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Modernization of Pedagogical Higher Education by Innovative Teaching Instruments

CONCEPT COURSE[1]

HIGHER EDUCATION INSTITUTION		Luhansk Taras Shevchenko National University
Institute (faculty), department or other structural unit conducting the course		Institute of Physics, Mathematics and Information Technologies of Luhansk Taras Shevchenko National University, Department of Information Technologies and Systems.
DESCRIPTION OF THE EDUCATIONAL DISCIPLINE		
1	Course name	Formation of computational thinking at school with the help of 3D modeling and robotics
2	Module code	[18COM611]
3	Cycle/level of higher education	Ukraine NQF – 7th level, FQ-EHEA – 2nd cycle, EQF-LLL – 7th level
4	Degree	Master's degree
5	Branch of knowledge, training direction	01 «Education», 014 «Secondary education»
6	Specialty, specialization (if any)	014.04 Secondary education (Mathematics)
7	Name of the educational program, which includes the course	014.04 Mathematics. Second level of higher education
8	Educational qualification	Master of secondary education (Mathematics), teacher of mathematics, teacher of higher education institutions
9	Characteristic of the course by the form of study	Full-time, part-time (with the use of digital learning technologies).
10	Status of the course	Compulsory (014.04 Mathematics), elective (for other specialties)

[1]* *Європейська Комісія підтримує створення цієї публікації, яка відображає лише погляди авторів. Комісія не несе відповідальності за будь-яке використання інформації, що в ній міститься.*

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11	Prerequisites for the course	Completed courses: computer science, physics, higher mathematics, programming, pedagogy, psychology, school course of computer science and teaching methods.
12	Year of study, semester	1st year, 2nd semester.
13	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.
14	Form of the final evaluation	Exam.
15	Study language	Ukrainian, English
16	Internet address of the permanent placement of course educational content	http://do.luguniv.edu.ua/course/view.php?id=26709
17	Developer(s), working group (members)	Hennadii Mohylnyi, Mykola Semenov, Volodymyr Donchenko

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 concepts:

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

Course Objective:	
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.	
Program competencies formed during the course	
Integral competency (IC)	Ability to create and implement pedagogical technologies based on the use of 3D modeling in teaching in STEAM.
General competencies (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) competencies (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.
Intended learning outcomes	
Intended learning outcomes [2]	**Forms and methods of assessment[3]**
ILO 1.1 Knowledge of the constructivism theory essence, developmental learning and STEAM technology.	self-assessment, peer assessment, expert assessment, tests laboratory, research work, design work, case-study
ILO 1.2 Knowledge of the technical features and software of 3D printers and robotics.	self-assessment, peer assessment, expert assessment, tests laboratory, research work, design work, case-study

[2] Національна рамка кваліфікацій. Додаток до постанови Кабінету Міністрів України від 23 листопада 2011 р. № 1341 (в редакції постанови Кабінету Міністрів України від 25 червня 2020 р. № 519). Режим доступу: https://zakon.rada.gov.ua/laws/show/1341-2011-%D0%BF/paran12#n12

[3] Підсумкова оцінка (ПО1, ПО2…); формувальне оцінювання (ФО1, ФО2…).

ILO 1.3 Knowledge of the principles of 3D printers application and robotics in the educational process.	self-assessment, peer assessment, expert assessment, tests laboratory, research work, design work, case-study
ILO 2.1 Provide effective support during STEAM education in 3D modeling and robotics.	self-assessment, peer assessment, expert assessment, tests laboratory, research work, design work, case-study
ILO 2.2 Identify the opportunities and features for the organization of STEAM learning in 3D modeling and robotics in real conditions.	self-assessment, peer assessment, expert assessment, tests laboratory, research work, design work, case-study
ILO 2.3 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.	self-assessment, peer assessment, expert assessment, tests laboratory, research work, design work, case-study
ILO 2.4 Understand the effectiveness of using different tools for the use of 3D printers and robotics in the learning process.	self-assessment, peer assessment, expert assessment, tests laboratory, research work, design work, case-study
ILO 2.5 Conceptualize, develop and implement a research project to evaluate students' achievements in STEAM learning.	self-assessment, peer assessment, expert assessment, tests laboratory, research work, design work, case-study
ILO 2.6 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.	self-assessment, peer assessment, expert assessment, tests laboratory, research work, design work, case-study
ILO 2.7 Organize and conduct STEAM learning in 3D modeling and robotics, achieving the quality of such learning with the	self-assessment, peer assessment, expert assessment, tests laboratory, research work, design work, case-study

use of a variety of software, technical and pedagogical solutions.	
Control of students' academic progress	
Tools to achieve learning outcomes	activity on didactic, role-playing game, practical lesson, laboratory work, project, control modular works (test and written work)
Summative assessment and feedback.	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) I Information about the results of assessment is available to the student on the site with the course content. T have lecturer's reviews with remarks and instructions. Each task has a time limit for its completion. The teacher an evaluation of the tasks completed. Defense and correction of the grade are done during the consultation sessions. Didactic games are evaluated on the basis of self-analysis, analysis and expert evaluation of the teache

	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.
Grading scale	

AMOUNT OF POINTS	ECTS Grade	GRADE ACCORDING TO NATIONAL SCALE	
		exam	test
90-100	A	excellent	pass
83-89	B	good	
75-82	C		
63-74	D	satisfactory	
50-62	E		
21-49	FX	fail	fail (possibility of retake)
0-20	F		fail (no possibility of retake)

The structure of the discipline

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

Course Program (content block)

Topic	Topics of seminars / practical / laboratory classes (if any)	Approximate topics for individual and / or group tasks (if any)	Tasks for individual work
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	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.	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.	Update knowledge of developmental learning, learn the main works of S. Papert, participate in discussions about developmental learning.

Topic 2. Research, development and implementation of innovative pedagogical technologies in the educational process during the study of 3D modeling and 3D printers.	Practical lesson 2. Development of 3D modeling methods at school using theoretical principles of constructivism. Laboratory work 1. Developmental learning in the process of building a 3D model. Topic: Developmental learning in the process of building a 3D model. Laboratory work 2. Use of mathematical addons and filters in the learning of 3D modeling.	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	Learning and comparison of different software.
Topic 3. Research, development and implementation of innovative pedagogical technologies in the educational process during the learning of robotics	Practical lesson 3. Creation of a pedagogical scenario for robot control with the use of computational thinking and constructivism. Laboratory work 4. Pedagogical construction of methods for learning the simplest algorithms for performers. Laboratory work 5. Pedagogical construction of methods for learning cycle and branching algorithms. Laboratory work 6. Algorithm for operating robot, event response and sensor usage.	Modeling the behavior of the gaming robot in standard situations	Conduct a comparative analysis of the programming language LOGO, Scratch, Turtle and software tools for programming robots Makeblock mBot, Makeblock Ultimate, LEGO Mindstorms EV3.
Module 2	STEAM		
Topic 1. STEAM education..	Laboratory work 7. Development of the concept, objective and learning outcomes of a STEAM course.	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).	Conduct research work on the peculiarities of implementation of STEAM education in the world.

		Skills of creating a course for the selected topic are formed.	
Topic 2. Pedagogical design of a digital STEAM course.	Laboratory work 8. Implementation of tools and rubrics for evaluating learning outcomes of a STEAM course. Laboratory work 9. Development of content for a STEAM course.	Each group develops a digital STEAM course on a selected topic. Skills to create a STEAM course are formed.	Conduct research work on existing 3D modeling digital courses with the use of different software and conduct a comparative analysis.
Topic 3. Development of a digital course (project work).	Laboratory work 10. Development of a digital training course (three teams - three courses) Laboratory work 11. Role-playing didactic game.	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.	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.

Technological and resource support used for a course (as needed))	
Use of opportunities of the innovation class as a component of the educational ecosystem MoPED	A class of creative training is used.
Recommended sources of information (including electronic resources)	**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/ruru/mindstorms/default.aspx?domainredir=www. mindstorms.com&ignorereferer=true
Internal quality assurance system of teaching the course	
Conducting student survey about the quality of teaching the course and the results of their success. Feedback from independent internal and external experts on the quality of teaching the course.	