Application of artificial intelligence and digital technologies in the organization of the educational process of specialists in the field of physics, engineering and metrology

S V Shamina, V D Munister, A L Zolkin, R A Verbitskiy and V V Dragulenko

1 Department Natural science disciplines, South Ural state agrarian University, Gagarin street 13, Troitsk 457100, Chelyabinsk region, Russia
2 Department of Mathematical Methods and Computer-Aided Design, Private educational institution "Donetsk Academy of Transport", Dzerzhinsky Street 7, Donetsk 83086, Ukraine; Department of Enterprise Economics, State educational institution of higher professional education "Donetsk National Technical University", Shimbakova Street 2, Pokrovsk, Donetsk region 85300, Ukraine
3 Computer and Information Sciences Department, Povolzhskiy State University of Telecommunications and Informatics, L.Tolstogo Street 23, Samara 443010, Russia; Natural Sciences Department, Private institution of higher education "Medical University" Reaviz, Chapaevskaya Street 227, Samara 443001, Russia
4 Engineering drawing department, MIREA - Russian Technological University, Vernadsky Avenue 178, Moscow 119454, Russia
5 Department of tractors, automobiles and technical mechanics, Federal State Budgetary Educational Institution of Higher Education “Kuban State Agrarian University named after I.T. Trubilin”, Kalinina Street 13, Krasnodar 350044, Russia

6 E-mail: shamina.troick2@mail.ru

Abstract. The article deals with the problems and the importance of modern advanced learning. A model of teaching for students mastering programs of secondary and higher vocational education, based on the terminal-matrix approach, which includes the integration of several related disciplines, is proposed. The importance of artificial intelligence methods in engineering, physical, engineering education is substantiated by the example of checking of research results.

1. Rationale
Acceleration processes in modern education are gaining momentum. The realities of our time no longer exclude advanced development and lifelong learning. The psychobiological acceleration of the development of the modern generation requires an adaptive approach to solving of new pedagogical problems.

First of all, it is necessary to focus on the fact that the shift between the conscious and the unconscious in the perception of learning is becoming more and more pronounced. If earlier, in the
pre-digital era, first-year students received acclimatization to knowledge, gaining a real, genuine picture of the diversity of sources of genuine knowledge, now this period is associated only with adaptation to a new mode of life, the study of spatial landmarks, structural units, involvement in a more active social life [1].

The distributed nature of the personal and educational relationships being built, expressed in an environment with a campus component, creates new, synoptic and associative connections for the student. This is a rewarding, socially adaptive time to be used in collaboration with engineering education methods based on the same spatial perception. Students who are already accustomed to searching for information while still in school need to find tools that will lead them to professional development.

But if we talk about the training of future specialists mastering programs in the field of exact sciences, such as physics or mathematics, then we must agree that it is extremely difficult to teach a simple model of advanced education for some students (especially for junior students).

It is necessary not only to provide true knowledge in a compact form with a certain time lead, but also agree with the assertion that without research, that is, gaining empirical experience, this knowledge will not be fixed in the student's memory [2].

2. Aspects of advanced education of engineering personnel in the context of the use of digital technologies

This issue is especially acute in the high alert conditions (in a difficult epidemiological situation caused by a pandemic). The experience of intensive work in this direction shows that distance learning levels all the benefits of advanced education. After all, it was not created for these purposes, but for some unknown reason, probably personal or procedural, it expresses the will in the context of remote education.

In addition, often, students cannot verify the truth of their judgements. In particular, it is true for exact sciences, where there is either a single true answer or an approximation taken for consideration. In metrology and physics, there is an axiomatic proposition explaining in an obvious way a small differentiation between the scalar value of responses from different experimenters. The accuracy of measurements, calculations and analyses can be violated and be outside of the permissible limits [3].

In this regard, a model for the application of artificial intelligence methods and modern information technologies is proposed. The implementation of the deterministic model is of a confirmatory, recommendatory and didactic nature.

The functional value is determined by the introduction of an innovative approach to the implementation of integrated programs of technical and natural science education as well as approbation of research results. The fundamental importance lies in obtaining competencies in the field of scientific work, self-examination, and a professional approach to the results of one's own research.

This implies the allocation of the model in the form of a state educational standard, as an interdisciplinary course. The general rationale for the form of application of this system is the growing need for professionals who are able to find specific solutions to problems in conditions of information entropy, data duality, the definition of skills for separating the qualitative and quantitative aspects in the system of analysing the object of study [4].

The integration tools were: CSSGrid layout methodology, artificial intelligence methods that are most widespread in the academic environment, terminal-matrix approach to data visualization, ladder logic languages within the general visual programming methodology. By means of brainstorming analysis, a differentiated arrangement of the developed additive and inclusive component, designated as integrated digital godegetics, was determined (see figure 1).
Based on the flow scheme, indicated in the form of a diagram, the relational essence of the components is determined. The main additive component is connected with the didactics of teaching disciplines in a cybernetic context, the integrative role of data representation, the main topic (subjectology), and indirectly with the metrological apparatus.

3. The context-oriented principle of an integrated system for the development of calculation, graphic and analytical work

Let's consider the components in more detail, and also form a more complete understanding of the model:

- Godegetics is the central element of this methodology. This name is an old Greek synonym for the word "didactics". In this case, it is determined by the subject category of the study. It represents the existing classical didactic tools for teaching a topic that directly needs practical consolidation. In fact, it includes a minimal thesaurus of terminology, mathematical apparatus, feasibility study of the calculation. This also includes the personal development of the teacher, as an indispensable side of the learning path. The proposed methodology implies two-way training according to the principle of "student-tutor" action [5].

- The main topic is the basis of the study. This includes the designation of the discipline, the level of training, the topic of the lesson, the subject and the purpose of the study. This implies an iterative approach to the studied problem. At the first stage, the teacher conveys the general topic of the lesson or practical lesson, which is reflected by a group of students. It is understood that the main topic may be different for each student. The degree of difference is determined by the level of the occupation. If this is a test on a general topic, then, of course, the degree of discrepancy shall not be great. The coefficient of divergence of the main topic for each student is determined by mathematical calculation and acts as the degree of depth of research. It shall be reflected in the formalization report, which will be discussed below.

The divergence coefficient (Kj) is calculated by the formula (1):

\[
K_j = \frac{1}{N}
\]

where, \(N\) is the number of topics in the discipline module per semester.
The parameter itself is the first, naive (according to Bayesian classification), scientometric parameter. It will give the student an idea of the variety of applied problems operating within the discipline. As an alternative value for N, one can interpret the number of considered tasks on an enlarged topic. The type of parameter in the format of real numbers will determine the scope of the studied problem. During studying of typical tasks in physics, mathematics, technical disciplines, it is recommended to apply an incentive algorithm, denoted as the product of coefficients for completed articles. With a certain threshold value of this product, it is possible to realize the point equivalent of the additional value to the metric of the assessment scale. For example, the European Credit Transfer and Accumulation System (ECTS).

1. The integrative role of data representation is the implementation of digital integrated learning. It is achieved by delegating the way of data visualization to the artificial intelligence methodology. The student builds the necessary model for the selection of ready-made or processing data, relying on the teacher’s reasoning (or discussing with him). And if earlier students of technical specialties studied the types of graphs, building them manually or in a semi-automatic mode (for example, in multi-editors, word processors, computer-aided design systems such as Microsoft Excel, Word, Mathcad), today we propose to focus on automation of these processes and natural typical procedures.

In the considered case, it is necessary to be based on the principle of creation of a certain, dynamically developed (during the whole learning process) portfolio, in the form of a web page or web application. The integrated role consists in a direct, invariant approach to the given task (the implementation of programs of related, digital education, in applied use) [6].

The proposed model is reduced to the fact that it is the web platform, that is the primary window into the world of information technology for every person who is not engaged in narrowly focused activities. It is necessary to consider that studying the base in the form of studying HTML / XML / JavaScript / CSS will allow each student to be identified in the world of the World Wide Web. The digital circuit is most obvious in the form of an information platform that has public value.

An important value of the ability to represent data in the form of web pages is the emergence of the HTML5 standard in 2014, which predetermined, at the declarative level, the stable operation of most of the necessary frameworks, elements and containers. Support for the native dynamic programming language JavaScript allows a person with a school base to quickly master the necessary requirements. This is achieved due to the lack of static typing, conceptual apparatus, an extended help system, and widespread use in various industries of automation.

The use model implies both spontaneous (based on empirical experience gained in the course of performing laboratory work by a student of a technical or natural science direction) experience of joint academic learning (along with solving the "main topic"), and academic experience (transforming the essence of the information technology and computer science course taught in colleges and universities in all specialties).

The primary priority is determined for the application of a web-based approach to the didactics of teaching information technologies for the specialty of the previously indicated categories.

A context-oriented approach to the solution and design of laboratory, computational work, demonstration exams (within the framework of WorldSkills) is to create a common exchange environment at the level of the founder of an educational organization or a municipal aggregator, carried out by regulation in the field of information policy. Kaggle is proposed as an analogue of such a system. It is a system for organizing competitions for data research, as well as a social network for data processing and machine learning specialists (see figure 2).

Obtaining of "advanced experience" to prepare specialists for admission to master's programs (in which the share of Research and development (R&D, R + D) prevails over lecture and simple practical activities) is invested to the integration and further development of educational opportunities [7].

2. The didactics of teaching in a cybernetic context boils down to conducting an experiment in which the original system is replaced by a model, which is then studied. In principle, modeling consists in creating a control system that is isomorphic or approximately isomorphic to a given one, and in monitoring of its functioning.
3. The metrological support component is reduced to identifying the strengths and weaknesses of simulation modeling (using machine learning algorithms proposed by the teacher or developed by a graduate student) in comparison with real calculations and measurements. The junior students express the role of the comparator, and the teachers - role of the expert system [8,9].

A graduate student in his final graduate work should approach the real values of the applied research area under consideration. This mechanism also determines the integration role of contracting between individuals.

Thus, the proposed scheme brings any form of settlement and graphic work of bachelor and college students (senior school students if necessary), under the form of research activities, supplementing it with its own methodological aspects in a more adaptive and integrated form (see figure 3).

**Figure 2.** Terminal interface of the portal.

**Figure 3.** Cycle of research and development.
The web-based approach to research reporting allows to conduct remote analysis, providing the open nature of research. The compositional logic of identifying the algorithm, its selection and calculation also determines the real author of the study. Thus, the possibility of illegal use of other people’s algorithms is excluded or minimized [10].

The role of an educational aggregator is reduced to creation of a database of artificial intelligence algorithms used in the fields of knowledge, adaptation of their manuals into the language of information carriers. Students are given the role of defining input data, valid implementation methods and writing the terminal form of the site.

4. Findings
Thus, the article outlines the problem in the advanced development of modern students, considers aspects of the technical support of research and practical work of students of technical and engineering specialties in conditions of remote work. Also, a model of advanced development for modern students has been determined, defining their level of knowledge of information technologies as high (in view of their involvement in the coming digital era), therefore, an approach has been identified that is reduced to a deep transformation of the methodology of teaching informatics to non-core specialists. The terminal form of representation of settlement and graphic works in the conditions of the modern market is indicated. As a result of the study, an analogue of a functional system for obtaining a certain educational level of training is proposed by native support of two training profiles (main specialty + web engineer / data analyst) already at the bachelor's or secondary vocational training level without compromising the didactics of the main specialization teaching.

References
[1] Kuzminov Ya and Frumin I 2008 Russian education 2020: model of education for economics based on knowledges: for IX International Scientific Conference Modernization of economics and globalization (Moscow: State University - Higher Educational Institution of Economics publishing house) 39 p
[2] Tsaturyan A M 2015 Pedagogical paradigms as a universal approach to the study of natural sciences. The first International virtual forum in Japan dedicated to Russian studies, culture, pedagogy Socio-cultural and philological aspects in educational and scientific context. Scientific journal. Articles, papers of the International forum in Japan (Saint Petersburg: Fora-print LLC) pp 661-5
[3] Kondratev A S and Priyatkin N A 2006 Modern technologies for teaching physics: Textbook (Saint Petersburg: Saint Petersburg University publishing house) 342 p
[4] Molchan I M 1998 Increasing of the role of a cosmic space in the course of general biology in the system of advanced education and scientific predictions of live ethics. Pedagogic periodical (Moscow: Moscow State Pedagogical University) 2 pp 51-2
[5] Tsaturyan A M 2012 Application of students’ mathematical knowledge during solving of physical problems in the process of final repetition of educational material Siberian pedagogic journal. Scientific periodical 3 (Novosibirsk: Novosibirsk State Pedagogical University) pp 231-6
[6] D.N. Lapaev et. Al 2017 R&D organization: Textbook (Nizhny Novgorod: Nizhny Novgorod State Technical University named after R.E. Alekseev) 15 p
[7] Vasina O V and Tretyakova V A 2019 Standardizing of research and development work. Scientific and technical project management: materials of the Third International research-to-practice conference (Moscow: Publishing house of the Moscow State Technical University named after N.E. Bauman) pp 54-61
[8] Yumashev A V, Utyuzh A S, Admakin O I, Doroshina V Y and Volchkova I R 2018 Effect of mesodiencephalic stimulation on adaptation to stress and academic performance of students International Journal of Learning and Change 10(4) pp 359-67
[9] Zhang T, Shaikh Z A, Yumashev A V and Chłąd M 2020 Applied Model of E-Learning in the Framework of Education for Sustainable Development. *Sustainability* **12** 6420

[10] Akhmetshin E M, Kovalenko K E, Mueller J E, Khakimov A K, Yumashev A V and Khairullina A D 2018 Freelancing as a type of entrepreneurship: Advantages, disadvantages and development prospects. *Journal of Entrepreneurship Education* **21**(2) https://www.abacademies.org/articles/Freelancing-as-a