Modernization of Pedagogical Higher Education by Innovative Teaching Instruments

Co-funded by the Erasmus+ Programme of the European Union

MoPED: Modernization of Pedagogical Higher Education by Innovative Teaching Instruments

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HANDBOOK

TITLE OF THE COURSE:

FORMATION OF COMPUTATIONAL THINKING AT SCHOOL WITH THE HELP OF 3D MODELING AND ROBOTICS

Speciality *«014.04 Secondary education (Mathematics)»*

Higher Education Degree: *Master*

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BRIEF SUMMARY OF THE COURSE:

The course provides the formation of future teachers' professional pedagogical competences for the ability of researching pedagogical activities in conditions of uncertainty and organization of the educational process in secondary schools based on the results of these studies. Attention is paid to the study and solution of problems of practical implementation of the constructivism theory in the educational process and ensuring its quality. Mastering the theoretical foundations and own research will allow teachers to design pedagogical scenarios and courses in the following areas and topics: creative development of 3D models with the use of engineering and mathematical methods; original approaches to solving mathematical problems with the use of 3D modeling; introduction of STEAM and creative multidisciplinary tasks for high school students based on real-life examples; formation of engineering and creative thinking skills; formation of computational thinking and programming skills and the ability to solve computer modeling problems using robotics (Makeblock mBot, Makeblock Ultimate, LEGO Mindstorms EV3); use of Blender, Tinkercad, GeoGebra and other software in the learning process.

KEY WORDS:

PEDAGOGICAL DESIGN, METHODOLOGY OF TEACHING, STEAM, DEVELOPMENTAL LEARNING, 3D MODELING, ROBOTICS IN SCHOOL, CONSTRUCTIVISM, COMPUTATIONAL THINKING, PROFESSIONAL COMPETENCE, PEDAGOGICAL COMPETENCE.

CONTENT

1. DESCRIPTION OF THE COURSE

1.1. The volume of the course in ECTS credits and its distribution in hours by the forms of organization of educational process and types of classes.

5,0 ECTS credits.
Total modules – 2.
Total hours: 150, including full-time form: 20 lecture hours, 40 hours of practical and laboratory classes, 90 hours – consultations, independent work of students; part-time form: 8 lecture hours, 10 hours of practical and laboratory classes, 132 hours – consultations, independent work of students
Lectures, practical and laboratory classes for part-time form are conducted with use of synchronous and asynchronous methods.

1.2. Characteristics of the course by form of study.

Full-time, part-time (with the use of digital learning technologies).

1.3. Status of the course.

Compulsory (014.04 Mathematics), elective (for other specialties).

1.4. Prerequisites for studying the course.

Completed courses: computer science, physics, higher mathematics, programming, pedagogy, psychology, school course of computer science and teaching methods.

1.5. Year of study, semester.

1st year, 2nd semester.

1.6. Form of final control.

Exam.

1.7. Language of the course.

Ukrainian, English.

1.8. Internet address of the permanent placement of educational content of the course.

http://do.luguniv.edu.ua/course/view.php?id=26709

1.9. Developers.

Hennadii Mohylnyi,
Mykola Semenov,
Volodymyr Donchenko.

1.10. Aims of the course.

Formation of general and professional competences of future teachers that are necessary for the effective use of 3D modeling technologies and educational robots in STEAM education.

1.11. Competences that are formed during the study of the course.

General competences (GC):

GC-1 Ability to abstract and analytical thinking
GC-2 Ability to solve a problem comprehensively, formulate an aim independently and conduct research.
GC-3 Ability to be creative in developing ideas and achieving research aims.
GC-4 Digital competence.

Professional (special) competences (PC):

PC-1 Ability to study the conditions and design pedagogical technologies for the organization of the learning process and the implementation of the process of teaching computer science in secondary schools using transdisciplinary approaches.
PC-2 Ability to use theoretical principles of constructivism for practical tasks of forming students' computational thinking and implementation of effective use of 3D printers and robotics as learning tools in the educational process.

1.12. Expected learning outcomes of the course.

ELO 1.1 Knowledge of the constructivism theory essence, developmental learning and STEAM technology.
ELO 1.2 Knowledge of the technical features and software of 3D printers and robotics..
ELO 1.3 Knowledge of the principles of 3D printers application and robotics in the educational process.
ELO 2.1 Provide effective support during STEAM education in 3D modeling and robotics.
ELO 2.2 Identify the opportunities and features for the organization of STEAM learning in 3D modeling and robotics in real conditions.
ELO 2.2 Conduct own research according to the peculiarities of the organization of the educational process and create pedagogical scenarios for STEAM training in 3D modeling and robotics.
ELO 2.3 Understand the effectiveness of using different tools for the use of 3D printers and robotics in the learning process.
ELO 2.4 Conceptualize, develop and implement a research project to evaluate students' achievements in STEAM learning.
ELO 2.5 Create new approaches to the use of developmental learning elements, ideas of constructivism, paradigms of formation of mathematical thinking and computational thinking during STEAM learning in 3D modeling and robotics.
ELO 2.6 Organize and conduct STEAM learning in 3D modeling and robotics, achieving the quality of such learning with the use of a variety of software, technical and pedagogical solutions.

1.13. Students' academic achievments control.

The following activities are evaluated: activity on didactic, role-playing game, practical lesson, laboratory work, project, control modular works (test and written work)
100 points for the course:
60 points – defense of laboratory works projects

40 points – control modular works.
Distribution of points by the forms of activity:
P 1.1 2% (LO 1.1)
P 2.1 2% (LO 1.1)
L 2.1 3% (LO 1.2, LO 1.3)
L 2.2 3% (LO 1.2, LO 1.3)
L 2.3 3% (LO 1.2, LO 1.3)
P 3.1 3% (LO 1.1, LO 1.3)
L 3.1 3% (LO 1.2, LO 1.3)
L 3.2 3% (LO 1.2, LO 1.3)
L 3.3 3% (LO 1.2, LO 1.3)
CMW1 20% (LO 1.1, LO 1.2, LO 1.3, LO 2.2))
L 1.1 5% (LO 2.2, P2.3, LO 2.4, LO 2.5)
L 2.1 5% (LO 2.2, P2.3, LO 2.4, LO 2.5)
L 2.2 5% (LO 2.2, P2.3, LO 2.4, LO 2.5)
PROJECT + BUSINESS GAME(CMW) 40% (LO 1.1, LO 1.2, LO 1.3, LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6)
Information about the results of assessment is available to the student on the site with the course content. The grades have lecturer's reviews with remarks and instructions.
Each task has a time limit for its completion.
The teacher conducts an evaluation of the tasks completed.
Defense and correction of the grade are done during the consultations and f2f sessions.
Didactic games are evaluated on the basis of self-analysis, analysis and expert evaluation of the teacher.
Project works are evaluated during open defenses: presentation and answers to questions.
Consultations are planned in a weekly course schedule, implemented both virtually and f2f.
Contact details of the teacher are presented in the course as an e-mail address.

Rating scale

<table>
<tr><th>Рейтингова оцінка</th><th>Оцінка за шкалою ECTS</th><th>Іспит</th><th>Національна залікова оцінка</th></tr>
<tr><td>90–100</td><td>A (outstanding performance without errors)</td><td>excellent/відмінно</td><td rowspan="5">evaluated/ зараховано</td></tr>
<tr><td>83–89</td><td>B (above the average standard but with minor errors)</td><td rowspan="2">good/добре</td></tr>
<tr><td>75–82</td><td>C (generally sound work with some errors)</td></tr>
<tr><td>63–74</td><td>D (fair but with significant shortcomings)</td><td rowspan="2">satisfactorily /задовільно</td></tr>
<tr><td>50–62</td><td>E (performance meets the minimum criteria)</td></tr>
<tr><td>21–49</td><td>FX (Fail – some more work required before the credit can be awarded)</td><td rowspan="2">unsatisfactorily /незадовільно</td><td>not evaluated (with the possibility of re-assembly)/ не зараховано (з можливістю повторного складання)</td></tr>
<tr><td>0–20</td><td>F (Fail – considerable further work is required)</td><td>not evaluated (without the possibility of re-assembly)/ не зараховано</td></tr>
</table>

2. COURSE CONTENT AND STRUCTURE

Content for full-time and part-time study

Names of content modules and topics	Number of hours											
	full-time form						part-time form					
	total	including					total	including				
		l	p	lab	ind	self.		l	p	lab	ind	self.
1	2	3	4	5	6	7	8	9	10	11	12	13
Module 1 Formation of computational thinking at school with the help of 3D modeling and robotics.												
Topic 1. General concept of developmental learning for the organization of learning with the use of 3D printers and robotics	10	2	2			6	10	2				8
Topic 2. Research, development and implementation of innovative pedagogical technologies in the educational process during the study of 3D modeling and 3D printers.	28	6	2	6		14	28	2				26
Topic 3. Research, development and implementation of innovative pedagogical technologies in the educational process during the learning of robotics	30	6	2	6		16	30	2		2		26
Total for module 1	68	14	6	12		36	68	6		2		60
Module 2 STEAM												
Topic 1. STEAM education..	18	2		2		14	18					18
Topic 2. Pedagogical design of a digital STEAM course.	22	4		2		16	22	2				20
Topic 3. Development of a digital course (project work).	42			18		24	42			8		34
Total for module 2	82	6		22		54	82	2		8		72
Total hours	**150**	20	6	34		90	150	8		10		132

2.1. Module 1. Formation of computational thinking at school with the help of 3D modeling and robotics.

2.1.1. Topic 1. General concept of developmental learning for the organization of learning with the use of 3D printers and robotics.

Aims and expected learning outcomes.

Aims:

Give information about the theoretical principles and methodology of developmental learning and constructivism, create conditions for the ability of students to use methodological and theoretical principles of developmental learning and constructivism in their own research, formulate theoretical principles of organization of educational process using 3D printers and robotics based on computational thinking, analyze conditions and describe their own methods for organizing developmental learning, motivate students to active learning in the course.

After finishing the topic, students should understand the basic paradigms of the course, have their own ideas about opportunities of 3D printing and robotics for developmental learning and have the prerequisites for their own research on the subject.

Criteria and forms for evaluating learning outcomes on the topic.

Form of evaluation – check of the completed tasks of the practical lesson.

Evaluation criteria:

- knowledge of theoretical principles and methodology of developmental learning and constructivism;
- search and analytical skills;
- knowledge of the content design principles for the school course of computer science;
- ability to predict, plan and design educational activities.

Levels:

excellent:

- student generates new ideas for the studying of 3D modeling and robotics and finds ways to effectively implement them in educational practice;
- independently conducts search and analytical activity;
- performs the tasks of the practical lesson with high quality.

satisfactory:

- student together with others generates new ideas for the studying of 3D modeling and robotics and finds ways to effectively implement them in educational practice;
- mostly independently conducts search and analytical activity;
- performs all the tasks of the practical lesson.

bare minimum:

- student only implements new ideas for the studying of 3D modeling and robotics and finds ways to effectively implement them in educational practice;
- conducts search and analytical activity with external assistance;
- performs almost all the tasks.

Digital tools.

Class of creative training: projector, multimedia chart, multimedia presentation, Python Turtle module.

Innovative learning technologies.

IBL - inquiry based learning, research learning.

Study of the topic also includes the use of connectivist methods, open discussion on the possibilities of 3D printing and robotics for developmental learning, research experiment during the lecture.

Lecture 1. General concept of developmental learning for the organization of learning with the use of 3D printers and robotics.

Topic: General concept of developmental learning for the organization of learning with the use of 3D printers and robotics. (*2 hours*)

Aims: to update the knowledge of the bachelor's degree in the theory of developmental learning; to outline the research objectives of the course.

Plan

1. Developmental learning (actualization of knowledge).
2. Postulates of constructivism theory.
3. Example of educational tasks on constructivism.

The feature of the lecture is the use of IBL, a joint research activity of the teacher and the students during the demonstration of different algorithms for performers.

The scheme of research of algorithms is as follows:

- orientation in the problematics;
- formulation of research questions and hypotheses;
- hypothesis research;
- analysis of research results.

Students at the lecture are invited to suggest changes in algorithms for the construction of various objects

Practical lesson 1. Analysis of curricula in computer science of general secondary education institutions, research of conditions and planning of studying 3D graphics and robotics at school. (*2 hours*)

Task: Based on the content analysis of the school course of computer science, investigate the opportunities for the implementation of STEAM-lesson on 3D modeling in high school. Suggest your own scheme for studying this topic.

Tasks for independent work.

Update knowledge of developmental learning, learn the main works of S. Papert, participate in discussions about developmental learning.

Methodological materials and instructions.

During the learning it's recommended to pay attention to the independent search for information on this topic.

The following information deserves special attention:

- experience of Massachusetts University of Technology (MUT) in using digital solutions for developmental learning;
- LEGO education experience.

2.1.2. Topic 2. Research, development and implementation of innovative pedagogical technologies in the educational process during the study of 3D modeling and 3D printers.

Aims and expected learning outcomes.

Aims - to form research skills of pedagogical design on the basis of modern achievements of the use of 3D printers in education; to show students' ability to analyze existing conditions for determination of appropriate methods and tools for studying 3D printers at school; to have the appropriate level of using hardware and software, to make a comparative analysis of their effectiveness in the educational process of secondary education institution.

Criteria and forms for evaluating learning outcomes on the topic.

Form of evaluation – check of the completed tasks of the practical lesson, defense of laboratory works.

Evaluation criteria:

- skills of research pedagogical activity on the topic;
- ability to transform knowledge of 3D modeling and machine graphics into pedagogical scenarios and creative tasks;
- ability to implement theoretical principles of constructivism in methods of learning 3D modeling at school;
- ability to analyze and independently find solutions for the use of special software for 3D modeling and 3D printing;
- ability to use a school mathematics course to form tasks on 3D modeling and 3D printing.

Levels:

excellent:

- student generates new ideas for learning 3D modeling and finds ways to effectively implement them in educational practice;
- independently conducts research activity on the subject;
- qualitatively performs tasks, actively participates in discussions, substantiates the advantages of their own judgments;
- demonstrates a professional level of knowledge of used hardware and software;
- sees prospects for further research on the subject, in particular some points in their own master's research.

satisfactory:

- student together with others generates new ideas for learning 3D modeling and finds ways to effectively implement them in educational practice;
- mainly independently conducts research activity on the topic;
- performs all the tasks on time, participates in discussions;
- demonstrates a satisfactory level of knowledge of used hardware and software;
- sees some prospects for further research on the topic, but does not fully formulate them.

bare minimum:

- student only implements new ideas of learning 3D modeling and finds ways to effectively implement them in educational practice;
- conducts research activity on the topic with external assistance;
- performs almost all the tasks;
- demonstrates a low level of knowledge of used hardware and software.

Digital tools.

LMS Moodle.
Blender.

Tinkercad.
GeoGebra.
Python + Turtle.
XYZPrinting.

Innovative learning technologies.

Research learning technology.
Problem-based learning technology.
Interactive learning technology.
Developmental learning technology.
Based on theoretical principles of constructivism learning technology.
Team work, work in groups learning technology.
Formation of computational thinking technology.

Lecture 2. The system of formation of computational thinking as an element of students' digital competence with the help of 3D modeling and developmental learning.

Topic: The system of formation of computational thinking as an element of students' digital competence with the help of 3D modeling and developmental learning. (*2 hours*)
Aims: to give information about a new scientific trend; to determine its research opportunities for the course.
Plan
1. Computational thinking approach.
2. Computational thinking and 3D modeling.
3. Computational thinking as the element of students' digital competence.

Lecture 3. Use of Blender.

Topic: Use of Blender. (*2 hours*)
Aims: to give information about the features of Blender for performing computational thinking tasks.
Plan
1. General information about Blender.
2. Use of addons and filters with mathematical functions.
3. Use of Python scripts.

Lecture 4. Use of hardware and software tools for 3D printing.

Topic: Use of hardware and software tools for 3D printing. (*2 hours*)
Aims: to give information about a methodology of the organization of lessons in innovative classrooms.
Plan
1. Preparing the printer for the work.
2. Quality check of 3D model.
3. The printing process.

Practical lesson 2. Development of 3D modeling methods at school using theoretical principles of constructivism

Topic: Development of 3D modeling methods at school using theoretical principles of constructivism. (2 hours)
Task: Using the scheme example develop a methodology of educational activity with the use of

innovative technologies.

Laboratory work 1. Developmental learning in the process of building a 3D model.

Topic: Developmental learning in the process of building a 3D model. (2 hours)
Task: Implement tasks from your own methodical scheme in Blender.

Laboratory work 2. Use of mathematical addons and filters in the learning of 3D modeling.

Topic: Use of mathematical addons and filters in the learning of 3D modeling. (2 hours)
Task: Develop a methodology of using mathematical addons and filters using computational thinking approaches.

Laboratory work 3. Software implementation of 3D model and printing.

Topic: Software implementation of 3D model and printing. (2 hours)
Task: Develop a methodology for creating a 3D map.

Topics of individual and / or group tasks.

Modeling a real 3D object (for example, a LEGO constructor element - using tools of the modeling environment, in real size and with the help of scripts)

Modeling a three-dimensional terrain map based on an orographic 2D terrain map.

Tasks for independent work.

Learning and comparison of different software.

Methodological materials and instructions.

When studying this topic, it's recommended to pay attention to independent learning of the features of existing hardware and software for organizing creative activities of students.

It is also advised to consider the opportunities of using mathematical competencies of students in the process of learning 3D modeling

2.1.3. Topic 3. Research, development and implementation of innovative pedagogical technologies in the educational process during the learning of robotics.

Aims and expected learning outcomes.

Aims - to form students' research skills of pedagogical design on the basis of modern achievements in the use of educational robots in education, to identify students' ability to analyze existing conditions, to determine appropriate methods and tools for studying robotics at school, to fluently use technical and software, to make comparative efficiency analysis of their use in the educational process in secondary education institutions.

Criteria and forms for evaluating learning outcomes on the topic.

Form of evaluation – check of the completed tasks of practical training, defense of laboratory work.

Evaluation criteria:

- skills of research pedagogical activity on the topic;

- ability to transform acquired knowledge on robotics into pedagogical scenarios and creative tasks;
- ability to implement theoretical principles of constructivism in methods of learning robotics at school;
- ability to analyze and independently find solutions for the use of special software for operating educational robots;
- ability to use the school course of computer science and mathematics for the formation of tasks in robotics.

Levels:

excellent:

- student generates new ideas for learning robotics and finds ways to effectively implement them in educational practice;
- independently conducts research activity on the subject;
- qualitatively performs tasks, actively participates in discussions, substantiates the advantages of their own judgments;
- demonstrates a professional level of knowledge of used hardware and software;
- sees prospects for further research on the subject, in particular some points in their own master's research.

satisfactory:

- student together with others generates new ideas for learning robotics and finds ways to effectively implement them in educational practice;
- mainly independently conducts research activity on the subject;
- performs all the tasks, participates in discussions;
- demonstrates a satisfactory level of knowledge of used hardware and software;
- sees some prospects for further research on the topic, but does not fully formulate them.

bare minimum:

- student only implements new ideas of learning robotics and finds ways to effectively implement them in educational practice;
- conducts research activity on the topic with external assistance;
- performs almost all the tasks;
- demonstrates a low level of knowledge of used hardware and software.

Digital tools.

S Makeblock mBot.
S Makeblock Ultimate.
S LEGO Mindstorms EV3.
Turtle module of Python language.
Scratch.
LMS Moodle.

Innovative learning technologies.

Research learning technology.
Problem-based learning technology.
Developmental learning technology.
Interactive learning technology.
Theoretical principles of constructivism learning technology.
Team work, work in groups learning technology.
Computational thinking formation technology.

Lecture 5. Formation of basic programming competencies in the school course of computer science.

Topic: Formation of basic programming competencies in the school course of computer science. (*2 hours*)
Aims: to give information about innovative methods of forming basic programming competencies.
Plan
1. Formation of students' basic programming competencies.
2. Interactive and game methods.
3. Examples of tasks.

Lecture 6. The system of forming computational thinking as the element of students' digital competence with the help of educational robots.

Topic: The system of forming computational thinking as the element of students' digital competence with the help of educational robots. (*2 hours*)
Aims: to give information about modern features of educational robotics.
Plan:
1. How to organize a robot assembly?
2. Movement of the robot.
3. Sensors of the robot, opportunity to form an understanding of programming methodologies.

Lecture 7. Methodology of creating research tasks for operating robots.

Topic: Methodology of creating research tasks for operating robots. (*2 hours*)
Aims: to give information about a methodology of creating the research tasks for operating robots.
Plan:
1. Methodical scheme of creating tasks for operating robots.
2. Use of heuristics.
3. Research objectives of operating robots.

Practical lesson 3. Creation of a pedagogical scenario for robot control with the use of computational thinking and constructivism..

Topic: Creation of a pedagogical scenario for robot control with the use of computational thinking and constructivism. (*2 hours*)

Laboratory work 4. Pedagogical construction of methods for learning the simplest algorithms for performers.

Topic: Pedagogical construction of methods for learning the simplest algorithms for performers. (*2 hours*)

Laboratory work 5. Pedagogical construction of methods for learning cycle and branching algorithms.

Topic: Pedagogical construction of methods for learning cycle and branching algorithms. (*2 hours*)

Laboratory work 6. Algorithm for operating robot, event response and sensor usage.

Topic: Algorithm for operating robot, event response and sensor usage. (*2 hours*)

Topics of individual and / or group tasks.

Modeling the behavior of the gaming robot in standard situations.

Tasks for independent work.

Conduct a comparative analysis of the programming language LOGO, Scratch, Turtle and software tools for programming robots Makeblock mBot, Makeblock Ultimate, LEGO Mindstorms EV3.

Methodological materials and instructions.

The following information deserves special attention:

- experience of Massachusetts University of Technology (MUT) in using digital solutions for developmental learning;
- experience of «LEGO education».

2.2. Module 2. STEAM

2.2.1. Topic 1. STEAM education.

Aims and expected learning outcomes.

Aims – to master the theoretical principles and methodology of STEAM education; to be able to analyze the conditions and describe own methods for organizing STEAM education; to master research methodology for creating a STEAM course, implementation of this course and research of its effectiveness on the theoretical level.

As a result, students should be able to develop the concept of a STEAM course, formulate the learning objective and choose learning activities to ensure the quality of such learning.

Criteria and forms for evaluating learning outcomes on the topic.

Evaluation criteria:

- skills of research pedagogical activity on the topic;
- ability to implement transdisciplinary principles in pedagogical scenarios of STEAM education;
- ability to implement theoretical principles of constructivism and developmental learning in STEAM education;
- ability to plan and design a STEAM course;
- skills to evaluate learning outcomes in a STEAM course.

Levels:

excellent:

- student generates new ideas in STEAM education and finds ways to implement them effectively in educational practice;
- independently conducts research activity on the subject;
- performs tasks qualitatively, actively participates in discussions, substantiates the advantages of their own judgments;
- demonstrates a professional level of pedagogical design of the concept, objective, teacher's and students' activities in a STEAM course;
- sees prospects for further research on the subject, in particular some points in the own master's research.

satisfactory:

- student together with others generates new ideas regarding STEAM education and finds ways to effectively implement them in educational practice;
- mostly independently conducts research activity on the subject;
- performs all the tasks, participates in discussions;
- demonstrates a satisfactory level of pedagogical construction of the concept, objective, teacher's and students' activities in a STEAM course;
- sees some prospects for further research on the topic, but does not fully formulate them.

bare minimum:

- student only implements new ideas regarding STEAM education and finds ways to effectively implement them in educational practice;
- conducts research activity on the topic with external assistance;
- performs almost all the tasks;
- demonstrates a low level of pedagogical construction of the concept, objective, teacher's and students' activities in a STEAM course.

Digital tools.

Classroom of creative training: projector, multimedia chart.

Innovative learning technologies.

Research learning technology.
Problem-based learning technology.
Interactive learning technology.
Transdisciplinary learning technology.
Developmental learning technology.
Theoretical principles of constructivism learning technology.
Formation of computational thinking technology.

Lecture 8. Paradigms of STEAM education.

Topic: Paradigms of STEAM education. (*2 hours*)
Aims: to give information about the paradigms of STEAM education in order make them understand the research opportunities of pedagogical design of digital learning content.
Plan

1. Paradigms of STEAM education.
2. Criteria of an effective STEAM course.

Laboratory work 7. Development of the concept, objective and learning outcomes of a STEAM course.

Topic: Development of the concept, objective and learning outcomes of a STEAM course. (*2 hours*)

Topics of individual and / or group tasks.

Group work for everyone: development of an oriented concept, planning and designing of activities in a STEAM course on the topic of "3D modeling of a real object" during laboratory work (workshop). Skills of creating a course for the selected topic are formed.

Tasks for independent work.

Conduct research work on the peculiarities of implementation of STEAM education in the world.

Methodological materials and instructions.

When analyzing the world experience, it's necessary to pay attention to how the conditions for the implementation of STEAM education are created. If there is a desire, try to formulate ways of further action at the level of Ukraine, region, school for further development of STEAM education.

2.2.2. Topic 2. Pedagogical design of a digital STEAM course.

Aims and expected learning outcomes.

Aims - to form students 'research skills of pedagogical design of a STEAM course, to show students' ability to analyze existing conditions and determine appropriate effective methods for designing a STEAM course, to acquire skills to implement ideas of developmental learning, constructivism in a STEAM course, skills to implement creative tasks in a STEAM course on 3D modeling and robotics.

Criteria and forms for evaluating learning outcomes on the topic.

Evaluation criteria:

- knowledge of paradigms of STEAM education;
- ability to develop requirements for a STEAM course;
- ability to design teacher's and student's activities in a STEAM course;
- the quality of educational content, the relevance of tasks and their compliance with the paradigms of developmental learning and constructivism theory;
- ability to design educational tasks on 3D modeling;
- ability to design educational tasks in robotics;
- ability to create rubrics for assessing learning outcomes of a STEAM course.

Levels:

excellent:

- student generates new ideas for STEAM education and finds ways to effectively implement them in educational practice;
- independently conducts research activity on the topic, determines the requirements for the implementation of STEAM course;
- independently creates elements of a STEAM course with high quality: learning content, tasks, tools and criteria of evaluation;
- qualitatively performs the tasks, actively participates in discussions, substantiates the advantages of their own judgments;
- demonstrates a professional level of pedagogical design of the concept, objective, activities of teachers and students in a STEAM course;
- sees prospects for further research on the topic, in particular some points in their own master's research.

satisfactory:

- student together with others generates new ideas for STEAM education and finds ways to effectively implement them in educational practice;
- mainly independently conducts research activity on the topic, determines the requirements for the implementation of STEAM course;
- mainly independently creates elements of a STEAM course: learning content, tasks, tools and criteria of evaluation;
- performs all the tasks, participates in discussions;
- demonstrates a satisfactory level of pedagogical design of the concept, objective, activities of teachers and students in a STEAM course;

- sees some prospects for further research on the topic, but does not fully formulate them.

bare minimum:

- student only implements new ideas for STEAM education and finds ways to effectively implement them in educational practice;
- conducts research activity on the topic with external assistance;
- creates elements of a STEAM course with external assistance: learning content, tasks, tools and criteria of evaluation;
- performs almost all the tasks;
- demonstrates a low level of pedagogical design of the concept, objective, activities of teachers and students in a STEAM course.

Digital tools.

LMS Moodle.
Blender
Tinkercad
GeoGebra
Python + Turtle
XYZPrinting
P Makeblock mBot
P Makeblock Ultimate
P LEGO Mindstorms EV3
Turtle module of Python language
Scratch

Innovative learning technologies.

Research learning technology.
Problem-based learning technology.
Interactive learning technology.
Transdisciplinary learning technology.
Developmental learning technology.
Theoretical principles of constructivism learning technology.
Formation of computational thinking technology.

Lecture 9. Prediction of learning outcomes for STEAM course.

Topic: Prediction of learning outcomes for a STEAM course. (*2 hours*)
Aims: to give information about the methodology of formulating learning outcomes for a STEAM course.
Plan
1. Bloom's taxonomy.
2. Development of expected learning outcomes.
3. Example.

Lecture 10. Development of a digital STEAM course and research of its effectiveness.

Topic: Development of a digital STEAM course and research of its effectiveness. (*2 hours*)
Aims: to give information about basic theoretical knowledge of digital course development.
Plan
1. Design of teacher and student activities.
2. Modeling a STEAM lesson.

3. Example of a STEAM lesson development.

Laboratory work 8. Implementation of tools and rubrics for evaluating learning outcomes of a STEAM course.

Topic: Implementation of tools and rubrics for evaluating learning outcomes of a STEAM course. (*2 hours*)

Laboratory work 9. Development of content for a STEAM course.

Topic: Development of content for a STEAM course. (*2 hours*)
Development of STEAM course according to the scheme.

Topics of individual and / or group tasks.

Group work for everyone: development of tools and rubrics for evaluating learning outcomes and content of a STEAM course on "3D modeling of a real object" during laboratory work (workshop). Skills to create a course for the selected topic are formed.

Tasks for independent work.

Conduct research work on existing digital courses in 3D modeling with different software and conduct a comparative analysis.

Methodological materials and instructions.

When analyzing various software tools, it's recommended to pay attention to their didactic features and accessibility for students.

2.2.3. Topic 3. Development of a digital course (project work).

Aims and expected learning outcomes.

Aims - to form students' practical skills of pedagogical design of STEAM course, ability to create own high-quality content of a STEAM course in a team, to acquire skills of implementing ideas of developmental learning, constructivism in a STEAM course, to acquire skills of implementing creative tasks in a STEAM course on 3D modeling and robotics.

Criteria and forms for evaluating learning outcomes on the topic.

Evaluation criteria:

- quality and completeness of methodological developments for the course;
- ability to work in a team;
- quality of planning the objective, learning outcomes and structure of the course;
- level of application of the innovative pedagogical technologies;
- quality of educational content, relevance of educational tasks and their compliance with the paradigms of developmental learning and the theory of constructivism;
- quality of 3D modeling tasks;
- quality of tasks in robotics;
- level of research and analytical activity.

Levels:

excellent:

- student generates new ideas for STEAM education and finds ways to effectively implement them in educational practice;
- acts as a leader in the team, organizes research activity on the topic;

- coordinates the creation of elements of the STEAM course in the team with high quality: educational content, tasks, tools and evaluation criteria;
- demonstrates a professional level of pedagogical design of the STEAM course, the relevance of educational tasks in 3D modeling, robotics and their compliance with the paradigms of developmental learning and the theory of constructivism;
- sees prospects for further research on the topic, in particular some points in their own master's research.

satisfactory:

- student generates new ideas for STEAM education and finds ways to effectively implement them in educational practice;
- acts as a leader in the team, organizes research activity on the specific area;
- takes active part in creating elements of the STEAM course: educational content, tasks, tools and evaluation criteria;
- demonstrates a satisfactory level of pedagogical design of the STEAM course, the relevance of educational tasks in 3D modeling, robotics and their compliance with the paradigms of developmental learning and the theory of constructivism;
- sees some prospects for further research on the topic, in particular some points in their own master's research.

bare minimum:

- student only implements new ideas for STEAM education and finds ways to effectively implement them in educational practice;
- conducts research activity on the subject with external assistance;
- creates elements of the STEAM course in a team with external assistance: educational content, tasks, tools and evaluation criteriaя;
- performs almost all the tasks.

Digital tools.

LMS Moodle.
Blender.
Tinkercad.
GeoGebra.
Python + Turtle.
XYZPrinting.
P Makeblock mBot.
P Makeblock Ultimate.
P LEGO Mindstorms EV3.
Turtle module of Python language.
Scratch.

Innovative learning technologies.

Research learning technology.
Transdisciplinary learning technology.
Developmental learning technology.
Theoretical principles of constructivism learning technology.
Formation of computational thinking technology.

Laboratory work 10. Development of a digital training course (three teams - three courses).

Topic: Development of a digital training course (three teams - three courses). (10 hours)

Topics of individual and / or group tasks.

Each group develops a digital STEAM course on a selected topic. Skills to create a STEAM course are formed.

Tasks for independent work.

Conduct research work on finding content for the course, make educational videos, analyze the requirements for the course, formulate criteria and assessment tools for the possibility of more effective work in the classroom.

Methodological materials and instructions.

When developing a course, attention should be paid to the ways of assessing learning outcomes.

2.2.4. Topic 4. Implementation of a pedagogical scenario, analysis of results, research of effectiveness of the developed digital course.

Aims and expected learning outcomes.

Aims - to form students' practical skills of STEAM course implementation, the ability to analyze and evaluate the learning outcomes in that course, the ability to analyze and determine ways for improvement and further research.

Criteria and forms for evaluating learning outcomes on the topic.

Evaluation criteria:

- quality of pedagogical scenario;
- quality of planning the objective, tasks and structure of the course;
- level of application of the newest pedagogical technologies;
- knowledge of actual material;
- ability to implement own project;
- quality of educational content, relevance of educational tasks and compliance with the paradigm of developmental learning;
- ability of self-analysis and analysis of the conducted lessons;
- quality of application of problem-based and developmental methods;
- activity during a business game.

Levels:

excellent:

- student generates new ideas for STEAM education and finds ways to effectively implement them in educational practice;
- conducts self-analysis, analysis of the effectiveness of implementation of the real STEAM course at a high level;
- demonstrates a professional level of application of the newest pedagogical technologies;
- sees prospects for further research on the topic, in particular some points in their own master's research.

satisfactory:

- student conducts self-analysis, analysis of the effectiveness of implementation of the real STEAM course at a satisfactory level;
- demonstrates a satisfactory level of application of the newest pedagogical technologies;
- sees prospects for further research on the topic, in particular some points in their own master's research.

bare minimum:

- student conducts self-analysis, analysis of the effectiveness of implementation of the real STEAM course;
- demonstrates a low level of application of the newest pedagogical technologies.

Digital tools.

LMS Moodle.
Blender.
Tinkercad.
GeoGebra.
Python + Turtle.
XYZPrinting.
P Makeblock mBot.
P Makeblock Ultimate.
P LEGO Mindstorms EV3.
Turtle module of Python language.
Scratch.

Innovative learning technologies.

Research learning technology.
Project learning technology.
Interactive learning technology.
Teamwork and formation of leadership qualities technology.
Peer-to-peer evaluation of learning outcomes technology.
Transdisciplinary learning technology.
Developmental learning technology.
Theoretical principles of constructivism learning technology.
Formation of computational thinking technology.

Laboratory work 11. Role-playing didactic game.

Topic: Role-playing didactic game. (6 hours).
Three teams implement the digital course developed in topic 3, there are three lessons: one team acts as teachers, the other two act as students. Upon completion: self-analysis, analysis, discussion, results and suggestions.

Topics of individual and / or group tasks.

Each group implements their own course and studies the course of another team as a student. Skills of self-analysis and quality analysis of STEAM course and its implementation are formed.

Tasks for independent work.

Search the Internet and master the following topics:
1. Introduction to the LEGO® Mindstorms® Education set. Review of electronic and mechanical components.
2. Software review.
3. Basics of robot programming.
4. Learning the structure and principles of programming sensors of the set;
5. Learning complex algorithmic constructions;
6. Work with mathematical operations and variables;
7. Interaction of robots with each other via Bluetooth;
8. Data registration;

9. Learning the structure and principles of programming additional sensors (temperature, infrared, remote control);
10. Construction and programming of multisensor robot with manipulator;
11. Developing the lesson based on the existing robot.
12. Developing the lesson based on your own model.

Methodological materials and instructions.

When implementing the course, attention should be paid to the introduction of theoretical principles of theories of constructivism and developmental learning.

2.3. TASKS FOR THE FINAL ASSESSMENT

2.3.1. List of questions for the final assessment.

1. General concept of developmental learning for the organization of learning with the use of 3D printers and robotics.
2. Research, development and implementation of innovative pedagogical technologies in the educational process during the study of 3D modeling and 3D printers.
3. Research, development and implementation of innovative pedagogical technologies in the educational process during the learning of robotics.
4. Use of Blender.
5. Use of hardware and software tools for 3D printing.
6. Research, development and implementation of innovative pedagogical technologies in the educational process when studying robotics.
7. Formation of basic programming competencies in the school course of computer science.
8. The system of forming computational thinking as the element of students' digital competence with the help of an educational robot.
9. Methodology of creating research tasks for operating robots.
10. STEAM education.
11. Pedagogical design of a digital STEAM course.
12. Development of a digital course (project work).
13. Implementation of a pedagogical scenario, analysis of results, research of effectiveness of the developed digital course.

2.3.2. The order of carrying out the final assessment.

The final assessment takes place according to the semester accumulation system.

3. LIST OF RECOMMENDED LITERATURE

Main:

1. Пейперт С. Переворот в сознании: Дети, компьютеры и плодотворные идеи: Пер. с англ./Под ред. А. В. Беляевой, В. В. Леонаса.—М.: Педагогика, 1989.— 224 с.
2. Роджерс Д.Ф. Алгоритмические основы машинной графики. (Procedural Elements for Computer Graphics) / Учебное издание. Перевод с английского С.А. Вичеса, Г.В. Олохтоновой, П.А. Монахова под редакцией Ю.М. Банковского, В.А. Галактионова. - М.: Издательство «Мир»1989.
3. Н.В. Морзе, Л.О. Варченко-Троценко, М.А. Гладун, Основи робототехніки: навчальний посібник / Н.В. Морзе, Л.О. Варченко- Троценко, М.А. Гладун. – Кам'янець-Подільський : ПП Буйницький О.А., 2016. – 184 с.
4. Шахинпур М. Курс робототехники. Пер. с англ. М.: Мир, 1990. — 527 с.
5. Briggs J. R. Python for kids: A playful introduction to programming. – no starch press, 2013.
6. Michael Gasperi. Extreme NXT: Extending the LEGO Mindstorms NXT to the Next Level, 2007. – 312 Pages.
7. Martijn Boogaarts. The LEGO Mindstorms NXT Idea Book: Design, Invent, and Build, 2007. - 344 Pages.
8. Bishop O. Programming Lego Mindstorms NXT [текст] / Owen Bishop. - Rockland : Syngress Publishing, Inc, 2008. - 198 p.
9. Ferrari M. Building Robots with LEGO Mindstorms NXT [текст] / Mario Ferrari, Guilio Ferrari, Ralph Hempel. - Rockland : Syngress Publishing, Inc, 2007. - 480 p.
10. Griffin T. Art of LEGO MINDSTORMS NXT-G Programming [текст] / T. Griffin. - San Francisco : No Starch Press, 2010. – 288 p.
11. Hestad D. Building LEGO Robots For First LEGO League [текст] / D. Hested. – Manchester : INSciTE, 2002. – 91 p. 5. Isogawa J. LEGO Technic Idea Book: Simple Machines [текст] / J. Isogawa. - San Francisco : No Starch Press, 2010. – 168 p.
12. LEGO Mindstorms EV3 [Електронний ресурс] – Режим доступу : https://www.lego.com/ruru/mindstorms/learn-to-program.

Additional:

1. Пейперт С. Переворот в сознании: Дети, компьютеры и плодотворные идеи: Пер. с англ./Под ред. А. В. Беляевой, В. В. Леонаса.—М.: Педагогика, 1989.— 224 с.
2. Роджерс Д.Ф. Алгоритмические основы машинной графики. (Procedural Elements for Computer Graphics) / Учебное издание. Перевод с английского С.А. Вичеса, Г.В. Олохтоновой, П.А. Монахова под редакцией Ю.М. Банковского, В.А. Галактионова. - М.: Издательство «Мир»1989.
3. Briggs J. R. Python for kids: A playful introduction to programming. – no starch press, 2013.

Other:

1. www.legoeducation.com
2. www.lego.com/education
3. www.prolego.com.ua
4. www.ni.com/
5. Google's Cloud Robotics – YouTube. URL:

https://www.youtube.com/watch?time_continue=9&v=eo8MzGIYGzs
6. Official site of Lego Engineering [Electronic resource]. — Available at: \www/URL: http://www.legoengineering.com/
7. Официальный сайт конструктора Lego Mindstorms NXT [Электронный ресурс]. — Режим доступа: \www/URL: http://www. lego.com/ru-ru/mindstorms/default.aspx?domainredir=www. mindstorms.com&ignorereferer=true