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EVALUATION CRITERIA FOR THE DIDACTIC CAPABILITIES OF DIGITAL PLATFORMS IN PHYSICS EDUCATION

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Abstract. This article examines the evaluation criteria for determining the didactic capabilities of digital platforms in physics education. The study focuses on how platforms such as PhET, GeoGebra, Algodoo, Easy Java Simulations, Moodle, Google Classroom, Kahoot, Quizizz, Zoom, Google Meet, and Google Forms can be assessed according to pedagogical purpose, scientific accuracy, visualization, interactivity, feedback, differentiation, monitoring, and methodological integration. The article argues that the effectiveness of digital platforms depends not only on technical functions but also on their alignment with learning objectives, the nature of physical concepts, students' cognitive needs, and the teacher's instructional design.

Annotation. The article explores the problem of evaluating the didactic potential of digital platforms used in teaching physics. It analyzes the methodological value of interactive simulations, virtual laboratories, learning management systems, online assessment tools, and communication platforms. Particular attention is paid to criteria such as visual representation of physical processes, support for inquiry-based learning, experimental modeling, formative assessment, accessibility, and evidence-based monitoring of learning outcomes.

Keywords: digital platform, physics education, didactic capability, evaluation criteria, interactive simulation, virtual laboratory, visualization, feedback, digital assessment.

Under the conditions of digital transformation, physics education is being renewed in terms of content, methods, forms of interaction, and assessment procedures. Digital platforms make it possible to demonstrate invisible processes, model experiments, organize students' independent work, provide feedback, and collect evidence about learning outcomes. However, the use of a platform does not automatically improve the quality of teaching. Its effectiveness depends on whether it is selected according to the learning objective, the scientific content of the topic, students' level of preparation, technical conditions, and the teacher's methodological approach.

Physics differs from many other school and university subjects because it studies processes that are often abstract, dynamic, microscopic, or impossible to observe directly in the classroom. Electric and magnetic fields, atomic processes, wave interference, molecular motion, nuclear reactions, heat transfer, and motion in different coordinate systems require not only verbal explanation but also visual representation, modeling, and guided analysis. For this reason, digital platforms have become an important methodological resource in physics teaching.

The didactic capabilities of digital platforms should be understood as their capacity to support the achievement of educational aims. These capabilities include the presentation of scientific information, visualization of physical phenomena, organization of students' practical activity, development of analytical thinking, provision of immediate feedback, support for differentiated learning, and monitoring of results. Therefore, the central question is not which platform is more modern, but which platform is pedagogically appropriate for a concrete topic, task, and group of learners.

Researchers in multimedia learning and science education emphasize that learning becomes more effective when students connect verbal information with visual models, practical activity, and reflection [1; 2; 5]. In physics, this principle is especially relevant because learners must connect formulas, graphs, diagrams, measurements, and real physical phenomena. Digital platforms can help students build this connection when the teacher organizes observation, prediction, experimentation, comparison, and explanation in a purposeful sequence.

Platforms used in physics education may be divided into several functional groups. The first group includes interactive simulation and virtual laboratory platforms such as PhET Interactive Simulations, GeoGebra, Algodoo, Easy Java Simulations, Open-Source Physics, and similar resources. These tools allow students to change variables, observe results, repeat experiments, and test hypotheses in a safe and flexible environment. The second group includes learning management systems such as Moodle and Google Classroom, which help teachers upload materials, assign tasks, set deadlines, collect students' work, and organize feedback. The third group consists of online assessment tools such as Kahoot, Quizizz, Google Forms, and Socrative, which support formative assessment and immediate checking of understanding. The fourth group includes communication and collaboration platforms such as Zoom, Google Meet, Padlet, and Google Docs, which can be used for discussion, reporting, group work, and reflection.

When evaluating the didactic capabilities of digital platforms in physics education, the first criterion is alignment with learning objectives. A platform should be selected only after the teacher has clearly defined what students must understand, calculate, observe, explain, or demonstrate. For example, if the objective is to understand the dependence of acceleration on force and mass, an interactive simulation is more suitable than a static presentation. If the objective is to check prior knowledge before a lesson, an online quiz may be more appropriate. If the objective is to organize independent study and collect assignments, a learning management system is required.

The second criterion is scientific accuracy and conceptual adequacy. A digital platform used in physics must present phenomena, formulas, units, graphs, and relationships correctly. An attractive visual model may be harmful if it simplifies the concept incorrectly or creates misconceptions. Therefore, the teacher should check whether the model corresponds to accepted scientific explanations, whether variables are named clearly, whether units are used properly, and whether the platform allows students to observe essential relationships without unnecessary distortion.

The third criterion is the capacity for visualization and modeling. One of the main didactic strengths of digital platforms in physics is the possibility of making invisible or complex processes visible. A good platform should help learners observe motion, interaction, direction, sequence, cause-effect relationships, and change over time. For example, animations of electromagnetic induction, wave superposition, refraction, or molecular motion can help students understand processes that are difficult to imagine from textbook descriptions alone.

The fourth criterion is interactivity. Students should not remain passive observers of a digital demonstration. The platform should allow them to manipulate variables, make predictions, compare results, answer questions, and draw conclusions. Interactivity transforms the platform from a demonstration tool into a learning environment. In this sense, the didactic value of PhET, GeoGebra, Algodoo, and Easy Java Simulations is connected with students' ability to test ideas and immediately see the consequences of their actions.

The fifth criterion is support for inquiry-based and problem-based learning. Physics education should develop not only knowledge of formulas but also scientific thinking. Digital platforms are didactically valuable when they help students formulate hypotheses, collect data, identify patterns, explain results, and solve practical problems. For example, in a lesson on uniformly accelerated

motion, students can use a simulation to change initial velocity or acceleration, record data in a table, construct a graph, and then explain the relationship between variables.

The sixth criterion is feedback and formative assessment. Digital platforms should help both teacher and student understand what has been learned and what still requires improvement. Online quizzes, automatic checking, progress indicators, teacher comments, and analytical reports provide evidence for instructional decisions. In physics, feedback should not be limited to marking answers as correct or incorrect. It should help learners understand the reason for an error, revise their calculation, interpret a graph, or reconsider a physical explanation.

The seventh criterion is differentiation and individualization. Students in the same group may differ in mathematical preparation, digital competence, conceptual understanding, and learning pace. A didactically effective platform should make it possible to assign tasks of different levels, provide repeated attempts, recommend additional resources, support individual progress, and allow students to learn at a suitable speed. This is particularly important in physics, where one student may need help with formula transformation, while another may need a more complex modeling task.

The eighth criterion is usability and technical reliability. If a platform is difficult to open, requires complicated registration, works only with strong internet connection, or has an unclear interface, much instructional time may be lost. For this reason, the teacher should evaluate the platform according to accessibility, language of the interface, device compatibility, speed, simplicity of navigation, and the possibility of using it in classroom and independent learning conditions.

The ninth criterion is methodological integration. A digital platform should not be used as an isolated element or decorative addition to the lesson. It should be included in the logic of the lesson: introduction, explanation, guided practice, independent activity, discussion, assessment, and reflection. The teacher's role remains central because the teacher defines the task, directs observation, prevents misconceptions, asks analytical questions, and connects digital activity with theoretical knowledge and problem solving.

The tenth criterion is inclusiveness, safety, and ethical use. Digital platforms should be accessible to students with different learning needs and technical possibilities. The teacher should also consider data privacy, responsible use of online tools, safe communication, and the prevention of distraction. The 2023 UNESCO Global Education Monitoring Report emphasizes that technology should be introduced on the basis of evidence, equity, appropriateness, and pedagogical control [6]. This principle is directly relevant to physics education as well.

Table 1. Evaluation matrix for the didactic capabilities of digital platforms in physics education

No.	Criterion	Didactic meaning	Indicator for evaluation
1	Alignment with learning objectives	The platform supports a concrete physics learning outcome.	The task matches the topic, lesson stage, and expected competency.
2	Scientific accuracy	The content, formulas, units, graphs, and models are conceptually correct.	The platform does not create misconceptions or distort physical laws.
3	Visualization and modeling	The platform makes abstract, invisible, or dynamic processes observable.	Students can observe change, interaction, direction, sequence, and cause-effect relations.
4	Interactivity	Students can manipulate variables and test ideas.	Learners predict, experiment, compare, and explain results.
5	Inquiry and problem solving	The platform supports hypothesis, data collection, graphing, and explanation.	The activity develops analytical and scientific thinking.
6	Feedback and assessment	The platform provides immediate or teacher-guided feedback.	Errors, progress, and achievement can be identified and corrected.
7	Differentiation	The platform supports different levels and individual pace.	Tasks can be adapted for students with different preparation and needs.
8	Usability and accessibility	The platform is simple, reliable, and accessible on available devices.	Technical barriers do not dominate the learning process.

This matrix can be used by physics teachers before, during, and after the lesson. Before the lesson, it helps select the most suitable platform. During the lesson, it helps organize observation, interaction, and discussion. After the lesson, it helps evaluate whether the platform supported understanding, activity, feedback, and independent learning. In this way, the matrix connects digital technology with pedagogical decision-making.

For example, in teaching the topic of light refraction, the teacher may compare a video demonstration, a PhET simulation, and a real laboratory experiment. The video may be useful for initial visualization, but it gives limited opportunity for manipulation. A simulation allows students to change the angle of incidence, observe the refracted ray, compare media, and analyze the relationship between variables. A real experiment develops measurement skills and practical accuracy. The most effective method is often the combination of these resources, because virtual and real experiments support different aspects of learning.

In teaching mechanics, Algodoo or similar simulation tools can be used to demonstrate force, friction, collision, and motion. However, their didactic value appears only when students receive a clear task: predict the result, change one variable, record the outcome, and explain the cause. Without such guidance, students may treat the platform as entertainment rather than as a scientific learning environment.

In teaching electricity and magnetism, interactive simulations are particularly useful because many processes cannot be seen directly. Students can observe electric field lines, current direction, resistance changes, magnetic interaction, and induction effects. When such simulations are followed by calculation, problem solving, and reflection, they help connect conceptual understanding with mathematical representation.

Learning management platforms also have specific didactic value. Moodle and Google Classroom can structure the learning process by storing lecture materials, laboratory instructions, assignments, rubrics, video explanations, and assessment results in one environment. This supports independent learning and makes the educational process more transparent. However, these platforms should not become only repositories of files. Their didactic strength increases when they are used for staged tasks, discussion questions, feedback, peer review, and progress monitoring.

Online assessment platforms such as Kahoot, Quizizz, and Google Forms are useful for quick diagnostics and formative assessment. In physics lessons, they can be applied at the beginning of a lesson to identify prior knowledge, during the lesson to check understanding of concepts, and at the end of the lesson to summarize results. The teacher should design questions that test not only memory but also conceptual reasoning, interpretation of graphs, identification of units, and explanation of physical situations.

Communication platforms such as Zoom and Google Meet are important for distance and blended learning. They allow teachers to explain, demonstrate, discuss, and guide students in real time. Nevertheless, the didactic effectiveness of online communication depends on the structure of interaction. A physics lesson conducted through video conference should include short explanations, visual support, questions, breakout discussions, screen sharing of simulations, and follow-up tasks.

Thus, the evaluation of digital platforms in physics education should be carried out through a pedagogical lens. A platform with many technical features may be less effective than a simple tool if it is not connected to the learning objective. Conversely, a simple simulation can have strong didactic value if it helps students understand a difficult concept, test a hypothesis, and explain evidence. Therefore, the principle of “placing the pedagogical task at the center, not the platform” should guide the selection and use of digital technologies.

There are also several limitations that must be considered. These include unstable internet connection, lack of devices, insufficient digital competence of teachers and students, limited availability of resources in the native language, and the risk of cognitive overload. In addition, ready-made digital content may not always correspond to the national curriculum, assessment standards, or students’ level. For this reason, teachers should adapt digital resources, prepare clear instructions, and combine technology with traditional explanation, real experiment, textbook work, and problem solving.

In conclusion, evaluating the didactic capabilities of digital platforms in physics education is one of the important tasks of modern methodology. The proposed criteria - alignment with learning objectives, scientific accuracy, visualization, interactivity, inquiry-based learning, feedback, differentiation, usability, methodological integration, and ethical use - make it possible to select digital tools consciously and effectively. Digital platforms do not replace the teacher; rather, they expand the teacher’s methodological opportunities and help organize learning on a more visual, interactive, and evidence-based foundation.

The effective use of PhET, GeoGebra, Algodoo, Easy Java Simulations, Moodle, Google Classroom, Kahoot, Quizizz, Zoom, Google Meet, and similar platforms can improve students’ understanding of physical concepts, increase cognitive activity, support motivation, and strengthen independent learning. Their didactic value is especially high when students observe dynamic

processes, manipulate variables, receive feedback, and connect digital models with real physical laws. Therefore, the assessment of digital platforms should become a regular component of physics teachers' professional and methodological activity.

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