

IMPROVING THE METHODOLOGY FOR DEVELOPING STUDENTS' CREATIVE COMPETENCES IN THE PROCESS OF DIGITAL TECHNOLOGIES (ON THE EXAMPLE OF HYDROLOGY AND HYDROGEOLOGY)

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Annotatsiya. Maqolada raqamli texnologiyalar sharoitida gidrologiya va gidrogeologiya fanlarini o'qitish orqali talabalarning ijodkorlik kompetentligini rivojlantirish metodikasini takomillashtirish masalasi yoritiladi. Asosiy e'tibor tayyor nazariy bilimni takrorlashga emas, real suv resurslari muammolarini tahlil qilish, gidrometrik kuzatuvlar, kartografik ma'lumotlar, suv balansi hisoblari va yer osti suvlari rejimi bo'yicha ijodiy yechim ishlab chiqishga qaratiladi. Maqolada empirik natijalar to'qib chiqarilmaydi; metodik takliflar xalqaro manbalar va fan mazmuniga tayangan holda asoslanadi.

Kalit so'zlar: raqamli texnologiya, ijodkorlik kompetentligi, gidrologiya, gidrogeologiya, GIS, MODFLOW, SWAT, muammoli ta'lim, kasbiy tafakkur.

Abstract. The article examines the improvement of methods for developing students' creative competence through digital technologies in hydrology and hydrogeology courses. The proposed approach connects water-related professional problems, digital data analysis, modelling, evidence-based decision-making and reflective assessment. The paper offers a methodological model rather than fabricated experimental statistics.

Keywords: digital technologies, creative competence, hydrology, hydrogeology, GIS, modelling, higher education.

Introduction

Teaching hydrology and hydrogeology in modern technical higher education institutions should no longer be limited to memorizing theoretical formulas or rewriting laboratory results. The variability of Water Resources, climatic factors, losses in irrigation systems, groundwater levels, salinity processes and situations associated with territorial water supply require the student to think independently, make decisions that rely on evidence and offer a creative solution. In this sense, digital technologies are not just a simple visual tool, but are considered a methodological environment that shapes the student's professional thinking.

The purpose of the article is to substantiate a digital-methodological approach that serves to develop students' creative competence using the example of the sciences of hydrology and hydrogeology. Here, creative competence is not limited to "saying something new." It is interpreted as the ability to select hydrological and hydrogeological data, verify them, analyze them using numerical tools, develop alternative solutions, explain model limitations, and defend the conclusion with scientific evidence.

As a scientific and methodological backbone of the study, official data on UNESCO'S ICT Competence Framework for teachers, OECD analyses on the digital educational ecosystem, WMO's guide to hydrological monitoring and information handling, the MODFLOW system of

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the USGS, and the SWAT model were studied. The overall content of these sources suggests that for digital tools to be effective in education, they must be linked to a clear learning objective, reliable information, active student engagement, and transparent assessment criteria.

The relevance of the topic is also that in the fields of water management, land reclamation, environmental monitoring, and territorial planning, the future specialist should not remain a mere executor of ready-made algorithms. It must critically see the real state, not accept the numerical result as automatic Truth, Check the source of information and the assumptions of the model. Such an approach forms the student as a responsible, careful and creative thinking person in the face of a scientific and practical problem.

The UNESCO ICT Competence Framework for Teachers refers to the application of digital technology in the educational system as a competency linked to educational content, pedagogical activity, assessment, professional development and educational management rather than a particular technical skill of the teacher (UNESCO, 2018). This idea is also important for the sciences of hydrology and hydrogeology: working with the program should not be divorced from the teaching goal, and the actions performed by the student should be linked to professional tasks.

The OECD Digital Education Outlook 2023 report states that the digital education ecosystem does not consist solely of a device or platform, in which issues of information systems, digital assessment, teacher competence, data use, and reliability are interrelated (OECD, 2023). Therefore, the use of a spreadsheet, GIS map, or model in a hydrology class should not be an isolated episode, but should be integrated into the course's purpose, assignment, and assessment system.

The WMO's Guide to Hydrological Practices focuses on the processes of observing, measuring, processing, and transforming hydrological data into information (WMO, 2008). This source provides an important methodological conclusion in the learning process: students should not accept a number about water consumption, precipitation, evaporation, or level as a ready-made value, but as scientific information that is associated with observation, error, time series, and interpretation.

In hydrogeological education, MODFLOW can serve as an important methodological example. According to the USGS, MODFLOW 6 is used to model groundwater flow as a three-dimensional and time-varying process (USGS, 2026). It is not necessary to fully teach all the technical complexities of this system during the lesson; but the concepts of aquifer, boundary condition, initial data, model scenario, and result interpretation can be conveyed through a practical task.

The official SWAT model information indicates that it can be used to simulate processes related to the quantity and quality of surface and groundwater from a small watershed to a river basin scale (Texas A&M AgriLife Research). This is conducive to developing scenario thinking in hydrology: students can discuss how land cover, precipitation, runoff, erosion, irrigation, and management decisions interact.

The approach proposed in the article was based on theoretical and methodological analysis, didactic modeling of the content of the subject, and methods for designing practical tasks. Empirical percentages, statistical indicators, or experimental results are not provided, as such data must be confirmed by special experimental testing, number of participants, diagnostic tool, and statistical calculations. Therefore, the article was developed as a scientific work of a conceptual-practical nature for an international conference.

The methodological analysis was organized around three questions. The first: what real-world professional problem does a student work on in the fields of hydrology and hydrogeology? The second: how does a digital tool help understand this problem? Third: How does the completed digital action demonstrate the student's creative competence? These questions allow you to distinguish the assignment from a mechanical exercise and direct it towards professional thinking.

Four indicators were identified in assessing creative competence: problem-solving, information processing culture, developing alternative solutions, and reflective reasoning. Problem-solving means that the student can identify the main question in a situation. A data-handling culture includes checking for source, unit of measure, time series, and error. An alternative solution shows that the student can compare multiple decisions. Reflection is defined by explaining the limits of the result, the level of confidence, and the practical implications.

The proposed model was conditionally named "HydroCreative". The purpose of the model is to transform a student from a simple executor of information processing into an author of evidence-based solutions. The model consists of five stages: problem statement, data preparation, numerical analysis, creative solution, and reflective defense. At each stage, the teacher asks guiding questions, but the final decision is made independently by the student or group.

Table 1. Application of the "HydroCreative" model in hydrology and hydrogeology lessons

Stage	Student Activity	Digital Tool	Creativity Outcome
Problem Identification	Analyzes water scarcity or water level decline.	Map and brief information.	Defines the main question and hypothesis.
Data Preparation	Checks dates, sources, units, and inconsistencies.	Excel, GIS attribute table.	Critically organizes and filters data.
Digital Analysis	Performs hydrograph, water balance, or map analysis.	GIS, spreadsheets, modeling concepts.	Identifies relationships and trends.
Creative Solution	Compares practical alternatives and solutions.	Diagram or scenario table.	Develops alternative decisions and solutions.
Reflective Defense	Explains results, limitations, and recommendations.	Presentation and report.	Defends evidence-based conclusions.

At the first stage of the model, the problem should have a vital and professional meaning for the student. For example, the assignment "calculate water consumption based on a given schedule" is necessary, but does not activate creativity enough. "In conditions of reduced flow, which irrigation regime saves more water and reduces the environmental risk?", which requires analysis, comparison, and decision.

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In the second stage, students learn to prepare data. In hydrology and hydrogeology, incorrect data cannot lead to correct conclusions. Therefore, the table checks for missing values, units of measurement, time intervals, coordinate systems, and source reliability. This process does not limit creativity, but rather grounds it in science.

The third stage involves numerical analysis. The student can construct a hydrograph, compare water balance elements, delineate a problem area on a GIS map, or understand scenario thinking through models such as MODFLOW and SWAT. Here, the program result serves as evidence for discussion, not a final judgment.

In the fourth step, a creative solution is developed. The solution must be technically feasible, environmentally conscious, and data-driven. For example, students can compare options such as increasing monitoring points in an area with increased drainage water mineralization, rescheduling irrigation times, or changing the well operation mode.

In the fifth stage, reflexive protection is organized. The student is not limited to the simple idea of "I think so"; explains which information he relies on, what hypothesis he takes, what is the limitation of the model or the result of the account. This stage connects creativity with scientific responsibility.

Example of practical tasks. The first task focuses on analyzing a river flow series. Students are given a table of water consumption for several years. They construct a hydrograph on a spreadsheet, separate the mean value and sharp deviations, and then discuss the factors that may affect the flow change. The creative outcome is that the student does not arbitrarily choose one reason, but rather compares the evidence with possible factors such as precipitation, temperature, water intake, and observation error.

The second task is devoted to the problem of water distribution for an irrigated area. The GIS map will display canals, collectors, cultivated areas, and water sources. The groups will develop three different scenarios for dealing with water scarcity: equal distribution of water, allocation of priority areas, or transition to water-saving technology. Each group will defend its decision with a map, a table, and a short explanation.

The third task is based on hydrogeological monitoring. Students are given data on level changes, debit, and mineralization of wells. They sort the values in a table, determine the probable link, and ask "which wells need additional monitoring?", in response. Creativity in this task is manifested in anticipating a possible risk and in the provision of a preventive recommendation.

The fourth assignment can have an interdisciplinary content. For example, students discuss how changes in land cover in a watershed can affect streamflow. This explains the general idea of the SWAT model as a scenario thinking tool. Students understand the relationship between input data, assumptions, and management decisions rather than deeply programming the model.

When performing such tasks, the teacher acts not only as a technical instructor, but also as a questioner and facilitator of scientific dialogue. He requires students to support each result with evidence, not hide uncertainty, and respectfully compare alternative solutions. In this way, the lesson process approaches the form of a small research project focused on a professional problem.

Assessment criteria and expected pedagogical outcome: When assessing creativity competence, a final score or a beautiful presentation is not enough. Assessment criteria should also cover the process. The first criterion is to understand the problem: was the student able to distinguish the main hydrological or hydrogeological question in the situation? The second

criterion-working with information: was the source, unit of measurement, error and time interval checked? The third criterion is digital analysis: did the graph, map, or table help explain the result? The fourth criterion is the feasibility of the solution: does the proposal fit with real conditions, environmental safety, and technical feasibility? The fifth criterion is reflection: did the student demonstrate the limitations of their conclusion?

The expected pedagogical result is that the student will perceive the sciences of hydrology and hydrogeology not as a "set of ready-made knowledge", but as a field of scientific and practical thinking that serves to solve real water problems. He does not use digital tools blindly, but rather critically analyzes information and models. This approach develops professional competence, digital literacy, and scientific creativity together.

At the experimental stage, Control and experimental groups, previous and subsequent diagnostics, accurate indicators and statistical analysis will be necessary to check this methodology. However, such figures are not cited in this article, since the percentage or result without evidence does not correspond to scientific demand. The purpose of the article is to propose a methodological model and a system of tasks that are justified for further empirical research.

Discussion: The content of hydrology and hydrogeology is conducive to creativity because information in these disciplines is not always complete, ideal, and uniform. Vacancies in hydrogeological observations, sharp fluctuations in meteorological rows, territorial differences in information about groundwater may occur. Such conditions teach students a culture of working with uncertainty, making cautious conclusions, and probing assumptions.

The didactic effectiveness of digital technologies depends on their selection in accordance with the learning objective. If the goal is to see changes in water consumption, a simple spreadsheet can also be effective. If the goal is to show spatial relationships, a GIS tool is needed. If the goal is to understand groundwater flow scenarios, a modeling concept such as MODFLOW is introduced. Therefore, the choice of technology should be based on didactic necessity, not fashion.

The approach suggested in the article is directly related to academic honesty. A student should not accept the output produced by the program as an automatic truth, but should indicate the model's input data, assumptions, and limitations. This requirement is consistent with the evidence-based approach in international scientific practice. At the same time, creativity is also not uncontrolled fantasy, but a professional quality that is linked to problems, evidence, constraints, and responsibility.

Interdisciplinary integration is also important. Hydrology and hydrogeology are closely related to mathematics, computer science, ecology, land reclamation, and engineering geology. Digital tools make this connection visible: a map develops spatial thinking, a table develops analytical thinking, a model develops cause-and-effect relationships, and a presentation develops scientific communication. Therefore, creativity can become a way to master the content of science, rather than a separate exercise.

Conclusions and recommendations

The example of hydrology and hydrogeology shows that digital technologies must be used in conjunction with real professional problems, reliable information, modeling culture, and reflective assessment to be effective in developing students' creative competencies. The main result of this is

not limited to the skill of using the program; the student learns to analyze the situation related to water resources, develop alternative solutions, and defend their decisions based on evidence.

The following recommendations are relevant for the practice of the international conference: to include at least one open-ended digital assignment on each topic; to harmonize hydrological and hydrogeological data in the form of a table, map and model; to add indicators of hypothesis, evidence, scenario, limitation and reflection to the evaluation criteria; to organize group protection and scientific discussion of students; to analyze

It is advisable to pilot this methodology in further studies, develop a diagnostic tool for indicators of creative competence, and statistically verify the results. At such a stage, only real measurements, the exact number of participants and open calculations should be brought. Only when this condition is met can the effectiveness of the methodology be assessed scientifically reliably.

The practical significance of the article is that the approach presented in it can be adapted to lectures, practical exercises, laboratory work, and independent learning assignments in hydrology and hydrogeology. For example, within a topic, a student first masters a theoretical concept, then works with a table or map, then prepares a group solution to a problem question, and finally defends their decision with evidence. This sequence transforms the lesson from simply providing information to a process of inquiry, analysis, and communication.

The limitations of the methodology should also be clearly stated. Not all higher education institutions may have the same software, internet speed, database, or teacher training. Therefore, when implementing a digital approach, it is not necessary to start with complex professional models. First, you can start by setting up the student's analytical and creative activities through spreadsheets, open maps, simple graphs, and questions based on real situations. In later stages, tools such as GIS, MODFLOW, or SWAT are meaningfully added.

In general, teaching hydrology and hydrogeology based on digital technologies should become a school of professional responsibility for the student. In dealing with water resources, a wrong assumption or unverified information can negatively affect a practical decision. Therefore, creativity, accuracy, ecological awareness, and adherence to evidence are considered complementary pedagogical principles in the learning process.

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