Features of training specialists in the field of environmental safety in water resources management

Shanshan Ren¹, Baoling Yang, Junzhong Wang, Yue Wang, Baktygul Narynbaeva, and Mukhame Imazov

Kyrgyz National University named after J. Balasagyn, Bishkek, Kyrgyzstan

Abstract. The article substantiates the necessity of transforming the educational process to train specialists in the field of environmental safety in water resources management. The main peculiarity of labor functions performed by such specialists is in the randomness and secrecy of natural processes and the appearance of consequences from any type of activity over a long period of time. It is necessary to understand the cause-and-effect relationships between processes and the individual parameters that affect the speed of their realization in order to solve such problems. The result of the research was the development of the training concept, which allows the presentation of a task as a set of elementary actions that require particular resource support for their fulfillment. Potentially possible problems in their fulfillment are determined. It is recommended that models of "digital twins" of systems capable of imitating the reaction to certain influences be used to improve the efficiency of the educational process and perform highly specialized actions.

1 Introduction

The development of production, changes in urban planning technologies, growth of material well-being, and cultural level of the population change the role of water in human life, increasing its consumption [1, 2]. At the same time, it is required to constantly and systematically study and develop complex organizational, legal, technical, and economic measures to protect water systems from anthropogenic environmental crises.

Studies related to water resource protection note that the establishment of such projects must meet the principles of:

- Consistency, considering the interests of different economic sectors and quantitative restoration of the level of the respective natural resource;
- Regionality, taking into account the stock of the resource at a particular location;
- Outpacing, where the rate of output of useful products must be higher than the rate of extraction of raw materials;

¹ Corresponding author: rss1917@163.com
- **Harmonization**, defining the processes of creation and operation of natural-technical, geotechnical, or ecological-economic systems consisting, for example, of production and interacting objects of the aquatic environment;

- **Interdependence** that protects other sites associated with the original natural feature;

- **Forecasting**, which includes a set of parameters of the state of a natural object describing the scale of changes from any external and internal influences [3].

Improvement of technologies and equipment in human economic activity and everyday life requires constant monitoring of water resources and modernization of measures related to the establishment of water protection areas and coastal protective strips, sanitary protection areas of water supply sources, construction of treatment facilities before the discharge of industrial and municipal wastewater into water bodies, the introduction of recycling water supply systems at industrial enterprises, collection, and treatment of stormwater from the territory of settlements, sites of enterprises or other objects.

All the above processes have specifics associated with highly specialized areas of activity of production enterprises, dynamically changing systems, a limited number of consumers, etc. To ensure monitoring of processes, effective management of their condition requires the training of qualified specialists with the necessary knowledge, skills, and competencies to work in a highly specialized segment of economic activity, able to respond adequately to changes in the state of natural objects, to use modern software and hardware in their activities.

Training such specialists requires adapting educational processes in educational institutions following the needs of enterprises, thus restoring the human resources potential for narrowly focused areas of activity, thereby combining the resources and capabilities of industry, the economy, and the state [4-7]. At this development stage of the national education system in the field of environmental safety, the initial stage of implementation of a practice-oriented approach in educational activities, involvement of industrial partners, and implementation of business requests are observed.

Thus, **the study aims** to develop the concept of creating educational programs related to training specialists in the field of environmental safety, taking into account the current demands of the labor market. For this purpose, it is required to carry out the tasks to identify the participants of the educational process, to structure the processes related to ensuring environmental safety in water resources management, to establish the peculiarities of the educational process implementation, and develop the concept of practice-oriented education in the training of relevant specialists.

**The study's theoretical significance** lies in the systematization of educational practices and structuring of educational content in the field of environmental safety. **The practical significance of the study** lies in the creation of a practice-oriented model for training specialists in the field of environmental safety.

## 2 Materials and methods

The study used general scientific methods to fulfill the set tasks.

Researchers comprehensively use structural analysis, decomposition, groupings, and synthesis methods to establish all objects in the subject area and their qualitative and quantitative characteristics. This approach is typical of research conducted in different fields: education [7, 8], ecology [2, 9], transportation [10, 11] and digital technologies [12]. As a result of methodologies application characteristic for the mentioned methods, allowed to establish not only objects and their characteristics, but also relations between them, allowing to form the rules of changes in the states of objects from the realization of internal processes and external influences.
Modular and interactive learning methods and business and role-playing games were used to create the educational concept. As noted by researchers engaged in the modernization of the educational process, taking into account the demands of society and industry, the development of digital technologies, these methods allow to implement competence-, system-, activity- and practice-oriented approaches to the training of specialists, regardless of the area of their future activities [4, 5, 8, 13].

Simulation methods were used to model individual processes that may occur during the implementation of the developed concept (e.g., workload of digital resources, hardware depreciation). Simulation modeling methods allow the creation of a digital copy of the subject area, which contains all objects, their characteristics, relations, and rules of interaction. As noted in studies devoted to the modeling of objects and processes of the subject area, this approach allows to determine the changes in the system that may occur over a short or long-time interval for the preliminary development of rules for operational control of the state of the real object [9, 10, 14].

3 Results

The participants of the educational process related to training specialists in environmental safety for water resources are educational organizations, enterprises implementing processes affecting nature, state authorities that control compliance with all requirements, and students. At the same time, students are those listeners who receive specialized education for the first time and specialists engaged in improving their qualifications or professional retraining.

The content of the educational program must meet the requirements necessary to perform labor functions at the enterprise in the field of environmental protection. The primary duties of a specialist who controls the ecological state of the environment include classifying the enterprise's waste by type, carrying out work to ensure compliance with environmental standards, collecting various samples, drawing up and maintaining documentation on equipment maintenance, preparing and sending reports to various supervisory authorities, etc.

Implementing all the above processes in natural conditions is associated with using highly specialized software, hardware, and technical means. At the same time, each enterprise or organization uses different solutions to ensure environmental safety. Therefore, specialist training related to the study of specific tools is not of high practical relevance, as the graduate will be artificially technically limited. At the same time, it should be noted that the development of technologies and software tools is currently being carried out at such a high rate that by the time the training is completed, the mastered software products or technological constructs will be obsolete.

Thus, labor functions or competencies should be formed based on finding a solution to the problem by any available means [4, 6]. This means that the task should be presented as a set of answers to the following questions: "what is the problem", "who is a participant in the problem", "what result should be obtained", "what tools (technologies) are available for use", "what steps are required to be performed", "what constraints may arise when performing any of the steps".

Using this approach allows us to represent any task through basic actions. Thus, an action requires specific resources: temporal, technical, organizational, and labor. At the same time, not only is the lack of resources perceived as a constraint, but also the hazards that may arise when performing certain activities (e.g., the risk of electrocution if safety procedures are not followed).

Actions performed during problem-solving aim to change the state of ecological processes. Such processes are irreversible, difficult to predict, and irregular. This is because
it requires processing and analyzing a large number of heterogeneous data, identifying patterns that need constant updating due to new events (e.g., changes in weather conditions, changes in economic activities of farms affecting the composition of soils and groundwater).

However, at the current stage of science and software development, it is possible to predict changes in natural processes with a certain accuracy [6]. For this purpose, digital twins are created based on simulation models based on parametric descriptions of the problem domain processes. Such digital twins create digital learning resources [9-11].

When forming a work function, using digital learning resources allows the educational organization to recreate conditions similar to real ones. If the task is presented as a set of actions that need to be performed, the digital twin is a tool that can show all the possible consequences of a decision over a given time. For example, a system dynamics model can be used to assess the condition of a water body after a discharge of process water into it, showing the survival rate of living organisms (fish, algae, and other organisms). This is done by estimating the rate of change in reproduction, death, and migration of organisms as a function of multiple parameters (e.g., water temperature, light, survival rate of each particular species of organism, water chemical composition). Using such a model in the educational process allows the reproduction of experiments with changes in different parameters for certain water bodies and economic activities that affect the ecosystem. From the perspective of the educational process, it allows us to show the consequences of the decision.

Digital models should accompany each stage of the educational process: current classes (practical or laboratory work, end-of-term control) and interim certification. At the same time, interim certification should be carried out as a practice-oriented assignment consisting of a task that simulates an actual situation arising in the protection of water resources. During the study, a set of tasks aimed at preserving living organisms in a water body when sewage, wastes of different industrial enterprises, shoreline changes from human economic activities, etc., enter the water body.

Thus, the general learning course of specialists in the field of environmental safety should combine theoretical and practical components. This should be based on the decomposition of the task into elementary actions, the performance of which is influenced by a number of parameters (required resources, classification of consequences, and emerging hazards). The transition to the next task should be carried out only after completing the previous task. Verification of task performance should be carried out by performance and using tools to implement individual actions, the quality of work performed, and other parameters.

Figure 1 shows the agent-based model of the students' passing process when using the developed learning methodology.

Student task requests are used as resources (three tasks are represented in the model that all must complete). At the same time, the time intervals of their execution are estimated, affecting the load of specialized software (or digital twins of real water systems). This approach allows for the formation of individualized learning plans, distribution of teaching load to the instructor, and evaluation of work in progress.
Fig. 1. Agent-based model of interim certification using simulation models of environmental safety of water resources.

4 Discussion

The development of educational concepts should correspond to the demands of the specialized industry or society and be adapted according to their changes. For this purpose, research identifies the competencies to be mastered and the means to achieve the planned result [4-6]. The study was conducted to ensure the training of specialists in the field of environmental safety for water resources and identified labor functions performed at enterprises, regardless of their profile. Based on this, the structure of the educational process for mastering professional competencies is defined as elementary actions that must be performed to obtain the final result, what resources are needed to perform them, and what limitations and dangers may arise during the performance of the actions. This approach allows the realization of competence-activity and system-activity approaches to learning, corresponding to modern pedagogical concepts [15, 16].

It is necessary to use digital resources capable of simulating the processes that occur in production and are associated with the impact on the ecological state of natural objects to effectively implement such a concept. Using such technologies at different stages of the educational process can "immerse" the student in an actual situation and show the significance and importance of the decisions made to solve the problem. This approach corresponds to the practice-oriented approach in education, which is characteristic of modern research related to the professional training of specialists [7, 8, 16].

5 Conclusion

The protection of aquatic ecosystems and the protection of water resources are related areas, the preservation of which ensures sustainable development under the implementation of different mechanisms for their protection. In addition to basic ecological knowledge obtained in the process of upbringing and education of an individual for human participation in nature conservation activities, it is necessary to train specialized specialists engaged in compliance with environmental legislation at enterprises and production facilities.

Such specialists can develop and implement technologies to minimize the negative impact of economic or industrial activities on natural objects. Effective management of such processes, implementation of green technologies, and operational management require appropriate training. It should combine theoretical and practical aspects related to modeling
different situations demonstrating changes in ecosystems and economic activities of enterprises.

References

5. O.A. Kosterova, Peculiarities of training specialists for highly specialized enterprises, Youth Week of Science IPMEiT, in Collection of works, pp. 198-200 (POLYTECHNIC PRESS, St. Petersburg, 2021)