Digitalization of ecological education: trends and direction of development

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Abstract. The article presents the results of the analysis of the problem of digitalization of education. Interrelations of digitalization of ecological education with noospheric essence of modern civilization and realization of the concept of sustainable development are established. Possibilities of use of developments of the Russian and foreign scientists and teachers are considered. The importance and main directions of development of digitalization of environmental education are shown. Attention is drawn to the need for digitalization of environmental education in the preparation of not only environmental specialists, but also specialists in other areas of training. Digitalization of education should be aimed at the formation of eco-cultural competencies. The article presents the results of an experimental study of the use of modern IT by various participants of the educational process. The studies were conducted by questionnaire method and allow to indicate the current directions of further development of digitalization of education, including environmental education.

1. Introduction

Developed a century ago by Pierre Teilhard de Chardin (1881-1955) and Édouard Louis Emmanuel Julien Le Roy (1870-1954) and their followers the concept of noospherism now has turned from theoretical constructions into a vector of scientific and technological progress of civilization [1; 2]. The concept of sustainable development formed by the international community under the auspices of the UN has become a tool for the implementation of noosphere ideas. Sustainable development is based on a comprehensive account of the internal and external results of anthropogenic activities of different nature (economic, ecological, social, etc.).) [3; 4].

Evaluation and planning of production and economic activities from the perspective of integrated accounting of its results impose new requirements on managers and specialists in various fields of activity and knowledge. The complexity of performance assessment implies the expansion of the scope of
professional competencies of all managers and specialists, primarily in the fields of ecology and social development.

Modern technologies ("the third worlds") are characterized by digitalization. Digitalization and IT provide the most effective increment of labor productivity and quality of final results of anthropogenic activities in all spheres. This fully applies to the education system at all levels. Digitalization of education has now become a leading trend in the development of pedagogical science and practice and is manifested both in new forms of educational activity (the use of tools and methods of computer science, computer technology and communication) and in the innovative modernization of the content of educational activities (interactive didactic components, automated business games, visualization of educational materials, the use of integrated databases to search for information by students and teachers, etc.).

The development and use of new forms and content of the educational process is an actual direction of development of modern pedagogical science [5; 6]. Ecological education is one of the areas most demanded by the practice of training personnel of various specialties in terms of digitalization of educational activities. Ecologization of professional activity is invariant with respect to specific professions and therefore has a universal character. Ecological competence of employees directly ensures sustainable economic development. In this regard the purpose of this article is to establish trends of digitalization of ecologically oriented educational activities and to determine the appropriate directions of its sustainable development.

2. Materials and methods
For preparing the article the authors studied the publications of Russian and foreign researchers. The materials of the analytical study that are of the greatest interest from the point of view of the topic of the article are summarized in the following, its third subsection. The selection of publications was carried out using scientometric resources e-Library, Scopus and Web of Science. The depth of search is five past years. Analytical processing of publications was carried out using logical, semantic and frequency analysis. The established trends are described in the conclusions.

Experimental studies of the authors were based on the results of surveys. For the survey, developed questionnaires were used, which reflected impersonal information about the respondent (his professional qualification level, age, work experience or duration of training), interests in the field of IT and the duration of the use of information tools in their activities. As respondents to the surveys involved educators of higher and secondary schools, administrators of educational organizations, university students and schoolchildren in Moscow and the Moscow region. The obtained survey materials were processed using the methods of math statistics and presented in tabular and graphical forms (subsection 4 of this article).

3. Trends in improving ecological education
Ecological education and features of its digitalization are depending on the required depth and volume of competencies reported to students and divided into two categories [5]: professional education of ecologists for whom the solution of problems of preservation and restoration of the environment is the end result of professional activity; the study of the basics of ecology and the specifics of the implementation of ecological activities by persons trained in other specialties and areas of training (not professional ecologists in the future).

In addition, it is necessary to take into account the cultural and national characteristics of the contingent of students. For example, in Japan, the national tradition is respect for the environment. Surveys conducted by the authors of the article in Russia showed that the understanding of the severity of environmental problems is mainly demonstrated by the educated part of society.
The highest form of environmental competence of the entire population is the state of public consciousness which is characterized by the presence of ecological culture. The education system at all levels should be aimed at the formation of ecological culture of citizens.

Digital technologies are being introduced in various Russian universities and are used by many educators. However digitalization lacks consistency. A single effective state system for the development of the digitalization process should be developed, which should be based on a reference model. The basic elements of such a model are proposed in [7].

Officials' attempts to manage the digitalization of education lead to the abstract formalization of this process and the erosion of its goals. This takes into account the purely quantitative results of the introduction of IT, set divorced from reality standards of citation and publication activity, etc. Therefore, digitalization should be carried out with the active participation of the most creative part of the scientific and pedagogical community. A positive trend is the general understanding of this problem, the development of adequate methods of assessing the reality of universities and educators on the basis of external examination of the achievements of scientific schools, the development of the institute of peer review, the return to the use of meaningful reports, the rejection of formal questionnaires [8].

An example of a successful state system for assessing the quality of ecological education is the system that has developed in China. This approach includes quantitative indicators. But at the same time it is based on a system of expert assessments. The assessments of a wide range of stakeholders – students, employers, civil servants, representatives of the scientific and pedagogical community are taken into account [9].

The problems of digitalization of education are relevant for such a computerized country as the United States. Statistical analysis of data obtained from 8 thousand respondents showed the presence of information overload of educators and students. As a result, sleep disorders, deterioration of health of people are noted. It is concluded that the digitalization of the educational process should be accompanied by a revision of the legal regulation of labor and educational activities, taking into account the complex of medical and environmental factors [10].

Summarizing it can be argued that the digitalization of the educational environment should be accompanied by the study of various problems, the formation of a science-based program for the development of IT in educational institutions, benchmarking of the international level.

Digitalization of educational technologies should be carried out taking into account the specifics of the various profiles of training. For example, it is natural for mathematicians and physicists to perceive environmental knowledge by simulating various processes on computer models. Therefore, when teaching ecology to students of physical and mathematical profile it is necessary to widely use dynamic computer models [11].

The use of ecological representations and analogies is effective in the study of computer science, even in secondary school. The systems approach which is the basis for object-oriented programming will be better understood when using analogies with ecological systems. The software environment is considered as some analogue of the natural environment [12]. A similar approach is proposed for the organization of training sessions for teachers. Students already have a certain environmental culture and knowledge, which helps them to master new knowledge in the field of digital technologies [13].
In research [14] the concept of "ecological environment" is offered to be used at formation of curricula of training of physicists. At the same time, ecological models should complement classical physical models.

Interprofessional approach in the study of the foundations of the theory of ecological systems allows expanding the concept of "ecosystem" to non-biological objects (in particular, social and educational processes). With this in mind, an online course using interactive and multimedia educational technologies has been developed [15].

It is unacceptable to go to extremes, requiring total digitization of all educational material, because not all educational materials can be effectively digitized [16].

The natural field for the application of IT in education is the creation and use of information databases. The study of the library site RNPLS&T, dedicated to the global environmental problems of our time (for example, climate change) shows how the resources of the site can be used to improve educational programs, workshops [17, 18]. But it should be remembered that the Internet resources themselves are not focused on «automatic» use in the educational process. Therefore, in [19] proposed measures for the adaptation of Internet resources for implementation in educational activities.

Simulation models of dynamic processes occurring in different ecosystems have a great didactic potential for studying ecological processes. Consider a few examples.

A computer stochastic model of the fish breeding process was used for educational and experimental production purposes by Japanese researchers to study the peculiarities of breeding the species Plecoglossus altivelis [20].

In the implementation of landscape design should take into account the human factor and complex feedbacks within the ecosystem of the territory. For this purpose, simulation experiments carried out on mathematical models for training and design purposes are used [21]. The cases containing models of development of architectural and planning decisions taking into account ecological consequences of their realization are developed and used at training of students also. The models are operated in Ecotect v5.20 [22].

Computer modeling on objects of ecological tourism allows to establish influence on a condition of these objects depending on intensity of a stream of tourists, level of their ecological culture and other significant external influences on a condition of environment. This program can be used for training and production purposes [23].

When teaching medical students, ecological competencies are formed systematically, taking into account the understanding of environmental conditions as an important factor in preserving human health and life. Computer modeling and special IT are successfully implemented in the study of many environmentally-oriented phenomena, concepts and processes, such as «biotic and abiotic factors», «system stability», «adaptability», «homeostasis» [24]. An interesting application is the use of smartphone capabilities to assess a healthy standard of living, taking into account related environmental factors [25]. Studies of German scientists on the example of the land of Bavaria have shown that the successful introduction of new digital technologies in the educational process is determined by the active participation of teachers and the revision of a number of assessments of their activities [26].

When teaching students of humanities and social training profiles, the main emphasis in the digitization of the educational process is not on simulation, but on the visualization of educational materials. For example, future journalists are deeply taught multimedia technologies [27]. Features of use of
modern digital information resources and ecological system thinking at training of writers-screenwriters are considered in paper [28].

Chinese teachers in the training of future translators developed and applied digital technologies focused on applied linguistic issues and the development of students' cultural characteristics of speakers of different languages, including their eco-cultural traditions. [29].

The Chinese experience in the combined use of information approach and elements of ecological thinking in teaching students studying in the field of arts is also interesting. In [30] the data obtained in the course of observations of a group of 257 students studying art are given. It is shown that the systematic approach that students learn during the lessons of ecology, contributes to the development of their skills to effectively solve creative problems. A similar study of 316 students of the faculty of music is described in [31]. The positive influence of "musical-ecological" education both on students' interest in learning and on the level of their learning outcomes is statistically confirmed.

Our analysis of cross-disciplinary trends in the field of digitalization of education has shown that it is possible to distinguish two categories of researches:
- first, on the restructuring of environmental education;
- secondly, the researches aimed at the greening of education.

A large number of researches argue the importance of developing people's ecological style of thinking and a deep understanding of the noosphere concept, according to which man is considered as part of nature [32; 33]. A similar position is developed in [34], but from philosophical and psychological positions. It is noted that the design of environmental education should delve deeper into the specifics of «human nature», skillfully combining a global vision, which is necessary when considering environmental problems, and local (national, cultural) perception of environmental problems by individuals.

In paper [35] the basic provisions which are the basis of activity of the international ecological Association ESA are considered. A "four-dimensional framework for environmental education" (4-DEE) has been established with priorities for study: key environmental concepts; environmental research practices; human-nature interactions; and cross-cutting themes such as the scale of ecosystems and their evolution.

On the basis of a survey of more than 200 major experts developed guidelines for the transformation of traditional static models used in environmental education, in dynamic and interactive models. It is established that for the success of such a transformation, the main attention should be paid to the effective exchange of information between the parts of the simulated system, the formation of a database, the quality of multimedia information, the convenience of interfaces and synchronization technologies of the system [36].

The article [37] deals with changes in the relations of specialists and production managers with the business environment in connection with the transition to sustainable development of the economy and social sphere. Successful implementation of sustainable development of regions and enterprises of various sectors of the economy imposes new requirements for the training and work of personnel, primarily specialists and managers.

4. Experimental studies of the use of digital technologies by subjects of the educational process
Currently, research is being conducted in the field of digitalization of ecological education in order to develop proposals for the rationalization of digitalization of ecological training (the research project RFBR N 19-013-00322 A "Multicultural design of ecological development of personality in digital
education”). To determine the initial prerequisites for the formation of project proposals with the participation of the authors of the article the study of the involvement of various subjects of educational activity in the use of digital technologies is carried out. The study is conducted using questionnaires, which contain questions addressed to respondents:

- the class or course in which the respondent students are enrolled, the student's specialty;
- educational level, qualification, specialization and age of the respondent-educator or administrator, his work experience in educational bodies;
- respondent's use of IT facilities by destination.

In total five groups of subjects-users of IT are considered:

- schoolchildren (grades 7-11);
- university students;
- teachers of secondary schools;
- university educators;
- administrators of educational organizations.

For Figure 1 results of statistical processing of questionnaire survey of various subjects-users are presented.

As can be seen from the presented diagrams, the use of IT for the purposes of educational activities by schoolchildren is insignificant. University students are much more likely to use opportunities to digitalize their education. As for the mentors of students (teachers, educators and administrators), these categories of users apply in their pedagogical, administrative and managerial activities IT tools with about the same frequency as students.

The presented experimental data characterize only one aspect of respondents' use of digital technologies. In the short article it is not possible to dwell on many other aspects of the problem, which were also studied in the statistical analysis of respondents' responses to questionnaires.

A pilot test of the questionnaire was carried out in educational organizations of Moscow and the Moscow region. Currently, the questionnaire survey is conducted in other regions of the Russian Federation.

5. Discussion and conclusions

Digitalization of education is one of the core areas of improvement of educational activities at different levels of training. Generalization of domestic and foreign experience in the field of digitalization of education has shown the high relevance of solving many problems, both theoretical and methodological and practical.

Digitalization of education is not confined to the «mechanical» use of IT. The main efforts should be directed towards setting and solving new problems, the prerequisites for the successful solution of which are provided by the digitalization of education.

The experimental study of the use of IT by the participants of the educational process shows the initial level of digitalization of education and allows to determine the actual problems of its further development.
1) Schoolchildren (grades 7-11)  
2) University students

3) Teachers of secondary schools  
4) University educators

Figure 1. Interests of various participants of educational activities in the field of digital technologies:
A – work in Internet (social networks, chats, mail);
B – Skype, Viber, WhatsApp, Telegram, etc.;
C – Internet surfing;
D – e-books, news;
E – watching movies;
F – games, music, photos, multimedia;
G – educational and career activity;
H – other.

5) Administrators
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