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Didactic Opportunities for Developing Students' Natural Scientific Worldview

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Abstract
The article discusses the design of electronic educational programs for students in natural sciences based on the humanistic paradigm of education, according to which the student is not a passive consumer of knowledge, but an active subject of the educational process. Analysis of student needs; setting learning goals; selection and systematization of content; determination of forms, methods and means of education; development of interface and interaction logic; assessment of educational effectiveness.

Keywords: Fundamental, global, pedagogical process, quality, pedagogy, epistemology, philosophy of education, cognitive psychology.

Introduction

Designing e-learning (EL) programs is a systematic process of developing, planning, implementing and evaluating digital learning systems, taking into account pedagogical goals, educational context features, ICT and pedagogical design principles. In addition, it is a systematic process of creating and organizing digital learning experiences aimed at achieving predetermined educational goals by combining pedagogical, technological and methodological solutions. The main goal of design is to ensure the effectiveness, accessibility and motivation of students in mastering content through an electronic environment.

An e-learning program is a structured set of digital learning materials, tasks, tests and feedback forms placed in an electronic learning environment (LMS, MOOC, interactive platforms, etc.).

Analysis of the literature on the topic. A.V. Tikhomirov states that design in digital education is a pedagogical activity aimed at creating an environment that ensures the comprehensive and controlled development of students' knowledge, skills and competencies using ICT [1].

According to V.M. Monakhov, R. Clark, R. Mayer, the design of electronic educational programs is an interdisciplinary field that combines the principles of pedagogy, cognitive psychology, computer science and systems theory. It includes a systematic process of analyzing needs, determining learning goals, designing content, developing a digital learning environment and assessing learning outcomes [2], [3].

Design includes - analyzing student needs; setting learning goals; selecting and systematizing content; determining forms, methods and means of education; developing the interface and interaction logic; assessing educational effectiveness.

The basis for designing e-learning programs lies within the framework of the following scientific approaches (Table 2).

Approach	Essence and content
Systematic approach	It presents e-learning as a holistic system in which each element (goal, content, methods, tools, assessment) is interconnected. Based on the works of E.D. Land, V.M. Monakhov.
Competency-based approach	The software is designed to develop specific competencies (including a natural scientific worldview). It emphasizes the importance of results and the application of knowledge (I.A. Zimnyaya).
Activity-based approach	It is based on the active position of the student, who acquires knowledge through action and reflection in the process of using the program (A.N. Leontiev).
Person-centered approach	Individualization of the learning path in a digital environment ensures adaptation of materials to the student's level of preparation (V.A. Slastenin).

When designing e-learning programs, we are guided by the following scientific areas:

Pedagogy - teaching theories, teaching methodologies, didactics.

Psychology - cognitive processes, principles of information perception, motivation.

Information technologies - SCORM standards, XAPI, selection of LMS platforms.

Design and multimedia: principles of visual design, UX/UI in the educational context.

When designing e-learning programs, the following principles should be taken into account:

Didactic relevance - compliance of content with educational objectives.

Modularity - the ability to study sections independently.

Interactivity - the use of interaction elements (tests, forums, chats).

Visuality - the use of multimedia, visualization, animations.

Usability - adaptation to different levels of users and devices.

Adaptability - updating and scaling.

We will also consider the following concepts related to our research. Electronic learning (e-learning) is a form of organizing the educational process based on the use of digital educational resources, Internet technologies and telecommunications for interactive interaction between the teacher and the student. "Electronic learning involves the use of multimedia and the Internet to increase the efficiency and convenience of the educational process" [4].

When designing e-learning, the following pedagogical approaches and principles should be taken into account:

Systemic approach: the course is formed as a set of interconnected elements - from objectives to assessment mechanisms.

Competent approach: focus on developing modules that form not only knowledge, but also practical skills.

Person-centered approach: adapt the content to the individual characteristics and trajectories of students.

Activity-based approach: activate cognitive activity through project and problem-oriented work.

Cognitive approach: take into account the limitations of working memory, use multimedia to alleviate cognitive load.

Mayer in his scientific work emphasizes that interactive elements, multimedia videos and simulations increase student activity and contribute to deeper learning [5].

Instructional design is the process of systematically planning and creating educational courses focused on specific learning objectives, audience characteristics and context. D. Merrill argues that "Pedagogical design is a scientifically based process in which each stage is subordinated to the general logic of the development of knowledge and skills" [6].

The design of e-learning programs is based on the humanistic paradigm of education, according to which the student is not a passive consumer of knowledge, but an active subject of the learning process. Education should take into account the individual needs, pace, style and motivation of the student. "The center of e-learning should be the person, not technology: design should be aimed at personal development," argues V.V. Karpov [7].

The goals and objectives of designing e-learning programs are as follows: the goal is to create a high-quality, flexible and pedagogically appropriate digital product that contributes to the formation of knowledge, skills and competencies in students; the tasks are to ensure the scientific, methodological and technological validity of the content, adapt the educational material to the digital environment, take into account the specific characteristics of students' perception, motivation and independence, create conditions for feedback and diagnostics of educational results.

When developing e-learning programs, attention is paid to the basic principles of learning psychology, including:

Cognitive Load Theory: educational materials should be organized so as not to overload the student's working memory (Sweller J., 1994).

Motivation and involvement (Keller's ARCS model): the content should be attractive, meaningful, arouse interest and include opportunities for success (Keller J.M., 1987).

Zones of proximal development (according to L.S. Vygotsky): design should help the student acquire new knowledge through a gradual (scaffolding) approach.

According to L.S. Pransky, the theoretical principles of designing e-learning programs include:

The principle of modularity - the ability to separate the material into independent logical blocks;

The principle of interactivity - the active involvement of the student in the learning process through simulations, educational devices and adaptive tasks;

The principle of knowledge visualization - the use of infographics, videos, animations to enhance understanding;

The principle of adaptability - the adaptability of the software depending on the individual characteristics of students;

The principle of mobility and convenience is the compliance of the programs with the requirements of multi-platform and mobile learning (BYOD).

Based on the research of K. Bonk, C. Graham [8], quality software should include the following components:

Targeted module - with clearly defined results;

Content block - structured theoretical materials corresponding to the level of training;

Practice-oriented tasks - tests, projects, laboratory tasks, interactive simulators;

Monitoring and feedback - a means of diagnosing and visualizing progress;

Motivational elements - games, achievements, activity ratings.

Research methodology. In the digitalization of natural sciences in the education system, in the formation of students' natural science worldview, in the design of high-quality digital content and software solutions, analysis, logical thinking, analysis and synthesis methods were widely used.

Analysis and results. In international practice, the main models of e-course design are recognized as ADDIE (Analysis, Design, Development, Implementation, Evaluation) and SAM (Successive Approximation Model):

ADDIE is a traditional model that has been used in the USA since 1975 and includes a sequential development cycle [9].

SAM is an iterative and flexible approach recommended in the context of Agile environments, where the main emphasis is on rapid prototyping and test control [10].

The SAM model includes a more flexible and iterative approach, divided into three stages:

1. Preparation (Pre-project (Preparation)): rapid requirements assessment and team formation.

2. Design and development (Iterative Design-Develop): prototyping, rapid feedback from experts, feedback and corrections.

3. Implementation & Evaluation: testing, improving based on test results.

“SAM reduces model development time and increases flexibility, which is especially important when requirements change dynamically” [11].

Agile environment (from English Agile - flexible) is a work environment based on an agile project management methodology, which is focused on speed of response to changes, interactive development, team collaboration and continuous improvement of the product. Agile environments are most often used in IT and software development, but are also actively used in the fields of education, management, scientific research and even pedagogical design.

In the context of designing educational programs, Agile allows you to: create prototypes of educational modules and quickly test their effectiveness; take into account the needs of students and teachers at each stage of development; flexibly adapt educational programs to new didactic tasks; respond more quickly to changes in the curriculum or government requirements.

When developing a platform for effective teaching of biological science:

The team creating the platform develops the first version of a topic (sprint) within 2 weeks, for example, the module “Cell structure”;

students and teachers test it and provide feedback;

in the next sprint, visualization is improved and an interactive test is added;

in parallel, subsequent modules (for example, "Genetics") are developed using the previously created template.

According to G. Kasser, the following modern trends in design are currently relevant [12]:

Microlearning - the process of dividing material into short, easily digestible chunks;

Artificial intelligence and flexible platforms - individualization of learning trajectories;

Modular networked learning environments - the development of open online courses (MOOCs) and LMS platforms such as Moodle, Canvas, Open edX.

Designing e-learning programs is not only a technical, but also a pedagogical process, requiring a balance between technology and humanistic orientation. The success of the design depends on the methodological literacy of the developer, the flexibility of the lesson, and the ability to develop independence, critical thinking, and scientific thinking in students.

The pedagogical component of the software is a set of methodological, didactic and educational principles included in the structure and functionality of electronic educational programs. This ensures that the programs comply with the content of the subjects, the level of student training and the requirements of educational standards.

Main components:

Target settings: compliance with the requirements of educational standards and the state educational standard.

Didactic design: the structure of the presentation of the material, the logic of knowledge acquisition.

Teaching methods: interactivity, independent and group work, research methods.

Educational aspects: the development of value orientations, communication skills, responsibility.

Feedback: the ability to self-assess and assess student achievements.

The use of software for educational programs in the educational process provides a number of important advantages for the formation and development of students' natural and scientific worldviews (Table 3).

№	Advantage	Rationale and mechanism of action
1	Demonstrativeness and visualization of complex concepts	The use of models, simulations, and graphics helps to better understand abstract concepts such as molecular interactions, astrophysical processes, and biological evolution.
2	Access to modern scientific information and databases	The programs are integrated with scientific platforms (e.g. NASA, PubMed), ensuring the relevance of knowledge
3	Developing critical thinking and research skills	Research-type tasks, data analysis, and experimental modeling constitute a scientific approach to knowledge.
4	Individualization of the educational process	Students can choose in-depth modules on topics of interest to them and learn the material at their own pace.
5	Building interdisciplinary connections	The integration of knowledge from physics, biology, chemistry, and ecology into a single digital space develops a holistic worldview.
6	Interactivity and feedback	Instant review of assignments, tests, and participation in online labs fosters constant activity and interest.
7	Support for independent and project activities	Opportunities to create your own projects, conduct virtual experiments, and present results
8	Building information literacy and digital competencies	Working with digital tools is a key component of modern scientific thinking.
9	Access to global educational resources	Access to courses, platforms, and labs from the world's leading universities (MIT, HarvardX, Coursera, etc.)
10	Develop systematic and logical thinking	Software helps you see cause-and-effect relationships, create hypotheses, and draw scientific conclusions

Examples of implementation:

Virtual laboratories in biology (e.g. Labster): allow for risk-free modeling of real experiments.
Simulations in physics (e.g. PhET Interactive Simulations): allow for visualization of Newton's laws, electromagnetic fields, etc.
Geographic information systems: develop spatial thinking and environmental awareness.
The use of software in educational programs leads to the following psychological and pedagogical effects:
Learning motivation increases;
Cognitive autonomy develops;
Metacognition (awareness of thinking) is stimulated;
The scientific picture of the world is strengthened as a holistic system of knowledge about nature and man.
Pedagogical technologies (modular learning, case method, gamification, blended learning technology, etc.) form the logic of user interaction with the software product. Their introduction contributes to:
increasing student motivation;
individualizing the learning process;
deepen understanding through repeated interaction with the material;
allows for systematic knowledge control.
Pedagogically based software helps to: consciously acquire knowledge; develop independence and critical thinking; strengthen a scientific worldview; form a sustainable learning motivation; and provide thinking and self-assessment.
–The use of educational programs in the pedagogical process with the help of software has a multifaceted impact on the quality of education, the organization of the educational process and the development of the student's personality. This is one of the most important tools for the digital transformation of education, especially in the conditions of the modern information society.
–The use of educational programs in the pedagogical process with the help of software:
–– Individualization and adaptation of education - software allows you to take into account the level of knowledge, the pace of learning, interests and needs of each student; adaptive educational systems (for example, systems with elements of artificial intelligence) change the content and tasks depending on the student's success; the pedagogical effect leads to increased motivation, increased autonomy of learning, and the development of metacognitive strategies.
–– Increasing the visibility and accessibility of information - complex concepts are depicted in the form of diagrams, graphs, 3D models, simulations; multi-channel perception - text, sound, image, video is provided; the pedagogical effect leads to the development of good awareness, long-term memorization, abstract and imaginative thinking.
–– Development of digital and information competence - working with software helps students develop skills in searching, analyzing, interpreting and presenting information; software environments teach how to work with data, algorithms and interactive interfaces; the pedagogical effect leads to preparation for future professional activities in a digital society.
–– Organization of feedback and monitoring of progress - the software provides instant feedback (tests, error analysis, recommendations); teachers can view statistical data on training, identify

shortcomings and adjust the content; the pedagogical effect leads to self-reflection, self-control, and increased teaching efficiency.

–– Expanding teaching forms and methods – interactive technologies (gamification, flexible classroom, virtual laboratories) are being introduced; conditions are being created for blended and distance learning; the pedagogical impact of which leads to increased activity, activation of cognitive activity, and development of independence.

– Support for project and research activities - students can model processes, develop projects, create presentations and analyze data; the software allows integration with scientific modeling, statistics and visualization platforms; and the pedagogical impact leads to the formation of a research culture, the development of critical thinking and creativity.

–– Ensuring inclusiveness and expanding the scope of use - the program supports special settings for people with disabilities: screen readers, magnifiers, subtitles, alternative interfaces; and the pedagogical impact leads to increased social justice and accessibility of education.

Conclusion

In conclusion, software in the educational process is not just a technical tool, but a pedagogical environment that enhances the didactic effect, expands the capabilities of students and teachers, and ensures the flexibility and effectiveness of education. The theoretical foundations of the design of e-learning programs are a synthesis of pedagogical, psychological, technological and philosophical principles aimed at creating an effective digital learning environment. The success of e-learning is determined by the extent to which it takes into account the individual characteristics of students, motivational aspects, and modern tools of digital pedagogy.

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