Borys Gricnhenko Kyiv University

OPEN EDUCATIONAL E-ENVIRONMENT OF MODERN UNIVERSITY

Collected Scientific Works

Within the framework
of the international project IRNET

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INTRODUCTION OF STEAM EDUCATION WITH THE USE OF 3D TECHNOLOGIES: MODELLING, SCANNING AND PRINTING

Nothing in the world happens without innovations: new ideas, new products, and new solutions of the existing problems. Without science, technologies, engineering and STEM there will be no innovations. Development of STEM education has fundamental importance for development of modern information society. Even today in Ukraine the process of introduction of STEM and STEAM in education gains the increasing value. Training courses dealing with questions of the "Internet of Things", built-in systems and other directions of modern engineering take root in higher education institutions. An example of such training course is training of students of various specialties of 3D printing technology and formation of skills of the use of these technologies for the creation of own innovative projects within their

professional competences. Possibilities of the use of 3D printing in educational activity are presented in the article. The analysis of experience of STEM and STEAM education in other countries is carried out.

Key words: *3D printing, 3D model, STEM, STEAM, Wiki-portal, wiki-technology, DesIRE.*

Introduction

Modern society cannot exist without such way of thinking which basis is innovations and creativity, scientific researches and developments. Many successful businessmen of the whole world have experience with innovative technologies that helps them to create new successful business. And as the practice shows, the majority of them are familiar with standards of STEM education. For this reason today this direction of educational activity is perspective and actual.

Nobody knows the exact origin of STEM education. Its acronym has appeared only in the last 15–25 years. Since then this direction became a key factor in educational policy. As the experience shows, 75 % of professions of modern society demand STEM connected skills and knowledge.

The majority of STEM education researches are concentrated on mathematics and information technologies used for training in these directions. Society does not rest on its laurels, there are new technologies, innovations, therefore for development in the population, especially in youth, desire and abilities to pursue science and technologies, STEM education needs to be developed at school on the basis of formal and informal principles. Overcoming of "STEM gap" – the existence of a large number of free workplaces due to the shortage of skilled workers in education is the main task for the majority of countries of the world. Finland considers that if the young man at the exit from school already owns an actual stock of practical knowledge taking into account all modern computer technologies and skills of effective information search, then it is possible to expect that it will bring benefit not only to itself, but also to the state. Therefore it has been entered the experiment of teaching youth from 15 years not of separate sciences, but the professional courses having a direct bearing on real life (Open Education Network, 2015).

There is an opinion that STEM is too narrow direction. One of its alternatives, which becomes popular now is STEAM (science, technology, engineering, art and mathematics) which was sounded for the first time in 2006. G. Yakman is considered to be the foundress of this direction that expresses opinion that "The science and equipment are interpreted through engineering and art, all this occurs counting on mathematical elements" (Project STEAM Educators, 2016).

3D Technologies Training: Modeling, Scanning and Printing

STEAM education assumes except providing the subject and specific knowledge connected with development of deductive, inductive, and logical thinking - increase in creativity, development of critical thinking, flexibility, adaptability, social and cross-cultural skills connected with art. Thus STEAM education is directed to the creation of comprehensively developed experts who are STEM competent, creative and innovative. in South Korea the Ministry of Education, Science and Technology has already accepted STEAM education as a means to enhance students' interest in STEM subjects, and as a result of the promotion of science and technology in South Korean society (The Australian Council of Learned Academies, 2013).

The National Science Foundation (NSF) and The National Endowment for the Arts (NEA) in the USA after bilateral discussion have come to the opinion that the addition of art (A) to STEM is obviously not enough. in addition, it is necessary to add the skills of thinking embodied in reading and letter, therefore STEAM is transformed to STREAM. Literacy is an important component for science and technologies, experts have to be able to write projects and experiments, to make reports, to communicate and cooperate properly.

As shows the experience of Queensland (Australia), efforts on carrying out the reforms in the direction of STEM and STEAM education promote increase of scientific literacy and success of youth (McDonald, 2015). The researches show that studying in younger school can develop their computing thinking by means of the use of computer programming and robotics (McDonald, 2015). Mathematics gives an opportunity to school students to develop their skills of reasonings by the means of development of algebraic reasons (McDonald, 2015).

The combination of active training and practice under the leadership of the teacher is characteristic for Junior School with the use of STEM and STEAM education (*Figure 1*).

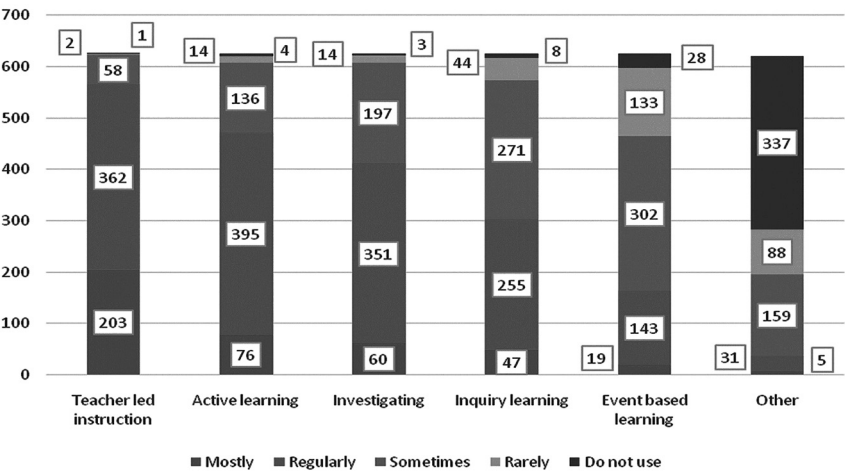Fig. 1. A combination of training and practice in Junior School of Queensland
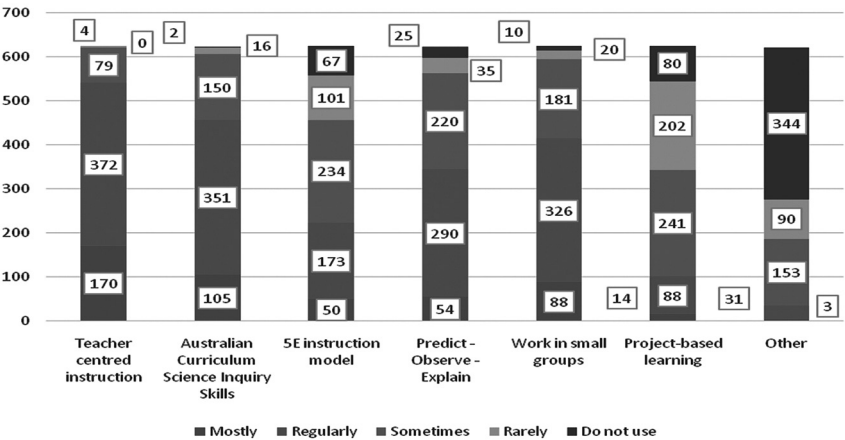(by the number of schools)

Fig. 2. Work in small groups in secondary and senior school of Queensland
(by the number of schools)

In secondary and senior school, the pupils work in small groups. Their task is to provide, observe and explain approach to any task of the teacher who carries out function of the observer (*Figure 2*).

STEM and STEAM in education provides motivations to studying, knowledge acquisition and abilities in practice a combination of aspects of science, technologies, mathematics, engineering and art. The principles of STREAM education are:

1. Practical integration of science and literacy: the model based on researches with the use of the instructions uniting a practical training, analysis, synthesis, lexicon, discussions and data management.

2. Possibility for training through scientific researches, reading, letter and the use of mathematical skills in a scientific context.

One of the questions, which causes keen interest in students of all specialties, is the use of 3D printing in educational process (in the context of combination scanning-design-printing). Characteristic feature of modern society is prompt development of IT industry, robotics, nanotechnologies, 3D printing and the Internet of Things, causes requirement to look for skilled experts on the world scene or at least the main skills of STEM and STEAM education in everyone. Software with an open source code allows to develop three-dimensional objects, and also to operate 3D printers for printing of the created objects. Material for the majority of modern 3D printers is biodegradable PLA plastic (polylactic acid) – environmentally friendly material received from cornstarch or ABS (acrylonitrile-butadiene-styrene) – polymer received from fossil fuel. Restrictions of the extent of printing object are the only restriction for this technology (depend on the printer and the size of a table for the printing of model). Big 3D model can be collected from several small plastic details.

It is possible to present the process of the embodiment of idea of 3D model and its printing by means of six simple steps:

– Creation of 3D model which we want to print (a stage of digital modeling).

– File storage of 3D model in STL format (.stl – Stereo Lithographic), containing all geometrical information necessary for display of digital model (stage export). Two previous steps are possible to be passed if to load already ready digital model from the Internet. If the model has been incorrectly designed or with not observance of grounds (a set of tops, edges and sides describing a form of many-sided object in 3D graphics and modeling), then it can have defects. For correction of defects, it is necessary to use the special program (stage of restoration of polygonal network or "mesh repairing").

– Transformation of digital model (technically it is a three-dimensional image of integral surface (grid) which centers are triangles)

in the command list - G-code which 3D-printer can understand and execute (stage of cutting or "slicing").

– Transfer through USB connection with PC or copying of 3D model ready file on a memory card, which will be read by the printer independently (connection stage).

– Start of 3D-printer, beginning of printing and expectation of the result (print).

– Removal of created object from a working platform, removal of accessories (resistance and / or raft – the supporting basis – if they are), cleaning of ready model surface (stage of final processing).

For today 3D printing in education still somewhat is novelty, is more used in engineering and physics, but creative application of 3D printing in biology and other sciences develops quickly. in education, 3D technologies can be applied for printing of the objects simulated on the basis of geometrical formulas for the best visualization of difficult structures. Design and production of 3D model as a prototype reduces time spent for development, production, estimates of result and correction of model defects (Lynch, 2015).

During 2016 in Borys Grinchenko Kyiv University it has been created the training program and corresponding methodology providing for introduction of the course "3D printing technologies" at the choice of students of different specialties in educational process with assistance of Tempus project 544091-TEMPUS-1-2013-1-BE-TEMPUS - JPCR for development of courses on built-in systems with the use of innovative virtual approaches for integration of science, education and industry in Ukraine, Georgia, Armenia. Before the course start it has been conducted the survey among students of the University and as it was revealed that studying of 3D printing technology has most interested students of the specialty "Primary Education" and "Design". The poll also has allowed to establish the main reasons for interest and to unite them in categories:

– Interest in innovative technologies for production.
– Application of 3D printing in various branches.
– Possibility of creation of new objects.
– Project work.
– Experience for future profession.
– Receiving of new knowledge.
– Practical skills.

Answering the questions of the questionnaire students have offered interesting options of the use of 3D printing technology – for historical

science, interior design, etc. On the basis of poll the program of training of additive technologies of students of different specialties has been developed (*Table 1*).

Table 1

Program of training course

Topic	Description
3D printers: basic concepts and types of printing	What is 3D printer and what are its types. 3D printing technology. Materials for 3D printing. Spheres of use of printing models. Novelties in the field of 3D printing
3D printing as a component of STEAM education	Importance of STEM and STEAM education, which provides motivation to studying in practice of synergy of science, technologies, mathematics, engineering and art. Introduction in education of the built-in systems and Internet of things as requirements of today. Skills of the successful expert in modern society develop promptly in the direction of innovations.
3D design and slicing	Concept about STL format, G-code, raft, carrier, delamination, filling of model. Work with Tinkercad service. Plane, addition of objects, formation of openings, import of ready models, export. Slicing of the created model – filling of model, addition of carrier and raft, control of work of right and left extruder of 3D printer.
Defects of 3D printing and ways of their avoidance	Features and the principle of operation of 3D printer in practice, replacement of filament. The defects arising during 3D printing and how to avoid them.
3D scanning of the person, creation of 3D model and its printing	What is 3D scanner and how scanning occurs? Types of 3D scanner. The basic principle of work – the principle of triangulation. Scopes of 3D scanner. Scanning of the person by means of 3D scanner, correction of the received model and its printing.
Project work	Implementation of joint project "University of Dream".

For methodical support of a training course at the choice of students of various specialties "3D Printing Technologies" has been created the project on Wiki-portal of Borys Grinchenko Kyiv University (Project on the Wiki-poral Borys Grinchenko Kyiv University, 2016) (*Figure 3*).

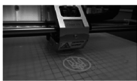| Home	Dictionary	Dictionary	dictionary	Creating эffektyvnah эlektronnah courses	Electronic courses on embedded systems	Laboratory for Embedded Systems	3D printing – from theory to practice

Content [Hide]
1 Lesson 1 "3D printers: basic concepts and types of print"
  1.1 Training Materials
2 Session 2 "3D printing as a component STEAM-education"
  2.1 Training Materials
3 Session 3 "3D design and staysinh"
  3.1 Training Materials
4 Session 4 "3D printing defects and how to avoid them"
  4.1 Training Materials

Session 1 "3D printers: basic concepts and types of print"

Description

May 11, 2016, students Borys Grinchenko Kyiv University took part in the pilot circle «3D printing - from theory to practice!» ,Which was initiated by Natalia Morse , Vice President for informational, educational, scientific and administrative activities in the international project Tempus DesIRE for the introduction of 3D printing technology in the educational activities of the university. Before the classes were involved Lily Varchenko-Trotsenko , researcher RL informatization of education, Maria Gladun , teacher cyclic commission mathematical economics and management sciences at University College, Anastasia Tyutyunnik , Methodist Centre for ICT competences of SRL informatization of education.

During the session participants learned about the technology of 3D printing, 3D printer types and their scope. Students learned about the basic concept of 3D printing and fields of application of additive technologies , considered features STL-format, reviewed the main materials used in the "growing" 3D models and were able to witness the printing process .

Attended by students of Humanities, Pedagogical Institute, University College and the Institute of Society.

Training materials
- 3D printers: basic concepts and types of printing
- Areas of use of 3D-printing
- Rules 3D printing

Fig. 3. The project on Wiki-portal

Wiki-portal is created as the platform used for realization of educational technologies focused on vigorous activity of students and teachers, all participants of educational process. Wiki-portal functions on "wiki" technology. Using wiki-technology, it is possible without any efforts to place various educational web resources, to exchange opinions, to reuse placed web resources on the basis of a contribution of many participants (Morze, Varchenko-Trotsenko, 2015). The main feature of technology is that any person can be registered and write article according to certain requirements. Other registered users can finish and make their changes. The history of creation of each article saves (Morze, Nataliia, et al., 2015). It allows a large number of users to work on one e-resource, to supplement with articles, to discuss, to insert images, polls on video, audio, cards of knowledge and other resources, that is to carry out electronic cooperation for creation of a joint resource.

On the page of the project, students can study the theory, find and add it, take part in discussion, find a large number of useful links, look

at practical tasks. The structure of the page is constructed in a chronological order of carrying out teaching with students. Each lesson contains the description and additional materials for acquaintance.

Initial poll of students has shown that it is interesting to students of nontechnical specialties to study additive technologies and to introduce them in further professional activity. 3D design, slicing and settings of 3D printing parameters, printing and correction of model is the most interesting for students (*Figure 4*):
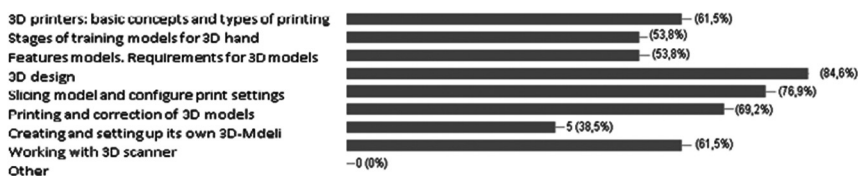

3D printers: basic concepts and types of printing	— (61,5%)
Stages of training models for 3D hand	—(53,8%)
Features models. Requirements for 3D models	— (53,8%)
3D design	— (84,6%)
Slicing model and configure print settings	— (76,9%)
Printing and correction of 3D models	— (69,2%)
Creating and setting up its own 3D-Mdeli	—5 (38,5%)
Working with 3D scanner	— (61,5%)
Other	—0 (0%)

Fig. 4. Respondents' answers concerning interest circle subjects

Such kinds of activity as practical tasks, discussions and performance of homeworks were most useful for students (*Figure 5*):
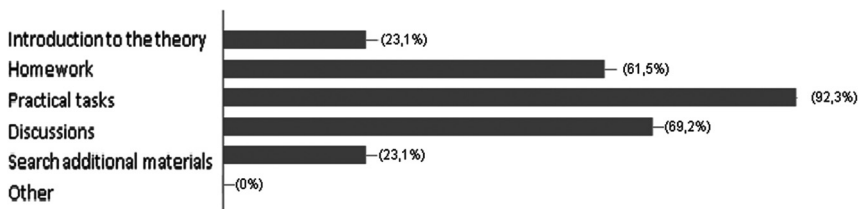

Introduction to the theory	— (23,1%)
Homework	— (61,5%)
Practical tasks	(92,3%)
Discussions	—(69,2%)
Search additional materials	—(23,1%)
Other	—(0%)

Fig. 4. Respondents' answers concerning interest circle subjects

Students consider that 3D printing training most of all develops such competences and skills as abstract thinking, assessment of own activity and electronic communication (*Figure* 6):

All the students without exception have noted in the questionnaire that they plan further to use actively acquired abilities.

On the basis of polls of satisfaction of students we can draw conclusions on expediency of introduction of discipline at the choice and next year for students of all specialties – 84,6 % have answered on the question of need for introduction of such discipline, 15,4 % – have found it difficult to be defined.
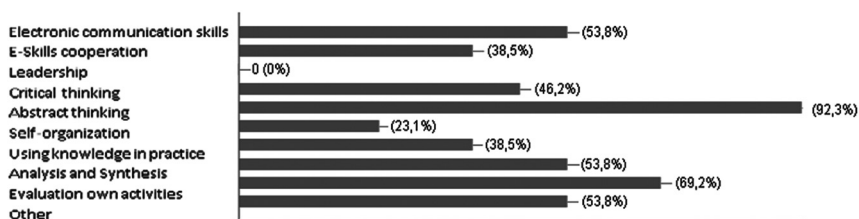
Fig. 6. Respondents' answers concerning skills and competences
which are developed by studying of 3D printing

Also on the basis of the poll it is possible to tell that 3D printing can actively be used in development of the built-in systems for various spheres of life and directly for their specialties.

Conclusions

In Ukraine, the process of introduction of STEM and STEAM education gathers pace. in educational institutions, the training courses dealing with questions of the Internet of Things, built-in systems and other directions of modern engineering take root. to the forefront, there are requirements of modern society –possession of knowledge of STEM and STEAM education not only from technical specialists, but also almost in all fields of activity. Training in such courses of students of different specialties becomes very actual. Alternative educational technologies cause the entry of new requirements to competences of teachers, changes of their usual methods of teaching material, new organization of training with the use of modern control facilities of educational process, new approaches to educational statistics, formation of training programs and methods of assessment. Keen interest at students of all specialties raises questions of the use of 3D printing (in a context of combination scanning-design-printing) in educational process, therefore there can be an introduction of experimental training of 3D printing technology as components of STEAM education and formation of skills of the use of these technologies at them for creation of own innovative projects within the professional competences. Continuous use of new means for training gives an opportunity not to stand on one place, accustoms to new style of behavior and easy solution of any situations.

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