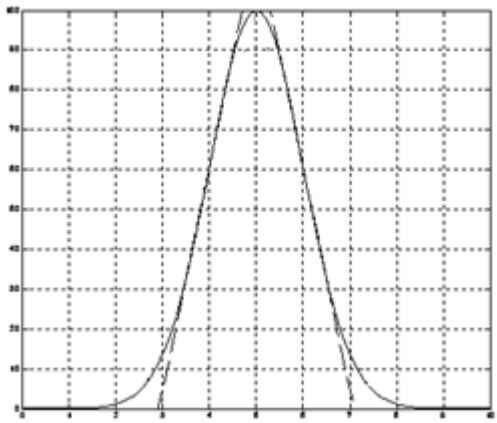


Figure 6. Substitution of the Gaussian curve by the trapezium

By this way there was created the trapezium with the shape optimized for problem solving with approximately identified measured values. Peripheral trapeziums of maximal and minimal values do not have descending parts towards extremes, their tops extends to extremes in consequence: a measurement of extremes is least precise and extreme values require extreme solution in wider measure.

Conclusion

The article describes suggestion of alternative model of measured value sensing by a man (pilot) when measured value is quickly seen (estimated) from instruments. This model can be used for high speed handling of measured values for approximate computation by a man, who is working with time lack and with high speed decision making. Simultaneously, the model is efficient base for exploitation at technical field to problem solving by fuzzy technology. Fuzzy technology uses similar principles as natural thinking of a man is, including estimation of values with specific probability of truth.

References

Driankov, D., Hellendoorn, H., Reinfrank, M. (1993). *An introduction to fuzzy control*. Berlin, Heidelberg: Springer-Verlag.

Kolesárová, A., Kováčová, M. (2004). *Fuzzy Množiny A Ich Aplikácie*. Bratislava: Stu.

PART THREE

SELECTED PROBLEMS OF PROFESSIONAL EDUCATION

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 23.09.2022
Accepted for printing: 10.11.2022
Published: 22.12.2022

DOI: 10.15584/jetacomps.2022.3.12

NATALIIA RIDEI[1], VALENTYNA TYMOSHENKO[2], NATALIIA TYTOVA[3], VIKTORIIA KHODUNOVA[4], ALONA BILETSKA[5]

Organization of Professional Training of Communication Management and Communications Specialists

[1] ORCID: 0000-0002-5553-059X, Doctor of Pedagogical Sciences, Professor of Ecology, Professor of Department for Adult Education, National Pedagogical Dragomanov University, Kyiv, Ukraine
[2] ORCID: 0000-0001-6379-0204, PhD (Pedagogical), Head of the educational and methodical office of the Kyiv Vocational College of Communication, Kyiv, Ukraine
[3] ORCID: 0000-0002-9415-4427, Doctor of Pedagogical Sciences, professor, Head of the Department of theory and methodology of vocational training National Pedagogical Dragomanov University, Kyiv, Ukraine
[4] ORCID: 0000-0001-7751-9992, PhD (Pedagogical), Associate Professor,Department of Pedagogy and Psychology of Preschool Education,National Pedagogical Dragomanov University, Kyiv, Ukraine
[5] ORCID: 0000-0002-0178-0542, PhD (Philosophy), Researcher at the Laboratory of Information Communications Central Scientifie Research Institute of Weapons and Military Eguipment of the Armed Forces of Ukraine, Ukraine

Abstract

The article substantiates, develops and experimentally verifies the model of the organization of professional training of communication management communications specialists in higher educational institutions in the synergy of functional and purposeful, content and methodological, organizational and technological as well as relevant subsystems. It clarifies and improves conceptual and categorical apparatus that belongs to the scientific thesaurus and vocabulary regarding information security in the field of education, science and innovation of the research apparatus. The communicative and motivational, participative and conative as well as informational and noospheric criteria have been determined. The following levels have been defined: medium, sufficient and high for the professional competence formation of communication management and communications specialists in higher educational institutions. The paper also defines educational and content modules of disciplines for communication management and communication specialists − management and educational policy, methodology of scientific research and training of profes-

sionally oriented disciplines; forms, methods and means for organizing educational and scientific as well as cognitive activity.

Keywords: professional competence, training of communication management and communications specialists, organization of educational process.

General statement of the problem

The legislation of Ukraine defines the top priorities that deal with implementation of the National Informatization Program, including the creation of the legal framework of information and technology support, the personal data and copyrights protection system as well as the development of national standards in the field of digitalization of economy and education, science and innovation. They also include formation of information and telecommunication infrastructure, network and platform organization of institutional activity, system development of the latest broadcast channels, fiber-optic and satellite systems of interactive online communication, development of computer-organized network of education system, science and innovation, as well as academic culture as a general component of the global network of scientific and metric Internet resources. The Program ensures information security measures of social and cultural, educational and scientific forms and systems, web and scientific-metric potential of academic schools of higher educational institutions (hereinafter referred to as HEI), including the personal data protection as an education applicant, scientific and social services, participants in the educational process, interested parties in the quality management system of education and scientific research as well as other involved representatives, including communication management and communications specialists.

Subject of research

The aim of the research is to substantiate theoretically and methodically the organization of professional training of communication management and communications specialists in higher educational institutions. The object of the research is the professional training of communication management and communications specialists in higher educational institutions. The subject of the study is the process of formation of professional competence among communication management and communications specialists in higher educational institutions.

Analysis of recent publications

The scientific and theoretical background of the study related with the formation of professional competence of future communication management and communications specialists in higher educational institutions is presented in the works of the following scientists: V. Andrushchenko, V. Beh, V. Bykov, A. Gurzhii, V. Kremen, V. Madzigon, V. Sydorenko (*philosophy of education,*

educational, humanitarian and social policy and didactics of higher education); H. Bilyavskyi, V. Horlynskyi, N. Demishkant, L. Melnyk, L. Moiseyev, N. Ridei (*lifelong education and sustainable development*); W.J. Duncan, J.E. Meya, F.J. Roethlisberger, G.A. Simon, R. Likert, F. Fiedler, P. Lawrence, J. Lorsch (*fundamental ideas of management*); A. Averin, V. Bakumenko, M. Bilinska, M. Bratko, G. Honcharuk, L. Hogina, R. Dyakiv, L. Kalinina, S. Knyazev, V. Malinovsky, N. Protasova, V. Troshchynskyi (*administration of HEI*). Particularly relevant researches are in psychological and pedagogical as well as philosophical fields in the course of *content analysis* (B. Berelson, P. Meiring, K. Neuendorf, A. Kumar, P.J. Stone, K. Krippendorff, M. White, E. Marsh, S. Stemler, H. Ioffe, L. Yardley) and *event analysis* of the information database of the educational and political phenomena development (I. Artyomov, V. Bakumenko, K. Borishpolets, S. Vyrovyi, S. Lacey, I. Reiterovich, D. Riff, S. Semin, S. Teleshun, O. Tytarenko, B. Watson, F. Fico); *educational process planning* (F. Henri); research of *subject-object and subject-subject relationships* (L. Baxter); *ways of coding* analyzed texts (K. Carli) and visualized images (P. Bell) *in social interaction* of participants of system processes (B. Prasad).

Presentation of the main material

The vocabulary related to information security in the field of education, science and innovation has been systematized. It is interpreted from the author's point of view as: „information and communication security of social and cultural forms of organization, administration, professional training of communication management and communications specialists" that is defined as an integrated system of hardware, software, information and technological support of organizational legal and regulatory means. They must be aimed at ensuring the protection of: informational space of the state, communities, social activities as well as separate citizens guaranteeing them self-esteem and national self-identity. The definition also includes cross-border, regional, national, informational and communication resources, the semantic purpose of information and telecommunication systems of professional training, informing and educating different categories of the public, who are guaranteed the right to access any information, especially educational, scientific and cognitive in the fields of science and knowledge of managing systemic social activity on the basis of sustainability. It is also considered to be an integral component of state sovereignty and national security, which characterizes the state of national interests, state protection in the information field, establishment of communicative harmonization, external and internal interaction.

Thanks to the methodological substantiation of the scientific thesaurus of the research, the definition of "professional competence" has been specified using verbal and non-verbal means to achieve the strategic goal of communica-

tive interaction in professional problem situations, which is singled out as a criterion of the communicative readiness of future communication management and communications specialist with information and communicative skills of establishing connection of professional and communicative interaction. The above mentioned definition is regarded as an integrated result of formation of dynamic complex of communicative qualities, abilities, skills, knowledge, habits, readiness,capabilities and responsibilities, which are necessary and sufficient to ensure communication in the process of performing functional and purposeful professional tasks by future communication management and communications specialists (communicative demonstration of which are the multimodal component of communication, semantic dynamics, accessibility and openness of the universalization of information technology support means). The event analysis was carried out to analyze the double series of processing information base of the communicative interaction of the administrative management organization in the HEI, which is determined by the classification features: managerial predominance of the subject phenomenon of leadership; functional purpose of the management entity; organizational and managerial influences on the object in relation to which the subject acts; transparency in the sequence of the system of analytical and informational monitoring of the status, development of forecasting and modeling of systems of different levels, as well as in the types of organization of the aimed designation.

Content and event analysis established that the main means of technical regulation are international standards of *general impact* of communicative interaction in the quality management system in the field of education regarding the regulation of safety, resource conservation, labor and information protection, verification of laboratory and testing activities and their reliable proof, environmental and energy management with guarantee of social responsibility as harmonized and ratified in regulatory and legal documents related to the implementation of Ukraine to the world organizations of quality regulation and their standardization. Another group of international standards includes special *impact* of information and analytical basis of ensuring communicative interaction in systems of different levels, types of organizations and management according to the aimed designation as well as in different types of using natural resources (social and cultural forms, educational and scientific systems of bio-social, urban, techno and agro purposes). They are similar to international standards of the Open Geospatial Data Consortium (eng. OGC), which regulates the requirements of technical regulation.

Standards of the general and special impact of technical regulation of information and communication technology (hereinafter – ICT) are designed for student-centered learning of portable educational programs, scientific and social services of the academic potential of higher educational institutions, which en-

sure compliance of professional training and organization of the educational process by means of ICT support in accordance with international and state licensing as well as accreditation requirements for the professional competence formation of future communication management and communications specialists under the conditions of harmonization in the fields of education, science and innovation.

The model of the organization of professional training of communication management and communications specialists in higher education institutions has been developed, substantiated and experimentally verified in accordance with the requests of social and economic order for the harmonization in educational, scientific, innovative fields as well as in social activity of sustainable development. It is regarded in *the functional and targeted subsystem* through the implemented fundamentals of methodological *principles*: scientific knowledge of system methodology, organization of the educational process, educational and cognitive activity, system analysis of quality; *semantics of professional training*: administrative management of professional training, educational, scientific, cognitive activity as well as communicative relationship.

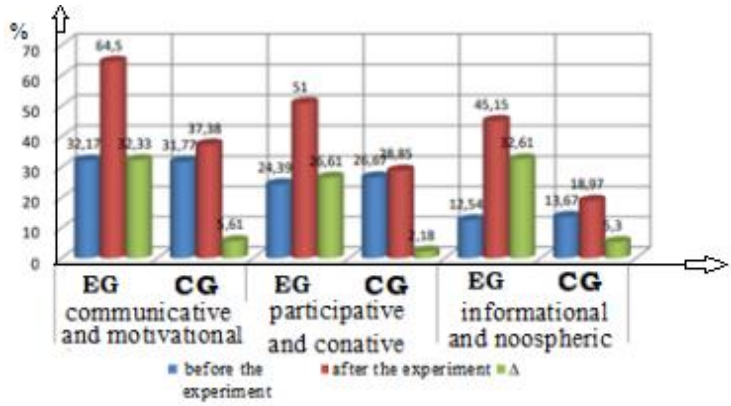
The content and methodological subsystem with the developed educational and content modules of technological support disciplines for communication management specialists as well as for information and communication relationship (informational and analytical monitoring of the educational process, information and technological support, ICT in education and social activity) has been substantiated. It also includes management and educational policy (educational management and policy, communication management, personnel management, information and communication management, computer engineering and software, telecommunications and radio engineering, information technology marketing and entrepreneurship). The subsystem also involves methodologies of scientific research and training of professionally oriented specialized disciplines. Management is among them (field of knowledge 073) which covers methodologies of pedagogical, social, psychological and communicative, public management, information and digital, system analysis of the constituent components quality of the research methodology, statistics, enterprise economics, teaching methods of telecommunications engineering, information and communication technology of communication relationship and telecommunications, postal communication, computing and programming technology, information and analytical monitoring, educational monitoring and metrics of quality policy, logistics of communication relationship, Internet marketing, ethics of business communication management as well as rhetoric).

According to Ford's method, the organizational and technological subsystem is specified in the components of the system and process implementation of educational technologies, ICT management, partial management procedures for

the realization of higher educational institutions academic potential, algorithms of technological organization of educational process (information and analytical, administrative and organizational as well as relevant) institutional regulations of higher educational institutions. 296 people took part in the experiment at the stages of pedagogical research (motivational, communicative interaction, audit, ascertaining, formative, conative as well as relevant).The incentive and motivational stage of communicative interaction involved checking the state of students' motivational reflection aimed at ensuring success (goals) or fear of failure to achieve the tasks according to the improved A. Rean's questionnaire.

Thanks to the modified method of diagnosing the motivational level of ensuring social communication and overcoming frustration (according to L. Wasserman and V. Boyko) with the applied rubric questionnaire, the degree of dissatisfaction was identified – interaction, which made it possible to evaluate its social and communicative support of the individual's life activities with the results of percentage division (in %) of very high level – 17, increased – 20, moderate – 18, uncertain – 15, reduced – 10. Very low level and no satisfaction made up a total of 20% of respondents.The audit stage was devoted to the screening of the components of professional competence of future communication management and communications specialists by audit diagnosis of integral, general and special components. Medium, sufficient and high levels have been determined, which made it possible to distinguish and diagnose professional abilities, skills and capabilities according to the state standards in the field of knowledge 07 "Management and administration" specialty 073 "Management" of education seekers involved in the pedagogical experiment.The audit stage of the pedagogical research proved the stability of high, sufficient and medium levels of the professional competence components of future communication management and communications specialists, which were synchronized and evenly distributed between the experimental (hereinafter – EG) and control (hereinafter – CG) groups. *The ascertainment stage* established the state of the entry level of the professional competence formation among future communication management and communications specialists in higher education institutions according to the above stated criteria. According to the survey data, the level of formation of the components of professional competence among the students at the ascertainment stage was almost aliquot. The verification of the levels of formation of professional competence among future communication management and communications specialists in higher education institutions was held at the formative and conative stage according to the communication and motivational criterion. It was studied in the context of the positive impact of the developed educational and content modules of the disciplines on the delta of level growth. The generalization of the results on the formative and conative stage of the pedagogical experiment testified the dynamics of the levels transformation of professional compe-

tence formation of future communication management and communications specialists in higher education institutions in EG (Graph 1).



Graph 1. Levels of formation of professional competence among future communication management and communications specialists in higher educational institutions at the formative and conative stage of the experiment in EG and CG

Significant differences in the obtained results in the EG and CG groups and between them were confirmed by K. Pearson's test (χ^2) with a reliable probability of 0.95 in favor of the EG group, which proves the effectiveness of the developed model. The relevant stage of the research was organized using expert evaluation of the implementation and establishing the reliability of the effectiveness of the applied modules and the model. Expert opinions, which were conducted according to the protocol of the examination of the dynamics of the professional competence formation among communication management and communications specialists, confirmed the positive experimental results which were evaluated at 85 points on a 100-point scale.

Conclusion

The article has revealed the theoretical and methodical principles of professional training of communication management and communications specialists which are defined as special professionally-oriented training with information and telecommunication support for communicative interaction according to the functional and purposeful aim in communicative types of social relations at the levels of the organization of communication, the transfer of information and analytical data based on harmonization in the fields of education, science and innovation. They are also founded on the following approaches: methodological (systemic, structural and functional, program-targeted, informational-innovative); educational and cognitive (transparent, participatory, diversive, bilingual, quality

management). The principles of scientific knowledge of system methodology (fundamental and philosophical, general, specific, scientific), the organization of the educational process (sequence, continuity, systematicity, prognostication and innovativeness), educational and cognitive activity (historical retrospective in the fields of science and knowledge, the potential of the level of knowledge), system analysis (system hierarchy, elementalism, general interaction of development, integrity, systematicity, formalism, normativity, goal setting). Information and communication manager of the new generation is a professionally oriented or mobile specialist who thinks progressively and innovatively, determined to work in a team with personal responsibility, motivated by the positive result of performing professionally oriented communicative tasks of harmonizing social activities in the field of education, science and innovation.Professional training of communication management and communications specialists is conducted in organizational and pedagogical conditions: student-centered ICT environment with acceptable means of technological support that enables the accommodation of multimodality, polysemantics, continuity, consistency, context, the connection of theory with the practice of scientific knowledge between the provider and the recipient of educational-scientific, portable, student-centered services of network, mixed, mobile as well as distance learning of divisional, translational, kaleidoscopic forms of organizing the educational process.

The formation of professional competence of future communication management and communications specialists in higher educational institutions is possible under the following organizational and pedagogical conditions: favorable ICT environment for student-centered learning of portable and educational programs of scientific and social services (cloud technologies that depend on type of system catalog, web metric services of coverage and functionality in the context of service access to IT); harmonization in the fields of education, science and innovation (global cross-border, regional, national academic potential of scientific heritage and mobility of academic community members , development of modern methodological directions of the prevailing social development paradigms based on sustainability with prolonged employment throughout life). They also include implementation of the policy of vocational training in the system of management of the education quality, safety, resource conservation, labor and information protection, verification of laboratory and testing activities and their reliable proof, environmental and energy management with a guarantee of social responsibility. The model of the organization of professional training of future communication management and communications specialists in higher educational institutions has been verified. During the formative and conative stage of the pedagogical experiment, it was found that for $\alpha = 0.05$, all observed values of the $\chi 2$ criterion exceed its critical value. Therefore, it can be asserted with 95% confidence that the communication management and communications

specialists in EG (compared to CG) had a significant (24.47%) increase in high and sufficient levels of the professional competence formation. The results of the study gave grounds for substantiating proposals regarding the prospects of professional training of future communication management and communications specialists in higher educational institutions.

References

Ridei, N.M., Tytova, N.M., Diegtiar, O.A., Pavlenko, D.H., Slabetskyi, O.M. (2021). Administrative Management of Improvement Processes of Socio-Cultural Forms Based on Principles of Sustainable Development of Education. *Journal of Higher Education Theory and Practice*, *21*(14), 102–111. https://doi.org/10.33423/jhetp.v21i14.4814.

Ridei, N.M., Tytova, N.M., Tymoshenko, V.I., Moroz, V.V., Bibik, N.V. (2021). Improvement of Methodological Approaches to Determining Directions of Financial Security of Ukraine. *Universal Journal of Accounting and Finance*, *9*(4), 613–622. doi: 10.13189/ujaf.2021.090409.

Ridei, N., Titova, N., Viktorova, L., Tsymbal, S. (2022). The problem of public administration of socio-cultural forms of organization in the field of education, science, innovation: current problems and vectors of development. *Financial and credit activity: problems of theory and practice*, *6*(41), 418–426. https://doi.org/10.18371/fcaptp.v6i41.251470.

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 4.01.2022
Accepted for printing: 10.11.2022
Published: 22.12.2022

DOI: 10.15584/jetacomps.2022.3.13

NADIYA MAKSYMENKO[1], **HANNA KOROBKOVA**[2], **IRYNA KYRPYCHOVA**[3], **NADIIA CHERKASHYNA**[4]

Formation of Professional Competencies in Students-ecologists as a Psychological and Pedagogical Problem

[1] ORCID: https://orcid.org/0000-0002-7921-9990, DrSc, Department of Environmental Monitoring and Protected Area, V.N. Karazin Kharkiv National University, Ukraine
[2] ORCID: https://orcid.org/0000-0002-0246-8585, Ph.D., Department of ecology and life safety, Luhansk National Agrarian University, Ukraine
[3] ORCID: https://orcid.org/0000-0003-4633-9379, Ph.D., Department of ecology and life safety, Luhansk National Agrarian University, Ukraine
[4] ORCID: https://orcid.org/0000-0002-4066-2530, Department of English language, School of Foreign Languages, V.N. Karazin Kharkiv National University, Ukraine

Abstract

The purpose of the study is to assess the compliance of professional competencies of graduates – environmentalists with the needs of the labor market. The work is based on the results analysis of a sociological survey conducted among graduates and stakeholders. The authors conducted a survey of graduates and their potential employers on their priorities among the professional competencies. The authors have analyzed professional opportunities of graduates-ecologists and the employers' requirements related to their competencies. In this regard, we calculated a rating of competencies significance for employers. The article compares professional expectations of the graduates and their employers. Conclusions. The authors conclude that students attach great importance to competencies, providing opportunities for professional growth, mastery of new technologies and application of innovations. Employers bring teamwork skills, professional skills and knowledge in the professional sphere to the fore.

Keywords: ecologist, competence, educational process, profession, polls

Introduction

Global changes in the world community (rapid technological progress, increasing anthropogenic pressure on the environment, waste accumulation and depletion of resources, etc.) increase the involvement of the Ukrainian society in

global processes, on the one hand, and on the other – exacerbate the need for highly qualified and professionally competent specialists. As Anufrieva rightly notes, education, above all, must meet the interests and demands of the society, and therefore, one of its main tasks is specialists' training aimed at the needs of today.

Unfortunately, sometimes in modern conditions, the "product" of the pedagogical system is a university graduate endowed with low cognitive and professional motivation, underdeveloped self-control and professional self-awareness as well as a formal attitude to acquiring a profession. This affects the development of personal and professional qualities (key competencies) of the future specialist, indicating the need for their formation during training at the vocationnal education institutions . Scientific and pedagogical literature pays much attention to the problem of professional competence formation.

Formulation of the problem

Professional competence means the unity of knowledge, skills, abilities, as well as readiness to act in a difficult situation and solve professional problems with a high level of uncertainty. It also includes ability and readiness to achieve a better result of work, attitude to the profession as one of the key personal values (Maksymenko, Titenko, Utkina, Nekos, Shkaruba, 2019). The level of professional competence is determined by the ability of the individual to be realized as a successful and effective specialist.

The concept of competence is broader than knowledge or skills, and implies the ability of a specialist to use acquired knowledge, skills, educational and life experience in a particular situation. We should also mention mastery of methods of finding the necessary information, ability to analyze it, see problems and solutions, self-efficacy, and an understanding of the need to learn throughout life.

Thus, the successful performance of their functional responsibilities involves a set of special knowledge and certain professionally significant personality traits. These components of professional competence are interrelated.

Competence is not specific subject skills, not even abstract mental actions or logical operations, but distinct, vital, necessary for a person of any profession and age.

The level of education, especially in modern conditions, is not determined by the amount of knowledge, their encyclopedic knowledge. From the standpoint of the competency approach, the education level is determined by the ability to solve problems of varying complexity based on available knowledge. The competency approach does not deny the importance of knowledge, but it emphasizes the ability to use it.

The main components of competence are:

1. Knowledge, not just rapidly changing information. Varieties of knowledge to be able to find and direct to their activities.

2. Ability to use this knowledge in a specific situation; understanding how this knowledge can be acquired.

3. Adequate assessment – yourself, the world, your place in the world, specific knowledge, its need for their activities, as well as the method of obtaining or using it.

A number of objective and subjective factors that depend on the society's level of development, the attitude of society to the area of activity under consideration, including the banal one – the level of payment for the future profession, influence the effectiveness of professional competencies formation. The article singles out pedagogical conditions created in a specific educational institution, in a specific specialty and in a professional environment.

The professional competence of the future specialist forms on the basis of theoretical knowledge, practical skills, significant personal qualities and life experience, which ensures his/her readiness to perform professional duties and ensures a high level of self-organization. Many factors determine the meaning of this concept, in particular, general civilization processes, globalization of economic, social and environmental problems, the study of which is one of the main tasks of the EPP (educational and professional program).

Analysis of the pedagogical literature on the essence of environmental competence reveals a fairly wide field of interpretations of this term. Thus, Tytarenko (2007) considers environmental competence of students as "the ability to apply environmental knowledge and experience in professional and life situations guided by the priority of environmental values and non-pragmatic motivation to interact with the environment based on the awareness of personal involvement in environmental problems, responsibility for environmental consequences of their own professional and household activity".

Traditionally, the learning process in higher education is organized as follows: acquaintance with the theoretical material in lectures, its consolidation during practical or laboratory classes, study and reproduction on the examinations.

Quite often, after graduation, the graduate forgets all the received information because it becomes outdated or does not allow to solve current professional problems – passively acquired knowledge does not give an opportunity to form their own opinions. In addition, training and skilled work are different forms of activity requiring different skills and abilities. For example, a diligent student may not be able to solve creative tasks as required by the conditions of professional activity (Yermakov, 2009).

Taking into account the analysis of theoretical sources and research results, the authors have established that the most important in the individual is the mo-

tivational sphere – a system of value orientations, a set of needs and goals that determine ways to develop and express potential abilities. The issue of motivation is one of the key issues anywhere, and the degree of motivation is considered one of the most important factors of successful activity.

Motivation is one of the fundamental problems studied by psychologists and educators. Its significance relates to the analysis of the individual's activity sources. The complexity and multifaceted nature of the motivation problem determines the multiplicity of approaches to understanding its essence, nature, structure, use of methods of its research.

Employers have recently been involved in the educational process to motivate the students. They participate in the formation of educational and professional programs, lectures and practical classes, including those at their workplaces, holding student internships, as well as training, master classes, etc.

It is important for employers to participate in formulating requirements for learning outcomes for a specific educational program, namely – professional competencies. Students' dreams do not always coincide with the needs of employers. An article is devoted to the study of this problem, the purpose of which is to assess the compliance of professional competencies of graduates – environmentalists with the needs of the labor market. The work is based on the results of a sociological survey conducted among graduates and stakeholders of the Educational and Scientific Institute of Ecology, V.N. Karazin Kharkiv National University (Ukraine).

Results of the research

V.N. Karazin Kharkiv National University has been training ecologists for more than a quarter of a century, majoring in 101 Ecology. Due to the high level of acquired knowledge, graduates are employed in various institutions, enterprises and organizations both in our country and abroad. Training of environmentalists in Ukraine is now carried out in accordance with two standards:

1. Standard of higher education of Ukraine: first (Bachelor's) level, field of knowledge 10 – Natural sciences, specialty 101 – Ecology, which was approved and put into effect by the Order of the Ministry of Education and Science of Ukraine dated 4.10.2018 № 1076;

2. Standard of higher education of Ukraine: second (Master's) level, field of knowledge 10 – Natural sciences, specialty 101 – Ecology, which was approved and put into effect by the Order of the Ministry of Education and Science of Ukraine dated 4.10.2018 № 1066.

All students master one list of disciplines, perform course and qualification work, undergo training and internships, etc. However, the career of each of them develops differently. What does it depend on? Which of the competencies is

a priority for the employer? What competencies do students prioritize? Our research, the results of which formed the basis of this article, is devoted to the search for answers to these questions.

The educational process in a higher education institution aims to train highly qualified specialists. Qualification is the ability to perform the tasks and responsibilities of the relevant work, determined by the name of the profession. To systematize the professions available in Ukraine, the current Classification of Occupations DK 003: 2010 of 01.11.2010 is used, based on the International Standard Classification of Occupations (ISCO 88: International Standard Classification of Occupations/ILO, Geneva), which facilitates the international exchange of professional information .

Ecology is a complex science that is not only based on diverse knowledge, but can also be part of various industries and areas of the economy. Table 1 presents a list of environmental professions according to the current Classification of Occupations.

Table 1. List of environmental professions (Classifier of professions, 2011)

code	Professional job title
2148.2	Specialist in geosystem environmental monitoring
2148.2	Specialist in remote sensing and aerospace monitoring
2149.2	Environmental engineer
2149.2	Research engineer
2211.2	Ecologist
2211.2	Ecology expert
2213.1	Junior researcher (agronomy, zootechnics, forestry, nature reserve)
2213.1	Researcher (agronomy, zootechnics, forestry, nature reserve)
2213.1	Researcher-consultant (agronomy, zootechnics, forestry, nature reserve)
2213.2	Engineer for the reproduction of natural ecosystems
2213.2	Engineer for the protection of natural ecosystems
2213.2	Forest protection and conservation engineer
2213.2	Wildlife conservation Engineer
2213.2	Environmental engineer
2213.2	Specialist in environmental education
2359.2	Organizer of extracurricular and out-of-school educational work with children
2411.2	Environmental auditor
2419.2	Specialist in economic modeling of ecological systems
2419.3	Civil service specialist
2442.2	Environmental management specialist
2447.2	Specialist in project and program management in the field of tangible (intangible) production

The study of normative disciplines defined by the standard allows students to form competencies that present them in the labor market. There are 2 groups of competencies: general and professional

Table 2. General and professional competencies of the master's specialty 101 Ecology (Standard of higher education of Ukraine, 2018)

General competencies	Professional competencies
Ability to learn and master modern knowledge	Awareness at the level of the latest achievements required for research and/or innovation in the field of ecology, environmental protection and sustainable use of nature.
Ability to make reasonable decisions	Ability to apply interdisciplinary approaches in critical understanding of environmental issues.
Ability to generate new ideas (creativity)	Ability to use the principles, methods and organizational procedures of research and/or innovation.
Ability to develop and manage projects	Ability to apply new approaches to the analysis and prediction of complex phenomena, critical understanding of problems in professional activities.
Ability to communicate in a foreign language	Ability to prove knowledge and own conclusions to specialists and non-specialists.
Ability to search for, process and analyze information from various sources.	Ability to manage the strategic development of the team in the process of carrying out professional activities in the field of ecology, environmental protection and sustainable use of nature.
The ability to motivate people and move towards a common goal	Ability to organize work related to environmental assessment, environmental protection and optimization of nature in conditions of incomplete information and conflicting requirements.
Ability to conduct research at the appropriate level	Ability to self-educate and improve skills based on innovative approaches in the field of ecology, environmental protection and sustainable use of nature.
	Ability to develop environmental projects independently through creative application of existing and generation of new ideas.
	Ability to assess the level of negative impact of natural and anthropogenic environmental hazards on the environment and humans.

Karazin University and Luhansk National Agrarian University conducted a study of the competence expectations of students to find out which of the acquired knowledge the graduates have the highest hopes for. We compared the results with the results regarding the competence expectations of the main employers. The initial precondition of the study is the fact that all masters are already familiar with the work of organizations and institutions focused on the employment of environmentalists. According to the curriculum of the Bachelor's degree's students underwent internships.

The survey is continuous, as it involves the entire staff of full-time masters. Students were asked to choose 5 out of 10 competencies, which, in their opinion, can provide them with successful employment. The same conditions are set for employers.

According to the results of the survey, the authors compiled a rating of general competencies. It turned out that the majority of masters put the ability to communicate in another language (70%) in the first place. In addition, more than 50% of respondents to the main competencies of the general group included: ability to motivate people and move towards a common goal; ability to generate new ideas (creativity).

Professional expectations of masters were assessed in points from 1 to 5 degrees of significance, in their opinion, of each of the competencies in future employment. Table 3 shows the results of the survey: frequency of responses to a particular assessment for each of the criteria.

Table 3. Assessments of the competencies importance by students

Competence	Rating				
	5	4	3	2	1
Awareness at the level of the latest achievements required for research and/or innovation in the field of ecology.	6 (30%)	12 (60%)	3 (15%)		
Ability to apply interdisciplinary approaches in critical under-standing of environmental issues.	11 (55%)	5 (25%)	4 (20%)		
Ability to use the principles, me-thods and organizational procedu-res of research and/or innovation.	6 (30%)	9 (45%)	5 (25%)		
Ability to apply new approaches to the analysis and prediction of complex phenomena, critical understanding of problems in professional activities.	12 (60%)	5 (25%)	3 (15%)		
Ability to prove knowledge and own conclusions to specialists and non-specialists.	8 (40%)	5 (35%)	7 (35%)		
Ability to manage the strategic development of the team in the process of carrying out professional activities in the ecology.	8 (40%)	10 (50%)	2 (10%)		
Ability to organize work related to environmental assessment, environ-mental protection and optimization of nature, in conditions of incomplete information and conflicting requirements.	6 (30%)	9 (45%)	5 (25%)		
Ability for self-education and training based on innovative approaches in the field of ecology, environmental pro-tection and sustainable use of nature.	6 (30%)	8 (40%)	6 (30%)		
Ability to independently develop environmental projects by creatively applying existing and generating new ideas.	8 (40%)	10 (50%)	2 (10%)		
Ability to assess the level of negative impact of natural and anthropogenic environmental hazards on the environment and humans.	10 (50%)	6 (30%)	4 (20%)		

After statistical processing of the received array of questionnaires, the authors calculated recurrence of the answers of a certain assessment on each of the criteria and rated the growth of the importance of each of the competencies according to the calculated average score (Table 4).

The analysis of the table shows that students prioritize the practical skills of applying knowledge, as well as the personal characteristics of the specialist as an organizer and manager. One should also note that the importance of professional training for all students is rated quite high (over 4.0 points). This can be explained by the confidence of masters in their professional knowledge and placing great hopes on them.

Table 4. Rating of the average weight of each competence with the students' opinion

№	Competence	Average score
1.	Ability to apply new approaches to the analysis and prediction of complex phenomena, critical understanding of problems in professional activities.	4.45
2.	Awareness at the level of the latest achievements required for research and/or innovation in the field of ecology, environmental protection and sustainable use of nature.	4.35
3.	Ability to apply interdisciplinary approaches in critical understanding of environmental issues.	4.35
4.	Ability to manage the strategic development of the team in the process of carrying out professional activities in ecology, environmental protection and sustainable use of nature.	4.3
5.	Ability to develop environmental projects independently by creatively applying existing and generating new ideas.	4.3
6.	Ability to assess the level of negative impact of natural and anthropogenic environmental hazards on the environment and humans.	4.3
7.	Ability to use the principles, methods and organizational procedures of research and/or innovation.	4.05
8.	Ability to prove knowledge and own conclusions to specialists and non-specialists.	4.05
9.	Ability to organize work related to environmental assessment, environmental protection and optimization of nature, in condi-tions of incomplete information and conflicting requirements.	4.05
10.	Ability to self-educate and improve skills based on innovative approaches in the field of ecology, environmental protection and sustainable use of nature.	4

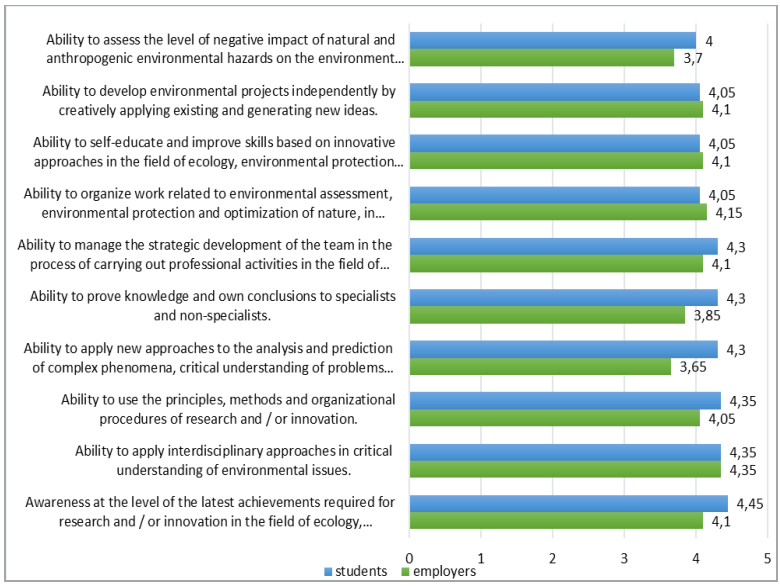
Table 5. Assessments of competencies importance by employers

Competence	Rating				
	5	4	3	2	1
Awareness at the level of the latest achieve-ments required for research and/or innovation in ecology and environmental protection.	6 (30%)	10 (50%)	3 (15%)		
Ability to apply interdisciplinary approaches in critical understanding of environmental issues.	11 (55%)	5 (25%)	4 (20%)		
Ability to use the principles, methods and organizational procedures of research and/or innovation.	6 (30%)	9 (45%)	5 (25%)		
Ability to apply new approaches to the analysis and prediction of complex phenomena, critical understanding of problems in professional activities.	5 (25%)	3 (15%)	12 (60%)		
Ability to prove knowledge and own conclusions to specialists and non-specialists.	5 (35%)	7 (35%)	8 (40%)		
Ability to manage the strategic development of the team while carrying out professional activities in the ecology.	10 (50%)	2 (10%)	8 (40%)		
Ability to organize work related to environ-mental assessment, optimization of nature, in conditions of incomplete information and conflicting requirements.	9 (45%)	5 (25%)	6 (30%)		
Ability to self-educate and improve skills based on innovative approaches in ecology and environmental protection.	8 (40%)	6 (30%)	6 (30%)		
Ability to independently develop environ-mental projects by creatively applying existing and generating new ideas.	10 (50%)	2 (10%)	8 (40%)		
Ability to assess the level of negative impact of natural and anthropogenic environmental hazards on the environment and humans.	6 (30%)	4 (20%)	10 (50%)		

A similar survey was conducted among employers, the results of which are given in Table 5. Respondents were asked to choose 5 competencies from the above list, which in the opinion of employers, are the most important for the employment of masters. The rating of employers is shown in Table 6.

Table 6. Rating of the average weight of each competence according to employers

№	Competence	Average score
1.	Ability to apply interdisciplinary approaches in critical understanding of environmental issues.	4.35
2.	Ability to organize work related to environmental assessment, environmental protection and optimization of nature, in conditions of incomplete information and conflicting requirements.	4.15
3.	Awareness at the level of the latest achievements required for research and/or innovation in the field of ecology.	4.1
4.	Ability to manage the strategic development of the team in the process of carrying out professional activities in the ecology.	4.1
5.	Ability to self-educate and improve skills based on innovative approaches in the field of ecology.	4.1
6.	Ability to develop environmental projects independently by creatively applying existing and generating new ideas.	4.1
7.	Ability to use the principles, methods and organizational procedures of research and/or innovation.	4.05
8.	Ability to prove knowledge and own conclusions to specialists and non-specialists.	3.85
9.	Ability to assess the level of negative impact of natural and anthro-pogenic environmental hazards on the environment and humans.	3.7
10.	Ability to apply new approaches to the analysis and prediction of complex phenomena, critical understanding of problems in professional activities.	3.65



Graph 1. Comparison of employers "needs and students" expectations

The analysis of the obtained results showed that the employers rated the ability to apply interdisciplinary approaches in the critical understanding of environmental problems and the ability to organize professional work in conditions of incomplete information and conflicting requirements. Awareness of the latest advances in research and/or innovation in the professional field is also important for practitioners.

Employers rated the lowest the ability to consider professional problems critically. A comparison of graduates "expectations and employers" needs is shown in Graph 1.

Conclusions

Based on the study, the authors have found that students attach great importance to competencies that give opportunities for professional growth, mastery of new technologies and the application of innovations. Employers bring teamwork skills, professional skills and knowledge in the professional sphere to the fore. The most important general competencies include good command of foreign languages, the ability to motivate people to do work and creativity.

References

Anufrieva, O.L. *Competence approach to economic education*. Retrieved from: www.cippe.edu.ua (23.06.2021).

Classifier of professions DK 003: 2010. Retrieved from: https://hrliga.com/docs/327_KP.htm (23.06.2021).

Maksymenko, N.V., Titenko, G.V., Utkina, K.B., Nekos, A.N., Shkaruba, A.D. (2019). Solving current environmental problems by harmonization of doctoral programs with european standards. *Bulletin of V. N. Karazin Kharkiv National University. Series "Geology. Geography. Ecology"*, *50*, 178–196. DOI: 10.26565/2410-7360-2019-50-14.

Markova, A.K. (1990). Psychological analysis of professional competence of teachers. *Soviet pedagogy*, *8*, 82–88.

Sectoral standard of higher education of Ukraine 8.04010601 "Ecology and environmental protection", approved by the Order of the Ministry of Education and Science of Ukraine from 7.03.2013 № 330.

Standard of higher education of Ukraine: first (Bachelor's) level, field of knowledge 10 Natural sciences, Specialty 101 Ecology, which was approved and put into effect by the Order of the Ministry of Education and Science of Ukraine dated 4.10.2018 № 1076. Retrieved from: https://mon.gov.ua/storage/app/media/vishcha-osvita/zatverdzeni%20standarty/12/21/101-ekologiya-bakalavr.pdf (23.06.2021).

Standard of higher education of Ukraine: second (Master's) level, field of knowledge 10 – Natural sciences, specialty 101 – Ecology, which was approved and put into effect by the Order of the Ministry of Education and Science of Ukraine dated 4.10.2018 № 1066. Retrieved from: https://mon.gov.ua/storage/app/media/vishcha-osvita/zatverdzeni%20standarty/12/21/101-ekologiya-magistr.pdf (23.06.2021).

Tabachnyk, D.V., Kremin, V.G. (2011). *National educational glossary: higher education*. Kyiv: Pleiades Publishing House LLC.

Tytarenko, L.M. (2007). *Formation of ecological competence in students of biological specialties of the university: dissertation abstract for scientific degree of Cand.of ped.sciences: special. 13.00.07 "Theory and methods of education"*. Kyiv.

Yermakov, D.S. (2009). *Formation of ecological competence of students: theory and practice*. Moskow: MIGE.

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 2.09.2022
Accepted for printing: 10.11.2022
Published: 22.12.2022
License: CC BY-SA 4.0

DOI: 10.15584/jetacomps.2022.3.14

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

Medical Data, Reconciling Research and Data Protection

[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

Abstract

Most of our medical records are being processed electronically, centralised and easily accessible. In this paper, we will discuss the advantages of the system for research, as well as its potential challenges.

Keywords: health data, privacy, data protection, GDPR, security, information, research, EMR, EHR, European Data Hub

I. The purpose and benefits of digital health data

1. Electronic Health Record (EHR) or Electronic Medical Record (EMR)

An electronic medical record (EMR) is a digital version of a chart with patient information stored in a computer and an electronic health record (EHR) is the systematised collection of patient and population electronically stored health information in a digital format. These records are shared through different countries and different medical departments. An EHR is a digital version of a patient's paper chart. EHRs are real-time, patient-centred records that make information available instantly and securely to authorised users. Hand-written data is replaced with electronic records to maintain the constant flow of patient-related data. Introduced in 2009, Today, over 80% of points of medical care are using this technology for billing and entry point of medical information. EHRs are built to easily share information with other health care providers and organisa-

tions – such as laboratories, specialists, medical imaging facilities, pharmacies allowing better diagnostics and patient outcomes based on the patient's medical history. It also improves patient participation, care coordination, and is cost saving. For instance, EHR alerts can be used to notify providers when a patient has visited the hospital, allowing them to proactively follow up with the patient. Every health provider can have the same accurate and up-to-date information about a patient. This is especially important with patients who are seeing multiple specialists, receiving treatment in an emergency setting or making transitions between care settings.

It can reduce medical errors and unnecessary tests and reduce the chance that one specialist will not know about an unrelated (but relevant) condition being managed by another specialist. An EHR not only keeps a record of a patient's medications or allergies, it also automatically checks for problems whenever a new medication is prescribed and alerts the clinician to potential conflicts. It can help providers quickly and systematically identify and correct operational problems. In a paper-based setting, identifying such problems is much more difficult, and correcting them can take years.

2. Individual patients' electronic records processing for wider scientific research projects

In data protection terms when data collected for one purpose is then deployed for a new, unrelated, purpose, we are engaging in secondary processing.

The secondary processing of personal health data for scientific research in the medical field is coveted for research and new treatments that improve public health. Its legal status, however, is far from unproblematic. An unclear status in law of data reuse is compounded by a shift in research towards decentralised clinical trials: deployment of new artificial intelligence technologies is leading to a rethinking of biomedical research from what was traditionally organised. This shift is all the more important as classical research tends to be questioned following various health scandals. Fewer people are willing to participate in medical trials. In digital research, AI tools are preferably deployed in the exploitation of databases to explore patient records, via medical imaging or connected medical devices. The analysis of the various data sets with more efficient computing capabilities makes it possible to increase the speed of discoveries, acting as an accelerator of research. Clinical procedures are simplified, time is spared, and, above all, the physical integrity of individuals is preserved. This shift, for instance, has allowed discovery of an antibiotic molecule capable of bypassing antibiotic resistance in February 2020 (Internet 1; Internet 2).

The primary advantage of digitalising research data is the increased ease of participation in research. Many studies struggle to recruit and retain sufficient participants. Less and less patients take part in clinical trials. A survey by CISCRP

(Internet 3) indicates that physical distance to research sites is one of the main barriers to increased participation.

The second advantage is the amount of data from a larger number of participants that a decentralized study can generate. Finally, decentralized clinical trials attract a more inclusive variety of participants. If the advantages are obvious, they are not inconvenient. Apart from the digital divide excluding the populations with less access to technology, data quality, security and strong medical ethics are required. Big data analytics, based on larger data sets, using tools or algorithms are big assets for medical and scientific research. Paolo and Bincoletto (2021) examine the secondary processing of personal health data for scientific research in the medical field. Looking at the controllers' obligations to comply with the data protection framework to safeguard fundamental rights and freedoms. After comparing the implementation of EU regulation into the French and Italian national legislations, they propose "a proactive, legal-technical e-health solution that complies with the rules and principles of the legal frameworks and empowers the individual's control over personal health data while promoting medical research. To this end, the data protection by design concept plays a central role, and an interdisciplinary approach is fundamental in combining legal and technical perspectives".

The case of Yoti illustrates the potentials for research and dangers for the data (Internet 4)

For many years, immigration departments have struggled with physical determination of the age immigrants claiming to be minor. Such determination by physical examination have never been accurate. The algorithm the company Yoti has created claims to have achieved the goal with high accuracy. For doing so, a large world wide database of children aged between 12 and 19 years old. Has be created. Admittedly some parents have received financial compensation in exchange of pictures of their children with month and year of birth. By creating a data set of children of various world ethnic faces, the algorithm can determine the face of a minor. So far, the software has been commercialised in supermarkets for the sale of alcohol or cigarettes. They are expanding with cinemas and other places where age verification is necessary. As mentioned, the software can be useful for immigration departments. Scientific research could certainly benefit from such database to study the ageing process in various ethnic groups. The dilemma here is how to create and store large scale biometrics data allowing a sensible secondary use of the information.

3. Big data and scientific research friend or foe

As indicated above, scientific research benefits from large scale data from various sources. This has been made easier and more cost effective thanks to digitalisation of information and cheap data storage. Big Data is defined by

Zulkarnain and Anshari (2016) as “datasets whose size is beyond the ability of typical database software tools to capture, store, manage, and analyze”. In Kaislere, Armour and Espinosa (2016), “Big data is data too big to be handled and analyzed bytraditional database protocols such as SQL”. Big Data are particularly large, complex datasets with high analytical potentials that automated processing can analyse at higher speed than traditional processing.

“Big data analytics in medicine and healthcare allows analysis of the large datasets from thousands of patients, identifying clusters and correlation between datasets.Moreover, improving predictive models using data mining techniques”.

Big Data has large potentials helping medical research to create new growth opportunities including in predictive healthcare. This is not without posing significant challenges such as the loss of privacy and confidentiality. Privacy and security are key concerns for individuals and all corporations involved.

However, open access to health data is beneficial to scientific research. We will further discuss the European initiatives. The following sections will draw data protection lessons from several European initiatives.

4. The requirement of quality data an essential parameter to integrate

Data accuracy is paramount for quality research results. Human or algorithm errors/biases or sometimes technology outcomes can alter results. This issue has been pointed out by the European Union Agency for Fundamental Rights (FRA, 2020) that raised serious concerns about the quality of medical data and the resulting risk of medical errors. “The quality of data in EMR/EHR also raises some concern. Studies where patients were shown their medical files and asked about their accuracy found that up to 50 % of information was incomplete or erroneous. Too many important data in EMR/EHR is unstructured in the form of free text, which further reduces data quality”. See also Miller (2019).

In order to be validly processed, row medical data requires to undergo initial “cleansing” (Stöger, Schneeberger, Kieseberg, Holzinger, 2021). In this paper, the authors take “an interdisciplinary look at some of the technical and legal challenges of data cleansing against the background of the European medical device law, with the key message that technical and legal aspects must always be considered together in such a sensitive context”.

These authors initially enumerate the typical data quality issues they suggest the cleansing operation should tackle: absence of data, dummy/default, noise (*a.k.a.* the “butterfly effect”, wrong data, inconsistent data, cryptic data, duplicate primary keys, non-unique identifiers, multipurpose fields, violation of (business) rules.

With reference to the ECJ and the German Supreme Court (Bundesgerichtshof) there are potential legal consequences for faulty data in medical AI, engaging the liability of the notified body towards third persons like patients in

case that an assessment procedure has been carried out without sufficient diligence (Case C-219/15 *Elisabeth Schmitt v TÜV Rheinland LGA Products GmbH* ECLI:EU:C:2017:128; BGH 17 February 2020, VII ZR 151/18).

The authors then suggest five necessary steps to use the raw data and transforms it into information that can be worked with in the subsequent analytical steps:

Parsing, Correcting, Standardizing, Matching, Consolidating.

Without going into further detail into these techniques, they suggest applying standardisation and corrections to data sets sometimes from unstructured information like manual diagnosis data to then compare and match to avoid duplication to finally solve inconsistencies. The quality of this cleansing process will have legal consequences as they point that any damage caused by malfunctions or other service provider due to these "faulty" data, will create a liability for the manufacturer of the medical device mostly under the Medical Devices Regulation (MDR). It is required that the product in question "shall be safe and effective and shall not compromise the clinical condition or the safety of patients". GDPR data accuracy requirement will not apply to the training data as data is mostly anonymised.

This has led the European Parliament to propose that developers should, where feasible, implement quality checks of the external sources of data and should put oversight mechanisms in place regarding their collection, storage, processing, and use of data (Art. 17 para. 3 European Parliament, *Framework of Ethical Aspects of Artificial Intelligence* – n 46).

Also, in its report on the safety and liability implications of Artificial Intelligence, the Internet of Things and Robotics, the European Commission has noted that Union product safety legislation now "does not explicitly address the risks to safety derived from faulty data. However, according to the 'use' of the product, producers [in terms of the MDR, manufacturers] should anticipate during the design and testing phases the data accuracy and its relevance for safety functions" (Commission, '*Report on the Safety and Liability Implications of Artificial Intelligence*' – n 18). The Report and the Whitepaper also call for product safety legislation to "provide for specific requirements addressing the risks to safety of faulty data at the design stage as well as mechanisms to ensure that quality of data is maintained throughout the use of the AI products and systems" (Commission, COM (2020) 65 final – n 3 – 15).

5. When Clinical Trials Go Digital, Ethics Is Needed

The pandemic accelerated the digitalisation of clinical research and widespread decentralised clinical trials have brought many improvements while privacy and ethics challenges took a back seat.

In June 2021, the World Health Organization published a guidance on *Ethics & Governance of Artificial Intelligence for Health* (Internet 5) outlining six key

principles for the ethical use of artificial intelligence in health. The 20 leading experts in ethics, digital technology, law, human rights, as well as experts from Ministries of Healthrecommended the technology must put ethics and human rights at the heart of its design, deployment, and use.

Artificial intelligence's potentials in healthcare are undeniable: from AI medical imaging, scanning patient health records to predict illness, monitoring devices to systems that help track disease outbreaks. Accessing medical speciality consultations to help evaluate symptoms in remote areas. Just to mention a few (Wetsman, 2019). The outbreak of the COVID pandemic also saw the surge of technological tools that were revealed to be controversial if not unnecessary tracking. The Bluetooth technology widely used was inappropriate to detect the contact tracing. In Singapore, the government admitted that the contact tracing application collected data about health that was repurposed beyond the original goal.

Additionally, some databases were hacked, and medical data were accessed by unlawful criminals (Internet 6). A report by WHO *Ethics and governance of artificial intelligence for health* warned about AI tools developed by private technology companies (like Google and Chinese company Tencent) that have large resources but not always the necessary ethical incentives. Their focus may be toward profit, rather than the public good. "While these companies may offer innovative approaches, there is concern that they might eventually exercise too much power in relation to governments, providers and patients" (Internet 7).

The report recommended six ethical principles: protect autonomy, promote human safety, ensure transparency, foster accountability, ensure equity, and promote AI that is sustainable.

In parallel, the new European regulation on AI, the AI Act (Internet 8) which could come into effect in late 2024 is a proposed European law on artificial intelligence (AI) – the first law on AI by a major regulator anywhere. The law assigns applications of AI to three risk categories (Internet 9). The Artificial Intelligence in Healthcare report (Internet 10) supports the European Commission in identifying and addressing any issues that might be hindering the wider adoption of AI technologies in the healthcare sector. The study has highlighted six categories where the European Commission is suggested to focus to support the development and adoption of AI technologies in the healthcare sector across the EU. These include:

1) a policy and legal framework supporting the further development and adoption of AI aimed at the healthcare sector in particular;

2) initiatives supporting further investment in the area;

3) actions and initiatives that will enable the access, use and exchange of healthcare data with a view to using AI;

4) initiatives to upskill healthcare professionals and to educate AI developers on current clinical practices and needs;

5) actions addressing culture issues and building trust in the use of AI in the healthcare sector;

6) policies supporting the translation of research into clinical practice.

The GDPR allows for code of conduct to be approved by national supervisory authorities. These can strengthen clinical research and pharmacovigilance.

The Spanish Code of Conduct (Internet 11)

A first national Code of Conduct was promoted by Farmaindustria in Spain regulating the processing of personal data in the field of clinical trials and other clinical research and pharmacovigilance. The code of conduct, regulates how the promoters of clinical studies with medicines and the CROs that decide to adhere thereto must apply the data protection regulations. Data controllers and data processors that adhere to the code of conduct are obliged to comply with its provisions.

The UK Code of conduct for data-driven health and care tech

Following a consultation, the UK Government has published a code of conduct for data-driven health and care technology to enable the development and adoption of safe, ethical and effective data-driven health and care technologies: "We have some truly remarkable data-driven innovations, apps, clinical decision support tools supported by intelligent algorithms, and the widespread adoption of electronic health records. In parallel, we are seeing advancements in technology and in particular artificial intelligence techniques" (Internet 12).

The Government has set out the behaviours expected from those developing, deploying and using data-driven technologies in the health and care systems:

1. Understand users, their needs and the context.
2. Define the outcome and how the technology will contribute to it.
3. Use data that is in line with appropriate guidelines for the purpose for which it is being used.
4. Be fair, transparent and accountable about what data is being used.
5. Make use of open standards.
6. Be transparent about the limitations of the data used and algorithms deployed.
7. Show what type of algorithm is being developed or deployed, the ethical examination of how the data is used, how its performance will be validated and how it will be integrated into health and care provision.
8. Generate evidence of effectiveness for the intended use and value for money.
9. Make security integral to the design.
10. Define the commercial strategy and consider only entering into commercial terms in which the benefits of the partnerships between technology companies and health and care providers are shared fairly.

6. The case of the French Health Data Hub and the COVID research

The French government has contracted the processing of health data with Microsoft, a US corporation. Microsoft is said to have the processing capabilities currently no other European company could have. Scientific research needs data on COVID patients to study the spread of the virus, the scale of long term COVID, the category of the population mostly affected or the effects of the various vaccines administered.

Several legal limitations had to be considered. First the question of the transfer of European data outside the European Union. United States being deemed a country of non-adequate data protection since the invalidation of the Privacy Shield agreement allowing the flow of data between the two continents. The French data Protection Supervisory authority, The *Commission Nationale Informatique et Libertés* (CNIL) published an opinion expressing their concerns. They recommended this measure to be only temporary, requiring further guarantees from Microsoft. The French Health Minister requested the data to be stored in data servers located within the EU. A measure that has limited protection as regardless of the localisation of the data, US NSA Section 702, The US Cloud Act and the Executive Order 12333 would apply.

If these are technical necessities to comply with the General Data Protection Regulation, basically requiring the same level of data protection wherever data travels, sharing data with a foreign company represents further challenges.

This is a consequence of the loss of data sovereignty that the European countries are facing. Dependence on foreign corporations for processing health data is by itself an issue. The quasi-monopolistic position of these corporations gives them excessive power of control over data. Data is processed, possibly monetised. The security of the data can be compromised as any database created is data at risk.

The GDPR has several principles applying to lawful data processing, from data minimisation, access limitation or ensuring data integrity. Big data analytics or algorithms are by essence thirsty for data. Scientific research benefits from the largest data sets. How to conciliate the legitimate needs of research with data protection principles?

7. Technical means of protecting medical data: encryption, anonymisation or pseudonymisation

With data becoming increasingly digitalised and widely accessible, securing health data is paramount. The first supplementary measure to secure data when transferred abroad is to apply a strong encryption, keeping the encryption key out of the reach of the US internet communication services. This is in fact difficult to realise when data needs further processing.Cybersecurity attacks and ransomware against hospitals are becoming a common threat. Health data have

high value and are regularly targeted by cyber criminals. Cyberattacks in the healthcare environment have tripled since 2018 to reach 45 million individual victims in 2021.

Medical data is collected from various sources:

- imaging techniques for diagnosis;
- electronic health records;
- robotics in surgical procedures;
- telehealth for efficiency or reaching patients in more remote locations;
- wearables to monitor individuals' health with various Internet connected devices with often weak security.

The use of open data sources is also instrumental in the field of genomics, where data related to genetic makeup, biomarkers and bioinformatics is used to derive better therapeutic solutions.

European healthcare requires stronger protection and security measures to protect health data.

Pseudonymised personal data are data where identifiers such as names are replaced by codes the research institutions keep. A 'code key' that is the link to the individual person is kept separately from the research data in order to protect the privacy of patients. Only fully anonymised data escape from the General Data Protection Regulation (GDPR) requirements. In the case of data for research, full anonymisation might render the data useless. Therefore, it is often not a possible option.

Pseudonymised data and even anonymised data are not exempt from re-identification. Even when name, date of birth or national security numbers are "anonymised", a full health history will reveal patients' age, gender, the places where they have lived, their family relationships and aspects of their lifestyle.

Privacy-enhancing technologies such as homomorphic encryption, differential privacy, federated analyses and use of synthetic data offer new ways for protecting the privacy of individuals. New promises are seen in synthetic data (Internet 13), still not exempt of criticism (Chen, Lu, Chen, Williamson, Mahmood, 2021). Issues of anonymisation and de-identification need to be addressed and appropriately managed (Internet 14).

Health data being more sensitive, requires extra layers of protection and appropriate security measures such as encryption. The GDPR applicability to the data set has implications in the free flow of data to countries outside the European Economic Area (EEA. This is a problem, for example, with researchers at federal research institutions in the United States. Transfers to international organisations such as the World Health Organization are similarly affected (Internet 15). The European scientific academies have recently published a report explaining the consequences of stalled data transfers and pushing for responsible solutions. (The European Academies Science Advisory Council, the Federation

of European Academies of Medicine & the European Federation of Academies of Sciences and Humanities (2021) (Internet 16; Bentzen et al., 2021).

The case of the Canadian PHIPA experience

Occasionally, there are privacy investigation decisions that stand out because of their precedent setting nature (Internet 17). One example is the PHIPA Decision 175 (Internet 18) which details an investigation into the sale of de-identified data by a health information entity to a third-party corporation. The data protection supervisory became aware of the situation through a news article and launched an investigation under the Personal Health Information Protection Act (PHIPA). It is admitted that de-identification is considered to be a use under PHIPA.

Such use for de-identification does not usually necessitate individual consents. Health information custodians, who have custody and control of personal health information have to be transparent to clearly and explicitly inform patients about their practices in their public notice. The necessity of transparency is emphasised. It is safe to consider de-identification to be considered data processing under the GDPR definition. Although, patients' consent is required in most cases. We will now take a deeper dive into the specific situation of the European health data and its challenges. How to reconcile the need to share data, open free access to the database, and keep data secure.

II – The paradigm of the European data sovereignty

The last few decades, we have witnessed major developments in the fields of internet communication and data digitalisation. Europe has dragged behind US or Chinese corporations. Our dependency on US corporations for cloud storage (AWS, Microsoft, Apple iCloud, etc…) or computer operating systems (Microsoft, Apple iOs or Google) or data analytics is undeniable. It's with the COVID pandemic that EU governments have had a wakeup call, realising the complexities of creating a contact tracing app without the help of a Google App or its ID verification Captcha. The de-centralised tracing application could not be successful. Since the European Court of Justice decision in July 2020 invalidating data transfers to the US, the use of US internet communication services became problematic. European countries are re-thinking data processing and data storage solutions including in the fields of health data and research.

1. European health data initiatives promise to open new perspectives for medical research

A – EU Health Data

New initiatives are underway for the EU Health data centre and common health data to be accessed more efficiently. "Early lessons learnt with COVID-19

have shown that the current system has not ensured an optimal response at EU level to the COVID-19 pandemic".

"Regarding health data, its availability and comparability, the Covid-19 pandemic revealed that the EU has no clear health data architecture. The lack of harmonisation in these practices and the absence of an EU-level centre for data analysis and use to support a better response to public health crises is the focus of this study. Through extensive desk review, interviews with key actors, and enquiry into experiences from outside the EU/EEA area, this study highlights that the EU must have the capacity to use data very effectively in order to make data-supported public health policy proposals and inform political decisions. The possible functions and characteristics of an EU health data centre are outlined. The centre can only fulfil its mandate if it has the power and competency to influence Member State public-health-relevant data ecosystems and institutionally link with their national level actors. The institutional structure, its possible activities and in particular its usage of advanced technologies such as AI are examined in detail".

Study by Henrique Martins of ISCTE-Lisbon University Institute and Faculty of Medical Sciences, UBI Portugal, was made public at the request of the Panel for the Future of Science and Technology (STOA) and managed by the Scientific Foresight Unit, within the Directorate-General for Parliamentary Research Services (EPRS) of the Secretariat of the European Parliament is staggering (Internet 19).

Sadly, the finding of this study is striking : the absence of harmonisation despite new initiatives such as the 'European Health Union' umbrella, or the EC proposal for the creation of a new European Health Emergency. "There is NO comprehensive health data governance at the EU level, and very few MS [Member States] could be said to have one at the national level as well while a centralised governance structure is needed to deal with large scale data for preventive and curative actions".

The suggested model could be Preparedness and Response Authority (HERA) (Internet 20). On 3 May 2022, the Commission published the Proposal for a Regulation of the European Parliament and of the Council on the European Health Data Space Act ("the Proposal").

European Data Protection Board (EDPB) and the European Data Protection Supervisory (EDPS) were required to give their opinions on this project (Internet 21)

Since the European Data Strategy for the creation of a single European Data Space for primary use of medical data, all EU citizens will have access to their electronic health records by 2030 thanks to the EU's central eHealth platform linking national contact points to the MyHealth@EU infrastructure and efficient national digital health authorities.

B – Joint Action Towards the European Health Data Space – TEHDAS

The European Health Data Space (EHDS) could enormously impact health research if it can overcome barriers to cross-border secondary use of health data and create trust amongst citizens, according to a Finnish health data stakeholder (Internet 22). The TEHDAS project, based on the European Commission's Health Programme 2020, develops European principles for the secondary use of health data from early 2020. Carried out by 25 European countries and coordinated by the Finnish Innovation Fund, Sitra (Internet 23).

European health projects will ease the share of data flow, with standardisation and the creation of a central authority. Free access to this data will benefit innovation at the European and international level.

III. Access to data for research

Re-using data and open science:

1- International cooperation

1.1 – Within the National and international initiatives supporting medical data health is the International Medical Informatics Association (IMIA) Open Source Working Group (OSWG) (Internet 24), "a voluntary group supported by IMIA that brings together researchers and practitioners from multiple countries with a diverse range of informatics experience but common interest in the adoption of open approaches to advancing the use of informatics to improve healthcare". This has led to the development of an open access database of Free, Libre, and Open-Source Software (FLOSS), called MedFLOSS (Internet 25) (www.medfloss.org), to apply in the medical domain to accelerate medical research.

1.2 – Harmony Alliancepromise to accelerate scientific research in Haematology

HARMONY claims to be the Next-generation science, sharing data and knowledge "To accelerate scientific research on Hematologic Malignancies (HMs), broad cooperation between all healthcare stakeholders is urgently needed. Each single piece of the puzzle, namely each set of data, might turn out to be the missing piece that will make it possible to treat the disease faster and better.

The HARMONY Alliance (Internet 26) has created a transparent and secure repository for data from various clinical studies. Everybody can contribute and help fight HMs".

"Sharing data is crucial to further research in Hematological Malignancies because many of these cancers are heterogeneous in terms of their genetic profile. Moreover, many genetic profiles are rare; many account for < 10% cases. In order to ascertain the prognostic or predictive value of genetic biomarkers, researchers need to study large cohorts of patients. This is only achievable by sharing data," says Anthony Moorman, Newcastle University, one of the HARMONY Key

Opinion Leaders for Childhood Leukemia and Project Leader of the HARMONY Research Project entitled 'Use of Big Data to improve outcomes for patients with Acute Lymphoblastic Leukemia (ALL) (Internet 27).

A – Call to Remove obstacles to sharing health data with researchers outside of the European Union (Internet 28)

Scientific academies in Europe (the European Academies Science Advisory Council, the Federation of European Academies of Medicine, and the European Federation of Academies of Sciences and Humanities) [The European Academies Science Advisory Council, the Federation of European Academies of Medicine & the European Federation of Academies of Sciences and Humanities (Internet 29) have joined forces to call attention to the challenges that affect not only European scientists but collaborators worldwide.

In this paper (Internet 30), the co-authors,Bentzen et al. develop the necessity to levy data sharing barriers: "COVID-19 has shown that international collaborations and global data sharing are essential for health research, but legal obstacles are preventing data sharing for non–pandemic-related research among public researchers across the world, with potentially damaging effects for citizens and patients. International sharing of pseudonymized personal data among researchers is key to the advancement of health research and is an essential prerequisite for studies ofrare diseases or subgroups of common diseases to obtain adequate statistical power".

Certainly, the way forward requires a move from the US. "The United States should be encouraged to establish enforceable data subject rights and effective legal remedies for European and other non-US research participants whose data are processed by US researchers. The voice of the health-research community must be heard by decision-makers at the national level, at the EDPB, and within the EU Commission Directorates-General involved, such as in the areas of justice, health and research. Without a quick resolution, European research potential will not be realized, and European citizens will fall behind".

We saw the importance for EU research to benefit from EU health data. Currently, European health data is targeted by US corporations. A situation that has been criticised.

B – GAFAM US Corporations access to EU health data

1 – The case of the NHS data agreement with DeepMind before Palantir

In this paper, *The Privacy and Security Implications of Open Data in Healthcare A Contribution from the IMIA Open Source Working Group*, the authors, Shinji Kobayashi, Thomas B. Kane and Chris Paton, raise the issue of data anonymisation, and other ethical, and governance challenges (George,

Whitehouse, Duquenoy, 2013; Hopia, Punna, Laitinen, Latvala, 2015; Menvielle, Audrain, Menvielle, 2017).

The paper reveals how in 2003, NHS England launched care.data in order to combine all healthcare records stored by general practitioners with all information stored by social services and hospitals. All data was held into the national Health and Social Care Information Centre (HSCIC) databases.

The Hospital Episode Statistics dataset on the other hand collects and curates data from 125 million individuals in England every year. If this data set can have huge potentials for research, it raises the methodology of conservation questions.

UK Care.data has been criticised for sharing data with pharmaceutical companies, insurance companies, health charities, hospital trusts, think tanks, and other private companies. In 2014, it was disclosed that anonymous, pseudonymous, and identifiable data was sold to 160 organisations (Bahatia, 2014). In response to a Freedom of Information request, HSCIC stated: "We recognise that there will however remain a latent risk that when combined with other sources of data, the identity of the individual may be ascertained". Care.data was closed in 2016 following general criticism and opt out.

In June 2017, Taunton and Somerset NHS Foundation Trust and DeepMind Healthcare signed a 5-year contract to develop and evaluate a system able to detect early signs of kidney-failure (Internet 31). Over 1.6 million live NHS data records were given to Google, via DeepMind.

In November 2017, the UK Information Commissioner ruled that the London's Royal Free hospital failed to comply with the Data Protection Act when it handed over personal data of 1.6 million patients to DeepMind (Internet 32). A DeepMind spokesperson said the firm "underestimated the complexity of the NHS and of the rules around patient data". According to the ICO, Elizabeth Denham, their "investigation found a number of shortcomings in the way patient records were shared for this trial. Patients would not have reasonably expected their information to have been used in this way, and the Trust could and should have been far more transparent with patients as to what was happening". The ICO warned that such work should never be "a choice between privacy or innovation".

Despite privacy advocates' hopes, this ruling did not exclude the use of the app. 'Streams' that has since been rolled out to other British hospitals, and DeepMind has also branched out into other clinical trials, including a project aimed at using machine-learning techniques to improve diagnosis of diabetic retinopathy (Internet 33), and another aimed at using similar techniques to better prepare radiotherapists for treating head and neck cancers.

Google's DeepMind Health systems have potential benefits for patients, nurses, and doctors (Internet 34). The DeepMind 'Streams' app allows clinicians to be informed when patient vital signs deteriorate using data from patient-monitoring technology that deliver in real-time significant patient life-sign indi-

cators to the clinician's mobile device. If the medical potentials have major benefits, they raise data ownership, secondary usage and ethics concerns.

Julia Powel, from the Faculty of Law and Computer Laboratory, University of Cambridge, was one of the early scholars warning about the ethical issues of Stream App (Internet 35) sharing NHS data with Google DeepMind.

Google DeepMind and healthcare in an age of algorithms (Internet 36)

"Data-driven tools and techniques, particularly machine learning methods that underpin artificial intelligence, offer promise in improving healthcare systems and services. One of the companies aspiring to pioneer these advances is DeepMind Technologies Limited, a wholly-owned subsidiary of the Google conglomerate, Alphabet Inc. In 2016, DeepMind announced its first major health project: a collaboration with the Royal Free London NHS Foundation Trust, to assist in the management of acute kidney injury. Initially received with great enthusiasm, the collaboration has suffered from a lack of clarity and openness, with issues of privacy and power emerging as potent challenges as the project has unfolded. Taking the DeepMind-Royal Free case study as its pivot, this article draws a number of lessons on the transfer of population-derived datasets to large private prospectors, identifying critical questions for policy-makers, industry and individuals as healthcare moves into an algorithmic age".

In a more recent episode, the NHS body was again criticised for being responsible for delivering IT strategy that struggled to ensure patients understand that medical data held by their GPs will be copied into a central database to be shared with third parties unless they opt out by 23rd of June 2022. Conflicting messaging overshadows NHS Digital's attempts to inform the public about patient data slurp (Internet 37).

When a new UK project came up, as reported by The Guardian (Internet 38), "more than a million people opted out of NHS data-sharing in one month in a huge backlash against government plans to make patient data available to private companies, the Observer can reveal. The General Practice Data for Planning and Research scheme is now on hold with no new date for implementation, and NHS (Internet 39). Digital has made a series of concessions to campaigners to try to salvage it".

The Guardian published an article by EerkeBoiten titled *Our personal health history is too valuable to be harvested by the tech giants* (Internet 40).

In December 2019 The Observer revealed (Internet 41) how UK medical data was allegedly sold to American drug companies with little transparency or accountability around the process. "US drugs giants, including Merck (referred to outside the US and Canada as MSD, Merck Sharp and Dohme), Bristol-Myers Squibb and Eli Lilly, have paid the Department of Health and Social Care, which holds data derived from GPs' surgeries, for licences costing up to £330,000 each in return for anonymised data to be used for research".

These revelations raise big questions over the transparency and claims of anonymity in NHS data transfers through the research scheme used by the health service. It appears that individual-level. NHS Digital has announced GP medical records in England would be collected via a new service called General Practice Data for Planning and Research (GPDPR) (Interned 42). It will replace the General Practice Extraction Service (GPES), which has operated for over 10 years.

More recently, it was revealed that Palantir awarded £23m deal to continue work on NHS Covid-19 Data Store (Internet 43) "The two-year contract was first reported today by (Internet 44) who have campaigned for transparency surrounding deals between the NHS and big tech firms". openDemocracy and Foxglove claim the contract was "secretly" signed "in apparent violation of their [the government's] prior promise to conduct future contracts between the NHS and big tech via a full and open public tender".

Medical data harvesting in France

The US Palantir's projects are not limited to the UK. It has been reported that US data giant Palantir is on a mission to seduce France's start-ups". Fears might not be unfounded as Palantir is said to be one of the most secretive companies in the world. Palantir (Internet 45) has expertise in big data analytics having initially worked for the US armed forces and intelligence services.

More recently, French investigative journalists (Internet 46) revealed how medical data was sold including drugs sold by pharmacists to Iqvia (Internet 47). The group had been tracking each patient via a unique identifier number to carry out "analyses of sales of health products aggregated by typologies of pharmacies, by main types of prescribers and by geographical areas".

Following the broadcast of the program, the French data protection authority, CNIL, referred the case to the Paris Judicial Court (Internet 48) asking Internet Service Providers (ISPs) to block access to a site hosting health data of nearly 500,000 people. The CNIL, which has already carried out three controls on this data leak, is continuing its investigations.

In April 2022, the French CNIL fined Dedalus 15 million Euros for their lack of security measures having led to the breach of medical data of 500.000 individuals online (Internet 49).

AMAZON, US online retailer coming big in the health data market medical data

The acquisition of One Medical gives Amazon access to more data. One Medical built its own electronic medical records system, and it has 15 years' worth of medical and health-system data that Amazon could tap.

In the US, it is reported that Amazon Pharmacy (Internet 50) has partnered with Blue Cross Blue Shield plans in five states and pharmacy benefit manager Prime Therapeutics to offer a prescription discount savings card (Internet 51).

Amazon's access to these medical data has to be considered in the context of the mass of various data the corporation has access to (Internet 52).

Medical data have high value. They are naturally targeted by big pharmaceutical companies.

As increasingly pseudonymised or even anonymised data have the potential to be re-identified, the share of such sensitive data is not without controversy. Article 29 working party (Internet 53) has specified that "to identify if a person is identifiable, account should be taken of all the means likely reasonably to be used either by the controller or by any other person to identify the said person". This is at the centre of the question of patients' data security. Patients might have personal reasons to remain anonymous therefore it is paramount the security and confidentiality of often sensitive medical data to be respected.

Conclusion

A balance must be struck between protecting individual patients' fundamental rights of privacy and dignity, the need for research to access data, and for the industry to study the impact of medical data on health improvement. Applying privacy by design, privacy enhancing technologies, anonymisation and encryption in full transparency and respect of individual needs and wishes is paramount. Health data has huge value. "Regulators" vigilance to monitor data handling is essential. EU health data sovereignty will not only improve the privacy of patients and protection of their data, it will also impact the European research capabilities.

References

Bentzen, H.B., Castro, R., Fears, R., Griffin, G., Meulen, V., Ursin, G. (2021). *Remove obstacles to sharing health data with researchers outside of the European Union*. *Nature Medicine, 27,* 1329–1333.

Bhatia, N. (2014). *Register of approved data releases – a Freedom of Information request to NHS Digital.* What Do They Know. Retrieved from: Chen, R.J., Lu, M.Y., Chen, T.Y., Williamson, D.F.K., Mahmood, F. (2021). Synthetic data in machine learning for medicine and healthcare. *Nature Biomedical Engineering, 5,* 493–497.

FRA (2020). *Getting the Future Right, Artificial Intelligence and Fundamental Rights*. European Union Agency for Fundamental Rights, 39.

George, C., Whitehouse, D., Duquenoy, P. (eds.) (2013). *eHealth: legal, ethical and governance challenges. 1st ed Heidelberg.* New York: Springer.

Hopia, H., Punna, M., Laitinen, T., Latvala, E. (2015). A patient as a self-manager of their personal data on health and disease with new technology--challenges for nursing education. https://royalsociety.org/-/media/policy/projects/privacy-enhancing-technologies/privacy-enhancing-technologies-report.pdf.

https://www.wired.co.uk/article/deepmind-ethics-and-society-artificial-intelligence?ref=hacker-noon.com
Internet 1: https://www.fondationlejeune.org/le-numerique-au-service-de-la-recherche/.
Internet 2: https://www.egora.fr/actus-medicales/sante-publique/39040-big-data-l-explosion-de-la--production-de-donnees.
Internet 3: https://www.centerwatch.com/articles/24924-patient-willingness-to-join-clinical-trials-drops-dramatically-new-data-show.
Internet 4: https://www.bbc.com/news/technology-61606477?piano-modal.
Internet 5: https://www.who.int/publications/i/item/9789240029200.
Internet 6: https://www.securityweek.com/mass-personal-data-theft-paris-covid-tests-hospitals.
Internet 7: https://www.theverge.com/2021/6/3/22514951/pandemic-public-health-solutions-google--apple-facebook.
Internet 8: https://artificialintelligenceact.eu/the-act/.
Internet 9: https://digital-strategy.ec.europa.eu/en/library/artificial-intelligence-healthcare-report.
Internet 10: https://inplp.com/latest-news/article/first-european-code-of-conduct-for-the-pharma--industry-approved/.
Internet 11: https://leeds.tech/news/code-of-conduct-for-data-driven-health-and-care-tech/.
Internet 12: https://onlinelibrary.wiley.com/doi/full/10.1111/coin.12427.
Internet 13: The Royal Society, Protecting Privacy in Practice. The current use, development, and limits of Privacy Enhancing Technologies in data analysis.
Internet 14: European Data Protection Board. https://edpb.europa.eu/system/files/2021-05/edpb_letter_out2021-0086_un_en.pdf.
Internet 15: The European Academies Science Advisory Council, the Federation of European Academies of Medicine & the European Federation of Academies of Sciences and Humanities. https://doi.org/10.26356/IHDT.
Internet 16: https://www.ipc.on.ca/ripe-for-public-debate-legal-and-ethical-issues-around-de-identified-data.
Internet 17: https://decisions.ipc.on.ca/ipc-cipvp/phipa/en/item/520967/index.do?q=phipa+175.
Internet 18: Study 21-09-2021, https://www.europarl.europa.eu/thinktank/en/document/ EPRS_STU (2021)690009.
Internet 19: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12870-European--Health-Emergency-Preparedness-and-Response-Authority-HERA-/public-consultation_en.
Internet 20: https://edpb.europa.eu/our-work-tools/our-documents/edpbedps-joint-opinion/edpb--edps-joint-opinion-032022-proposal_en.
Internet 21: https://www.euractiv.com/section/health-consumers/news/legal-issues-not-infrastructure-hampers-research-in-health-data-revolution/.
Internet 22: https://tehdas.eu/.
Internet 23: https://www.thieme-connect.com/products/ejournals/html/10.1055/s-0038-1641201.
Internet 24: www.medfloss.org.
Internet 25: https://www.harmony-alliance.eu/en/about-us.
Internet 26: https://www.harmony-alliance.eu/projects/research-project/use-of-big-data-to-improve--outcomes-for-patients-with-acute-lymphoblastic-leukemia-all-2019.
Internet 27: https://www.nature.com/articles/s41591-021-01460-0.
Internet 28: https://doi.org/10.26356/IHDT.
Internet 29: https://www.nature.com/articles/s41591-021-01460-0#ref-CR3.
Internet 30: https://www.thieme-connect.com/products/ejournals/html/10.1055/s-0038-1641201#ORkobayashi-42.
Internet 31: https://www.theguardian.com/technology/deepmind.
Internet 32: https://www.theguardian.com/technology/2016/jul/05/google-deepmind-nhs-machine--learning-blindness.

Internet 33: https://www.theguardian.com/technology/2016/aug/30/google-deepmind-ucl-ai-radio-therapy-treatment.
Internet 34: The Privacy and Security Implications of Open Data in Healthcare https://www.thieme-connect.com/products/ejournals/html/10.1055/s-0038-1641201.
Internet 35: https://www.deepmind.com/blog/scaling-streams-with-google
Internet 36: https://pubmed.ncbi.nlm.nih.gov/29308344/.
Internet 37: https://www.theregister.com/2021/05/24/nhs_digital_gp_data_store/.
Internet 38: https://www.theguardian.com/society/2021/aug/22/nhs-data-grab-on-hold-as-millions-opt-out.
Internet 39: https://digital.nhs.uk/data-and-information/data-collections-and-data-sets/data-collections/general-practice-data-for-planning-and-research.
Internet 40: https://www.theguardian.com/commentisfree/2020/feb/16/our-personal-health-history-is-too-valuable-to-be-harvested-by-tech-giants.
Internet 41: https://www.theguardian.com/politics/2019/dec/07/nhs-medical-data-sales-american-pharma-lack-transparency.
Internet 42: https://digital.nhs.uk/data-and-information/data-collections-and-data-sets/data-collections/general-practice-data-for-planning-and-research.
Internet 43: https://www.digitalhealth.net/2020/12/palantir-awarded-23m-deal-to-continue-work-on-nhs-covid-19-data-store/.
Internet 44: https://www.opendemocracy.net/en/ournhs/controversial-tech-firm-palantir-23m-nhs-data-deal/.
Internet 45: https://www.pearltrees.com/idigital2/palantir/id52210664.
Internet 46: https://www.francetvinfo.fr/replay-magazine/france-2/cash-investigation.
Internet 47: https://www.nextinpact.com/article/45660/donnees-pharmacies-et-iqvia-cnil-sexplique-et-va-mener-controles.
Internet 48: https://www.cnil.fr/en/node/120954.
Internet 49: https://www.cnil.fr/fr/fuite-de-donnees-de-sante-sanction-de-15-million-deuros-lencontre-de-la-societe-dedalus-biologie.
Internet 50: https://www.mobihealthnews.com/tag/amazon-pharmacy.
Internet 51: https://www.mobihealthnews.com/news/amazon-pharmacy-partners-five-blues-plans-offer-prescription-discount-card.
Intermet 52: https://news.yahoo.com/amazons-empire-surveillance-recent-billion-132800720.html.
Internet 53: https://ec.europa.eu/justice/article-29/documentation/opinion-recommendation/files/2014/wp216_en.pdf.
Kaisler, S.H., Armour, F. J., and Espinosa, A.J. (2016). *Introduction to the big data and analytics: concepts, techniques, methods, and applications minitrack*. Proceedings of the Annual Hawaii International Conference on System Sciences (pp. 1059–1060).
Menvielle, L., Audrain, A.-F., Menvielle, W. (2017). *The digitization of healthcare: new challenges and opportunities*. Polgrave Macmillan.
Miller, D.D. (2019). *The medical AI insurgency: what physicians must know about data to practice with intelligent machines*. Art. no. 62.
Nurse Educ Today, *35*(12), e1-3.
Paolo, G., Bincoletto, G. (2021). *A proactive GDPR-compliant solution for fostering medical scientific research as a secondary use of per-sonal health data*. Trento Law and Technology Research Group Research Paper no. 46.
Stöger, K., Schneeberger, D., Kieseberg, P., Holzinger A. (2021). Legal aspects of data cleansing in medical AI. *Computer Law & Security Review*, *42*.
Wetsman, N. (2019). Artificial Intelligence aims to improve cancer screening in Kenya. *Nature Medicine*, *25*, 1630–1631.
Zulkarnain, N., Anshari, M. (2016). *Big Data: Concept, Applications, & Challenges*. International Conference on Information Management and Technology (pp. 307–310).

PART FOUR

SELECTED PROBLEMS OF EDUCATIONAL RESEARCH CONDUCTED IN THE DOCTORAL SEMINAR

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 1.11.2022
Accepted for printing: 4.12.2022
Published: 22.12.2022

DOI: 10.15584/jetacomps.2022.3.15

GRZEGORZ ZAŁĘSKI

Using Selected Methods of The *SDP-System* Device, as a Tool For Computer-Assisted Brief Pedagogical Diagnosis

ORCID: 0000-0001-6240-2935, Master degree, University of Applied Sciences in Tarnow, Poland

Abstract

The article presents, present , practical requirements towards educationistsas diagnosticians. It is an attempt to answer constantly changing provisions in thematter of organizing and providing psychological and pedagogical help in publicschools. The work includes description of specified test exercises, from IntegratedMeasurement of Psychological Variables System (*SDP-System*), which based onvalidation analysis so far were acclaimed as accurate and reliable. In *System*, testexercises are built inter alia based on test modules using graphic marks, presentingpictures and psychomotor exercises. These exercises may be successfully usedby educationists and technical or vocational education teachers in order to determinepredispositions, potential and students aptitudes.

Keywords: educational computer programs, pedagogy of work, SDP-System

Introduction

Computer assisted diagnosis allows educationists to objectively evaluate students, with relatively small time expenditure and effort spent on collecting and analyzing data. Educationists' decisions based on quantitative data are considered as fundamental in improving effectiveness and minimizing bias in their work (Van der Kleij, Feskens, Eggen, 2015).

School is an environment, in which order and support for students are provided in the first place. In Poland the change of laws was proposed, concerning psychological and pedagogical help in public educational institutions. Underlining challenges placed before educationists. According to new laws, school educationists should do examinations and diagnostic activities connected to recognizing inter alia. Needs, predispositions, interests and students problems. Addi-

tionally specialists in that area should attend in determining necessary learning conditions, specialized equipment, using inter alia. Information and communication technologies (Decree MEiN, 2022). That claim of competence is without a doubt a great organizational challenge for schools, and also specialists who work there.

Research concerning psychological and pedagogical diagnosis are considered as mostly rooted in modern education, as regards practical research. Currently described kind of diagnosis is an organized process of collecting and analyzing data, which is specified by cognitive activity. Diagnostic activity is a connection of so-called cold knowledge (scientific, theoretical) and the hot knowledge (experiences), (Wysocka, 2013). Pedagogical diagnosis used in the process of education is an activity having to describe a given state of affairs and explain the mechanisms that condition specific phenomena. Drawn conclusions are also classified to specific types, categories and characteristics (Skibska, Wojciechowska, 2014).

Unfortunately, psychodiagnostics conducted by educationists in schools, is often directed by coincidence and not based on psychometric tools, which we can see for example in psychological and pedagogical clinics. Use of modern methods and technologies, would contribute nor only to deepening psychodiagnostic component, but also development of teacher's professional activity (Minakhmetova, Pyanova, 2016).

The subject matter of the study

Presented work is a voice in the discussion about uses of practical psychometric methods in schools, thereby improvement of the teachers diagnostic workshop. Palka (2010) has written that *reflection over pedagogicalexaminations methodology should be a continuous process.* Diagnostics should also be a field to search for new ways to practice the science in spaces rarely used to this time. The key contents in the voice taken, should concern inter alia how educationists can manage the challenges before him. With the help come technological solutions, specifically a possibility to use specific tests of integrated psychological and pedagogical systems, named *SDP-System.*

Research methodologies and tools.Practical requirements towardsdiagnostician, use of psychometric tests in pedagogical diagnosis

Strength of practical pedagogical diagnosis is its right use in the education process,such as determining a student's strengths and weaknesses, wordingof learning plans, tracking his progress and relay the bright feedback. Essentiallythis process applies to three questions: *Where am I going?*; *How to get there?*; *Where next?* (Hattie, Timperley, 2007). Educationists, practical specialists cansmoothly carry out a student's thought this way.

Wysocka (2013) gives the criteria that pedagogical diagnosis should meet in terms of practice, should be: practical; decisive; complete; valuing; permanative; descriptive-explanatory; dynamical; interdisciplinary and multifaceted. These types of requirements are met by the testing method, more specifically psychometric diagnosis. Should be emphasized, that as in psychology , as in pedagogy – the term of test is identical with a tool, which meets the terms of standardization, objectivity and normalization. Diagnosis using psychometric tools, which meets methodological criteria, minimizes the risk of abnormality while evaluating a child's capabilities. It enables an objective measure of examined traits for educationists (Stemplewska-Żakowicz, 2009).

Both traditional psychometric tools, as well as these implemented by computer technology, provide a possibility of organizing pedagogical diagnosis on a new level. Nowadays, school educationists not only don't have access to computer diagnosis systems, but have limited resources for traditional tests, or they may be not allowed to use some psychometric tests. In pedagogy the term of test is used wider than for example in psychology and concerns both normalized diagnosis, as well as informal. These tools may have the form of questionnaire, achievement tests, tests of unfinished sentences or inventory (Niemierko, 2009). Among them we can enumerate psychometric tools, to which educationists have full access. It's for example *Cognitive function diagnosis battery-PU1 LTE*; *Battery for methods of diagnosispsychometric development of children from age of five to six – BATTERY-5/6c* and others (PTPiP, 2022). Availability to the most of the tests is however restricted, or for the people with a psychology profession diploma, or necessity for paid training. Among such tools we can list: *Verbal Fluency Test* or *TMK – Raven Matrices Test in the color version.* Listed example methods concern cognitive functioning diagnosis and psychometric efficiency and are meant for individual examination of children and school youth.

The answer for current legal requirements, methodical, put before an educationist working in education may be the use of computer technology, based on an integrated test system, available for every specialist. Creation of multi-scale computer systems for screening diagnosis may be involved with technological challenges and organization. Technology must be able to serve a wide range of systems, devices, and school browsers. One of the examples of use compatible systems in schools was software *Expert 3.0*, including automatic pedagogical tests. Automatic diagnosis technology is a testing strategy oriented for pedagogical diagnosis, integrated with the school grading system. Software *Expert 5.05* is a Ukrainian product, based on inter alia mathematical tests. Advantage of this IT system is its modular design, which allows the test position author to create and add data. The system's database is based on test subject base, so it refers inter alia to monitoring student's achievements. After the examination, the diagnostician gets statistical data about every knowledge element. Data is presented with

the help of a graph in a spreadsheet. It also includes information about student's strengths and weaknesses and possible recommendations about further diagnosis (Bilousova et al., 2020).

Development (analysis of research results). Uses of specific tools *SDP--System* in pedagogical diagnosis

Objective, suitable, exact, consistent and free from prejudices – these requirements should be fulfilled by computer systems including psychometric tests. These requirements are possible by the Polish invention: *SDP-System.* It's an Integrated Measurement of Psychological Variables System. It consists of three elements: Test Apparatus, consisting of exhibition monitor and keyboard; Computer and Professional software. Serves inter alia to measure cognitive and psychometric functions and it's a proposition for all specialists, for whom overall assessment of human function is necessary. Main goal of *SDP-System* is to create a possibility of projecting and making tasks for testing mental, cognitive and motor capabilities of a human, in relation with evaluation of his capabilities in different areas of activity and diagnosis of possible deficits. Adopted psychometric tests, of which advantage of authoring tools – may successfully, without any license restrictions, be adopted in school educationist or technical education teacher's practice. Below a couple of example tools are included in *SDP-System* are presented, which based on validation research among adults, confirmed high reliability and accuracy (Horoszkiewicz, Korchut, 2020), confirming at the same time the requirements related to so called goodness of psychometric test (Brzeziński, 2002).

Number location test

This test evaluates efficiency of operating memory and observation. Tool consists of two boards separated into square fields, in which two-digit numbers are placed. Task requires us to memorize numbers from the first board, after which we search for them on the second board. In order to do the task, the diagnosed person moves the displayed frame using the keyboard. Software registers the execution time and the amount of repeated reactions in order to improve erroneous reactions. In order to evaluate reliability of the test, the system uses a method of repeated measurement. Homogeneity of test positions was also specified by calculating Cronbach's reliability coefficient. Based on the executed Kołmogorow-Smirnow test, the average reaction time in the Number location test was specified; it is also characterized by appropriate relevance.

The line test

The line test may be used as a way to measure the reliability of the visual receptor. A significant variable measured by this test is shifting and concentra-

tion of attention. It lets us evaluate the observation capabilities of the examined person by concentrating on a "detail" of the presented picture. During the test, there are 9 boards exposed, differing from each other by the amount of horizontal, thin and black lines placed on a white background. The task requires us to count the lines and to write down their amount using the keyboard. To evaluate accuracy of the test, the *test-retest* was used. The homogeneity of the test positions was specified by calculating Cronbach's reliability coefficient. In the context of accuracy the results got by statistics analysis encourage a careful approach to the results in this test task.

Simple Coordination Test

It is a modified method of visual-motor examination and precision of moves. Numbers are shown successively on the monitor, on which we have to react by pushing the keyboard button with the exposed number. In the task two examination modes can be used: imposed, where pace of exposition is stable and forced mode, where the next exposition has its place after the right reaction of the examined person. To evaluate reliability of the test, method *test-retest* was used. The homogeneity of the test positions was specified by estimation of the Cronbach's reliability coefficient. Based on the execution of the Kołmogorow-Smirnow test it was also specified that average reaction time in *Simple Coordination Test* is an accurate indicator.

Complex Coordination Test

It's a method of psychometric efficiency measurement extended by the element of thinking. Exposed stimulus is based on simple mathematical tasks, based on adding and subtracting single numbers. Task of the examined person is a specific reaction by pushing a button with expected result. Method demonstrates the thinking time component in psychometric reactions. To evaluate the reliability of the test, *test-retest* was used. Homogeneity of the test positions was specified by the estimation of the Cronbach's reliability coefficient. Based on the execution of the Kołmogorow-Smirnow test, it was also specified that the average reaction time in the Simple *Coordination Test* is an accurate indicator.

Precision and Thinking Indicator (PiM)

Is an amount of correct reactions in test tasks concerning simple and complex coordination at a forced pace. Results are showing a general level of visual-motor coordination efficiency that requires precision and fast thinking. To evaluate reliability of the test, *the test-retest* method was used. Homogeneity of test positions was specified by estimation of a Cornbach's reliability coefficient. Based on the execution of the Kołmogorow-Smirnow test it was also specified that *PiM* variable is an accurate indicator differentiating the results in the scope of this variable.

Conclusions

In education institutions there is a constant need for information about students. Concerning their abilities, potential, changes, constraints, predispositions or capabilities. Diagnosis was always a daily educational element. School educationists, in order to assess the student, often prepared and used their own, intuitive diagnostic tools (McMillan, 2003). Criteria of that opinion's objectivism was often unfulfilled. In a situation with lack of diagnostic tools, educationists led students for preliminary diagnosis to the closest Psychological and Pedagogical Clinic. Currently introduced provisions in terms of organization and providing psychological and pedagogical help in public schools, are a big challenge for education employees.

Pedagogical diagnosis in schools should be based inter alia on test tools, and thus quantitative diagnosis, guaranteeing objectivism, reliability and result accuracy. Additionally, this type of tests shouldn't be time consuming, which would prompt educationists and teachers to use them more often.

Since the answer for current and methodical provisions put before educationists working in education may be use of computer technology – proposition of use of integrated psychometric tests seems to be reasonable. Use of specified tests tools like*SDP-System*, should be preceded by numerous validation examinations amid polish students, in order to confirm their psychometric goodness according to this age group.

References

Bilousova, L., Kolgatin, O., Kolgatina, L. (2013). Pedagogical Diagnostic with Use of Computer Technologies. *CEUR Workshop Proceedings*, *100*, 209–220.

Brzeziński, J. (2002). *Metodologia badań psychologicznych*. Warszawa: Wyd. Naukowe PWN.

Hattie, J., Timperley, H. (2007). The Power of Feedback. *Review of Educational Research*, *77*(1), 81–112. doi: 10.3102/003465430298487.

Horoszkiewicz, K., Kochut, A. (2020). *Współczesne narzędzia pomiaru psychofizjologicznego: SDP-system. Podręcznik dla użytkowników*. Katowice: Wyd. Psychotronics publishing.

Kleij Van der, F.M., Feskens, R.C.W., Eggen, T.J.H.M. (2015). Effects of feedback in a computer-based learning environment on students' learning outcomes: A meta-analysis. *Review of Educational Research*, *85*(4), 475–511. doi: 10.3102/0034654314564881.

McMillan, J.H. (2005). Understanding and Improving Teachers' Classroom Assessment Decision Making: Implications for Theory and Practice. *Educational Measurement*, *22*(4), 34–43. doi: 10.1111/j.1745-3992.2003.tb00142.x.

Minakhmetova, Z., Pyanova, E.N. (2016). Teacher's Psycho-diagnostic Activities in School Educational System. *International Journal of Environmental & Science Education*, *11*(7), 1579–1588.

Niemierko, B. (2009). *Diagnostyka edukacyjna. Podręcznik akademicki*. Warszawa: Wyd. Naukowe PWN.

Palka, S. (2010). Badania z pogranicza pedagogiki i innych nauk. W: *Podstawy metodologii badań w pedagogice* (pp. 313–315). Gdańsk: GWP.

Pracownia Testów Psychologicznych i Pedagogicznych. *Produkty*. Retrieved from: https://pracowniatestow.pl/ (30.10.2022).

Rozporządzenie MEiN. Retrieved from: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20220001593 (30.10.2022).

Stemplewska-Żakowicz, K. (2021). *Diagnoza psychologiczna. Diagnozowanie jako kompetencja profesjonalna*. Gdańsk: GWP.

Wysocka, E. (2013). *Diagnostyka pedagogiczna: nowe obszary i rozwiązania*. Kraków: Impuls.

Wysocka, E. (2013). Wschodząca dorosłość a tożsamość młodego pokolenia – współczesne zagrożenia dla kształtowania tożsamości: analiza teoretyczna i empiryczne egzemplifikacje. *Colloquium, 1*, 69–96.

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 4.11.2022
Accepted for printing: 4.12.2022
Published: 22.12.2022

DOI: 10.15584/jetacomps.2022.3.16

SANDRA ŚCIERANKA

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

The Role of Mediation in a Teacher's Work

Abstract

This article deals with the use of mediation in the educational space of the teacher's work. It discusses the essence of mediation and the contemporary transformations and difficulties that are taking place in school institutions, directly related to the person of the teacher. The quintessence of the considerations is the presentation of mediation in the context of challenges for the teacher, as an alternative method to improve dialogue and alleviate emerging conflicts and misunderstandings especially in teacher-student, teacher-parent, and student-student relations.

Keywords: mediation, school, teacher, student

Introduction

The school is an institution that, right after the home environment, represents one of the most important stages in everyone's life and is thus an area of constant change. It is also a space where various misunderstandings and conflicts occur on many levels. Nevertheless, conflicts are an integral part of everyone's life, so it is impossible to exclude them completely, especially from school life. They are also an indispensable part of social functioning because every person is different, has a different personality, or is characterized by different experiences, so in the face of conflicting individual conditions, misunderstandings are formed in all aspects of life. Therefore, there is a need for the introduction and use of an alternative method to enable constructive resolution of disagreements through mediation.

Furthermore, using this tool, any difficult situation can be used to educate students and develop certain competencies. It is also becoming noticeable that the introduction of mediation activities into the school and peer environment has

many positive effects, not only on the resolution of misunderstandings and prevention of violence, but also significantly improves cognitive and social skills among both students and teachers.

Theoretical foundations of mediation

Mediation is a scientific field that is viewed in various aspects and in connection with which one can find many definitions. The very phrase mediation means to mediate a dispute (Latin: mediare) or impartial, middle (Latin: medius) (Kalisz, Zienkiewicz, 2009, p. 43).

The Mediator's Code of Ethics defines this process as a voluntary and confidential search for agreement for people who are stuck in a common conflict with the help of an impartial and neutral mediator. The main goal of this mediation is primarily to assist the mediating parties in deciding to bridge the disagreement in a mutually acceptable way (Polish Mediation Center, 2020). Mediation is also a platform that creates conditions for the peaceful resolution of disputes, and especially creates a space for conversation, during which everyone can outline their concerns, needs, or simply express their opinions honestly. This is also due to the fact that mediation is described as a tool for innovative and effective management of conflicts that have occurred, while the role of the mediator himself is to listen to the conflicting parties and direct the conversation in such a way as to lead to the resolution of the dispute, the development of a settlement and a sense of victory by both parties (Jastrzebska, 2014(3), p. 3).

There is also an educative definition of the interpretation of mediation, which is defined as some kind of exchange that takes place between parties having difficulties in their mutual correlations (Swiatkowski, 2012). In the approach discussed above, the mediator's role largely boils down to creating a sense of security in which this exchange can naturally occur. Mediation proceedings are also characterized by a specific approach to conflict because it is seen in the context of something natural, but not negative – it seeks positive change. In view of this, the conflict itself (from Latin conflictus – event) is identified with the problem to be solved, which at the same time is the foundation for clearing the situation, relationship and understanding of the other party, including realizing the existence of the conflict and starting to work on it (Morek, 2009, pp. 15–29).

It should also be noted that mediation is systematized in legal norms and is included in the Code of Civil Procedure, Criminal Procedure, or in juvenile cases (this is related to the type of case in which the proceedings are conducted). And in the case of a school institution, mediation is included in the Regulation of the Ministry of Education as an effective tool for psychological and pedagogical assistance (Regulation of the Ministry of Education, 2017, Art. 24, para. 6).

In order to be able to talk about a properly conducted mediation procedure, despite the fact that it is an informal activity, five main principles should be observed, which should be absolutely respected.

The principle of voluntariness manifests itself in the informed and independent consent of the parties to the conflict to participate in the mediation proceedings, as well as the specific person of the mediator. This consent can be changed at any time during the proceedings.

The principle of confidentiality applies to all persons participating in the mediation (the parties to the conflict and the mediator), which guarantees that all information obtained in the course of the activities will not be used in any way.

The principle of acceptability is expressed in the widely understood acceptance of the person of the mediator, as well as the fact that this is a person whose goal is to help level the existing conflict.

The principle of impartiality refers to the equal and uniform treatment of the parties to the conflict by the mediator. In this procedure, each participant has equal rights.

The principle of neutrality means that the mediator does not have the ability to impose solutions on the parties. Any terms of settlement are formulated by the clients, while the mediator only helps to clarify the given solutions, as mediation puts the dexterity in the hands of the conflicting parties (Polish Mediation Center, 2020).

Difficulties in teacher's present work as a challenge for mediation

School is a place where students spend a great deal of time acquiring not only knowledge but also appropriate social behavior and proper interpersonal relations. However, more and more often it is the school that is becoming the point of complex, various conflicts, and misunderstandings. Because over the years there are huge changes taking place in society, related both to changes in the political and political system, but most importantly in the way children and young people behave, parents' expectations of the role of teachers, including a decline in the authority of the teacher through which many disputes arise in the relationship teacher-parent, management-parent, and student-student (Wajerowska-Oniszczuk, 2003(4)).

In the student-student relationship, it is increasingly possible to see an intensifying rivalry between students, which takes the form of negative emotions in the form of jealousy, dislike of the other person, and even hostility, resulting in ridicule, quarrels, and malice. There is also the use of aggression and violence, as well as overtly presented intolerance (due to appearance, origin, or dress) towards the otherness of other students.

Among the currently emerging conflicts in the school space on the teacher-parent line can include inadequate requirements for the tasks of the teacher because due to the emerging problems of care and education, parents (often too busy) require not only that the teacher perform the teaching function, but also the educational function. In addition, they direct all the responsibility for aca-

demic performance towards teachers. Thus, in the situation of emerging learning difficulties, inappropriate social behavior, or non-acceptance of the required rules, then a double conflict arises between student-student and teacher-parent. This is the reason why more and more often parents do not feel the educational role of their own children, diverting this entirely to the institution of the school, as a result of which there are resentments and conflicts that accumulate on the teacher.

The most noticeable conflict in the management-parent area at the moment is the issue of placing religion (which is an optional subject) in the middle of the lesson plan. This controversial subject is expanding the scale of the conflict, in which many more people are involved. The ground for disagreements arises on the grounds of organizing care or arranging time for students who do not participate in the aforementioned lesson (Kowalczyk, 2021).

Also, at the early elementary and school stages, there are numerous misunderstandings in the teacher-student context because due to what is presented in the home environment regarding the person of the teacher, so very often the child translates it to the school environment. Unfair grading, "the lady is picking on you", are the most common areas in which conflict arises both in the case of the teacher-student and then the teacher-parent, because observing the growing attitudes of entitlement to the person of the teacher, the parent unscrupulously , "attacks" without knowing the whole truth (Woźniak, 2021).

In view of the above, the planes where conflicts most often occur are listed, and it becomes apparent that the modern teacher not only has a huge amount of top-down duties to fulfill but also faces the challenge of maintaining appropriate relations with the external environment. In addition, the examples cited are also a confirmation of the need for and definition of the space eligible for mediation.

Mediation in the school environment

Two of the most common types of mediation can be distinguished in relation to the educational space. These are school mediation and peer mediation, in which the mediation action is similar, while the difference lies in the party who is involved in the dispute (Ombudsman for Children, 2017, p. 4). The first of these, school mediation, occurs when a disagreement is mitigated by an adult prepared to do so, i.e. with the appropriate competence and knowledge (e.g., management, teacher, educator), and arises on the line of student-student, teacher--student, teacher-parent, management-parent, teacher-teacher, teacher-director. It is also worth noting that this is an important task that falls under the responsibility of the school establishment because, despite everything, mediation with children is much more difficult and demanding than with adults. This is due to the fact that the mediator not only accompanies, helps to resolve a given conflict situation, but also influences the formation of attitudes towards both the conflict

and the possibilities of its mitigation or leveling, which can be used in the future by the student. Therefore, also in this case, the teacher has a real influence on the creation of attitudes of his students.

Peer mediation (less common), on the other hand, occurs when the conflict arose between students, and the role of mediator is played by another student who has been prepared for this activity (thus meeting the relevant criteria such as being over 13 years of age, or characterized by a gentle disposition, responsible, and most importantly – having the appropriate communication skills), but is also assisted by a school mediator. It is used when the cause of the conflict is a difference of opinion on the issue under discussion. This happens when the conversation turns into a conflict of values because neither of the parties can accept the other point of view, being convinced that they are right. This type of mediation definitely makes it easier for young people to open up and discuss the problem, because they have a sense of equality with the mediator, thus the person coordinating the course of the dialogue.

There is no doubt that the school and especially the person of the teacher, for it is largely with him that the school period is identified, should meet the emerging difficulties, conflicts, and helplessness that affect students and their home environments. It should be shown that conflicts can be resolved, but in a different way from what students are currently doing. Aggression and violence are an unconstructive approach to the problem. The method used by schools, on the other hand, is to put the issue in the hands of the "school referee", who is usually the headmaster or a teacher. His role boils down to asking "what happened?" and "who started it" and then imposing the appropriate punishment. As a result of such a procedure, there is no discussion of the situation, no deeper analysis of the situation, and ultimately the conflicted parties do not reach a common understanding of each other and a sincere agreement (Woźniak, 2021).

The mediator, on the other hand, listens, facilitates the conversation, participates in the meeting, and helps to develop an agreement that is accepted in its entirety by both parties to the conflict. Mediation also makes it possible to voice one's point of view, in the literal sense of, "face the conflict" and then provides an opportunity to outline solutions on one's own, which seems extremely important both in the context of the educational process carried out by the teacher and with regard to the further development of the child. Undoubtedly, it is a time for both parties (the perpetrator and the victim, in the case of violence) to understand the situation that has arisen and to realize the reasons for behaving in the way they did. Mediation proceedings teach not only to speak but first of all to listen, which is sorely lacking in everyday communication, and is undoubtedly an important skill in the process of shaping young personalities (Wajerowska-Oniszczuk, 2003). Therefore, it becomes extremely important that both the school and the teacher are open to innovative work methods and actively use the available alternatives to bring order and social order.

Mediation as a challenge and benefit in teacher's work

The benefits that accrue from the use of mediation both in the work of the teacher and in the school institution as a whole are numerous. It significantly influences the improvement and development of communication skills, which then translates into the creation of correct interpersonal relations both with regard to students and mediators, i.e., teachers, management, or other school employees. Participants in mediation learn to be assertive in expressing their feelings and needs, but at the same time are able to listen to the other side. With regard to students, this is important because the mediation space provides an opportunity for students themselves to understand their own behavior and attitudes, to realize that conflict does not necessarily mean something negative. Mediation leads to learning how to analyze and draw conclusions and, above all, how to deal constructively with the conflicts encountered. This lays the foundation for the proper functioning of the child in adulthood, because if at the school stage (at which time the child is susceptible to the formation of his personality and the assimilation of acceptable patterns) he acquires knowledge of dispute resolution, then it will certainly be easier for him to find his way in various situations in the future. This is crucial, since the school stage is the time to formulate and teach appropriate attitudes, while this opportunity is severely limited in adolescence, where behavior is heavily influenced by the peer group, as well as the rebellious period.

In addition, mediation also provides a space to counteract the occurrence of violence, aggression, or "hate" at school. Because during the conversation, there is an opportunity to look at the problem in a multifaceted way and positive relationships are created. This has a huge impact on the whole situation, as the mediator limits negative emotions, giving the feeling of an "adult" approach to the problem – not a childish insult or complaint, or an independent, often forceful solution. Mediation, therefore, teaches to resolve disagreements without using violence. Surely this brings more benefits than the attitude of a "judge-teacher/director". Undoubtedly, too, such an approach influences a lasting understanding between students minimizing the occurrence of a similar incident in the future (Raszewska-Skałecka, 2013, pp. 71–83).

The mediation process also introduces a proper culture of dialogue and fosters friendly relations between all those associated with the educational institution, i.e., teachers, parents, management, or other employees, even in the face of the occurrence of differences in opinion. Because mediation protects the interests of the parties, accepts their rank and importance on an equal footing. Mediation is a method that also significantly affects the creation of a positive image of both the school and the person of the teacher, as it provides an opportunity to talk, and therefore to take into account every rationale, so that no one feels left out or their position disregarded (Czyżowska, 2018(34), pp. 1–10). Through the

opportunity for constructive conversations with parents, there is a chance to discuss all expectations and solutions, so that cooperation goes as well as possible, and thus the teacher is actually free to realize himself in his work.

It is also worth emphasizing the advantages that arise from conducting these proceedings for the teacher himself. Well, with the conduct of mediation, teachers undoubtedly have the opportunity to develop even more strongly their skills in understanding the point of view of another person. In addition, it also influences the expansion of self-awareness in the emotional plane, i.e. they more consciously use in their daily work the fact that emotions significantly affect the behavior of students (Ibarrola, Iriarte, 2013, 180–189).

Performing this role of mediator is not an easy function; however, a teacher is a profession that is characterized by those qualities that are most important in mediation. Thus, a teacher should treat all students the same, inspire development, express empathy, understanding, actively listen, and respond adequately to the needs of students. Thus, these are priority qualities for the mediator's persona because, just like the teacher, the mediator accompanies the student in making actions and decisions. Therefore, it can be said that the role of the mediator is anchored in the role of the teacher. In view of this, fulfilling oneself as a mediator is not only a challenge, but also a mission that the teacher faces.

Conclusions

Undoubtedly, mediation used in the school space is an alternative method for resolving conflicts of various backgrounds, reducing the negative effects of misunderstandings, and at least to some extent preventing the increase of violence and aggression among students. It is also worth noting that it has a positive impact on both students and teachers, as it enables cognitive, moral, and emotional development. Furthermore, the use of this process can contribute to improving relations with parents of students, including respect for common needs, which will certainly translate into the overall functioning of the child in the school. Adequate dialogue is the way to a proper joint relationship, which is of great importance especially in the early childhood and school stages. And, by the same token, such an attitude will definitely facilitate the work of teachers.

Nevertheless, mediation is not the answer to all problems that arise at the school level, because it is voluntary, so no one can be forced into it. However, looking at mediation in a broader context, analyzing its advantages and the good resulting from it, its existence should be popularized in Polish education.

References

Czyżowska, N. (2018). Mediation at school – a tool for the development of students and teachers. *Scientific Quarterly Fides et Ratio*, *2*(34), 1–10.

Ibarrola, S., Iriarte, C. (2013), Evaluation of a School Mediation Experience, Procedia. *Social and Behavioral Sciences*, *84*(2), 180–189.

Jastrzębska, E. (2014). Mediation as a method of conflict resolution. Mediation in family and guardianship matters. *Scientific Quarterly Fides et Ratio*, *3*(19).

Kalisz, A., Zienkiewicz, A. (2009). *Judicial and out-of-court mediation. Outline of the lecture*. Warszawa: Wolters Kluwer Polska.

Morek, R. (2009). In: E. Gmurzyńska, R. Morek (eds.), *Mediation. Theory and Practice* (pp. 15–29). Warszawa: Wolters Kluwer business.

Kowalczyk, K., (2021). *The trend of giving up religion lessons continues. The guilty ones include overloaded lesson plans*. Retrieved from: https://www.bankier.pl/wiadomosc/Trend-rezygnacji-z-lekcja-religii-utrzymuje-sie-Winne-m-in-przeladowane-plany-lekcja-8187141.html (17.07.2022).

Ombudsman for Children (2017). *Standards of peer and school mediation in schools and other educational institutions*. Retrieved from: http://brpd.gov.pl/sites/default/files/standardy_mediacji_rowiesniczej_i_szkolnej_w_szkolach_0.pdf (16.07.2022).

Polish Mediation Center 2020. Retrieved from: https://mediator.org.pl/ (16.07.2022).

Raszewska-Skałecka, R. (2013). Peer mediation as an instrument of counteracting aggression and conflict resolution at school. In: M. Tabernacka (ed.), *Mediation over divisions* (pp. 71–83). Wrocław: Legal and Economic Digital Library.

Regulation of the Ministry of National Education of 9 August 2017 on the principles of organization and provision of psychological and pedagogical assistance in public kindergartens, schools and institutions. Journal of Laws 2020, item 1280.

Świątkowski, M. (2012). *Polish labor law*. Warsaw: LexisNexis.

Wajerowska-Oniszczuk, B. (2003). *Mediation in schools*. Retrieved from: https://psychologia.edu.pl/czytelnia/59-niebieska-linia/826-mediacja-w-szkolach.html (16.07.2022).

Woźniak, K. (2021). *Mediation at school – a modern method of solving school disputes*. Retrieved from: https://securityinpractice.eu/mediacje-w-szkole-nowczesna-metoda-rozwiazywanie-szkolnych-sporow/ (16.07.2022).

© University Press 2022
ISSN 2719-6550
ISSN 2719-7417 online

"Journal of Education, Technology and Computer Science"
No. 3(33)/2022
www.eti.ur.edu.pl

Received: 2.11.2022
Accepted for printing: 1.12.2022
Published: 22.12.2022

DOI: 10.15584/jetacomps.2022.3.17

BEATA SEMKÓW-NĘDZA

Practical Application of ICT During Physics Lessons

ORCID: 0000-0002-1231-0685, M.Sc., eng., University of Rzeszow, Institute of Pedagogical, Poland

Abstract

The constant changes taking place in society, digitization, the use of ever newer technological solutions, should also generate changes in the way knowledge is transmitted to students. The article presents examples of information and communication technology (ICT) tools used in physics lessons. The ways and advantages of using the modern ICT tools discussed are also presented. The use of modern ICT tools should facilitate the understanding of physical phenomena and concepts.

Keywords: ICT tools, physics, key competencies, smartphone

Introduction

The last decades of the 20th century brought intensive development of modern technologies. Today's students belong to the first generation growing up surrounded by modern technology and communication tools. They spend a significant part of their lives with a smartphone or other mobile device. Today's young people use the latest tools of the digital era, which have already become an integral part of their lives. There has been a radical change in students' behavior, perception of the surrounding world and students' perception of stimuli (Prensky, 2001, p. 1). A number of terms are known in the literature about modern students. Digital Natives (Prensky, 2001, p. 1), the Homo Zappiens generation (the generation of multimedia children), the Millennial Kid (the child of the turn of the millennium) (Tanaś, 2004, p. 7), Homo Interneticus (the modern man connected to the Internet) (Walat, 2016, p. 236).

The article will present selected ICT tools, examples of application and the benefits of using a specific tool during a physics lesson. Simulations of experiments, physical measurements using applications available for smartphones

and other applications that introduce an element of surprise during the lesson, interactive games to test the knowledge acquired by students will be discussed in detail.

The subject matter of the study. Modern technologies in education

The key competencies established by the European Parliament and the Council of the European Union have become a response to the continuous development of modern technologies and the constant changes in society. Key competencies are called a combination of knowledge, skills and attitudes appropriate to the situation, which are necessary for self-realization and personal development (Council Recommendation of 22 May 2018 on key competences for lifelong learning. Official Journal of the European Union C189/7, 2018). Eight key competencies were specified, among which were digital competencies.

Analyzing the information, from the recommendations of the Parliament of the European and the Council, it should be noted that having digital competencies is essential for living in a modern society. Key competencies are necessary when communicating, seeking creative and innovative solutions. It is also important to be aware of the opportunities offered by modern digital tools, the limitations, consequences and risks associated with their use (Council Recommendation of 22 May 2018 on key competences for lifelong learning. Official Journal of the European Union C189/9, 2018).

Key competencies, including digital competencies, should be formed during the teaching-learning process, in the course of each lesson. The problem of using modern tools of technology and communication in the daily work of the teacher, was also included in *the Integrated Skills Strategy 2030* (Integrated Skills Strategy 2030, p. 31).

Research methodologies and tools

The research was conducted using the analysis of commonly available solutions regarding the possibility of using ICT in teaching physics in the school environment.The priority task of a modern school is to develop key competencies among students, which in the future, will allow them to function independently in a digital society. This raises the question of how to integrate modern ICT tools into the educational process. ICT tools should become an integral part of every lesson.

Analysis of research results. ICT tools in teaching physics

The necessity of using modern technology and communication tools is accentuated in many scientific studies. Similarly, the advantages of using these tools during lessons. The article will present selected applications of ICT tools, with a particular focus on physics lessons and the benefits of incorporating

a particular tool into the teaching-learning process. Physics is classified as a natural science. The task of physics is to learn about the laws governing nature, physical phenomena, properties and transformations of matter and energy. When considering the use of ICT tools during physics lessons, it is worth starting with one of its most essential elements – experience, since observation and experience are among the basic research methods in physics.

Physics lessons should educate a scientific view of the surrounding world. An experiment, an experiment conducted during a lesson, is an indispensable part of it. In the curriculum basis for teaching physics, there are numerous references to performing experiments during lessons, such as *planning and carrying out observations or experiments and making inferences based on their results* (Regulation of the Minister of National Education of February 14, 2017 on the curriculum basis for kindergarten education and the curriculum basis for general education for elementary school, including for students with moderate or severe intellectual disabilities, general education for an industry first-grade school, general education for a special school for work, and general education for a post-secondary school, Journal of Laws 2017 item 356, p. 153).

The above quote emphasizes the necessity of conducting experiments in the course of a physics lesson. Unfortunately, the reality of the classroom introduces many constraints on how to conduct an experiment during a lesson. The school's physics lab may not be equipped with the right equipment for the number of students in the class. Some experiments pose a danger during the lesson. It is also worth noting the need to explain a given experiment, which is not an easy task for students, especially at the molecular level. In the described situations, simulations of experiments, animations, virtual laboratories, e-experiments become very helpful. The teacher has a wide choice of websites, where modern multimedia tools are available that will accurately reproduce the experience in question. Appropriate to the topic of the lesson and thoughtfully simulations of experiments help students understand physics.

American physics didacticians N.D. Finkelstein, K.K. Perkins, W. Adams, P. Kohl and N. Podolefsky in their research showed that a group of students in which the teaching process was supported by simulations achieved better results and understood physics to a greater extent, compared to students taught by traditional methods (Sokolowski, 2009, p. 43). The author of the aforementioned article referred specifically to *PhET* simulations (Internet 5).

PhET simulations are a free tool available to both student and teacher. The authors provide dozens of interactive simulations in physics and other science subjects. For example, using a simulation on diffusion, a teacher can explain the phenomenon to students, illustrating the process of mixing of molecules, which is invisible to the human eye. The user can choose the appropriate parameters of the experiment, setting, for example, temperature, mass and other physical quantities depending on the simulation (Figure 1).

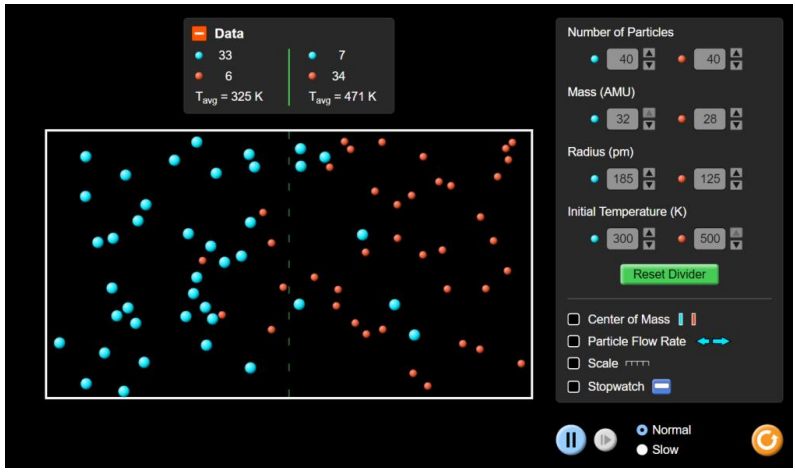


Figure 1. *PhET* simulation showing the diffusion process

Other physical simulations are also available. Worth mentioning are the interactive tools provided by the Czech teacher Vascak (Internet 14). The site offers simulations and animations of physical experiments on many school topics, such as the principle of the hydraulic press (Figure 2).

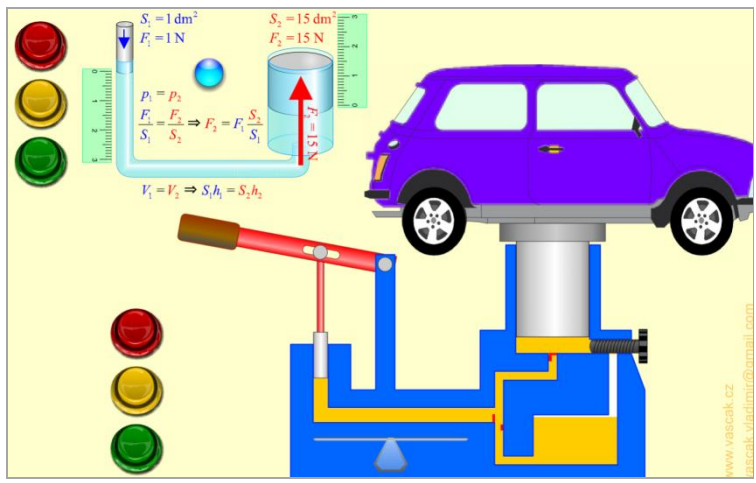


Figure 2. Simulation showing the principle of the hydraulic press

At this point it is also necessary to introduce the three-dimensional *e-Experiments in Physics*, made available free of charge on the website of the Gdansk University of Technology (Internet 1). Using the *e-experiments*, for example, one can perform an interactive experiment to investigate what the period of oscillation of a mathematical pendulum depends on (Figure 3).

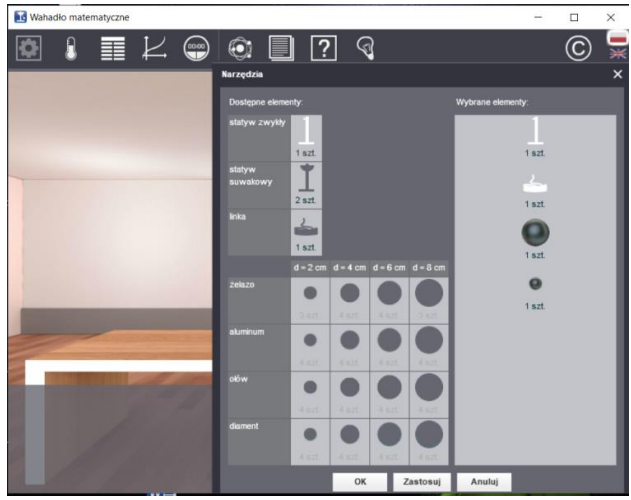


Figure 3. Simulation showing the creation of an experimental set-up to study the dependence of the period of oscillation of a mathematical pendulum on selected factors

A physics teacher can also use a number of other websites where simulations and animations of experiments are available. Some examples include: *physics classroom* (Internet 13), *Apps on Physics* (Internet 15), *Virtual Physics Laboratory* (Internet 2).

Measurements also play a very important role in physics. Referring again to the core curriculum for teaching physics: *a student distinguishes between the following concepts: observation, measurement, experiment; carries out selected observations, measurements and experiments using their descriptions* (Regulation of the Minister of National Education of February 14, 2017 on the core curriculum for pre-school education and the core curriculum for general education for elementary school, including for students with moderate or severe intellectual disabilities, general education for an industry school of the first degree, general education for a special school for special needs, and general education for a post-secondary school, Journal of Laws 2017 item 356, p. 153). In the implementation of the presented requirements from the core curriculum, students' smartphones are becoming helpful.

Modern smartphones are equipped with numerous sensors that, with the use of appropriate applications, allow the user to perform a specific measurement. An application that is very popular among physics teachers is *phyphox* (Internet 6). Using the application, one can, for example, record raw data from a magnetometer, determine acceleration and position. The app's authors have also offered ready-made guidelines for conducting an experiment, often with instructions in the form of a video. Among the proposed experiments are a free fall test, elevator speed test, among others.

Another application available for smartphones is the *Physics Toolbox Sensor Suite*. This app provides similar measurements to the *phyphox* app described earlier.

When discussing the apps available for smartphones, it is worth noting the apps that allow generating sounds of a set frequency, as well as creating oscillograms of sounds of different heights and volumes. Referring again to the provision from the core curriculum: *the student experimentally observes oscillograms of sounds using various techniques* (Regulation of the Minister of National Education of February 14, 2017 on the core curriculum for pre-school education and the core curriculum for general education for elementary school, including for students with moderate or severe intellectual disabilities, general education for an industrial school of the first degree, general education for a special school for special education and general education for a post-secondary school, Journal of Laws. 2017 item 356, p. 158), applications will be presented that enable the implementation of this requirement using ICT tools.

These functions are available in both *phyphox* and *Physics Toolbox Sensor Suite* applications. There are also applications designed exclusively for the aforementioned measurements. Among them are *Frequency Generator*, *Sound Analysis Oscilloscope*, for example. Figure 4 shows sample oscillograms of sounds, created successively in the *Sound Analysis Oscilloscope application* (Figure 4a) and *Physics Toolbox Sensor Suite* (Figure 4b).

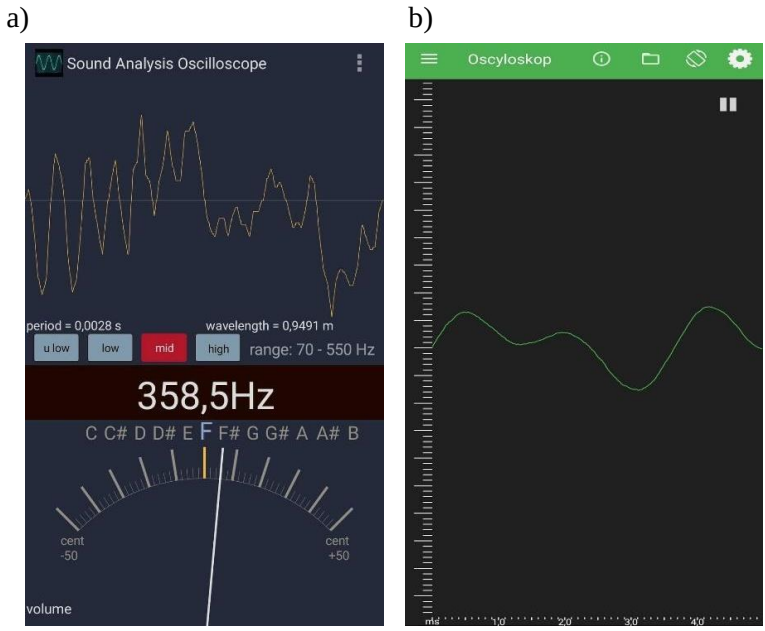


Figure 4. Smartphone screenshot showing oscillograms of sounds, sequentially in the a) *Sound Analysis Oscilloscope app*, b) *Physics Toolbox Sensor Suite app*

In order to increase students' interest during the lesson, to introduce an element of surprise, it is also worth introducing online tests and other ICT tools for getting immediate feedback from students. Mind maps (*mind mapping*) are becoming increasingly popular. The purpose of creating a mind map is to increase the effectiveness of remembering and reproducing messages, through the process of organizing knowledge and linking information to previously acquired knowledge (Marian, 2008, p. 100). Creating a mind map together with students will work well during a lesson summarizing a section. Mind maps can be created using traditional techniques and by using modern tools available online for this purpose, such as *Miro* (Internet 4), *Mindomo* (Internet 12) applications. Also of great interest among students are online tests that introduce elements of *game-based learning* (game-based education) during lessons. One of the most popular platforms for creating online tests is *kahoot* (Internet 3).

Using the *kahoot* platform, an interactive test can be created for students. A great advantage for both the student and the teacher is the immediate feedback on the correct and incorrect answers given by the students. Other exemplary educational platforms for creating online tests are *wordwall* (Internet 9), *quizlet* (Internet 8). The advantage of the wordwall platform is the creation of quizzes, using various templates, such as wheel of fortune, find a pair, true or false, missing word. *Quizlet* allows the creation of tools such as fiches, picture cards, supporting the learning of concepts and definitions, which in the case of teaching physics is also of great importance.

Another tool for conducting a quick question in the classroom is *Plickers* (Internet 7). The unquestionable advantage of this tool is the need for only one smartphone – the teacher, unlike previous apps. Each student is given a unique pre-printed code, which he or she must point in the direction of the teacher. The student indicates one of the answers (A, B, C, D) by setting the code with the corresponding edge up. The teacher immediately receives the results in the form of a bar chart and the answer given by each student.

Conclusions and generalizations

Summarizing the previous considerations, it should be said that modern ICT tools enable interesting solutions during lessons. ICT tools modify the teaching-learning process. By integrating ICT tools into the teaching process, the teacher can increase the effectiveness of teaching and directly influence the process of students' understanding of physics. ICT tools can be used in various combinations and teacher-student, teaching-student activity interactions. Focusing on physics lessons, it is important to appreciate the role of simulations, animations and other interactive tools, the use of which will allow students to present experiments that previously could only be carried out in well-equipped laboratories. In the process of teaching-learning physics, the smartphone has also become a use-

ful tool. Thanks to the sensors hidden in the smartphone, it can be successfully turned into an accurate measuring device. It is also worth remembering to use the smartphone as a tool for communication, as well as a tool for solving online tests and building interaction during lessons.

References

Council Recommendation of 22.05.2018 on key competences for lifelong learning. Retrieved from: https://eur-lex.europa.eu/legal-content/PL/TXT/PDF/?uri=CELEX:32018H0604(01)&from=EN (28.08.2022).

Integrated Skills Strategy 2030 (general part). Retrieved from: https://efs.mein.gov.pl/zintegrowana-strategia-umiejetneosci-2030-czesc-ogolna/ (20.08.2022).

Internet 1: http://e-doswiadczenia.mif.pg.gda.pl/glowna-pl (16.08.2022).

Internet 2: http://fizyka.if.pw.edu.pl/~wlf/ (16.08.2022).

Internet 3: https://kahoot.com/schools-u/ (20.08.2022)

Internet 4: https://miro.com/mind-map/ (20.08.2022).

Internet 5: https://phet.colorado.edu/ (20.08.2022).

Internet 6: https://phyphox.org/ (16.08.2022).

Internet 7: https://www.plickers.com/ (20.08.2022)

Internet 8: https://quizlet.com/pl (20.08.2022)

Internet 11: https://wordwall.net/pl (20.08.2022)

Internet 12: https://www.mindomo.com/mind-maps-for-education (20.08.2022).

Internet 13: https://www.physicsclassroom.com/Physics-Interactives (16.08.2022).

Internet 14: https://www.vascak.cz/physicsanimations.php?l=pl (20.08.2022).

Internet 15: https://www.walter-fendt.de/phys.htm (16.08.2022).

Marian, M. (2008). Mnemonics and "mind maps" as tools to support the learning process. *WSOWL Scientific Notebooks*, *4*(150), 100.

Prensky, M. (2001). Digital Natives, Digital Immigrants Part 1. *On the Horizon*, *9*(5), 1. doi: https://doi.org/10.1108/10748120110424816.

Regulation of the Minister of National Education of 14.02.2017 on the core curriculum for pre-school education and the core curriculum for general education for elementary school, including for students with moderate or severe intellectual disabilities, general education for an industrial school of the first degree, general education for a special school for special education and general education for a post-secondary school. Journal of Laws. 2017 item 356, p. 153. Retrieved from: http://prawo.sejm.gov.pl/ (20.08.2022).

Sokolowski, A. (2009). Physical simulations as an effective teaching aid. *Photon*, *107*, 43–47.

Tanaś, M. (ed.) (2004). *Pedagogy @ computer means and media*. Warsaw, Cracow: Impuls.

Walat, W. (2016). Homo interneticus – a challenge for modern education. Education – Technology – Informatics, *4*(18), 235–242.

LIST OF REVIEWERS IN YEAR 2022

Fabian Andruszkiewicz – University of Opole (Poland)
Mirosław Babiarz – Jan Kochanowski University in Kielce (Poland)
Jacek Bartman – University of Rzeszów (Poland)
Wojciech Czerski – Maria Curie-Skłodowska University (Poland)
Paulina Forma – Jan Kochanowski University in Kielce (Poland)
Jarmila Honziková – University of West Bohemia in Pilsen (Republika Czeska)
Milan Klement – Palacký University of Olomouc (Czech Republic)
Aneta Klementowska – University of Zielona Góra (Poland)
Sławomir Koziej – Jan Kochanowski University in Kielce (Poland)
Bogdan Kwiatkowski – Rzeszow University of Technology (Poland)
Danka Lukáčová – Constantine the Philosopher University in Nitra (Slovakia)
Ladislav Rudolf – University of Ostrava (Czech Republic)
Elżbieta Sałata – University of Technology and Humanities in Radom (Poland)
Čestmír Serafín – Palacký University of Olomouc (Czech Republic)
Ján Stebila – Matej Bel University in Banská Bystrica (Slovakia)
Anton Stoykov – Trakia University (Bulgaria)
Bogusław Twaróg – University of Rzeszów (Poland)
Anna Winiarczyk – Jan Kochanowski University in Kielce (Poland)
Tamara Zacharuk – Siedlce University of Natural Sciences and Humanities (Poland)