Application of 3D Printing and 3D Scanning Technologies in Educational Activities

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Abstract. The article analyzes the spheres of 3D printing and 3D scanning modern technologies application, defines the perspectives of 3D technologies development, and proves the expediency of these technologies application in educational activities of a modern institution of higher education. The authors developed the training course curriculum that allows the students not only to acquire the knowledge and practical skills in the field of 3D printing (scanning), but also to get acquainted with the basics of entrepreneurship and principles of 3D technologies transfer. The article gives the matrix that describes in detail the competences, acquired by the students after getting acquainted with the course materials, developed by the authors.

Keywords: Higher Education, Knowledge Transfer, 3D Printing, 3D Scanning, Matrix of Competence, Training Course.

Key Terms: Academia, Knowledge Technology, Knowledge Transfer, Management.

1 Introduction

Nowadays 3D printing and 3D scanning technologies, originated around three decades ago, gain more and more popularity. 3D technologies are actively used not only by scientific specialists, but also by many companies, producing and designing goods of a wide range. A sharply increasing interest in 3D technologies is explained by the possibility to essentially reduce, with their help, the expenses of complicated technical goods production due to reducing the costs of making sketches, models, prototypes [1–5]. 3D printing is actively used in architecture, building, small-scale production, functional testing, medicine, and manufacture of wearing apparel, footwear, jewelry, toys and souvenirs [6]. The experts call 3D printing "a salvation of economy" and "a breakthrough in medicine"; emphasize ecological compatibility and easiness of use of modern 3D devices [7].

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According to some forecasts, by 2050 every third family in the developed world will have a 3D printer at home; and by the end of the 21st century the copying machines, designed for analyzing and reproducing any structure with the precision up to an atom, will be created [8].

3D printing and 3D scanning technologies are actively used in the educational process for producing visual aids. Besides, the penetration of 3D printing in more and more spheres entails the growth of demand for qualified specialists in this field. Therefore, 3D printing technology and equipment application in a modern institution of higher education (IHE) will allow:

- to increase scientific potential;
- to significantly improve the IHE competitiveness at the global level;
- to train highly-qualified personnel.

A tremendous advantage of 3D technologies application is a significant increase of students' interest in the educational process. Modern postgraduate students and young scientists need skills of working with 3D equipment for their successful career. The preparation and organization of qualification courses, teaching the principles of work with modern 3D equipment, by the IHE is very promising.

3D technologies and equipment are actively applications by Norwich University (the USA), Exeter University (the United Kingdom), Staten Island Technical High School (Island), University of Sunderland (England), Stellenbosch University (South Africa), Massachusetts Institute of Technology (the USA), Budapest University of Technology and Economics (Hungary). At the same time, in Ukraine nowadays there are no institutions of higher education, using these technologies in the educational process and research work.

Thus, the development of an innovative course, dedicated to 3D technologies and permitting to acquire skills of working with 3D equipment, and its introduction into the educational process of a modern Ukrainian institution of higher education is the task of a current importance.

2 The Training Course "3D Printing Technology Transfer"

2.1 General Description and Structure of the Course

At the Dniprodzerzhynsk state technical university (DSTU) and the Kyiv State Maritime Academy (KSMA) the 3D equipment was purchased within the framework of realization of the international project "Knowledge Transfer Unit From Applied Research and Technology-Entrepreneurial Know-How Exchange to Development of Interdisciplinary Curricula Modules" (Reference Number: 544031-TEMPUS-1-2013-1-AT-TEMPUS-JPHES, Project Duration: 36 month, 12/2013 11/2016) [9–11].

Moreover, the KTU staff of the Dniprodzerzhynsk state technical university and the Kyiv State Maritime Academy jointly with the representatives of UdG

(Spain) developed a curriculum of the multidisciplinary course "3D PRINTING TECHNOLOGY TRANSFER". As a result of getting acquainted with this course materials the students (post-graduate students) will not only study the modern technologies of 3D printing and scanning, their history, used materials, a sphere of application, and get practical skills of making prototypes, but also master the principles of 3D technologies transfer, the basics of entrepreneurship; get acquainted with the instruments, allowing to carry out the effective 3D technologies transfer in Ukraine and abroad.

The relevance of the training module.

The module is oriented at a wide range of students, who want to have a confident understanding of the current concepts of knowledge economy, knowledge transfer, modern principles of 3D printing technology, and approaches to the implementation of 3D printing technology transfer. Nowadays 3D printing technology is effectively used in various fields of engineering. The transfer should ensure handing of 3D production from developers to customers.

The global scientific and technological transformations are the main world trends of modern society development. They determine a transition from the primary industrial economy to the postindustrial knowledge-based economy. The knowledge transfer is a multidimensional and multi-branch process of transmission of different forms and types of knowledge. The application of modern innovative technologies transfer, such as 3D printing technology, is the most efficient.

The application of modern knowledge transfer principles in 3D printing technology area helps developers to attract potential customers (investors) and to achieve maximum economic benefit.

The aim of the module is a creation of students knowledge system about knowledge transfer and 3D printing technology transfer.

Target group: Phd students, graduates who have a bachelor degree or a master degree.

Didactical approach

There are lectures, practical tasks, teachers consultations (both individual and collective) and students' self-guided work with an overall guidance of teachers with the aim to achieve the objectives. Students receive methodological support in the form of a program (curriculum) of the discipline, and a manual. It contains lectures and recommendations for self-guided work, a list of recommended literature and other useful recourses.

Time requirements / duration: 3 months

2.2 Curriculum of the Course

The developed course consists of 5 training modules:

Part 1: KNOWLEDGE TRANSFER

Module 1: *Basics of Knowledge & Innovation Transfer*

Session 1: *Types of knowledge transfer*

The knowledge transfer concept. The history of the European knowledge transfer system. A university as a basis of the knowledge-based society. The paradigm

of the knowledge triangle: education science innovation. The current state of knowledge transfer in Ukraine. Systems of internal and external knowledge transfer.

Session 2: *Technology transfer*

The definitions of embodied and disembodied technologies. The components of knowledge transfer: transfer of legally described technologies; transfer of know-how; transfer of physical products and economic benefits; transfer of skilled labor. Technology transfer as the main component of knowledge transfer.

Session 3: *Innovation transfer*

The definition of innovation. The definition and nature of innovation as an object of transfer. The mechanisms of innovation transfer. The methods that help to determine the costs of the object of transfer.

Module 2: *Management of Knowledge Transfer*

Session 1: *Knowledge transfer infrastructure*

The concept of a knowledge transfer unit. Target groups, mission, organizational structure and staffing of a knowledge transfer unit. The list of services of a knowledge transfer unit. Capacity building of a knowledge transfer unit.

Session 2: *Knowledge transfer management*

General description of project management. The main forms of organizational structure of a project. Common approaches to project planning. Practical principles of project management. The structure of a project. Resource planning, costs and project budget.

Session 3: *International knowledge transfer*

The definition of international knowledge transfer. Forms of explicit and implicit knowledge. Phases of internal knowledge transfer.

Module 3: *Advanced topics of Knowledge Transfer*

Session 1: *Acknowledgment with Erasmus+ and Horizon 2020 EU Programs*

The definition of international knowledge market. Single European space of Higher Education. Single European space of Research. EU programs Erasmus + and Horizon 2020.

Session 2: *Acknowledgment with National Transfer Technology Network (NTTN)*

European and Ukrainian Technology Transfer Networks. The principles of work in NTTN. The ways of preparation of the description of innovative solutions; technologies, ready for introduction; promising scientific projects and ideas. The methods of search for scientific innovative projects and offers.

Part 2: 3D PRINTING TECHNOLOGY

Module 1: *Basics of 3D printing and 3D scanning*

Session 1: *The history of 3D printing technology*

Prototyping. Stereo lithography Apparatus as the first device for 3D printing. Laser 3D printer. Inkjet 3D printer. Solidscape company. PolyJet technology.

Session 2: *3D printing technologies*

StereoLithography Apparatus, SLA. Selective Laser Sintering, SLS. Selective Laser Melting, SLM. Electron Beam Melting, EBM. Multi Jet Modeling,

MJM. Laminated Object Manufacturing, LOM. 3DP. Fusing Deposition Modeling, FDM.

Session 3: *Materials for 3D printing*

ABC-plastic. Acrylic. Beton. Hydrogel. Paper. Gypsum. Wood fiber. Ice. Metal powder. Nylon. Polycaprolactone (PCL). Polycarbonate (PC). Polylactide (PLA). Polypropylene (PP). Polyphenylsulfone (PPSU). High Density Polyethylene (HDPE). Chocolate.

Session 4: *3D scanning technologies*

Methods of scanning: contact and noncontact. Active scanners. Passive scanners.

Session 5: *Critical issues of 3D printing*

Module 2: *Application of 3D printing and scanning*

Session 1: *The fields of 3D printing application*

Architecture. Building. Small-scale production. Functional testing. Medicine. Education. Manufacture of wearing apparel. Manufacture of footwear. Jewelry. Packaging design. Printing toys and souvenirs. Geographic Information Systems.

Session 2: *3D printing software*

Provision of information for 3D printing. File formats. Software for 3D printing: paid and free. Basic principles of 3D models. Preparation of models for 3D printing.

Session 3: *The fields of 3D scanning application*

Engineering analysis. Digital analysis. Digital archiving. Architecture. Medicine. Examples of using of 3D scanning technology.

Session 4: *Scanning and printing of a 3D model*

Scanning with a digital camera and scanner. Using special software. Optimizing the Printing Process. Scanning and Printing with a Higher Resolution. Modeling and Printing with Precision. Manipulating Meshes and Bridges.

Session 5: *Creating a project and printing a 3D model*

Different ways of 3D prototyping and mesh grid creation. Slicing. Shells and surface layers. Reviewing the print results.

2.3 Competences

Acquaintance with the course materials will give students the opportunity to possess the following competencies:

General competences

1. Use of English language
   (a) use specific English terminology in the area of Management of Knowledge Transfer in oral speech;
   (b) use specific English terminology in the area of Management of Knowledge Transfer in writing;
   (c) make presentations in English with the help of specific terminology in the area of Management of Knowledge Transfer;
   (d) Read English literature in the area of Management of Knowledge Transfer.

2. Gather and select information efficiently
   (a) independently gather and select information from specific Web-resources;
   (b) independently gather and select information from specific literature;
   (c) independently gather and select information from news, specific conferences and seminars.
3. Use information and communication technologies.
   (a) use information and communication technologies for different tasks;
   (b) select and use the most appropriate information and communication technologies;
   (c) select and use modern information and communication technologies for team work and management;
   (d) select and use modern information and communication technologies for international knowledge transfer.
4. Work in teams.
   (a) form a team; make a list of roles and a list of activities for each role;
   (b) work independently in a team, select an appropriate role;
   (c) prepare formal documentation and reports about teamwork; use different shared recourses;
   (d) use results of teamwork.
5. Communicate orally and in writing.
   (a) communicate orally and in writing about specific problems, ideas, solutions, results;
   (b) use presentations, supporting materials, software, videos and other resources in communicate orally and in writing;
   (c) communicate orally and in writing on topics in the area of knowledge transfer management.

Special competences

1. Problem solving.
   (a) accurate formulation of problems;
   (b) search for different solutions of specific problems;
   (c) form criteria for solutions evaluation, select appropriate solutions.
2. Use explicit and implicit forms of knowledge.
   (a) independently use explicit forms of knowledge;
   (b) confidently identify and use implicit knowledge necessary for solving specific tasks.
3. Use software for 3D modeling, 3D printing, 3D scanning.
   (a) independently select and use appropriate 3D modeling software for different projects;
   (b) independently select and use appropriate 3D printing software for different projects;
   (c) independently select and use appropriate 3D scanning software for different projects.
4. Use 3D equipment.
   (a) independently select and use appropriate 3D printing technologies for different projects;

(b) independently select and use appropriate 3D printing materials for different projects;
(c) independently select and use appropriate 3D scanning technologies for different projects.

5. Customer focus.
   (a) perform marketing researches (interviews with customers, analysis of literature, news and web-resources); create a list of products and services required by customers;
   (b) continuously develop and improve services required by customers;
   (c) prepare descriptions of innovations required by customers;
   (d) use individual approach to each customer.
6. Critical thinking.
   (a) independently analyze and systematize tasks, ideas, methods, solutions, tools and results;
   (b) independently analyze exceptions;
   (c) independently analyze and correct mistakes.
7. Life long learning.
   (a) evolve with the needs, improve their intellectual level;
   (b) apply the acquired knowledge for solving new multidisciplinary tasks.

3 Conclusion

Thus, the course "3D PRINTING TECHNOLOGY TRANSFER", developed by the authors, allows the students not only to master knowledge and practical skills in the field of 3D printing (scanning), but also to get acquainted with the basics of entrepreneurship and the principles of 3D technologies transfer. The competences, acquired by the students after getting acquainted with the course materials, will allow them to become highly qualified specialists demanded in a modern labour-market.

Course "3D PRINTING TECHNOLOGY TRANSFER" is effectively implemented not only in the curricula of bachelor's and master's degrees, but is also used for the preparation of post-graduate students, retraining and refresher courses. Thus, the introduction of a course developed by the authors in educational activities will enable higher education institution to develop "learning throughout the life" concept, using the competency approach. In addition, the reading of the "3D PRINTING TECHNOLOGY TRANSFER" course in DSTU and KSMA allows us to develop activities according to the knowledge triangle concept: "education - science innovation".

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