Pre-edited version

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ROZWÓJ MAŁEGO BIZNESU NA PLATFORMIE FABLAB

DEVELOPMENT OF SMALL BUSINESS ON FABLAB PLATFORM

Kluczowe słowa – Małe firmy, fablab, innowacji
Key words – Small business, FabLab, innovations

Streszczenie

Małe firmy mają wiele zalet podczas pracy z niszowymi produktami przeznaczonymi dla wąskiej grupy docelowej. Specjalistyczny popyt nie tylko tworzy wysokie ceny, ale także zapewnia długoterminowe partnerstwo z kupującymi. Jednak produkty lub usługi wysokiej jakości wymagają drogiego, nowoczesnego sprzętu, który nie zawsze jest dostępny dla małych firm.

Fablab stały się oryginalną platformą do szybkiego wdrażania pomysłów biznesowych w postaci prototypów produktów, do transferu wiedzy o innowacyjnych technologiach „cyfrowych” dla przemysłu, do badań i wdrażania nowego sprzętu. Te mini-fabryki są nie tylko wyposażone w najnowocześniejszy sprzęt do szybkiego prototypowania i oprogramowanie do projektowania modeli 2D i 3D, ale także wykorzystują nowoczesne podejście do zarządzania projektami, znajdując idealne rozwiązanie w zakresie projektowania produktów i innowacji marketingowych.

Aby zwiększyć wydajność i konkurencyjność małych firm, proponuje się dostosowanie produktów i produktów opartych na platformie FabLab, wprowadzając innowacje potrzebne konkretnemu użytkownikowi końcowemu.

Abstract

Small business is characterized by a number of advantages while serving niche markets with products designed for a narrow target audience. Demand for such products fosters not only high prices setting up, but also ensures long-term partnership relations with buyers. However, high quality products or services require the use of expensive, up-to-date equipment which is not always available to small businesses.

Fabrication laboratories (FabLabs) became the original platforms for: rapid implementation of business ideas in the form of product prototypes, transferring knowledge about innovative “digital” technologies for industry, research and introduction of new equipment. These mini-factories are equipped not only with a set of advanced rapid prototyping equipment and software for the design of 2D and 3D models, but they also use modern project management techniques, approaches for finding perfect solution of product design, innovation marketing.

Products’ adaptation on the basis of the FabLab platform by introducing innovations required by the end-user aimed at improving the efficiency and competitiveness of small businesses is offered.

Introduction

The idea of the FabLab (Digital Fabrication Laboratory, fabulous laboratory) establishment originated as an educational component for students and young people “How to Make (almost) Anything” developed and delivered by Prof. Neil Gershenfeld in the Center for Bits and Atoms (CBA) at the Massachusetts Institute of Technology in 2001 (Gershenfeld, 2005). Digital fabrication is the process of designing a digital item which is then fabricated. Numerically controlled machines touch almost every commercial product, whether directly (producing everything from laptop cases to jet engines) or indirectly (producing the tools that mold and stamp mass-produced goods) (Gershenfeld, 2012).

The key to global success is faster responsiveness to customers’ needs and market changes that is built into their business strategy as well as into their manufacturing system. The global manufacturing enterprise must possess reconfigurable manufacturing systems whose capacity can be easily changed to adapt to market demand, and its functionality can be cost-effectively adapted to introduce new products with short lead times. An emerging market in industrialized countries is created around cost-effective personalized products – ideally, each product will be made exactly for an individual customer’s needs (a market of one) (Yoram Koren, 2010).

Research results

The high cost and technical difficulty of making product prototypes have long been roadblocks for small business owners seeking to innovate. The primary obstacle for most people to pursue digital fabrication is caused by the considerable expenses related to the machines. Fablabs have spread up around the world, putting digital fabrication within financial reach of small businesses and significantly simplifying the process of prototype development, since they allow a community to gain access to the technology without the users having to front all the expenses themselves. In some fablabs, the users only pay for the materials they use, while others charge a fee depending on the amount of time and machines used (Yocum, 2015; Dali, 2015).

The technology has since developed to where the human part of the process is all digital and machines can take care of the rest. This enables any user to create products for a market of one. No market size is too small (Dali, 2015).

The competitive advantage of small business is serving narrow market segments. The degree of competition in the niche is small as large corporations prefer larger markets to operate in. Serving niches aims at identifying, meeting and exceeding the specific needs and wants of particular clients, often individual ones. Success in doing so will make it possible to build strong long-term relationships with customers.

Niche products are the ones that are designed for specialized demand and are having high added value. These are, for example, equipment for divers, dental and printing equipment, ATMs and expensive sports cars (Stadchenko, 2010).

A FabLab (digital fabrication (fabbing laboratory) is a small-scale workshop with an array of computer controlled tools that cover several different length scales and various materials, democratizing manufacturing technologies previously available only for expensive mass production (Menichinelli, 2011). Fablabs are special entities organized to allow intended users to foster innovation and invention by supplying resources that allow the transformation of computer data into tangible objects (e.g. prototypes) for a wide variety of goals, including but not limited to educational and entrepreneurial ones (Pauceanu & Dempere, 2018).

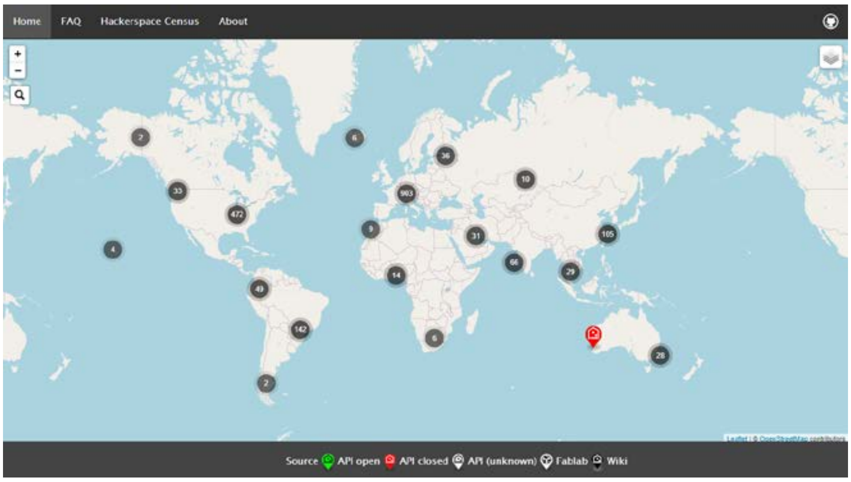
The FabLabs are a living project; they are based on a shared knowledge network which distributes processes and projects on the Internet. The difference between this and similar projects already in existence is that the network is based on new physical production methods and their evolution into accessible tools to bring manufacture to the level of the individual (Diez, 2012). Capdevila I. defines FabLabs as spaces of collaborative innovation which appear as environments where entrepreneurs can develop their projects by collaborating with peers, as well as spaces where the conditions for collective creativity motivate individuals to become entrepreneurs or intrapreneur (Capdevila, 2014). Makerspaces, FabLabs and hackerspaces tend to create a local community around certain shared practices (Capdevila, 2017).

FabLabs are a global network of local labs, enabling invention by providing access to tools for digital fabrication (CBA-MIT, 2012). The Fab Foundation puts forward the requirements for the equipment needed for fablab to operate: a laser cutter for 2D and 3D structures, a 3D printer, a high-resolution CNC milling machine for precision parts, large wood router, a suite of electronic components and programming tools for rapid circuit prototyping (Fab Foundation). This is a minimal set of equipment that remains unchanged for two decades and needs to be upgraded through the attraction of new design technologies, providing existing 3D printers with new opportunities to accurately replicate business ideas for advertising, packaging, individual food samples, new robotic systems for construction or welding, sewing digital equipment.

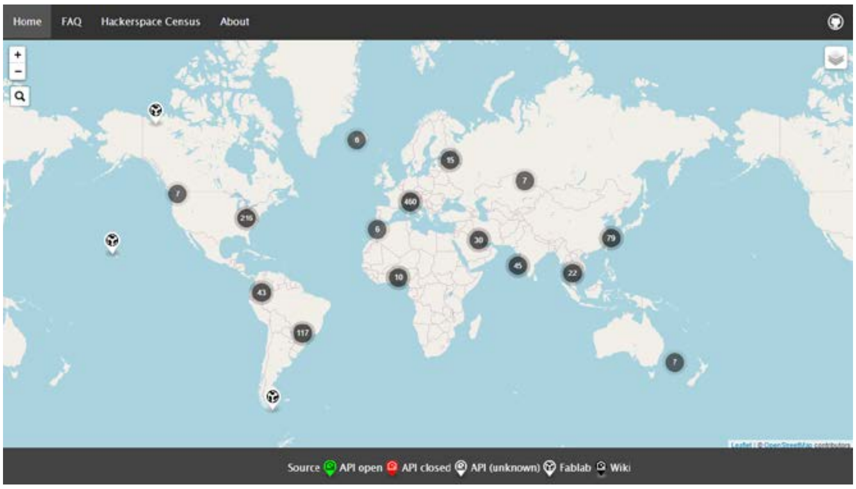
The research lab has created prototyping capabilities for personal fabrication to solve their needs. The available laboratory equipment made it possible a very precise machining on CNC machines and to qualitatively control the processes through microcontrollers. Engineering capabilities have provided numerous opportunities for innovative solutions of ordinary tasks. On the other hand, the concept of personal fabrication enables creating everything that could be imagined and designed in designer computer programs. Although the use of innovative equipment even 20 years after the opening of the first fablab does not allow to solve all problems of modern industrial technological enterprise, it still remains an innovations incubator for regional small enterprises and individuals-entrepreneurs.

An important feature of fablabs, unlike other innovative labs and maker spaces, is their membership in the global FabLab network. They are united not only by the availability of specialized equipment, but also by other general principles: the availability of public access to the laboratory, the signing of the FabLab Charter, the constant participation in the activities of the FabLab network through taking part in the video conferences, annual meetings and the FabLab Academy operation.

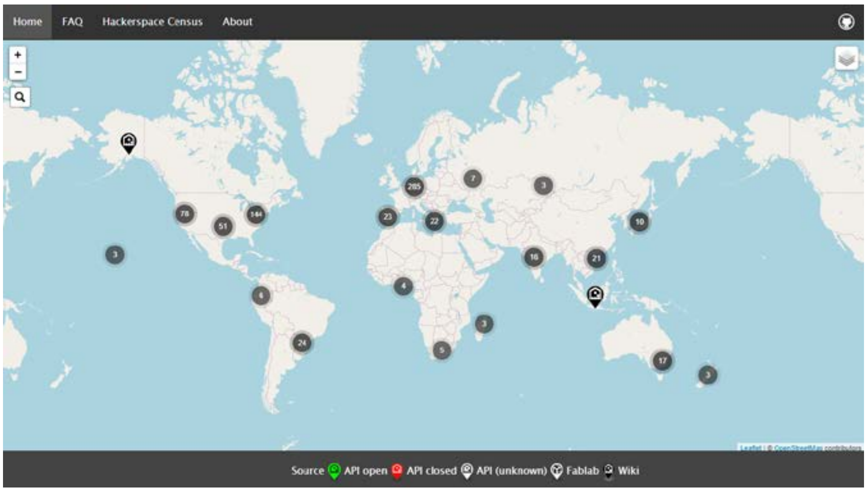
A dynamic map of innovative laboratories (hackerspaces, makerspaces and fablabs) and hubs has been offered (Borghuis). At the same time, annual control over their existence and constant updating of data is carried out. For example, only data on the fablab which are “active” are taken into account (Figure 1).



a) active laboratories of makers around the world (1948 units) as of March, 2020



b) active fablabs (1070 units) around the world as of March, 2020



c) active hackerspaces around the world (725 units) as of March, 2020

Figure 1. Map of innovative laboratories of makers (hackerspaces, fablabs)

Source: Borghuis D., *A dynamic map of all hacker/maker spaces and fablabs*

In (Pauceanu & Dempere, 2018) it is stated that Fablabs became very popular around the world due to the following significant reasons: they contribute significantly to innovations' development and entrepreneurship enhancement; they provide entrepreneurs (or soon-to-be entrepreneurs) with the access to technology for developing prototypes free of charge; they provide connection to other tools of economic development in the ways that will optimize business results.

In 2018 within the Erasmus+ programme of the European Union a project "Development of a network infrastructure for youth innovation entrepreneurship support on FabLab platforms" (561536-EPP-1-2015-1-UK-EPPKA2-CBHE-JP, FABLAB Project) has been launched. Three FabLabs have been established at Simon Kuznets Kharkiv National University of Economics (KhNUE) (Erasmus+ FABLAB in KhNEU), Integrated Manufacturing Engineering Department and the Educational and Scientific Complex "Institute of Applied Systems Analysis" (IASA) of NTUU KPI (FabLab KPI) and at Ternopil Ivan Puluj National Technical University (TNTU). The coordinator of the international FABLAB project was the Buckinghamshire New University (UK). Achievements of TNTU in the framework of the FABLAB project are identified and analyzed in (Vitenko, Marynenko, Lazaryuk, Shanaida, 2019) as well as the role of FabLab platforms in the ukrainian economy innovative development.

Information on new fablabs' opportunities is available in the EU Erasmus+ FABLAB project results (Erasmus+ FABLAB in TNTU; Erasmus+ FABLAB in KhNEU). For example, FabLab "Youfactory" in Lyon is equipped with basic machinery for prototyping and production: laser cutter, CNC milling machine, vacuum forming machine, electrical facilities and more. The second floor accommodates a co-working space, office and display equipment and a range of 3D printers. As "Youfactory" is a private for-profit company, the access to equipment and services is available upon subscription.

Next Lab Digital Laboratory in Lyon is a fablab for those engaged in visual digital arts. Fablab is equipped with quality audio and video equipment and used as a testing ground for digital art projects before they are released. The project aims to give room for cooperation between artists and engineers in digital art. The potential clients of the digital laboratory are local authorities, concert venues and event agencies

Another famous FabLab "DTU Skylab" in Denmark, an innovation center for the development of creativity and entrepreneurship, which is located on the campus of the Technical University of Denmark. The target audience of this center are students of DTU and partner universities. The purpose of the organization is the development of student entrepreneurship in three main directions: student innovation, business cooperation and academia. The center consists of several areas, among which are: a co-working area, event space, meeting rooms, laboratories, shops for metalwork, woodwork, welding and prototyping, etc. The rapid prototyping lab provides access to such equipment as a 3D printer, a laser cutting machining and a 3D scanner. All the equipment has detailed instructions for use and students are able to produce a prototype completely on their own.

Other fablab in Denmark “FabLab RUC” is an open laboratory. One does not have to be a Roskilde University student to attend it. The lab makes various equipment available: tools for materials treatment (wood, plastic, metal, fabric), as well as for electronic works, programming and automated production. The admission to the laboratory is free, payment is only necessary for used materials. This laboratory is very appreciated by the organizers of various events. For example, a rock festival in Denmark has put the laboratory to use to create a luminous musical forest, as well as a giant fire fountain.

Very interesting mobile FabLab BUS is a part of the Danish fabrication laboratory. It is a small production laboratory placed inside a standard city bus. It has a set of equipment for prototyping: laptops, 3D printers, cutters, a milling machine, a 3D scanner. Moreover, the bus has an area allocated for coworking. The bus is popular with companies as well, which have their employees learning more about new technologies. From 2013 to 2015 mobile fablab toured around the cities of Denmark in order to increase awareness of students and employees about technologies and techniques that are available in fabrication laboratories.

Many innovative solutions are presented by the fablabs’ members in the network as detailed technical reports on their implementations, which is an important assisstance to the fresh fablabs participants.

Similarities and differences of skills, technologies used and customers served among the main European laboratories (Italy, France, Germany, the Netherlands and Spain) and the American ones have been studied in (Santos, Murmura & Bravi, 2018).

Results of surveying 131 students enrolled in a business administration undergraduate program at a large Midwestern university (USA) testify that initiatives by business schools and entrepreneurship programs to invest in digital manufacturing technology are to be supported as they help increase students’ confidence in their technological and entrepreneurial abilities (Monllor & Soto-Simeone, 2019).

The labs give students an opportunity for hands-on experience, allowing them to develop both strong technical skills and an innovative and entrepreneurial mindset (Silva, Almeida & Strokova, 2015).

In relation to its effectiveness, since 2001 in MIT and since 2005, when the first FabLab was created outside of MIT, the model has proved to be a facilitator for the creation of regional innovation, building bridges and relationships between experts in technology, design, education, small business owners and entrepreneurs, architecs, artists, non-profit organizations, etc. (Jamil, Ferreira, Pinto et.al, 2018).

The possibility of low-cost fabrication provided by fablabs to business customers who previously conceived making things as not viable has been found by P. Troxler and P. Wolf (Troxler & Wolf, 2010).

As stated by Capdevila (2014, 2017) FabLabs are spaces for prototyping and in some cases, members of these spaces have started a business from the activities taking place in the space. However, FabLabs are not spaces to develop commercial projects. The activities focusing on the commercial exploitation of the results of the experimentation and exploration have to be done outside the FabLab. According to the FabLab Charter (CBA-MIT, 2012) commercial activities can be prototyped and incubated in a fablab, but they must not conflict with other uses, they should grow beyond rather than within the lab, and they are expected to benefit the inventors, labs, and networks that contribute to their success.

P. Troxler, among other studies analyzed FabLabs in terms of value proposition, revenue model, processes and resources, marketing, and innovation partnerships (using activities of 10 fablabs as case studies of 45 then existing). He has found out that the labs were primarily offering infrastructures to students, and they were relatively passive in reaching out to potential other users. They had so far created a limited innovation ecosystem, which got used rather rarely. Two value propositions have been identified by P. Troxler, namely labs providing facilities and labs providing innovation support (Troxler, 2010).

According to (Innovation Potential & Specialization Strategy Papers, 2017), fablabs increase the innovation performances of companies and related economic outcomes stimulating new opportunities for growth and market in the territory and internationally; encourage the birth and the development of innovative entrepreneurial initiatives, with particular reference to the intensive knowledge and emerging sub-sectors etc.

Among the niche fablab products the following ones may be named: three-dimensional advertising products, art products, equipment for athletes (various simulators and sports equipment), disabled (prostheses, exoskeletons, wheelchairs, etc.), dental prosthetics, medical industry (modeling of bone structure and their three-dimensional printing in the purposes of post-traumatic reconstruction, printing orthesis, masks, protective shields, etc.), new composite materials, support process of modeling, prototyping and testing, in range of automation and robotics as well as smart creative technologies, including design (Innovation Potential & Specialization Strategy Papers, 2017), single products manufactured on a 3D printer and laser cutter.

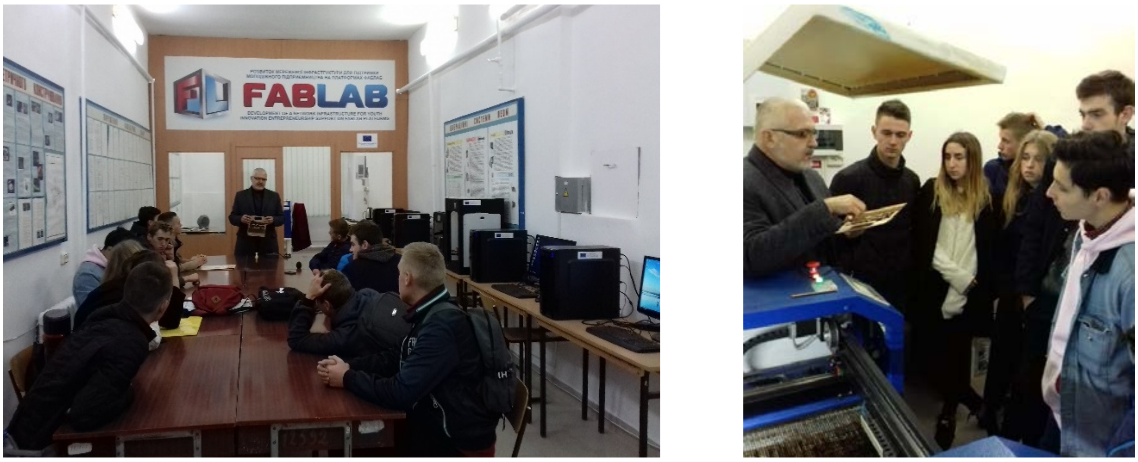
By searching for “fablab creations” in one’s preferred search engine and one discovers images of anything from clothes to replacement parts for broken equipment, from guns to farming equipment, from prosthetic limbs to furniture, from houses to robots to new 3D printing machines. Companies use fablabs to create prototypes of new ideas (Dali, 2015).

In Ukraine as of 2020 ten FabLabs are being registered in Kyiv (Fabricator, IZOLAB, Hobotorez, Hangar159), Odesa (MiRONAFT, .buro, HUB LAB), Kharkiv (Garage Hub), Sumy (3dinnovationlab), and Vinnytsia (Kvadrat) (The current official list of FabLabs, International FabLab community).

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), Ternopil Ivan Puluj National Technical Univeristy (TNTU), Sumy State University, National Aviation University, Volodymyr Dahl East Ukrainian National University in Severodonetsk, Lviv Polytechnic National University.

On the 2nd of May, 2018 at the TNTU the FabLab TNTU and 3D Technology Center within the framework of the mentioned project was opened. 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, business and industry based on fablabs (Figure 2).

“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 Yasniy during the Opening Ceremony (The new FabLab laboratory at TNTU is designed to support the development of innovative technologies).



a) an educational area

b) practice work at the laser cutter machine

Figure 2. FabLab TNTU, Ternopil, Ukraine

The FabLab TNTU is a free workspace for students and juniour researchers. Its primary challenge is to provide students the opportunity to realize their technical and creative ideas. There are 5 well-skilled experts and plenty of modern equipment, which give an opportunity to create almost anything.

The FabLab at TNTU is equipped, according to the requirements of the world Fab Foundation association, by two 3D printers, laser cutter, CNC milling machines, 3D scanner, CAD/CAM computer stations, as well as Arduino electronic prototyping kits (FabLab TNTU, 3D Technology Center Equipment).

The FabLab TNTU was created 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 tasks solving, innovative marketing and project management; retrain teachers in the field of 3D modeling and 3D printing and prototyping.

Participants of the FABLAB educational program are trained on the principle of creating their own innovative product, including the stage of its physical model or prototype development.

The developed business proposal makes it possible to design idealized sketches of the product, to set its technical and operational requirements. As a result, technical workers are given a design that has physical and technological contradictions. To solve these types of technical problems, the algorithm of solving the inventive problems (TRIZ) is used. The result of this analysis is a working product design with the necessary parameters for its operation and exploitation.

Working sketches of individual units and parts of innovative product allow to prepare 3D models in the design programs and to carry out mathematical modeling and optimization of their parameters. The learning outcome of the 3D Design and Manufacturing course is a digital format for drawing of product’s details and its wiring diagram.

The final step in creating an innovative product is to manufacture it using innovative laser prototype on a rapid prototype equipment, 3D printer or a CNC machine. The electrical part of the device is assembled with the aid of an electronic prototyping platform.

Project management allows trainees to develop a clear plan for the implementation of their entire innovation project. For this purpose modern approaches of project management are applied. At the stage of marketing analysis, the search for analogues and analysis of known solutions and business ideas for the implementation of an innovative project is carried out. Contemporary marketing theories, tools and techniques are offered to the fablab’s users.

Entrepreneurial education is particularly important in increasing entrepreneurial intentions in students at the upper secondary level, and the fablab is an ideal venue for such entrepreneurial education (Dali, 2015).

The training programme at the FabLab TNTU is aimed not only at studying individual disciplines, but also at mastering the algorithm of working with a technical idea. Participants of the educational process take part in the development of a computer solid model of the idea, its physical prototype for testing by the end user, and further industrial reproduction during the implementation of the business projects. The initial idea of an innovative product goes through the following stages:

– planning of necessary design and search works by the means of project management;

– detection and resolution of technical contradictions using the TRIZ methodology;

– production of working drawings and product models in engineering software for 2D and 3D graphics; production of the first prototypes;

– modelling of individual components of the product in the engineering software to clarify the design of individual elements, the manufacture of a working prototype;

– conduction of the marketing research, clarification of the prototype’s component composition;

– development of a business plan, manufacture of a limited amount of prototypes for the market testing.

The students project teams is constantly looking for ways to improve the prototypes for innovative products. As a rule, such products are designed for a small number of unique consumers of a certain niche category. An example of prototype of a gift box for coffee and sweets with an original geometric shape and decoration, shown in Figure 3. The uniqueness of this prototype is explained by the possibility of its decoration with embossed inscriptions up to the customer's choice using the fablab equipment.

Figure 3. Students' innovation prototypes, FabLab TNTU, Ternopil, Ukraine

During the short time of the fablab existence, students and staff at the university have already been able to develop 2D and 3D models of unique equipment and to manufacture prototypes with complex geometry in the form of 3D printing.

An important feature of creating an innovative product is that a significant part of its preparation can be carried out by distance learning, using both the developed within the FABLAB project methodological materials and training materials available in the worldwide FabLab network.

Conclusions

Currently fablabs are not only laboratories for individual products fabrication on demand and demonstration of new technologies for young people, but also the ones that independently create and test technological ideas for startups and small businesses.

The activities of educational and innovation research centers on the FabLab platform are based on the idea of broad involvement of young people, students, business representatives and initiative citizens into projects implementation. The process of creating a new product from idea to prototype is implemented by one or more working groups using modern modeling and prototyping technologies, conducting marketing research and fabrication process management development. This approach makes it possible to combine in a unique conglomerate the needs and ideas of businesses, mindset of student's youth and the life experience of older generation. This is facilitated by the establishment of a university-enterprise-business network comprising local industrial and small businesses.

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