WORLD CONFERENCE ON STUDENT - CENTERED LEARNING APPROACHES

IMPROVING THE CONTENT OF THE ASTRONOMY COURSE BASED ON DIGITAL DIDACTIC RESOURCES

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Abstract

This article examines methodological approaches to improving the content of the astronomy course based on digital didactic resources in pedagogical higher education institutions. Particular attention is given to the integration of interactive learning materials, astronomical visualization tools, virtual observations, computer simulations, multimedia resources, and electronic assessment instruments into the structure of course content. The article also discusses the potential of digital resources to facilitate the understanding of abstract astronomical phenomena, strengthen interdisciplinary connections with physics, mathematics, and computer science, and support students' independent cognitive activity.

Keywords: astronomy education, digital didactic resources, digital learning environment, interactive learning, virtual observations, computer simulations, independent learning.

СОВЕРШЕНСТВОВАНИЕ СОДЕРЖАНИЯ КУРСА АСТРОНОМИИ НА ОСНОВЕ ЦИФРОВЫХ ДИДАКТИЧЕСКИХ РЕСУРСОВ

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Аннотация

В статье рассматриваются методологические подходы к совершенствованию содержания курса астрономии на основе цифровых дидактических ресурсов в педагогических высших учебных заведениях. Особое

внимание уделяется интеграции интерактивных учебных материалов, средств астрономической визуализации, виртуальных наблюдений, компьютерного моделирования, мультимедийных ресурсов и электронных средств оценивания в структуру содержания курса. Также анализируются возможности цифровых ресурсов в обеспечении понимания абстрактных астрономических явлений, укреплении межпредметных связей с физикой, математикой и информатикой, а также развитии самостоятельной познавательной деятельности студентов.

Ключевые слова: астрономическое образование, цифровые дидактические ресурсы, цифровая образовательная среда, интерактивное обучение, виртуальные наблюдения, компьютерное моделирование, самостоятельное обучение.

INTRODUCTION

The development of digital technologies has created new opportunities for improving the content and organization of higher education. In this context, astronomy education requires particular attention because the subject deals with celestial bodies, cosmic processes, astronomical observations, and phenomena that are often difficult to observe directly or understand through verbal explanations alone. In pedagogical higher education institutions, astronomy plays an important role in developing students' scientific worldview, spatial thinking, logical reasoning, and understanding of the fundamental laws governing the universe. However, the effectiveness of astronomy instruction depends not only on the scientific accuracy of the educational material but also on how the content is structured, presented, and connected with students' practical learning activities.

Traditional textbooks and oral explanations remain important components of the educational process. Nevertheless, they may not always provide sufficient opportunities to visualize the three-dimensional structure of celestial systems, observe the apparent motion of celestial bodies, investigate astronomical phenomena

dynamically, or analyze observational data. Digital didactic resources can help address these limitations by combining textual explanations, diagrams, animations, interactive models, virtual observations, and assessment materials.

Digital resources should not be introduced into astronomy instruction merely to increase the number of technological tools used in a lesson. Their selection and application must be determined by the scientific content of the topic, the intended learning outcomes, students' prior knowledge, and the specific didactic tasks to be accomplished. Therefore, improving the content of the astronomy course on the basis of digital didactic resources involves the systematic revision of educational materials, the integration of digital and traditional learning methods, and the development of methodological conditions that promote meaningful learning.

LITERATURE REVIEW AND METHODOLOGICAL APPROACHES

Digital didactic resources are educational materials and software-based tools designed to support the acquisition, application, analysis, and assessment of knowledge. In astronomy education, these resources may include electronic learning materials, animated explanations, interactive star maps, virtual planetariums, three-dimensional models, computer simulations, video lessons, digital observation records, and online assessment systems. The educational value of these resources is determined by their ability to support specific learning objectives rather than by their technological complexity. Mayer's research on multimedia learning emphasizes the importance of coordinating verbal and visual representations in ways that support meaningful cognitive processing [1]. This perspective is particularly relevant to astronomy, where students need to connect abstract concepts with visual representations and explanatory models.

Digital astronomical tools also provide opportunities to explore celestial objects and phenomena that cannot always be observed directly during classroom instruction. For example, the Stellarium planetarium software enables users to explore the

appearance of the sky, identify celestial objects, and examine their apparent positions at different times [2]. Celestia and NASA Eyes provide additional opportunities for exploring celestial objects and astronomical systems through interactive visualization [3, 4].

However, the availability of digital resources does not automatically guarantee improved learning outcomes. Their educational effectiveness depends on the relevance of the selected material, the clarity of instructions, the logical sequence of learning activities, and the relationship between digital representations and the scientific concepts being studied.

Improving the content of an astronomy course through digital resources requires a combination of interconnected methodological approaches.

1. Content-oriented approach. This approach involves analyzing the existing course curriculum, identifying essential concepts, and determining which topics require additional visualization, simulation, or interactive investigation. Digital materials should complement and clarify the scientific content rather than replace its theoretical foundations.

2. Visualization-based approach. Astronomical concepts such as planetary motion, lunar phases, eclipses, stellar evolution, and the structure of galaxies can be represented through diagrams, animations, and three-dimensional models. Such representations help students connect abstract explanations with observable or modelled phenomena.

3. Interactive approach. Interactive exercises, virtual observations, problem-solving activities, and digital tests encourage students to engage actively with the learning material. Students can formulate hypotheses, modify simulation parameters, compare results, and explain the relationships they observe.

4. Modular and systematic approach. Course content is organized into logically connected learning modules. Each module includes theoretical explanations, digital

resources, practical or investigative activities, and assessment tasks. This structure supports a gradual transition from initial understanding to application and analysis.

5. Differentiated and learner-centered approach. Digital resources and assignments can be selected according to students' levels of preparedness, individual learning needs, and interests. Additional explanations, introductory exercises, and more complex investigative tasks can be provided where appropriate.

6. Interdisciplinary approach. Astronomy course content should be connected with physics, mathematics, and computer science. Mathematical calculations can be combined with astronomical simulations, physical laws can be used to explain celestial processes, and digital tools can support the processing and visualization of observational data. These approaches should operate as an integrated methodological system. Their coordinated application enables digital resources to become an integral part of course content and learning activities.

The selection of digital resources should correspond to the characteristics of each astronomy topic.

Electronic learning materials. Electronic textbooks, structured presentations, glossaries, diagrams, and topic summaries provide systematic access to essential concepts and terminology.

Video lessons and animations. These resources are useful for explaining dynamic processes, including solar and lunar eclipses, planetary motion, the formation of astronomical phenomena, and stages of stellar evolution.

Interactive star maps and virtual planetariums. Software such as Stellarium enables students to investigate celestial coordinates, locate astronomical objects, examine the visible sky, and compare its appearance at different times.

Three-dimensional models and simulations. Digital models support the study of planetary systems, celestial trajectories, spatial relationships, and selected astronomical

processes. Their use should be accompanied by explanations of model assumptions and limitations.

Virtual observation activities. Students can carry out guided investigations using simulated or digitally represented observations, record results, compare observations under different conditions, and formulate evidence-based conclusions.

Interactive assessment resources. Online quizzes, topic-based tests, digital worksheets, and electronic portfolios can be used to monitor students' understanding, identify misconceptions, and provide feedback.

The pedagogical value of these resources depends on their purposeful integration into the learning process and their alignment with the content and expected outcomes of the course [5, 6,7].

RESULTS

The methodological analysis makes it possible to identify several important directions for improving astronomy course content through digital didactic resources.

1. Structuring course content around learning objectives

The first direction involves reviewing the content of each topic and determining the knowledge, skills, and learning outcomes that students are expected to achieve. On this basis, digital resources can be selected according to their intended educational functions. For example, the topic of planetary motion may combine theoretical explanations, visual representations of planetary orbits, a computer simulation, calculation tasks, and questions requiring students to interpret the results. This organization ensures that digital resources are connected with the scientific content of the topic and contribute to its systematic acquisition.

2. Integrating theoretical explanations with visualization

Astronomy includes numerous concepts that involve spatial relationships and processes occurring over long periods or at distances that cannot be directly experienced. Digital visualization can make these concepts more accessible. For

example, when studying the phases of the Moon, students can compare the relative positions of the Sun, Earth, and Moon with the appearance of the illuminated lunar disk as observed from Earth. When studying stellar evolution, they can examine visual representations of different stages in the development of stars. Such activities should be accompanied by explanatory questions that help students understand why the represented phenomena occur rather than simply memorize their visual appearance.

3. Organizing interactive and investigative learning activities

Digital resources create opportunities to transform students from passive recipients of information into active participants in the learning process.

A digital learning activity may require students to:

formulate a question or hypothesis about an astronomical phenomenon;

select an appropriate digital tool or model;

change observation conditions or simulation parameters;

record and compare the obtained results;

explain the observed relationships;

formulate a conclusion based on the evidence.

This sequence supports the development of independent thinking, analytical skills, and the ability to use digital resources for educational and investigative purposes.

4. Strengthening interdisciplinary connections

Improving astronomy course content also requires the integration of knowledge from related disciplines.

Physics provides the laws and principles necessary to explain gravitational interactions, light, radiation, and the motion of celestial bodies. Mathematics supports calculations involving distances, angles, periods, and orbital parameters. Computer science contributes digital modelling, data processing, and visualization techniques.

The integration of these disciplines allows students to understand astronomy not

as an isolated collection of facts but as a field of scientific knowledge based on interconnected concepts and methods.

5. Improving monitoring and assessment

Digital assessment resources can be integrated into each stage of the learning process. Introductory questions can be used to identify students' prior knowledge, interactive tasks can monitor understanding during instruction, and final assignments can assess the application of acquired knowledge.

Assessment should include not only factual knowledge but also the ability to interpret astronomical representations, explain observed phenomena, work with digital tools, analyze information, and justify conclusions.

The results of digital assessments can support feedback and help teachers identify topics that require further explanation or additional learning activities.

DISCUSSION

The improvement of astronomy course content through digital didactic resources requires a clearly defined sequence of methodological actions. The following framework is proposed.

Stage 1. Analysis of course content

The existing curriculum, syllabus, learning materials, and expected educational outcomes are examined. Topics are identified according to their conceptual complexity, visualization requirements, and potential for practical or investigative activities. At this stage, it is important to distinguish topics that can be adequately explained through textual and graphical materials from those that require dynamic models, virtual observations, or interactive simulations.

Stage 2. Defining didactic objectives

Specific learning objectives are established for each topic or module. These objectives may involve understanding astronomical concepts, explaining physical processes, interpreting visual information, applying mathematical relationships, or

conducting digital investigations. The objectives should be expressed in terms of observable learning outcomes so that the suitability of the selected resources can be assessed.

Stage 3. Selecting and evaluating digital resources

Digital resources are selected according to their scientific accuracy, pedagogical relevance, usability, accessibility, and compatibility with the intended learning activities.

The following criteria can be used:

Scientific accuracy: the resource represents astronomical concepts and phenomena correctly.

Didactic relevance: the material contributes directly to the learning objectives.

Visualization quality: visual representations clarify essential concepts and relationships.

Interactivity: students can actively explore, investigate, or respond to the learning material.

Accessibility: the resource can be used under the available technical and educational conditions.

Assessment potential: the resource supports feedback, self-assessment, or the evaluation of learning outcomes.

The selected resources should be evaluated in relation to their specific educational purposes rather than treated as interchangeable technological tools.

Stage 4. Developing digital learning modules

The selected materials are organized into coherent learning modules. Each module may contain the following elements:

Topic title and learning objectives.

Key concepts and theoretical explanations.

Illustrations, animations, or video materials.

Interactive models or virtual observation activities.

Practical assignments and investigative questions.

Self-assessment questions and tests.

Independent learning tasks and recommended resources.

Reflection and summary of learning outcomes.

This structure enables students to move from conceptual introduction to visualization, practical investigation, knowledge consolidation, and assessment.

Stage 5. Integrating resources into the learning process

Digital modules are incorporated into lectures, practical classes, seminars, and independent learning activities. The teacher provides instructions, identifies the central scientific problem, guides students' work with digital tools, and helps them interpret the results. Digital resources should be used in combination with other instructional methods where appropriate. For instance, a virtual simulation may be followed by a mathematical problem, a discussion of the underlying physical principles, or an analysis of actual astronomical observations.

Stage 6. Monitoring and methodological improvement

The implementation of digital learning modules should be accompanied by the collection and analysis of evidence concerning student learning. Possible indicators include conceptual understanding, accuracy in interpreting astronomical representations, successful completion of practical tasks, participation in investigative activities, independent learning performance, and the quality of students' explanations. Feedback from students and teachers can be used to identify unclear instructions, technically difficult activities, unnecessary content, and gaps in the logical sequence of materials. The modules can then be revised to improve their scientific clarity, usability, and pedagogical relevance. The proposed framework establishes a methodological connection between curriculum analysis, digital resource selection, learning activity design, implementation, and evaluation. Its practical application requires adaptation to

the educational programme, available technological infrastructure, and students' prior knowledge.

CONCLUSION

Improving the content of the astronomy course based on digital didactic resources is an important methodological direction in the modernization of astronomy education at pedagogical higher education institutions. The analysis indicates that digital resources can support the understanding of abstract astronomical concepts, improve the visualization of celestial phenomena, facilitate interactive learning, and strengthen connections between astronomy, physics, mathematics, and computer science.

The proposed methodological framework includes curriculum analysis, the definition of didactic objectives, the selection and evaluation of digital resources, the development of structured learning modules, their integration into educational activities, and continuous monitoring of learning outcomes. The effectiveness of this approach depends on the scientific accuracy of the selected materials, their alignment with learning objectives, the logical organization of course content, and the purposeful combination of digital resources with theoretical explanations and practical tasks. Digital didactic resources should therefore be considered not merely as supplementary technological tools but as components of a coherent methodological system for organizing astronomy education.

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