

# THE INTRODUCTION OF FABLAB PLATFORMS AS DETERMINANT OF THE UKRAINE'S ECONOMY INNOVATIVE DEVELOPMENT

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## Abstract

Results of the implementation of the Erasmus+ project “Development of a network infrastructure for youth innovation entrepreneurship support on fablab platforms” (FabLab project), an active participant of which is Ternopil Ivan Puluj National Technical University (TNTU), are presented in the paper. The concept and meaning of fabrication laboratory are identified. Open laboratories’ origin and development both in Ukraine and all over the world are described. Hackerspaces’, makerspaces’, FabLabs’ activities, aims and objectives are characterized. The number of FabLabs globally, in Europe and in Ukraine is estimated. FabLabs, operating at Ukrainian universities, are studied. Achievements of TNTU in the framework of the FabLab project are identified and analyzed. It is determined that FabLabs must be considered in terms of education and training of talented youth focused on scientific, technical and engineering activities.

**Keywords:** open laboratories, hackerspaces, makerspaces, fabrication laboratory, Fab Labs.

## INTRODUCTION

The creative economy, as a model of growth, is based on the infrastructure and achievements of the knowledge economy with institutions, ideas and norms. The innovative ecosystem of creative industries includes a variety of formal and informal institutions that shape social interaction in the process of idea creation and commercialization. The growth of a creative economy depends foremost on the quality of human capital, the number of innovations and investments which should be provided with an appropriate “soft” infrastructure of creative spaces and effective management.

In 2015, implementation of the Erasmus+ project “Development of a network infrastructure for youth innovation entrepreneurship support on fablab platforms” (FabLab project) has started. Its participants are universities of European Union (EU) countries, Ukraine (including Ternopil Ivan Puluj National technical University, TNTU) and Belarus (<http://fablab-erasmus.eu/>) [1]. The goal of the FabLab project is to create conditions for the development of innovations and engineering creativity, to improve students’ employment through the university interaction with business and industry based on FabLabs. The coordinator of the European project FabLab is the Buckinghamshire New University (United Kingdom, UK).

Specific project objectives are stated as: establishment of university fablabs; development of teaching methodology and courses content, and modernization of the partner countries universities curricula; creation of a network infrastructure to support innovative youth entrepreneurship through networking of universities, business and industry.

## **RESEARCH RESULTS AND DISCUSSION**

FabLab is a cut-across initiative that bridges the gap between people, educational institutions and business organizations, it educates by providing hands-on learning opportunities for all users, and also providing means for users to develop their ideas through rapid prototyping machines and other technological apparatus [2].

The concept of FabLab (fabrication laboratory), which is based on the idea of personal digital production, was invented 20 years ago by Neil Gershenfeld, a researcher at the Massachusetts Institute of Technology (MIT) and coined by MIT's Centre for Bits and Atoms. Since then, the FabLab idea has spread throughout the world, has gained particular popularity in such European countries as France, Denmark, Spain and the UK, and has been rapidly developing in Africa and Asia. FabLab is a broad movement, better known as "open laboratories". These open spaces are established by different communities, united around common values, sharing of knowledge, ideas and practices. Their establishment is followed by the rapid development of the novel production technologies, which are being actively implemented.

FabLab is a small-scale workshop equipped with flexible computer-controlled tools and systems for the production of digital fabrications of widely distributed products, which are used to encourage creativity and innovation among individuals irrespective of their geographical and demographical status. Since the inception of FabLab at MIT in 2001, FabLab have been duplicated throughout the globe at an exponential rate (Figure 1) [2].

### **Open laboratories' movement origin and development**

The open laboratories' history in Ukraine takes its origin from large industrial centers, where the industrial development and the development of scientific centers were taking place simultaneously.

Technical workshops, technical work groups, aircraft, automobile, ship and space modelling groups and workshops, radio amateur groups have been existing in Ukraine for over 60 years. Mainly they are out-of-school educational establishments for development of students' creative flairs through creation of new and useful material technical objects. The stations for young technicians should be pointed out among them. They are the out-of-school educational children's art institutions that have the courses on modelling, radio design, folk crafts, technical design, toys design and informatics. As a rule, they are equipped with small universal machine tools for electric circuits mechanical processing and assembling. The stations for young technicians are financed from the city budget and have their own teaching staff.

Junior Academy of Sciences of Ukraine (JAS), with its branches in all regions of the country, is an important institution for development of students' scientific work in Ukraine. The JAS is the educational system that provides organization and coordination of students' scientific research activity, creates the terms for their intellectual, spiritual, creative development and professional self-determination, assists the increase of scientific potential of the country.

At the technical universities of Ukraine, and at the TNTU in particular, there is a specialist preparation system that involves the obligatory students participation in

research work from the very beginning of their studies. In almost six years of studies a student passes all the stages of a classic scientific research: preparation of literature review, implementation of patent information research, experimental and/or design work. Over 30 years ago, a course called “Fundamentals of engineering art” was introduced in Ukraine. It is oriented to increase the qualification of a future engineer as an innovator, creator that must in short terms implement new technical ideas in life.

Open technical creative associations such as makerspaces and hackerspaces have begun to appear in Ukraine since 2010. Such first well-known foreign associations are the Tech Model Railroad Club at the MIT, Steve Wozniak’s Homebrew Computer Club and c-base hackerspace in Berlin. Some of the most well-known hackerspaces also are Chaos Computer Club in Cologne, Metalab in Vienna, HackerbotLabs in Seattle, HacDC in Washington, NYC Resistor in New York, Noisebridge in San Francisco and Cyberpipe in Ljubljana [3].

A hackerspace or hackspace is the real (opposed to virtual) place, where people with alike interests, mostly in science, technology, digital or electronic art, gather, communicate and collaborate. Firstly, hackerspace is a community of like-minded people who share the interest to mastering and non-standard use of new technologies, free distribution of knowledge, nonhierarchical forms of self-government. Secondly, hackerspace is a particular apartment, physical space, where the community meetups and communication, ideas exchange, collaborative creative and productive activities take place.

Some of the typical hackerspace activities include: gaining the knowledge and knowledge exchange, presentations and lectures, social activities including games and entertaining activities. Hackspaces provide the necessary infrastructure for these activities: apartments, food and drinks, electricity, servers and computer networks with the Internet access, audioequipment, videoprojectors, play stations and various tools. The membership fees usually constitute the main source of hackspaces’ income, although some have third party sponsors.

There are the following key differences between the hackerspaces, makerspaces and fablabs in Ukraine [4]:

- 1) time of foundation (hackerspases appeared earlier – the world’s first hackerspace called c-base was opened in 1995 in Berlin);
- 2) own international network and identification:
  - hackerspaces have Hackerspases Passports [5];
  - fablabs are the members of Fab Lab Foundation at MIT with the obligatory list of hardware equipment and software [6];
- 3) hackerspaces work mainly with the programmes while fablabs work with the physical materials. But this division is gradually erased as many fablabs turn into makerspace or co-working for engineers, and hackerspaces acquire their own 3D printers and machines.

There are also establishments that are different from hackerspaces and fablabs. Technoshops, first established in 2006, sell the products created by skilled craftsmen.

Since 2011 makerspaces (originate from the Make Magazine [7]) serve as creative spaces for inventors [8].

The common thing for all these creative associations is that they work with the open-access information and open-access technologies. That is why such creative associations as hackerspace, makerspace, technoshop and fablab can be presented all in one place.

As of October 2019 the number of fablabs in the network around the world accounts for 1789 laboratories (see Figures 1, 2) [10].

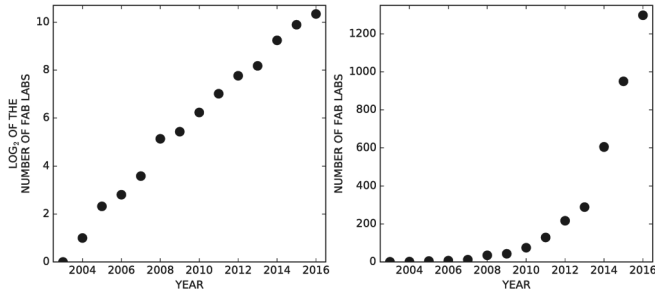


Figure 1. The number of fab labs, on logarithmic and linear scales

Source: Cutcher-Gershenfeld, Joel & Gershenfeld, Neil & Gershenfeld, Alan (2017). *Designing Reality: How to Survive and Thrive in the Third Digital Revolution* [Online]. – Available at: <http://designingreality.org/>

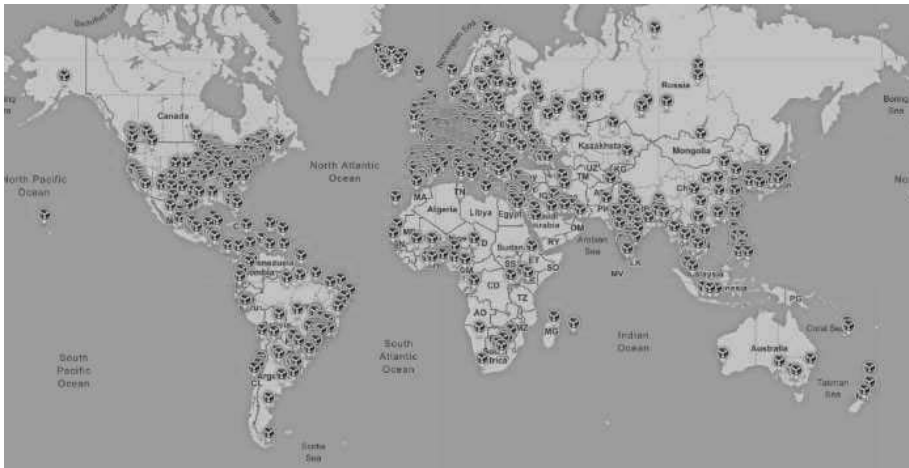


Figure 2. Worldwide network of FabLabs

Source: FabLabs map [Online]. – Available at: <https://www.fablabs.io/labs/map>

There are 225 FabLabs in the United States; in Europe, France is leading with 216 fablabs, 190 ones operate in Italy, 66 – in Spain, 60 – in Germany, 39 – in the Netherlands, 16 – in Poland (Figure 3) [10].

In [2] analysis if the FabLab initiative plays a part (if any) in a country’s innovativeness (i.e. standing in the index) was carried out. The research results testify that the FabLab initiative intangibly contribute to the human developmental attributes

(such as science, technology, engineering, arts, and mathematics (STEAM)), thereby enriching some of the factors that promotes innovation and sustainability as a whole.

Ukraine holds 47<sup>th</sup> position in the Global Innovation Index (GII) 2019, being the second one among lower-middle income innovation economies. Switzerland is the most innovative country in the 2019 report, followed by the United States, the Netherlands and the UK [11].



*Figure 3. FabLabs in Europe*

Source: FabLabs map [Online]. – Available at: <https://www.fablabs.io/labs/map>

It should be noted, that experts from the GII 2014 report [12] pointed out on three key factors:

- the inexistence of FabLab in a country does not necessarily mean the country would not be innovative;
- the numbers of FabLab’s workshops present in a country does not signify that the country is more innovative than the others;
- FabLab’s contributions in a country’s innovation index is not quantifiable (yet).

Despite the factors stated above, the FabLab initiative contributes immensely in ensuring sustainable development thereby creating long-term values.

The association of radio amateurs is considered to form the basis for creation of the opened technical creative associations in Ukraine [13]. The festival called “de:coded” became the place for communication for young specialists in computer

technologies. It took place every year from 2006 to 2011 in Lviv, and positioned itself as an IT-festival [14]. There a network of the personal contacts of future leaders of the hackers' movement was created.

Based on the popularity of the profile Internet resources (makezine.com, instructables.com, hackaday.com) around 2010 and due to the growth of the personal interest to the idea of hackerspace among the techno-enthusiasts in Ukraine, the first Ukrainian hackerspace, called Hackerspace, was founded in 2012 in Kyiv [13; 15].

Since 2013, in the powerful hackerspace a team of techno-geeks, programmers and inventors has been working on the projects featuring 3D printer design, 3D scanning and automated devices. Nowadays, the Hackerspace Kyiv, which since 2014 is called HackLab, mostly works on the original hardware and robotics systems development (Figure 4, a) [13; 16].

In summer of 2013, the hackerspace called KHackerSpace was established in Kharkiv. In 2015 there were about 30 members in Kharkiv hackerspace community. Many of them are the authors of original technological designs and projects. The hackerspace members take active part in educational scientific activity. During 2014-2015 KHackerSpace took part in numerous public events (Figure 4, b) [13; 17].

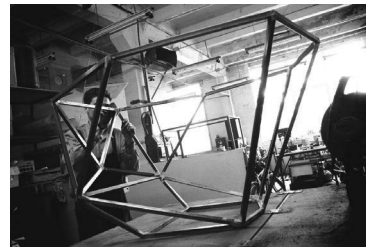
Another important centre of hackers movement in Ukraine is Lviv. In November, 2013 a small apartment was found in Betaplace (Betalab since 2015) co-working [13; 18]. In May, 2015 Lviv Hackerspace took part in the interdisciplinary project called Cyber Pills for Mental Health and from the organizational point of view, it is close to the fablab format. Current projects include: electronics, Arduino, Linux, ARM, Raspberry, motion control, measurement, etc., 3D printing with the substances for different applications, CNC, numerical control, R&D, new technologies, electromechanical devices, lasers, robotics and others (Figure 4, c).



a) HackLab in Kyiv, Ukraine



b) KHackerSpace in Kharkiv, Ukraine



c) Hackerspace Betalab in Lviv, Ukraine

*Figure 4. Main centres of hacker's movement in Ukraine*

Sources: HackLab [Online]. – Available at: <http://hacklab.kiev.ua/>, KHackerSpace [Online]. – Available at: <https://www.facebook.com/khackerspace/>, Hackerspace Betalab [Online]. – Available at: <https://www.facebook.com/betalablviv>

Among three main centres of hacker's movement, the two ones – in Kyiv and Lviv – have obtained some external features of Fablab/Makerlab format. Yet they have kept the organizational features of traditional hackerspace community. In its turn, Kharkiv KHackerSpace is an example of large public association which follows the European line of development with the considerable number of projects on

software and radio electronics development. Furthermore, Kharkiv community demonstrates an outstanding activity in various public events, scientific and educational area and art projects.

### **FabLabs in Ukraine**

Support of EU programs significantly contributes to the development of FabLabs. Also the state decentralization policy has allowed local governments to allocate some funds for independent projects from communities through public initiative contests. As a result, in 2018, open space creative projects on fablab platforms won competitions in Kyiv and Odessa.

In Ukraine as of 2019 at [fablab.io](http://fablab.io) nine fablabs are being registered in Kyiv (Fabricator, IZOLAB, ProtoRoboLab), Odesa (MiRONAFT, .buro, HUB LAB), Kharkiv (Garage Hub), Sumy (3dinnovationlab), and Vinnytsia (Kvadrat).

IZOLAB ([izolab.ua](http://izolab.ua)) is considered to be the first Ukrainian fablab platform. It is due to the official registration of this fablab on the website of the nonprofit organization called The Fab Foundation (USA) [19] (Figure 5, a). The laboratory of digital production IZOLAB was established in 2014 in Kyiv after the fund “Isolation” moved from Donetsk. Currently, IZONE is a creative union that functions at national and international levels. The IZOLAB laboratory was founded as a profitable private initiative and simultaneously a public organization. Currently there are seven workshops in the creative space of IZONE: IZOLAB, fotolab, wooden, etching, IZONE – café and silkprint. It is possible to say, that this fablab is a makerspace, a technoshop and a co-working at the same time, which has the necessary set of fablab equipment [20].

In June, 2016 the second Ukrainian fablab, called Fablab Fabricator, was established in Kyiv – an opened innovative workshop in accordance with The Fab Foundation regulation (Figure 5, b) [21; 21a].



a) IZO LAB / FabLab, Kyiv, Ukraine Workshop on building robots, 2016



b) FabLab Fabricator in Kyiv, Ukraine

*Figure 5. Biggest Ukrainian FabLab platforms*

Sources: Fabfoundation [Online]. – Available at: <http://fabfoundation.org/fab-labs/>, IZONE Creative Community [Online]. – Available at: <https://izone.ua/ru/lab/1>, FabLab Fabricator [Online]. – Available at: <http://www.fabricator.me/>, <https://www.the-village.com.ua/village/business/businessmen/263279-business-owners-fablab-fabricator>

FabLab Fabricator develops the wide range of interesting educational programmes for people of different age. Fablab Fabricator staff has adopted the

courses to satisfy the professional needs. They are intended to expand the knowledge horizons for the interested enthusiasts in different areas of science and technology: IT, product design, wearables, robotics, 3D-modeling and 3D-printing, electronics, virtual reality. Fablabs offer their visitors an access to 3D printers, milling machines with CNC, laser cutters, radioequipment.

In 2017 in Sumy, an ATO veteran created an open fabrication factory “Bobry” (Figure 6) [22; 22a]. It is an association of engineers, inventors, handmakers, startups who are ready to share their experience, equipment and take part in interesting projects. The community creates socially-oriented products, such as recumbent bicycles for the sports rehabilitation of soldiers with severe injuries, or wooden toys and dollhouses



*Figure 6. Open laboratory “Bobry” in Sumy, Ukraine*

Source: Open laboratory [Online]. – Available at: <https://bobry.in.ua/>, <https://www.facebook.com/bobryinua>, <https://www.radiosvoboda.org/a/veteranskyj-biznes/29903217.html>, Veteran Business: Successful Passing Experience to Beginners [Online]. – Available at: <https://www.radiosvoboda.org/a/veteranskyj-biznes/29903217.html>

### **FabLabs at Ukrainian universities**

The establishment of new fablabs in Ukraine is most intensively done at universities – active participants and drivers of innovative knowledge. As a rule, the laboratory is operated on the basis of a combination of commercial and non-commercial models, the latter one can be fully used in universities. Its realization is possible through a common creative space for individual and collective work on scientific and technical projects, creation and implementation of educational courses for student audience and teaching staff.

Among the Fablabs established on the basis of higher educational establishments (HEIs), MiRONAFT FabLab, since 2014, [23; 24], the Research Laboratory of Mechatronics and Robotics, – the largest innovative FabLab laboratory (acquired the status of FabLab in 2017) in Ukraine and Europe, established on the basis of the Odesa National Academy of Food Technologies (ONAFТ), which hosts 400+ residents and is currently carrying out 15 projects, should be named first (Figure 8, a). MiRONAFT has become a place where everyone, regardless of age, skills, place of study or work, with due consultation from the staff, will be able to realize his/her idea completely free of charge. Each resident is provided with a workplace for the development, assembly, testing of the prototype, as well as hand tools, software, specialized literature and expertise advice upon one condition – 20% of the time spent in the laboratory such person should voluntarily devote to the assistance in organizing and conducting events in the laboratory: festivals, exhibitions, master



classes, trainings, etc. Among the main activities of the laboratory are robotics clubs for schoolchildren, master classes on the basics of modern robotics (pneumatics, hydraulics, electric manipulators, programming controllers, CNC machines). As a regional center for the development of 4.0 technologies within the framework of the Association of Industrial Automation Enterprises of Ukraine, the laboratory carries out a whole range of activities to popularize 4.0 technologies in industrial segments at the local level. On the basis of the laboratory, the All-Ukrainian Olympiad in Mobile Robotics “RoboRace Odessa Grand Prix” takes place.

Since 2015, the opened laboratories are being established also at different universities of Ukraine – the National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute (NTUU KPI), Sumy State University (SSU), National Aviation University (NAU), Volodymyr Dahl East Ukrainian National University (SNU) in Severodonetsk. It is planned to open one more university-based FabLab at Lviv Polytechnic National University [25].

In 2018 within the FabLab Project three FabLabs have been established at Simon Kuznets Kharkiv National University of Economics (KhNUE) (Figure 7, a) [26; 26a] and at the Integrated Manufacturing Engineering Department and the Educational and Scientific Complex “Institute of Applied Systems Analysis” (IASA) of NTUU KPI (Figure 7, b) [27] and at TNTU (Figures 9–11) [28].



a) FabLab at KhNUE, Kharkiv, Ukraine



b) FabLab at the IASA of NTUU KPI, Kyiv, Ukraine

*Figure 7. FabLabs established within the Erasmus+ project “Development of a network infrastructure for youth innovation entrepreneurship support on fablab platforms” implementation in Ukraine*

Source: Erasmus+ FABLAB [Online]. – Available at: <https://www.hneu.edu.ua/erasmus-fablab/>, FabLab of Simon Kuznets KhNEU [Online]. – Available at: <https://www.hneu.edu.ua/fablab-fabryka-laboratoriya-hneu-im-s-kuznetsya/>, FABLAB KPI [Online]. Available at: <https://itm.kpi.ua/fablab/>

FabLab KhNEU is a modern factory for 3D modeling, 3D printing, prototyping and technical creativity, created in 2018 as part of the European project Erasmus+. FabLab KhNEU provides free access for initiative young people and students to the modern equipment – 3D printers, laser cutters, milling machines, Arduino kits, raspberry platforms and sensors for the Internet of Things. The purpose and objectives of FabLab KhNEU: to develop of engineering creativity and innovativity for youth, to train students and creative people.to encourage youth entrepreneurship, to promote engineering specialities, to improve the skills of univesity teachers.

FabLabKPI was established in framework of Erasmus+ project have an equipment for machining, 3D printing, work with electronics, technical measurements and auxiliary equipment. FabLabKPI implements projects of students and professors of the Igor Sikorsky Kyiv Polytechnic Institute and cooperates with business. The most interesting projects: Formula Student KPI, City Electric Vehicle ZEUS, Modular Camper CangUA, Agricultural Robotractor FLIbot, Robot-andriod POPPY, Mobile Platform.

The electronics laboratory Lampa [29], also at NTUU KPI, is the opened laboratory for high-quality, free and interesting studying of electronics (Figure 8, b). It functions on the basis of the Department of electronic numerical apparatus constructing. The laboratory works in both educational and student development directions, starting with the implementation of the diploma and courseworks prototypes and resulting in own startups.

Sky Lab at NAU is an opened laboratory with scientific engineering designs developed by students and teachers (Figure 8, c) [30]. It functions on the basis of the Department of electronics at Scientific Educational Institute of Aeronavigation of NAU. In the laboratory there is minimal necessary equipment for studying electronics, that includes electronic boards (arduino uno / due, raspberry pi, intel edisson / galileo), educational boards, components, soldering station and more. Any student can come and accomplish a coursework or diploma project, or a startup prototype. Students can also get recommendations concerning modern software and board design both from teachers and advanced students, and from engineers-designers.

Laboratory “3D-innovation” was opened on the basis of SSU at the Faculty of Electronics and Information Technology in 2015. The main activities of the laboratory are: development, testing and use of 3D-printers, scanners and Embedded Electronic Systems based on Arduino and Raspberry Pi, design, simulation and manufacturing complex unique products from different types of plastic, manufacture of metal products using CNC-milling, development and implementation of augmented and virtual reality, production of unmanned aerial vehicles (quadcopters, hexacopters and gliders), holding seminars, conferences and courses related to 3D-printing and using artificial intelligence algorithms in embedded systems (Figure 8, d) [31].

On the basis of FabLab Sever at (SNU) in Severodonetsk students and pupils create a variety of objects made of wood, plastic, metal or cardboard, trainings and workshops, IT forums are held (Figure 8, e) [32]. FabLab was initiated by “Terre des hommes” (Tdh) organization and funded by the Ministry of Foreign Affairs of the

Netherlands. The project aims to support children and young people affected by the conflict in eastern Ukraine. Tdh started using FabLab for educational and humanitarian purposes in Greece in 2017 to help young people and communities affected by the refugee crisis. Both refugees and locals use this space to turn their ideas into life and develop their skills while improving their integration and resilience [32a].



*Figure 8. FabLabs operating at Ukrainian universities*

Sources: MiRONAFT FabLab [Online]. – Available at: <https://www.robot.onaft.edu.ua>, Lampa [Online]. – Available at: <https://www.facebook.com/lampa.kpi/posts/1664814657110749/>, Department of Electronics at NAU [Online]. – Available at: <http://kafelec.nau.edu.ua/IoT-ukr.html>, 3dinnovationlab [Online]. – Available at: <https://www.fablabs.io/labs/3dinnovationlab>, FabLab.Sever [Online]. – Available at: <https://www.facebook.com/FabLab.Sever/>

### **FabLab at TNTU**

On the 2<sup>nd</sup> of May 2018 at Ternopil Ivan Puluj National Technical University the TNTU FabLab within the Fablab project [28] as the 3D technologies center “FabLab” was established by the Rector’s Decree. It was established to set up the interaction between the university and industrial enterprises, stimulate youth entrepreneurship, improve the quality of education, teach graduate and post-graduate students, and creative youth from Ternopil the engineering fundamentals of 3D modeling and computer-aided design, prototyping and 3D printing, the theory of inventive problem solving, innovative marketing and project management, retrain teachers in the field of 3D modeling and 3D printing and prototyping.

“For the educational institution, FabLab has to become an integral part of the innovative infrastructure. We hope to actively introduce prototype creation technologies, 3D printing and 3D modelling into the educational process of all specialties and, in particular, into machinery engineering”, – said Rector Petro Yasnii during the Opening Ceremony.

The FabLab laboratory at TNTU is equipped, according to the requirements of the world Fab Foundation association, by two 3D printers, laser and milling machines with numerical control software, 3D scanner which are connected to computer automated production technological preparation stations based on modern software, as well as Arduino electronic prototyping kits.

Primary challenge of the TNTU FabLab is to provide students the opportunity to realize their technical and creative ideas. There are 5 well-skilled TNTU experts and plenty of modern equipment, which provide an opportunity to create almost anything.

The TNTU FabLab located in the TNTU campus on premises of Faculty of Engineering of Machines, Structures and Technologies. Work areas of the Fablab TNTU are demonstrated in Figure 9.

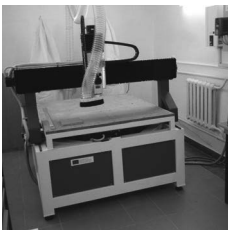


a) 3D modeling and design work area



b) 3D printing work area

c) laser cutting work area



d) CNC milling machine work area

e) workbenches and tools' box

*Figure 9. Work areas of the FabLab TNTU*

Source: 3D technologies center "Fablab" [Online]. – Available at: <https://fablab.tntu.edu.ua>

Events organized by the TNTU FabLab so far:

1. Presentation of Fablab equipment for teachers and students of Technical college of TNTU in Ternopil, June 21<sup>th</sup>, 2018 (Figure 10, a). Participants of FabLab project have shown the peculiarities of the application of 3D printing for teachers and students of Technical college of TNTU in Ternopil.

2. Workshop for students and meeting participants of partner universities within the Project, September 14<sup>th</sup> – 15<sup>th</sup>, 2018 (Figure 10, b): demonstration of equipment's possibilities in Fablab TNTU. During the short time of the Fablab Laboratory existence, researchers at the University have already been able to develop 2D and 3D

models of unique equipment and to produce prototypes of workpieces with complex geometry in the form of 3D printing.



a) Presentation of Fablab equipment for teachers and students of Technical college of TNTU



b) Workshop for students and meeting participants of partner universities within the FabLab project



c) Demonstration of 2D and 3D modelling and equipment for students of vocational school

d) Demonstration of 2D and 3D modelling and equipment for participants of Students Intellectual Festival “Vunderkinder”



e) Presentation of the Fablab equipment for secondary school pupils from Ternopil technical lyceum



f) Rector TNTU, Doctor of Technical Sciences, Professor P.V. Yasniy, the head of the Western Scientific Center of the National Academy of Sciences of Ukraine, the director of the Physics and Mechanics Institute named after. G.V.Karpenko, Academician of NAS of Ukraine Z.T. Nazarchuk, Chairman of PJSC “Ternopilgaz” O.I. Karavansky during a master class with a laser cutter

*Figure 10. Events organized by the FabLab TNTU, Ternopil, Ukraine, 2018-2019*

Source: 3D technologies center “Fablab” [Online]. – Available at: <https://fablab.tntu.edu.ua>

3, 4. Presentation of the FABLAB project results. Demonstration of 2D and 3D modelling and equipments for students of vocational school, 9 October, 2018 (Figure 10, c) and for participants of Students Intellectual Festival “Vunderkinder”, November 4th, 2018 (Figure 10, d): technological capabilities of the Fablab laboratory equipment have been demonstrated. Students have created models for laser cutting and 3D printing.

5. Introductory Workshop. Presentation of the Fablab equipment for secondary school pupils from Ternopil technical lyceum, held on 14 November, 2018 (Figure 10, e). Pupils have created models for laser cutting and 3D printing. The models were cut on a laser cutting machine.

6. Extended meeting of the Supervisory Board of Ternopil Ivan Puluj National Technical University, 12 December, 2018 (Figure 10, f). Supervisory Board members, scholars and entrepreneurs took an excursion to the FabLab Innovation Laboratory based on the 3D Technology Center. The equipment of the laboratory was demonstrated to the scientists, heads of industry companies and master classes for laser machine and 3D printer were conducted.

There are five courses developed within FABLAB to support the innovation and creativity within the five partner countries universities: 3D Design and

Manufacturing, Rapid Prototyping and Manufacturing, Theory of Innovative Problem Solving, Market Diffusion, and FABLAB Project management (Figure 11).

The project aims at piloting the courses on at least 20 students in each of the FabLabs established in order to test the relevance and to fine-tune the mode of delivery that is the most appropriate for each of the participant university. Universities where the FABLAB courses are being implemented are using the generic training materials developed within the Project. However, the aim of piloting is to create the condition for enhancing the content of the learning materials and to find the best mode of delivery.



Assoc. Prof. Valeriy Lazaryuk,  
Theory of Innovative Problem Solving,  
Fablab Project Management



Assoc. Prof. Volodymyr Shanaida,  
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Management



Prof. Tetiana Vitenko,  
3D Design and Manufacturing, Fablab Project  
Management



Prof. Nataliia Marynenko,  
Market Diffusion, Fablab Project  
Management

*Figure 11. FABLAB courses delivered by the FabLab TNTU team members*

Source: 3D technologies center “Fablab” [Online]. – Available at: <https://fablab.tntu.edu.ua>

Network developed by the Fablab TNTU includes cooperation with such legal entities as LLC “SAYUZ”, LLC “SPE “Teplobak”, TC “SINAY”, TC “3DDevice”, PBS “Marketing Techology Ltd”, LLC “VATRA Corporation”, Corporation “Science Park “Innovation-Investment Cluster of the Ternopil Region”.

The FabLab is able to provide the necessary conditions under which the formation and development of all the necessary practical skills and creative thinking become possible.

## CONCLUSION

Nowadays, FabLabs significantly contribute to the promotion of high-tech, original projects. Such laboratories make it possible to ideas to become real, technical implementation of which required significant costs and complex production facilities earlier.

Existing FabLabs are laboratories with a set of standard equipment for the realization of participants' diverse interests, encourage innovative activities through open access to tools and advanced equipment for creation of the prototype, facilitate participants' intellectual development through the implementation of training courses and the ability to learn and practice own things making, are communication, knowledge and experience dissemination centers among FabLabs participants worldwide.

Thus, FabLabs must be considered in terms of education and training of talented youth focused on scientific, technical and engineering activities. Establishment and operation of such structures enables representatives of science, business and education to meet, experience and competences to be exchanged, teams for implementation of specific projects to be formed, specialists to be trained. This should be considered as an important indicator of economic development in a particular region, raising the index of creativity, the degree of self-realization of young professionals and the widespread involvement of advanced technologies in a variety of industries and creative activities.

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