Journal of Information Technology Management

Print ISSN: 2008-5893

Online ISSN: 2423-5059

Artificial Intelligence in Solving Educational Problems

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Abstract

External factorsexert an enormous influence on the exigencies of changing the technological course of individualsectors. Digitalizationrepresents not a new milestone in the evolution of education, but its technological and methodological development. Due to a period of constraints, caused by COVID-19 pandemic, educational institutions at all levels in most countries have been forced to resort to digitalization of the learning process. Intelligent learning software provide their users with a variety of options to design and individualize the learning process, as well as independence from time and space. Teachers benefit from flexible content generation and just-in-time assessment of learners' progress, evaluation of large task sets, knowledge sharing with other teachers and knowledge institutions. Learners benefit from anytime availability of learning tools and just-in-time feedback. In our investigation, we

consider the current state-of-the-art of educational software. Considering the results of quantitative empirical study and analysis of educational issues solvable by artificial intelligence, we present a developed and tested framework for selected educational problem.

Keywords: Educational Software; Artificial Intelligence; Empirical Study.

Journal of Information Technology Management, 2022, Vol. 14, Special Issue, pp. 132-146
Published by University of Tehran, Faculty of Management
doi: https://doi.org/ 10.22059/jitm.2022.88893
Article Type: Research Paper

Received: January 21, 2022
Received in revised form: March 29, 2022
Accepted: July 14, 2022
Published online: September 13, 2022

Introduction

In order to strengthen future sustainability, many countries exploitresilient solutions and innovative potentials as can be retrieved from published research findings from Pakhnenko et al. (2021), Petroye et al. (2020),Vasilyeva et al. (2020; 2021) Vorontsova et al. (2020), Yarovenko et al. (2020). Organizations also follow this trend.This statement is proven in the studies of Brimah et al. (2020), Kotenko et al. (2021), Lazorenko et al. (2021), Ziabina et al. (2021). Digitization is driving the development of many sectors: the country's economy, as well as the corporate, education and financial sectors. In recent years the research findings of Artyukov et al. (2021), Chigrin & Pimonenko (2014), Gallo et al. (2019), Lopez & Alcaide (2020), Lyeonov et al. (2019), Njegovanovic (2018), Obeid et al. (2020), Phillips & Kasztelik (2021), Skrynnyk & Vailyeva (2020), Smiianov et al. (2020) prove this point.

According to Artyukhov et al. (2021), Liuta et al. (2021), the level and quality of education depend on a number of factors: internal factors of the education system and external (political, economic, social and societal) influences. Further consideration reveals that education also impacts on the sustainability of the country (Matos & Kasztelnik, 2021; Ramazanov et al., 2020). These theses areproved by the findings of the Ayad & El-Aziz (2018), Vorontsova et al. (2020), Miller (2020), Novikov (2021), Pavlenko et al. (2020), Yapo (2019) research. In conjunction Cosmulese underlines the rapid digitalization in educational institutions (Cosmulese et al., 2019). Companies also express their willingness to contribute to education (Buchynska et al., 2020).

The experience of pandemic distanced learning (homeschooling, homestudying) highlights the importance of digital technologies in education despite earlier controversial discussions about the positive and negative effects of digitization in education (Petroye et al., 2020). Our earlier research, conducted in 2019-2020, found that learning with artificial intelligence has high efficiencies, especially for operational learning objectives (Skrynnyk & Vasylieva, 2020). Method pool of artificial intelligence technologies offer numerous efficiency and effectiveness advantages and enable broad interdisciplinary and transfunctional usage.

Research methodology

Trend analysis of educational software

Despite the fact that digitization is relevant to all countries to different degrees, the users are at different levels of knowledge and the application of educational software has different depths depending on the country. The currency of educational software varies from country to country. This is illustrated by the trend analysis, which was carried out using Google Trends. The terms searched for include: "educational software", "learning software", "teaching software".

Research analysis of educational software

In order to create a complete overview of existing, developed or designed educational software, we conducted a scientific publication analysis in Scopus and Web of Science databases. This exploration provided the outline about theadoption of artificial intelligence technologies for solving concrete educational issues.

Quantitative empirical study of educational issues

The qualitative empirical study was conducted among the German and Ukrainian respondents and is based on a survey of teachers and learnersin educational institutions. We investigate the essential problems and their causes, which relate to the process of teaching, the preparation of learning material, the mediationof learning material, the productivity of imparting the material and its success, as well as the measurement of success, the organizationof the learning process and communication under the assumption of the use of digital media. Under consideration were following teaching, learning and management systems (with examples):

Knowledge monitoring systems

• Tools for examination of mathematical tasks (WeBWorK)

• Vocabulary trainer practices the vocabulary with learners

Content creation and management

• Language learning software offers targeted learning from previously created media according to the learner's level of knowledge

Learning process execution and learning environments:

• Intelligent Tutor System (ITS), utilizes the techniques of Artificial Intelligence to create an interactive environment that considers the various cognitive styles of learners and combines their educational technological resources with the requirements of the pedagogical methodology (Nunes, 2018).

• Educational (learning) games (EG) enable user-friendly mediation of learning content with direct interaction of participants. The orientation of learning games differs between the virtual game environment and game-based learning design.

Learning management systems for course administration:

• Electronic grade bookrecords data on lesson planning, assignments, grades, etc.

• Learning management system aims to improve all management activities for educational courses and programs.

The educators were questioned about the use of technologies and motivation: which of the listed technologies they know, which of them they have already applied in their daily work, how good they think the technology or the idea behind it is and whether they would like to use it or not. Further followed the block of questions about the current solution of educational issues (how to solve the issues and with which digital tools). The motivation part included the block of questions about the reasons for refraining from using for each of the digital tools:

• low level of awareness (educators have lack of or no knowledge about software of this type);

• acquisition effort on the part of the educational institution (financial effort, no acquisition permission on the part of the responsible person);

• lack of confidence in the technology (lack of operator knowledge, fear of use, lack of confidence in the reliability of the technology, effort to learn or operate is greater than benefits, no or lack of expert experience);

• lack of suitability of software for transmission of subject aspects (software does not cover any/low number of teaching activities, software does not use appropriate range of methods for application, software is highly differentiated by special purpose);

• lack of political support for software usage.

Determination of the number of respondents by the suitable tool was based on the stochastic sample formula with confidence level of 95% and margin of error of 10% in each case (Sample calculation). According to this formula, corresponding to the number of teachers in Germany (just over 720,000), 97 teachers were interviewed (Federal Statistical Office of Germany). Equivalent to the 440,000 teachers in Ukraine, 97 respondents were questioned (Federal Statistical Office of Ukraine). The second part of the quantitative empirical research consisted in interviewing learners. They were asked about the failures in the teaching process, grading and organization of learning events and lessons. The number of learners was determined according to the same principle and amounted to 97 in each case. Due to the mode of survey (online), has participated in the study larger proportion of respondents and amounted to the conclusion 275, 113, 247, 106, respectively.

AI based framework for selected educational issue

In this part, the results of the solution and publication analyses as well as those arising from the empirical study were analyzed. The quantitative empirical analysis revealed that most educators have the same issues. We selected the most prioritized one, coded and tested a solution accordingly. We present the framework in results.

Results of investigation

Trend analysis of educational software

The analysis revealed that the search trends in the period (March 2020-April 2021) approximate very closely to the cumulative trend of the last five years. Fig. 1 illustrates the trends. According to the analysis results presented in Fig.2, Ghana, China - for “learning software”and Ireland -for “teaching software” stand out as the forerunners in the interest for “educational software”.

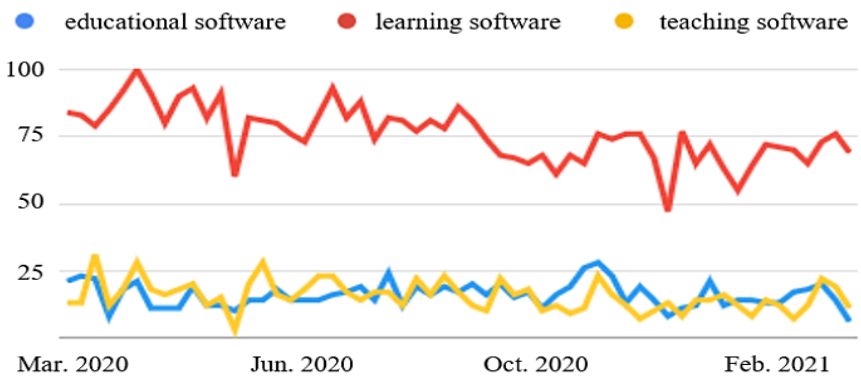

Figure 1. Trend development for educational software", "learning software", "teaching software"

Source: own processing

In line with the current trend, the consistency in the development of scientific and practical interest is further anticipated. The relevance of cross-national technology transfer increases in importance, which is highlighted by researchof Artyukhov et al. (2021).

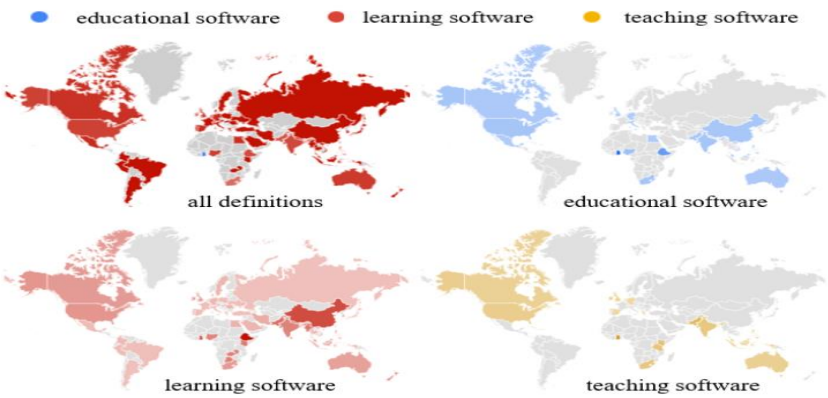

Figure 2. Regional allocation of requests for searched definitions, Source: own processing

Research analysis of educational software

Searching for "educat* software", "learn* software", "teach* software" revealed over 6000 hits in both databases. The results were refined according to the criteria: deployable in educational institutions, goal-oriented (effectiveness/efficiency) implementation of software, interdisciplinary applicable, timeliness: the last five years. Compared to the GoogleTrend analysis, the USA and China issued the greatest number of publications by a wide margin. From the four groups of publications on educational software: usage in/for knowledge transfer, evaluation of learner characteristics (engagement, load, etc.), development of software per se or by learners, communication and collabo-ration in the educational software field, we have prioritized the first one and included it in further consideration.

After filtering, 483 publications were selected for further consideration. Depending on the focus on the educational goal and the technology used, these publications are grouped in:content creation and management systems, knowledge monitoring systems, learning process execution and learning environments and learning management systems for course administration.

Technologies on which the educational software arebased include: Machine Learning (396), Deep Learning (157), Neural Networks (126), Data Mining (95), Big Data (74), Decision Making (49), Natural Language Processing (45), Deep Neural Networks (39), Decision Trees (34), Natural Language Processing (48), Image Processing (26), Reinforcement Learning (24), Convolutional Neural Network (42), Artificial Neural Network (21), Computer Vision (21), Pattern Recognition (20), Augmented Reality (18), Data Analytics (17), Text Mining (15), Learning Analytics (14), Random Forest (14), Speech Recognition (14).The underlying approaches fulfil the purposes of object classification, prediction, decision-making and related process optimization, solution finding, analysis and systemization of data, simulation, diagnosis. Summative, the issues presented in Table 1 can be exemplified:

Table 1. Educational issues of evaluation of learning success solvable by AI

Educational issue and solution	**Example**
Creativity demanding tasks: verification for accuracy, correctness and evaluation	
Hand-and typewriting recognition	Composition, open questions, complex multi-way maths/physics,... tasks
Speech recognition	Poetry declaration
Content analysis	Answers to open questions, composition, essay
Picture analysis and classification	Themed painting tasks
Reproduction of known/ required content, arithmetic tasks	
Hand-and typewriting recognition	Dictation, simple arithmetical tasks
Speech recognition	Reading aloud or repeating content in a foreign lan-guage
Picture classification	Painting test for school entry, drawing in of forces in mechanics
Consideration of cognitive-emotional state of users	
Social computing, Emotional computing	Recognize emotions, predict subsequent behavior and act preventively
Other issues	
Search	Educational assistants/ bots
Optimization	Simulation
Decision-making	Recognizing potential progression of the learning process

Source: own processing

Findings of quantitative empirical study

Quantitative empirical study reveals that although learning management systems tend to have the highest level of awareness and usage, most users perceive knowledge monitoring systems to provide the greatest potential for application. The educators from Germany and Ukraine present approximately the same proportionality in the awareness of the indicated types of software. The main difference is in the usage: Ukrainian respondents tend to use learning management systems (89%). On the other hand, the percentage of software utilization for content creation is comparably high among the German respondents (73%). The percentage of software for learning process execution is approximately the same and similar for both groups of respondents (43%).

Fig. 3 presents percentages of respondents and preferences in relation to all possible alternatives.

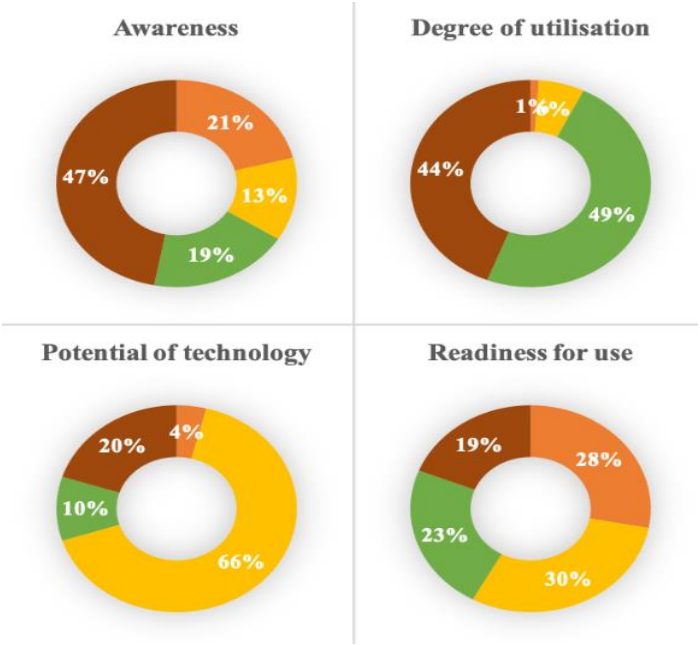

Figure 3. Findingsof quantitative empirical study. Part 1
Source: own processing

In general, content creation software as well as knowledge monitoring and learning process execution systems are not widely adopted by respondents. The reasons for this differ and are illustrated in Fig. 4. Considering the utilization of concretely mentioned digital tools: for the content creation mostly, software without direct reference to artificial intelligence are applied: Arithmetic, text, and presentation creation software, as well as the AI-assisted search engines and editing software. Only 9 out of a total of 388 respondents entered having applied distinct content solutions for their learning events (virtual/augmented reality, simulation of object behavior). For the learning process execution, according to respondents, online meeting and interaction solutions are mostly (98%) used. For learning management, 44% of respondents utilize digital grade books or similar systems.

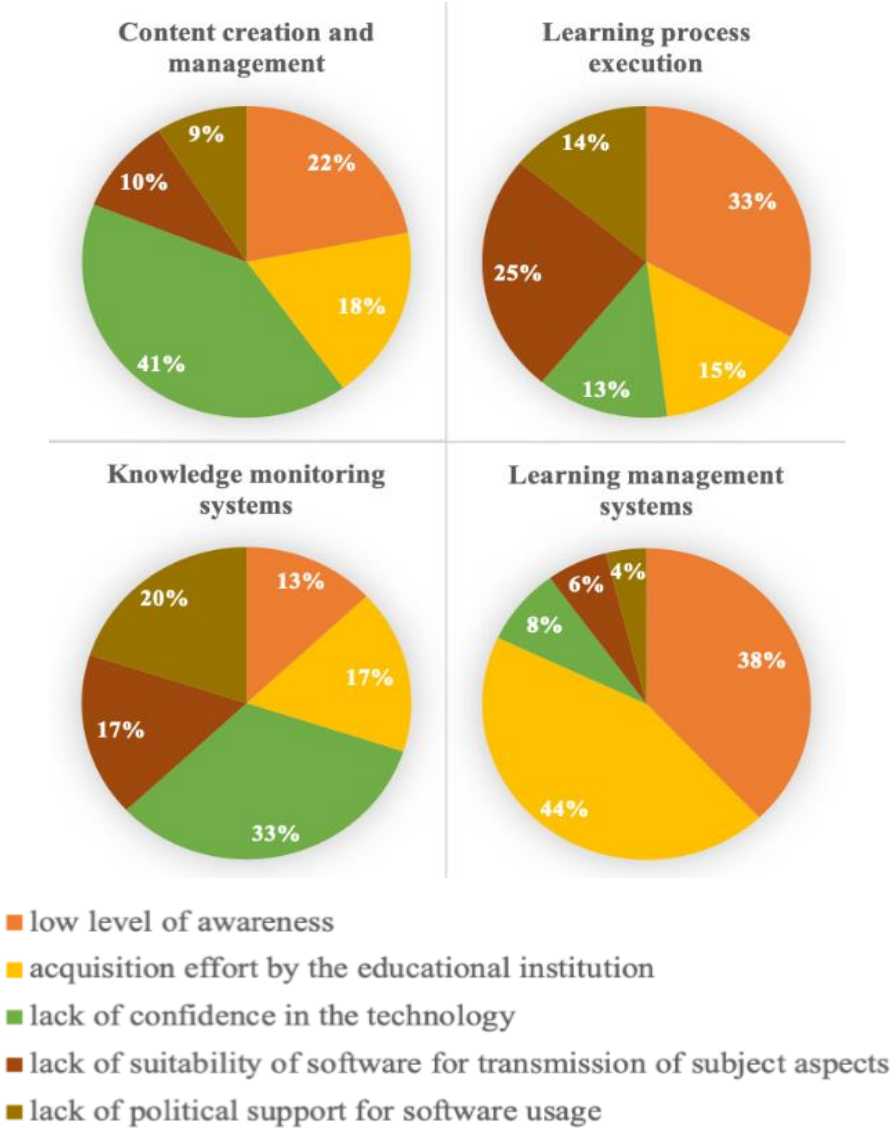

Figure 4. Findings of quantitative empirical study. Part 2

Source: own processing

The knowledge verification is remarkable: 62% of respondents from Ukraine stated to verify the learned content by checking photos of the written material sent by learners. This finding inspired us to rethink this solution and offer a simple way for teachers to solve the issue.

The results indicate that in comparison with the German learners, the majority of respondents from Ukraine expressed dissatisfaction with the explanation of grades and lack of clarity of the grading system. In contrast, the German respondents emphasize the poor organization of the learning process.

Educational solutions based on artificial intelligence

Generally, the recognition of an object, its comparison with known patterns and prediction of behaviour is performed by machine or deep learning with user-defined activation functions, optimisers, APIs, etc. In detail, the following methods are applied for the defined purposes:

• Hand-and typewriting recognition - Convolutional or Recurrent Neural Networks or combination of both types

• Speech recognition - Deconvolutional Neural Networks, Time Delay Neural Network, Long Short-Term Memory

• Content analysis - Convolutional Neural Networks, Long Short-Term Memory

• Picture analysis and classification - Convolutional Neural Networks, Zero-Shot Learning

• Social computing – Deep Neural Network, Multi-Layer Perceptron

• Emotional (affective) computing - Convolutional Neural Networks

Artificial intelligence based solution for selected educational issues

The analysis of results of the quantitative empirical study of educational issues reveals that both educators and learners emphasize improvements for knowledge monitoring/performance measurement and grades system. This proves the potentials for application of artificial intelligence for evaluation of learning success.

Since most educators interviewed entered performance measurement in the review of written tasks as a weakness in digital education, we compiled, developed and tested a framework for text recognition from the image. This is divided into the recognition of handwriting and typewriting and the following validation of content (Fig. 5).

This framework includes artificial intelligence models (deep learning. NLP) for handwriting recognition and correctness verification (linguistics) and the rule-based part for computational verification and keyword-based content evaluation.

The framework can be used standalone or as part of the complex learning system. The advantages of this are rapid review of written material (a few seconds per image, a few minutes for a class of 20-30 learners) and immediate transparent grading with number and location of errors input.

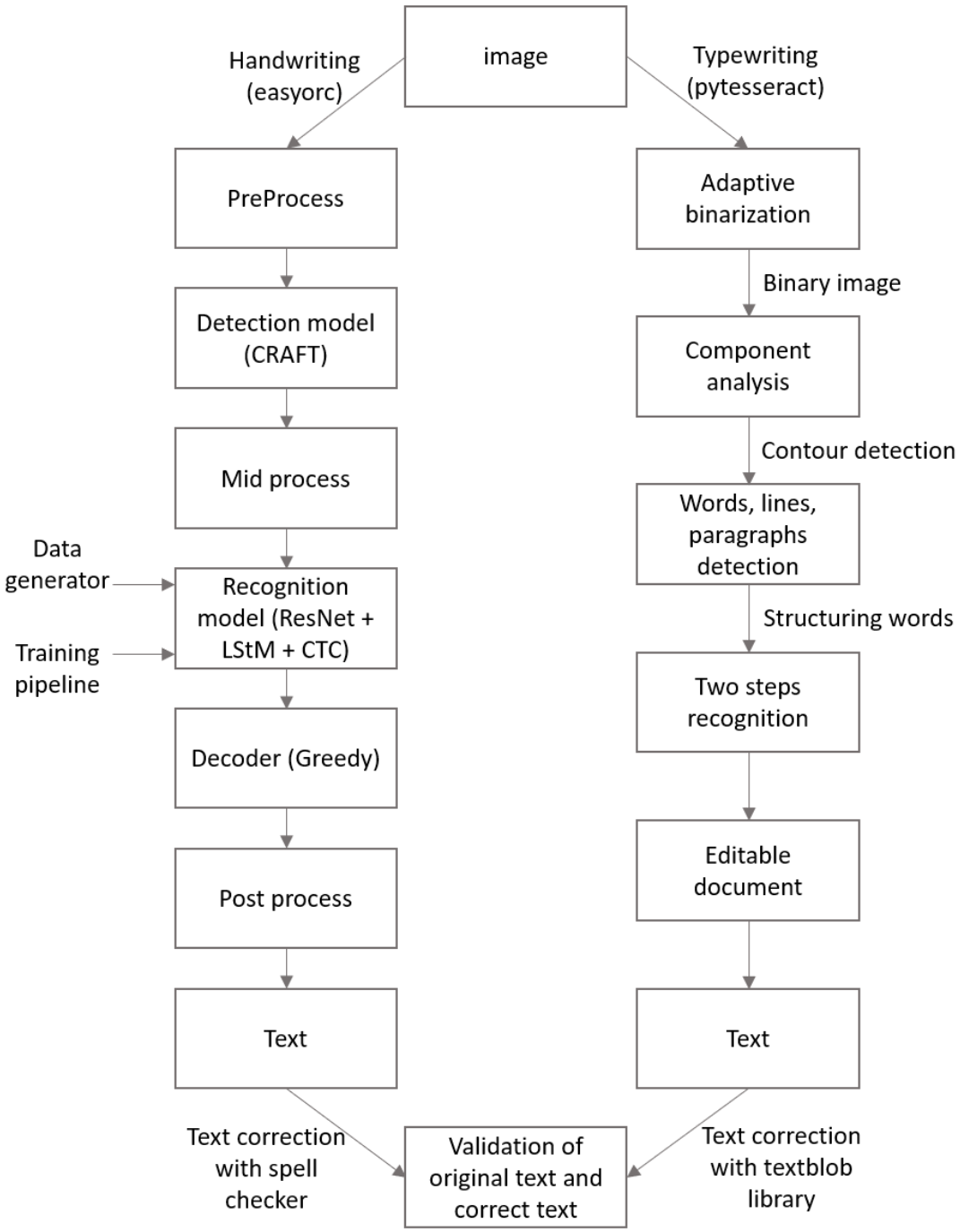

Figure 5 Text recognition and correction

Figure 6. provides the obtained test results

Source: own processing

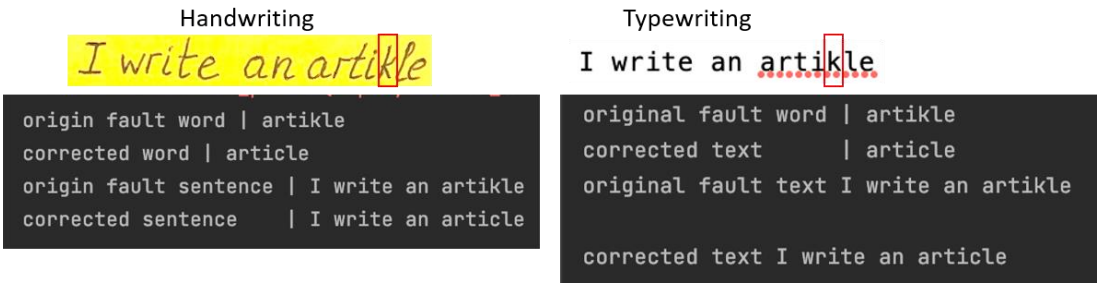

Figure 7. Findings of quantitative empirical study. Part 1

Source: own processing

Conclusion and discussion

Since we have no intention to offer a market-ready solution for educational institutions, we demonstrate how practitioners can solve the selected educational problems by using some open source artificial intelligence tools and libraries. These can be extracted directly from the described process and implemented as a complete system or a part of an existing one.

Digital education cannot replace the performance of teachers. However, a significant advantage in education can only be achieved in combination with innovative technologies, education and leadership forms, such as transformational educational leadership (Matos & Kasztelnik, 2021). We recognize that digitization of education will continue to evolve and remain as relevant to society as environmental education (Obeid et al., 2020). This field will not only innovate education, but also ensure the future sustainability of the IT companies and innovation potential of the country (Bilan et al., 2020; 2019; Gontareva et al., 2020; Ivanova & Kordos, 2017).

Acknowledgements

This research was funded by the grants from the Ministry of Education and Science of Ukraine “Reforming the lifelong learning system in Ukraine for the prevention of the labor emigration: a coopetition model of institutional partnership” (reg. n. 0120U102001), “Convergence of economic and educational transformations in the digital society: modeling the impact on regional and national security” (reg. n.0121U109553).

Conflict of interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article

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Bibliographic information of this paper for citing:

Skrynnyk O., Lyeonov S., Lenska S., Litvinchuk S., Galaieva L., Radkevych O. (2022). Artificial Intelligence in Solving Educational Problems. *Journal of Information Technology Management*, 14 (Special Issue), 132-146. https://doi.org/ 10.22059/jitm.2022.88893