NEWTON – FABLABS AS A NEW WAY OF IMPROVEMENT FOR EDUCATION IN TECHNICAL DISCIPLINES

Tomáš Zeman, Oto Sládek, Jaromír Hrad

Abstract

In the present paper we introduce an ongoing research EU project NEWTON, the program of which includes also integration of FabLabs (Digital Fabrication Laboratories) in education of university and secondary school students with the help of digital fabrication technologies. NEWTON develops an integrated technology for enhanced learning (TEL) methods and tools, to create or interconnect the existing state-of-the-art teaching labs into one platform that will support fast dissemination of learning content to a wide audience with special focus on increasing the learners' quality of experience, improving the learning process and extending the learning outcomes. In this context, digital fabrication is used as an educational tool, through which we attempt to create a working learning environment in order to improve the students' motivation. FabLab part is based on the approach considering technology as a building material, the need of 'learning by doing' approach, the importance of learning to learn to keep learning or the benefits of enjoying while learning.

Keywords

FabLab; education; modern forms of education; engineering design; fabrication; secondary schools; students; university.

1. Problem and Motivation

At present, the interest in technical disciplines is decreasing. This is evident both at the secondary and tertiary level of the educational system. At the same time, the rapid development of ICT and robotics, followed by their implementation into industry (see Industry 4.0), will soon require a large number of professionals capable of "servicing" the new systems (in this context, "servicing" will be really sophisticated), but also to design and develop them. Therefore, schools are facing a challenge to attract sufficient number of students capable of ensuring smooth implementation of new technologies in the future.

One of the ways to succeed is an attractive approach to education, which, on the one hand, helps to attract students, and on the other hand make the lessons modern and efficient. At present, LMS systems are commonly used, MOOC courses are used to a lesser extent (and specifically); education with real technology is also used (laboratory and network equipment measurements – locally or remotely), as well as computer simulations and modeling, including virtual laboratories (MATLAB

etc.). However, the connection with the real world of technology is not very common yet. It turns out that one of the right approaches may be the use of so-called FabLabs.

2. FabLabs

A FabLab is a small-scale workshop with a set of flexible tools and machines controlled by a PC or a control system. A FabLab environment is an inspiring and creative surrounding that provides students with digital fabrication resources and allows educators to develop hands-on and collaborative teaching practices. For its own intrinsic nature, it can be seen as a laboratory to acknowledge and embrace different learning styles where "students can concretize their ideas and projects with intense personal engagement". This approach stimulates students to come up with new concepts and ideas and specially to fabricate a prototype. It is a perfect illustration of "learning by doing" because all the tools necessary to bring a product to a realization are at hand. The main factor that actually limits a wider spreading of the FabLab concept is the lab set cost. Fabrication machines and materials are expensive and not all educational institutions may afford purchasing of the equipment to start (and maintain) a FabLab. Providing a Fab Lab with ubiquitous access is not simply a matter of connecting the digital fabrication equipment to the Internet, but a challenging task that entails rethinking the whole software and hardware infrastructure and involves the design of an ad-hoc communication stack to manage real-time access and control of the networked equipment, addressing all the security issues that might arise by exposing the equipment to the network.

One of the goals of NEWTON project is empowering the FabLab infrastructure by:

1. Providing digital fabrication equipment with support for pervasive and ubiquitous Internet access.
2. Building a virtualization layer on top of the FabLab infrastructure in order to expose to the Internet the digital fabrication equipment as a web service.

2.1 Available Technologies

FabLabs currently include computer-controlled machines, such as e.g. laser cutter, CNC milling machine, cutter plotter, 3D scanner, 3D printer, etc.

The electronics inventory includes commercial off-the-shelf kits like Arduino, Scratch, etc. for people learning electronics or intending to use them as development platforms.

Other, follow-up parts of the FabLab system will be the newly designed interfaces that are able to interconnect the above-listed FabLab devices with appropriate remote control SW environments. It is typical for the implementation that is being prepared within the NEWTON project that each FabLab is network-integrated in the Cloud, and the resulting unit will serve for education through a standardized interface. For this reason, integration into standard LMS-type systems is also supported.

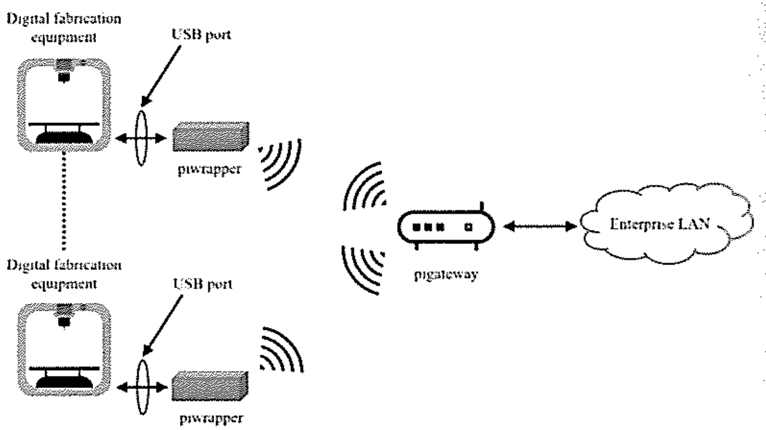


Figure 1: Simplified FabLab network infrastructure

3. Use Cases and Scenarios

The mentioned scenarios will target the use of the FabLab as a support tool for students, used to fabricate small-scale prototypes to demonstrate or prove the concepts developed in theoretical classes and virtual labs using the hands-on approach. All of them will leverage the infrastructure and contents developed to provide students with a personalized learning environment that assists them during the whole fabrication and experimentation process, establishing a clear link between theoretical concepts and their practical application.

The scenarios will target both the local and remote access to digital fabrication facilities using the management interfaces for batch production and the interfaces for students with disabilities. The goal is to demonstrate the effectiveness of the FabLab in development of problem solving and collaborative skills among students, building team commitment, bringing emotion and motivation into activity designs, and to increase the interest in science, engineering, design and related subjects.

In order to deeply explain the suggested scenarios, it will be necessary to provide a general explanation on how the learning experience works in a FabLab.

Users learn by designing and creating objects of personal interest. Empowered by the experience of making something themselves, they gain deep knowledge about machines, materials, design process, and engineering that turns into invention and innovation. In educational settings, rather than relying on a fixed curriculum, learning happens in an engaging, personal context, one in which students go through a cycle of imagination, design, prototyping, reflection and iteration, as they find solutions to challenges or bring their ideas to life.

Digital fabrication goes from the design (digital design) to the fabrication (fabrication machine). That implies that students interested in prototyping something, regardless of the specific technology to be used, should follow this workflow scheme:

- Learning how to use software that helps them with the design process.
- Using the software to make their own design (object, model or prototype).
- Teachers should provide them with the proper instructions how to use a machine to prototype their designs. These could be fabricated with a laser cutter, vinyl cutter, CNC machine or 3D printer.
- Students should prototype their own designs, assemble all the pieces and test the final object.

In order to integrate the above-mentioned FabLab teaching experience with the NEWTON platform, we propose two different scenarios.

3.1. Scenario 1: Games to Learn FabLab Technologies

FabLab learning experience could be acquired through games that allow turning learners into gamers. Games could be considered as a transition from novice to master. There could be small achievable challenges along the way to reach the overall goal. Teachers should offer small incremental challenges to improve the gamers' skills.

3.2. Scenario 2. Serious Game to Learn FabLab Workflow

Once students have learned how to use different Fab Lab technologies, they should gain experience of the workflow that will allow them to use the technologies they need to fabricate a prototype.

4. Target Group and Large-scale Pilot Testing

The target groups are students of engineering schools – secondary schools, higher schools and universities – and their teachers. Depending on the specific tasks, the results can be used also at other types of non-engineering schools, especially grammar schools – there it will be mainly basic introduction to different technologies so that students who still do not have clear focus can be supported in gaining the interest in technical disciplines for their further study.

Within the NEWTON project, in which the above-mentioned FabLab systems including their interconnections will be prepared, pilot testing is planned. Given that a total of 14 partners from 7 European countries are involved in the project, the pilot testing will be really extensive – we expect the involvement of hundreds of students from different types of schools.

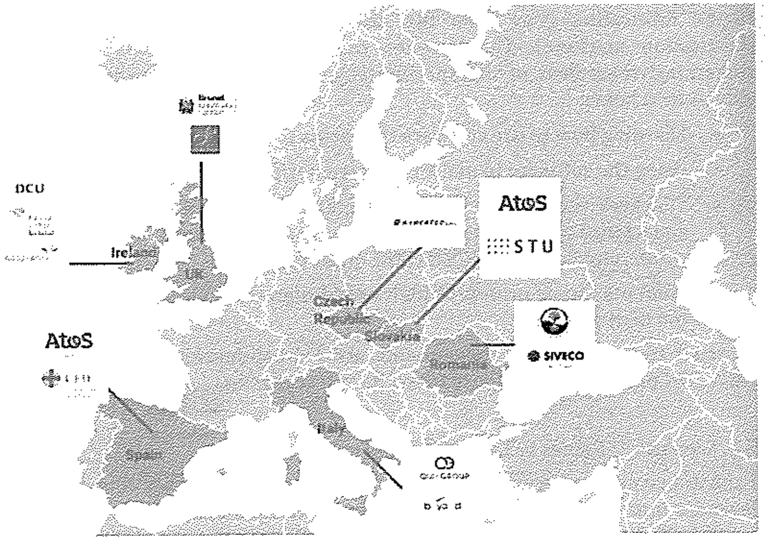


Figure 2: Partners of project over EU

5. Conclusion

At present, appropriate educational models (cases) are being selected to be used in teaching; at the same time, FabLab remote control and interfaces (plug-in components) for interconnection with electronic learning management systems are being developed. Consideration is given to localization of already completed training programs, so that candidates for pilot testing (especially at secondary schools) are not limited due to the language barrier. In addition, methodological guidelines for teachers as well as tools for feedback collection and system evaluation will be developed. We expect the pilot run to begin in the first half of 2018, so the results can be available in autumn 2018.

References

[1] NEWTON project portal [online]. Available from: http://www.newtonproject.eu

[2] Digital Fabrication as a Tool for Teaching High-School Students STEM at the University, Covadonga Lorenzo CEU University, IDC 2017, June 27–30, 2017, Stanford

Ing. Tomáš Zeman, Ph.D.
Czech Technical University in Prague, Faculty of Electrical Engineering
Technická 2, Praha 6, CZ-166 27, Czech Republic
e-mail: zeman@fel.cvut.cz

Ing. Oto Sládek, Ph.D.
KYBERTEC, s.r.o.
Tovární 1112, Chrudim 4, CZ-537 01, Czech Republic
e-mail: sladek@kybertec.com

Ing. Jaromír Hrad, Ph.D.
Czech Technical University in Prague, Faculty of Electrical Engineering
Technická 2, Praha 6, CZ-166 27, Czech Republic
e-mail: hrad@fel.cvut.cz

Název: Sborník příspěvků z konference a soutěže eLearning 2017
Editorka: Petra Poulová
Návrh obálky: Michaela Mitáčková
Rok a místo vydání: 2017, Hradec Králové
Vydání: první
Náklad: 70

Vydalo nakladatelství Gaudeamus, Univerzita Hradec Králové
jako svou 1627. publikaci.

ISBN 978-80-7435-691-9

Editor:
doc. RNDr. Petra Poulová, Ph.D.

Recenzenti:
Mgr. Miloslava Černá, Ph.D.
Dr. Sue Greener
doc. PhDr. Blanka Klímová, M.A., Ph.D.

Publikace neprošla jazykovou úpravou.
Za obsahovou správnost odpovídají autoři příspěvků.

Vydalo nakladatelství Gaudeamus, Univerzita Hradec Králové
jako svou 1627. publikaci.
Hradec Králové, 2017

ISBN 978-80-7435-691-9

Sborník příspěvků z konference s mezinárodní účastí eLearning 2017 a 17. ročníku soutěže eLearning.

Konferenci a soutěž uspořádala Fakulta informatiky a managementu Univerzity Hradec Králové ve spolupráci se zájmovým sdružením EUNIS-CZ ve dnech 8. a 9. listopadu 2017.

Na uspořádání konference a soutěže dále spolupracovaly: zájmové sdružení EUNIS-SK, Česká asociace distančního univerzitního vzdělávání a Česká společnost pro systémovou integraci.

Programový výbor a odborná porota:
Mgr. Miloslava Černá, Ph.D.
Dr. Sue Greener
doc. Ing. Jan Hán, Ph.D.
doc. PhDr. Blanka Klímová, M.A., Ph.D.
doc. Ing. Jan Lojda, CSc., MBA
Dr. Catherine Matsuo
doc. RNDr. Jaroslava Mikulecká, CSc.
doc. Ing. Arnošt Motyčka, CSc.
prof. Tatiana Polyakova, Cand. Pedag. Sc.
doc. RNDr. Petra Poulová, Ph.D.
Dr. Maria Teresa Restivo
PhDr. Lucie Rohlíková, Ph.D.
assoc. prof. Dr. Tiia Rüütmann
doc. PhDr. Ivana Šimonová, Ph.D.
prof. PaedDr. Gabriel Švejda, CSc., dr.h.c.
RNDr. Darina Tóthová, Ph.D.
prof. Ing. Milan Turčáni, CSc.
RNDr. Stanislav Zelenda

Organizační výbor:
Helena Holubičková
Ing. Věra Palánová
doc. RNDr. Petra Poulová, Ph.D.
doc. PhDr. Blanka Klímová, M.A., Ph.D.
Ing. Hana Šrámková, Ph.D.
Adam Richter

SOUTĚŽ A KONFERENCE eLEARNING

Již po osmnácté se začátkem listopadu setkávají na půdě Univerzity Hradec Králové odborníci zabývající se možnostmi využití digitálního vzdělávání.

V závěru roku 2000 uspořádala Fakulta informatiky a managementu Univerzity Hradec Králové společně se sdružením EUNIS-CZ (Evropská Organizace pro Univerzitní Informační Systémy – nezávislé zájmové sdružením, jehož členem může být každá právnická osoba činná v zavádění, rozvoji, řízení nebo používání informačních systémů na vysokých školách) historicky první seminář věnovaný otázkám implementace distančního vzdělávání na vysokých školách. V následujícím roce byl seminář doplněn o soutěž eLearningových produktů a původně jednodenní seminář se v průběhu let rozrostl ve vícedenní konferenci s mezinárodní účastí.

Záměrem soutěže vyhlašované Univerzitou Hradec Králové a sdružením EUNIS-CZ je:

- představit nejlepší výukové produkty využívající informační technologie,
- podporovat tvorbu v oblasti eLearningových produktů,
- umožnit srovnání eLearningových produktů,
- přispívat k posilování obecného povědomí o možnostech vzdělávání s podporou moderních technologií,
- stimulovat spolupráci v oblasti eLearningu.

V rámci 17. ročníku soutěže mají účastníci konference možnost shlédnout ve dvou kategoriích osm soutěžních produktů.

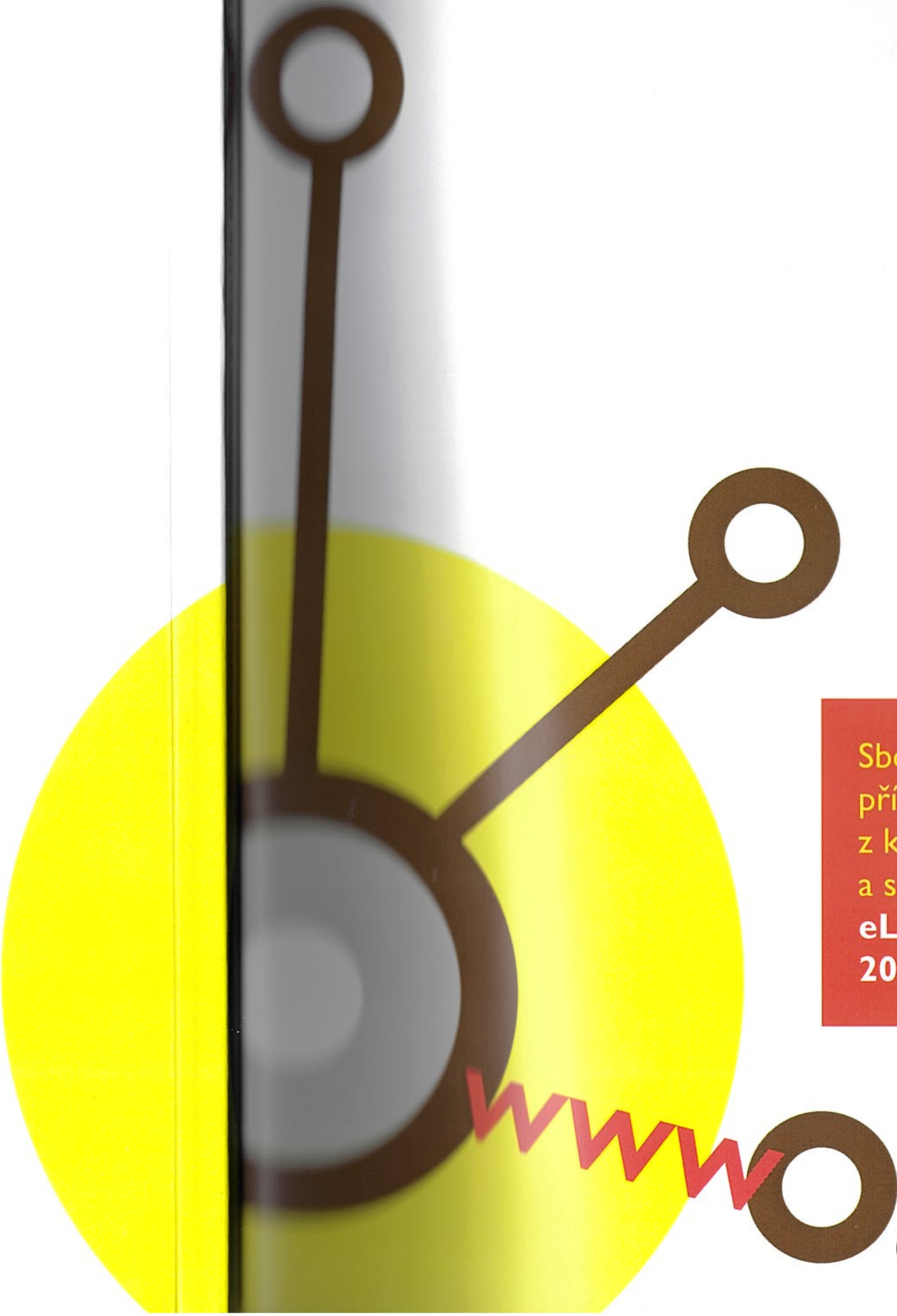
Přejeme Vám, aby i letošní ročník konference byl pro Vás zajímavou inspirací.

Za organizátory soutěže a konference eLearning 2017
Petra Poulová

Editorka Petra Poulová
ISBN 978-80-7435-691-9
Gaudeamus, UHK
Návrh obálky Michaela Mitáčková

FIM UHK

EUNIS - CZ



Sborník příspěvků z konference a soutěže eLearning 2017

eLEARNING