

BRIGHT

Erasmus+ strategic partnership for Higher Education

BOOSTING THE SCIENTIFIC EXCELLENCE AND INNOVATION
CAPACITY OF 3D PRINTING METHODS IN PANDEMIC PERIOD

O3 - BRIGHT 3D printing virtual laboratory room

Project Title	Boosting the scientific excellence and innovation capacity of 3D printing methods in pandemic period 2020-1-RO01-KA226-HE-095517
Output	O3 - BRIGHT e-learning virtual laboratory platform – description of 3D printing virtual laboratory room and supporting capabilities
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1 Introduction

As it has been described in the main report related to the BRIGHT virtual laboratory platform that has been conceived in the BRIGHT project (main concept and vision), The BRIGHT Virtual Laboratory has been conceived as a web-based platform, that is accessible by WWW browser. BRIGHT virtual laboratory platform contains a number of basic modules – virtual rooms that are accessible from a main, web-based interface.

The scheme in Figure 1 presents the initial idea of the BRIGHT VL. In the first concept, it was assumed that there will be 4 rooms, each with a specific purpose – CAD, CAE, 3D Printing and testing. In each room, it was proposed that – apart from standard educational content – there will be more sophisticated, interactive solutions, such as VR and AR applications, along with e-library of models and presentations / teaching resources integrated into the rooms.

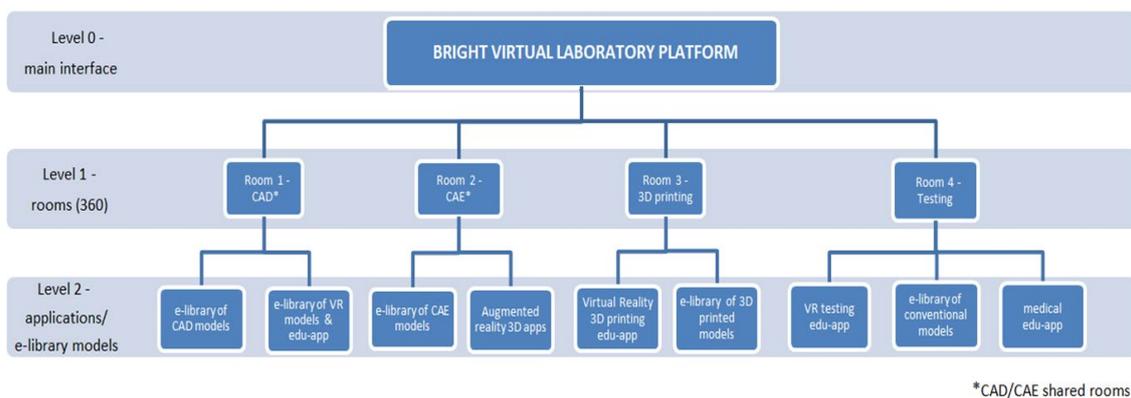


Figure 1. Initial concept of the Virtual Laboratory in the BRIGHT project

Taking into consideration this the initially planned “rooms” were mapped as following in terms of thematic rooms (according to the experience and expertise of BRIGHT consortium partners):

1. CAD: main room at TUCN + supporting capabilities in PUT, UNI and STU rooms
2. CAE: main room at TUCN + supporting capabilities in BIZZCOM
3. 3D Printing (Rapid Manufacturing): main room at PUT + supporting capabilities in TUCN and BM Plast
4. Testing: main room at UNI + supporting capabilities in STU, UNIPU, BIZZCOM and BM Plast

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In this report there are provided details about the thematic 3D printing / Rapid Manufacturing virtual laboratory room (room number 3) which is relying on basic main room that has been constituted at PUT partner, being completed with the supporting capabilities of TUCN, like shown in Figure 2. Scheme realized in Figure 2 has been conceived, realized and has been posted on the BRIGHT project website from where the BRIGHT platform can be accessed before going to visit the rooms of the BRIGHT institutions (see: https://bright-project.eu/?page_id=320). In this way like shown in Figure 2, anyone who is accessing the virtual laboratory in order to take one visit on several BRIGHT institutions in virtual way can do it much better oriented before starting to visit the laboratories, by doing according to the steps that are necessary related to the conceiving, manufacturing and testing of medical parts. After performing the CAD design of medical products and after validating of the solutions that have been made through simulations that have been made by CAE, as one my notice in the scheme presented in Figure 2, manufacturing of medical parts by 3D printing processes are following next in the chain.

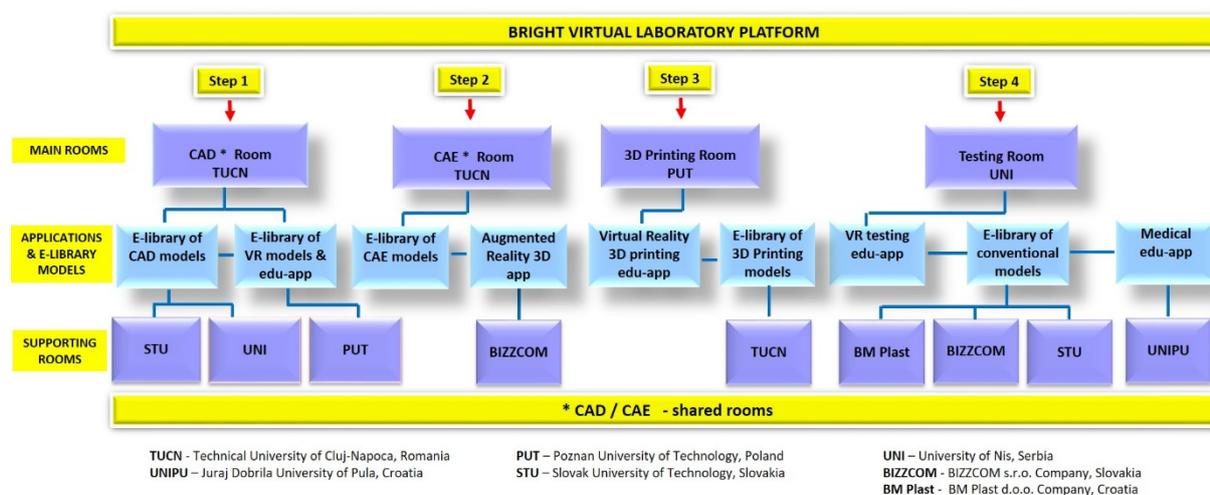


Figure 2. Main concept of BRIGHT virtual laboratory platform in terms of thematically rooms and apps

3D printing solutions of PUT and TUCN partners have been considered feasible, comprehensive and complementary, as they are available within big infrastructure of these institutions comprising tens of 3D printers that are different in terms of working principle

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(PUT has few equipment items that TUCN doesn't have in 3D printing domain and vice-versa). Teaching facilities have been used by the BRIGHT professors (coming from all BRIGHT higher educational institutions) in time of pandemic in relation with their students and have been used also during the BRIGHT summer school 2022 event held in Croatia and Multiplier Event held in 2022 also in Croatia, in which more than 150 students and pupils had the chance to experience the platform, to test the facilities and to download and use the existing resources that can be found on the BRIGHT virtual laboratory (3D printing rooms).

2. Virtual 3D printing laboratory room description

2.1. Accessing the virtual 3D printing laboratory room from the BRIGHT platform

As one may notice in Figure 1, in order to access the 3D printing laboratory rooms, this can be done from the main www BRIGHT virtual laboratory interface. The main interface of the Virtual Laboratory platform is available through the main website of the BRIGHT project - <https://bright-project.eu/>. After accessing the website, there is a link in the upper panel, named "Virtual Laboratories" (Figure 3).

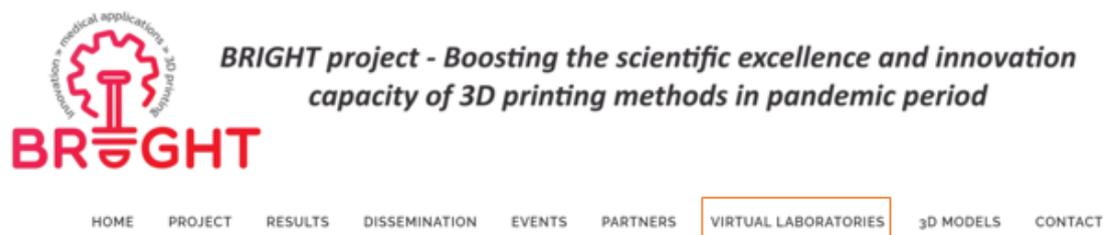


Figure 3. BRIGHT project website – access to WWW interface of Virtual Laboratory

Selecting the link related to Virtual laboratories this will lead further on to the opening of the interface (located at https://bright-project.eu/?page_id=320). It contains map of Europe, with pins representing laboratories of project consortium partners. Clicking on the name of each partner opens a new window, in which the selected virtual laboratory is presented and can be directly interacted with.

2.2. Virtual 3D printing laboratory room of Poznan University of Technology



Figure 4. Access to 3D printing room of Poznan University of Technology (PUT)

By accessing the link provided in relation with Poznan University of Technology (see Figure 4), the main 3D printing room which is one faithful representation of PUT’s laboratory of Rapid Manufacturing is opening. The 3D printing laboratory room of PUT has been captured using Matterport software and camera, providing very advanced capabilities. The PUT laboratory is available from the main interface, but also can be accessed in “open access” mode through a short link– <http://3dspot.pl/120BM>. The initial view is of a simplified 3D model (resulting of 3D scan performed by the camera) of the whole PUT laboratory (Figure 5). Then, the view starts outside, on a corridor of building of Faculty of Mechanical Engineering of PUT (Figure 6). The whole VL Room is representing a single, advanced and packed laboratory of Rapid Manufacturing (3D Printing).

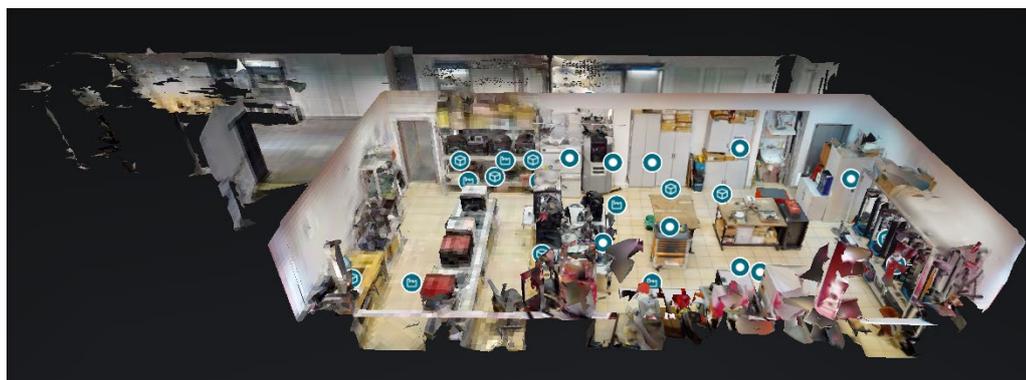


Figure 5. Virtual Laboratory of Rapid Manufacturing at Poznan University of Technology (PUT) – outside view

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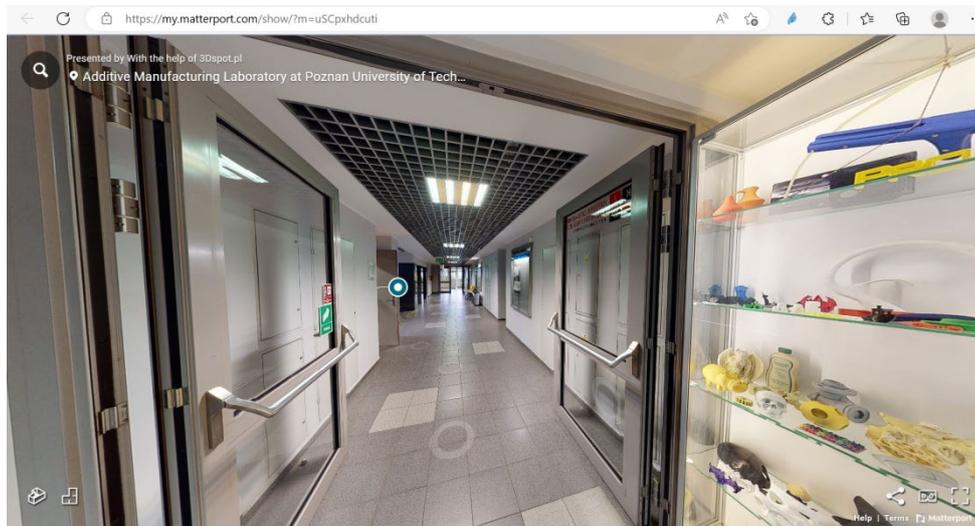


Figure 6. Corridor of building of Faculty of Mechanical Engineering of PUT

By walking further on the indicated route leading to the 3D printing laboratory of PUT, right at the entrance by pointing out to the pin that is places visible and very suggestive right on the entrance to 3D printing laboratory, there are indicated details about BRIGHT project and user has possibility to access the BRIGHT website if he is interested to find more about the BRIGHT project (see Figure 7).

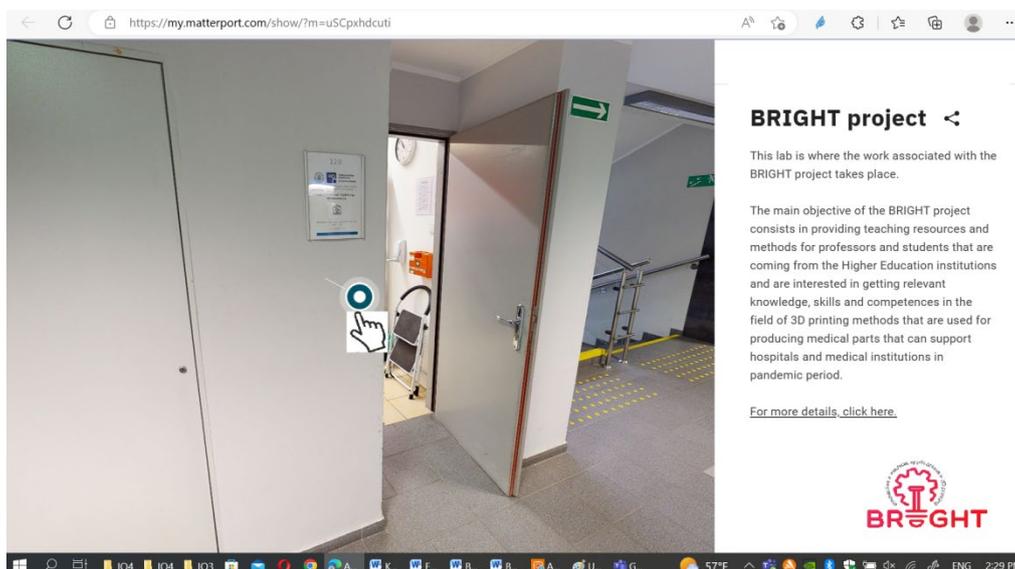


Figure 7. Main entrance of PUT 3D printing laboratory pointing out to the BRIGHT project website

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From there, going on into the laboratory, the user who is accessing it can have a quick overview on the facilities that the 3D printing laboratory of PUT is offering in terms of equipment items (the laboratory has more than 40 3D printing machines, vacuum casting systems, auxiliary tools, etc.), but also different types of applications (parts) that have been realized by the students during the BRIGHT project (see Figure 8).

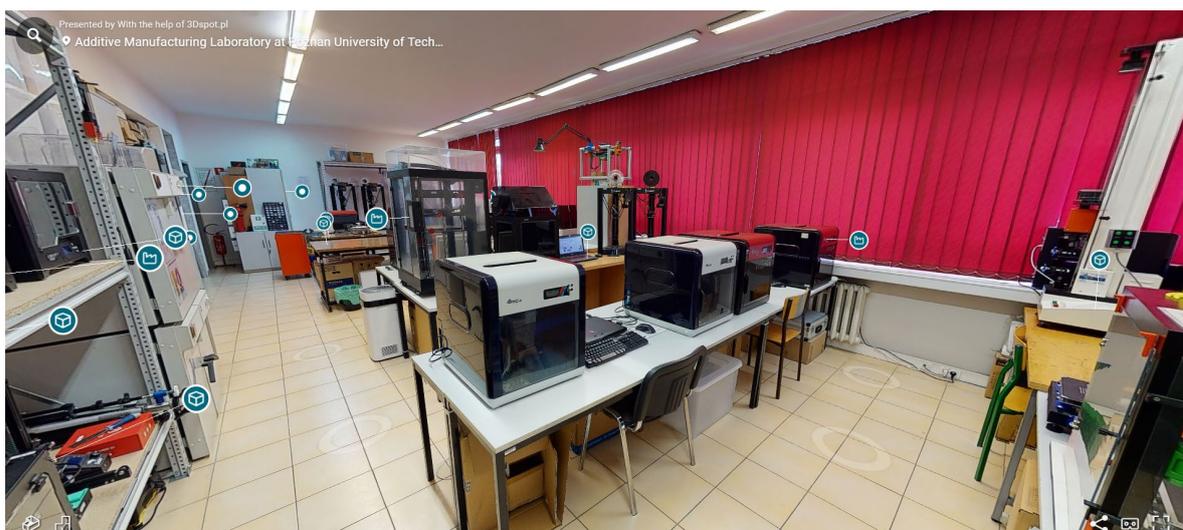


Figure 8. Virtual Laboratory of Rapid Manufacturing at Poznan University of Technology – inside view

Basic Virtual Reality 360 images related to the 3D printing laboratory of PUT provides the possibility of moving between different spots of the laboratory and free rotation of camera around; the 360 image being possible to be perceived on all kinds of devices (computers, smartphones and selected VR goggles).

In terms of equipment items, while going from one to another, the user can find by clicking the indicated pins different types of annotations at specific equipment, with possibility of clicking to obtain more information (e.g. 3D printer name, model and parameters with link to producer's website).

User can find also videos showing and describing the working principle of different types of equipment items realized by different producers and also videos on how pre-processing steps are needed to be realized in order to print specific medical parts (see for example the one shown in Figure 9).

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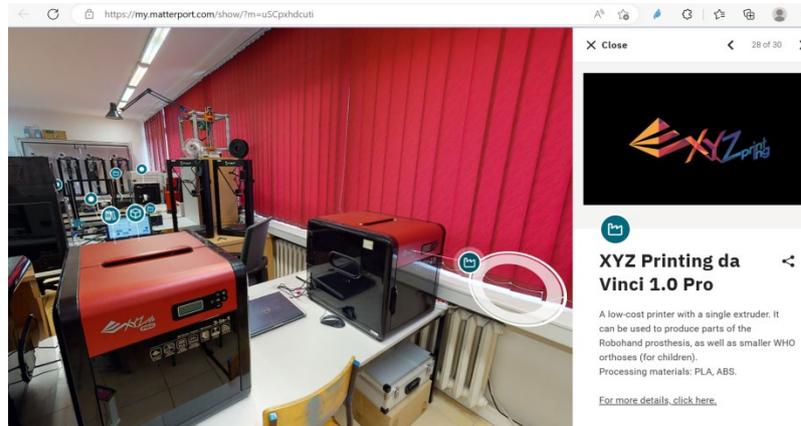


Figure 9. Specific details provided about 3D printing equipment found in the 3D printing laboratory of PUT in Virtual laboratory room

Within the PUT 3D printing laboratory there are provided also videos to specific equipment items that were tagged with annotations referring to the teaching content for student, created during the BRIGHT project (see Figure 10). Educational videos of 3D printing of medical parts have been uploaded using laboratory's own YouTube channel.

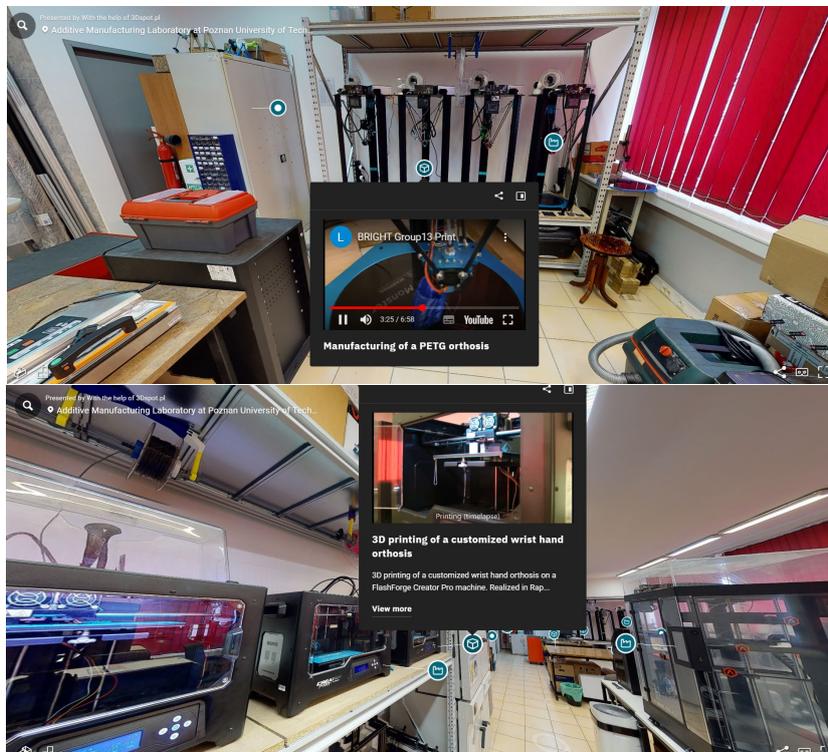


Figure 10. Educational videos of 3D printing of medical parts (BRIGHT case studies)

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Videos about the webinar that has been produced by the BRIGHT consortium about 3D printing processes has been also integrated within the realized room, as shown in Figure 11. Integrating of this webinar in the room is highly important since it provides in video format and accompanied with descriptions the importance of each step in realizing the pre-processing steps and producing of medical parts by different types of 3D printing technological methods.

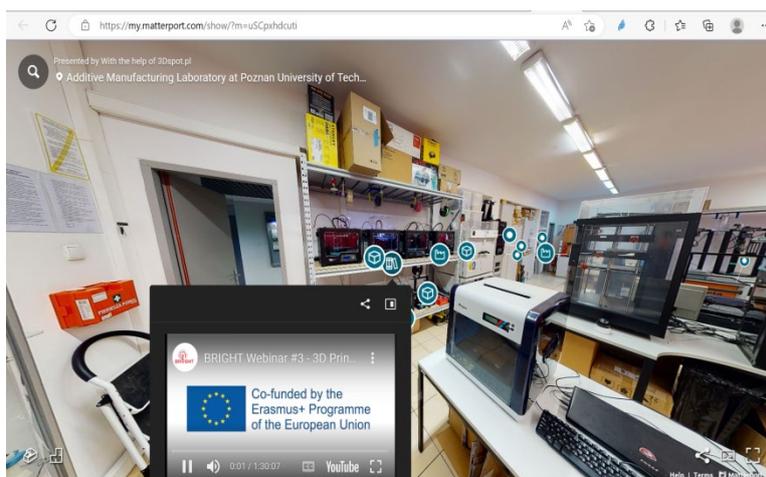


Figure 11. Webinar of 3D printing accessed through the Virtual 3D printing room of PUT

Educational videos related to the post processing of 3D printed parts (Figure 12) and mechanical testing strength testing as well as 3D scanning accuracy measurement that were done during the BRIGHT summer school 2021 edition (Figure 13) have been integrated within the Virtual 3D printing room of PUT as well.

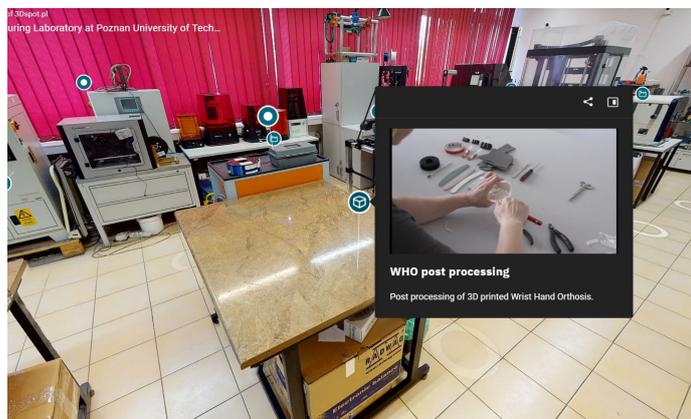


Figure 12. Educational video of post processing of medical parts

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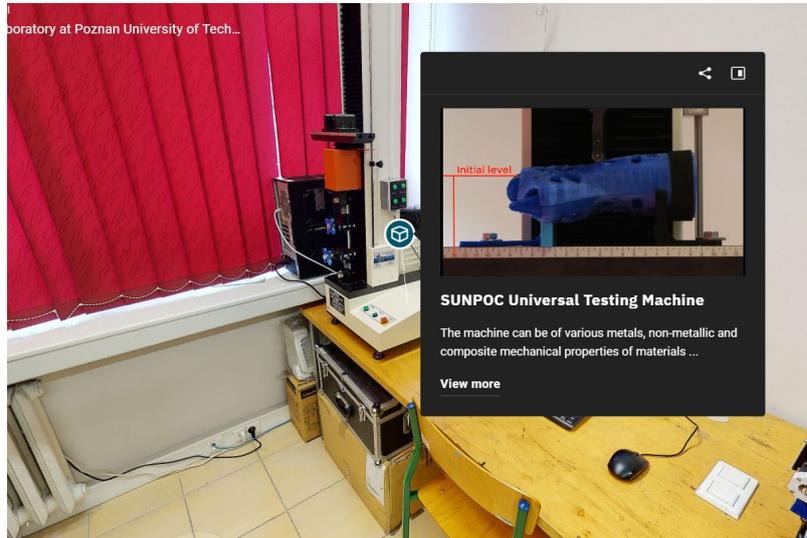


Figure 13. Educational video of testing of 3D printed medical parts

Additionally to the provided videos, within the PUT 3D printing virtual room, relevant images related to the containing tools and materials that are necessary to be used in a 3D printing laboratory have been introduced in order to help students to understand much better the work processes that are used in this type of laboratory (see Figure 14).

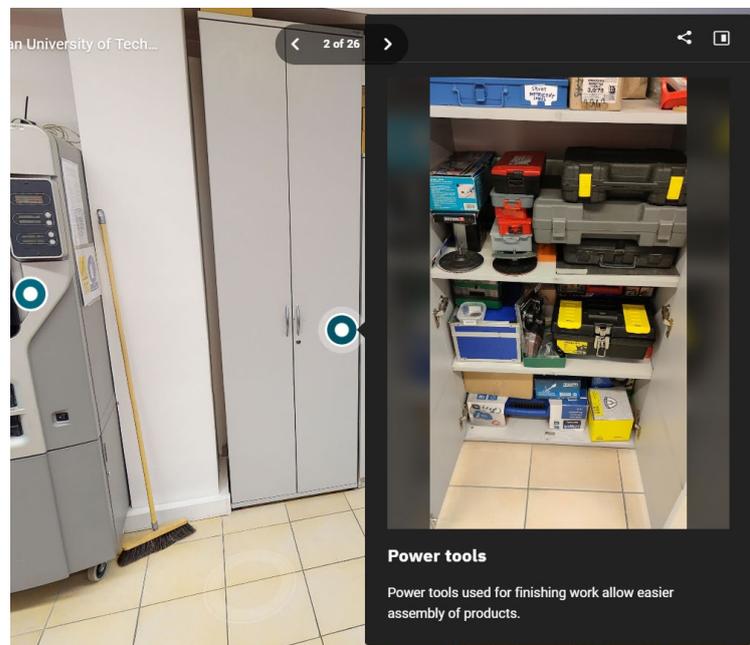


Figure 14. Photographs of equipment and tools needed for 3D printing laboratory

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In addition to all these types of teaching resources that have been provided in this chapter there are many other similar examples that can be visualized by accessing the following link: <http://3dspot.pl/120BM>, but there are also links to educational interactive Virtual Reality application that have been made for the BRIGHT project, allowing to take part in the process of 3D scanning, design, 3D printing and post processing of customized orthoses, like shown in Figure 15. In this figure is shown the exact spot from which one immersive Virtual Reality application has been created by team of Poznan University of Technology can be accessed and downloaded in the Virtual Laboratory of PUT. The annotation also contains a short YouTube video presenting the functions and operation of the VR application

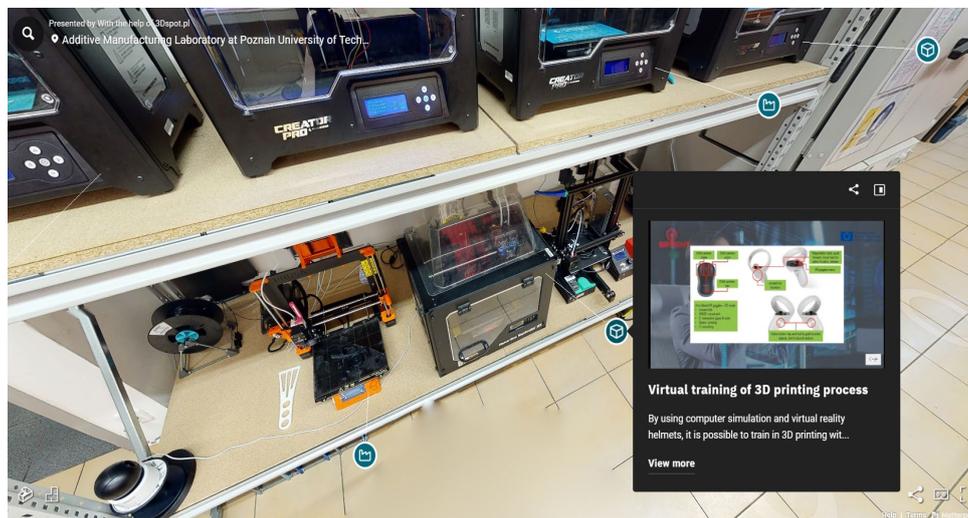


Figure 15. Virtual Reality applications that have been made for the BRIGHT project, allowing to take part in the process of 3D scanning, design, 3D printing and post processing of customized orthoses

The application is an interactive training scenario, focused on design (CAD) and manufacturing (3D printing) of one of two orthopedic products: a wrist hand orthosis (WHO) and an ankle foot orthosis (AFO). The process is based on results of AutoMedPrint project realized at PUT, and its subsequent results. It contains the following procedures:

- 1) selection of the medical product, with appropriate descriptions
- 2) 3D scanning of a patient (digital avatar of one of team members, with use of digital twin of AutoMedPrint equipment)

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- 3) 3D configuration of product CAD parameters
- 4) 3D printing (preceded by material selection and loading)
- 5) post processing of 3D printed products
- 6) try-on (assembly) with the digital patient

Since this presentation is related to the facilities provided about 3D printing thematic virtual room, in this presentation have been included details about the simulation realized in VR mode about 3D printing and additional post-processing steps for the 3D printing process topic (steps 4, 5 and 6 given above), the rest of the steps being presented and included in the thematic room related to CAD virtual laboratory room (that has been assigned to TUCN partner) as shown in Figure 2.

The application is an immersive, PC VR application created in Unity software. It is compatible with the OpenVR standard, meaning that all VR goggles able to run through SteamVR software. After opening the application, the initial screen is a menu, as presented in Figure 16. The menu allows to select the following options:

- start training – this loads the training scene and starts the actual simulation,
- instructions – a screen with information about controls, movement and interaction,
- project info – a board presenting information about the BRIGHT project, partners and short description of O3,
- quit – this turns off the application



Figure 16. Main menu of the Virtual Reality application for 3D printing teaching

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After all steps related to 3D scanning and Computer Aided Design have been undertaken like they have been described in the CAD thematic room report by finalizing in this way the training in CAD (see Figure 17), the user can go in continuing with the steps that are related to the 3D printing process.

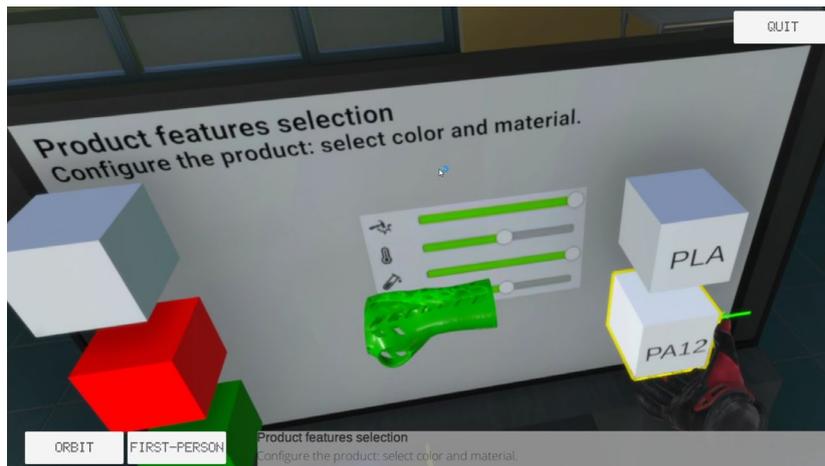


Figure 17. Finalizing CAD training step in VR

In order to realize the training about the manufacturing (3D printing process, like FDM), the user is able to configure for the beginning in VR first of the most important 3D printing parameters (like setting the orientation of the part to be 3D printed, setting up the layer thickness, scanning strategy, etc. (see Figure 18)

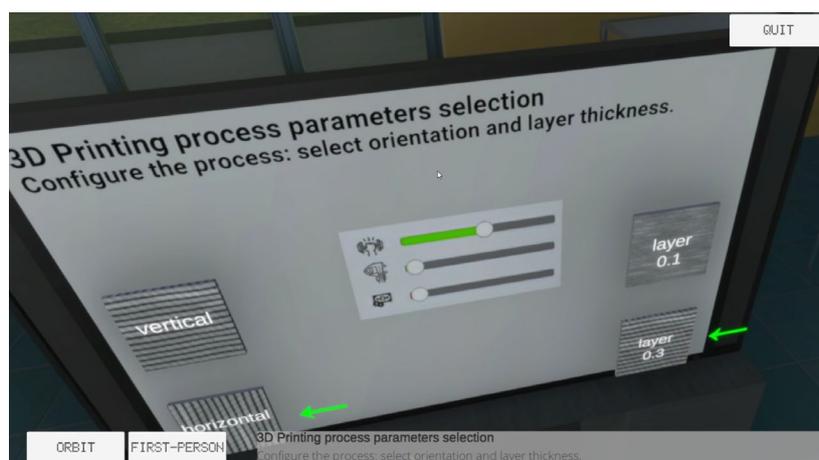


Figure 18. Configuring of the 3D printing parameters in VR related to the 3D printing process

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Next steps to be followed by the user in continuing are dedicated to the manufacturing process itself. The student must pick a specific roll of polymer filament, in a selected color, from the cabinet in the room and install it in the 3D printing equipment (Figure 19).

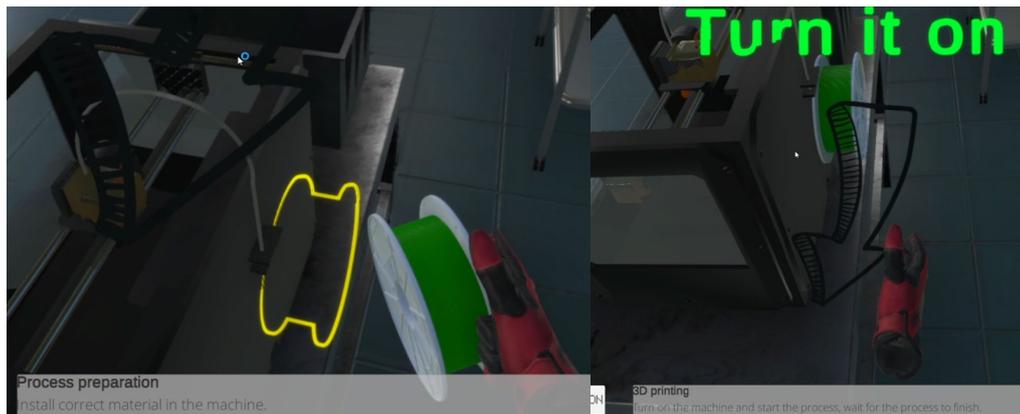


Figure 19. Installing the material and turning on the machine

After this process has been realized (only after this process has been made and pre-configuration of technological parameters needed has been set up) 3D printing (Fused Deposition Modelling) process can begin. The layer deposition is simulated, being speed up little bit (normally, the process takes several hours) – see Figure 20.

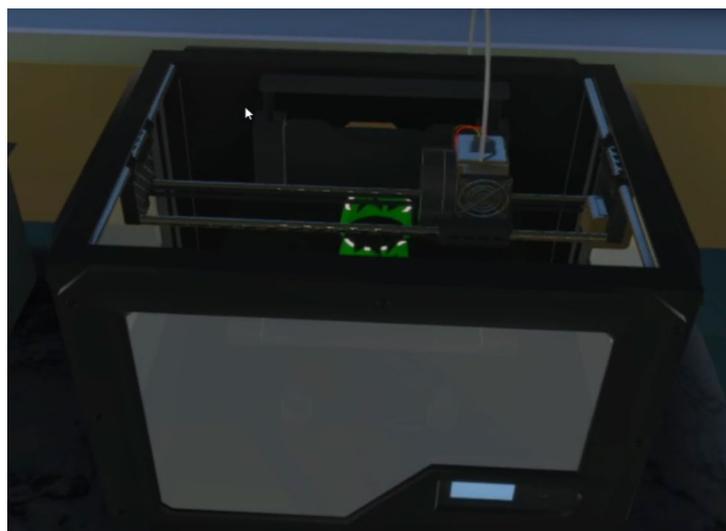


Figure 20. Simulation of 3D printing process

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The next important step in the whole process of manufacturing of medical devices simulated in the VR application for 3D printing is post processing. The user is therefore being asked to remove all parts from the 3D printing equipment as soon as the simulation of 3D printing process is being finished and then to manually polish the realized parts at the working table as shown in Figure 21.



Figure 21. Post processing of simulated 3D printed parts

In order to finalize the scenario in one very practical manner and to have one final completion of the chain, one final step has been included in the VR application being dedicated on the assembling of the orthosis on patient's limb – the user needs to bring the parts to the patient (who is present in the scene) and assemble them (see: Figure 22).

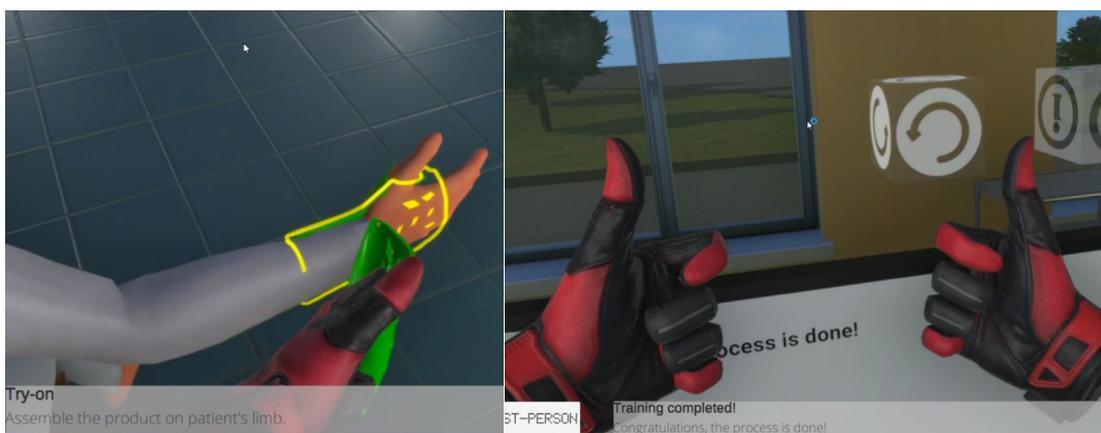


Figure 22. Assembling the product and finalizing the scenario

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2.3. Additional supporting capabilities of Technical University of Cluj-Napoca

Additional support related to 3D printing virtual laboratory main room of PUT has been provided by TUCN in their virtual laboratory rooms (like shown in Figure 2). Even if the 3D printing room provided by PUT Poznan in terms of teaching resources, facilities, diversity of provided resources, case study examples could be considered enough for such type of a virtual room, at the level of BRIGHT consortium it has been decided, taking into consideration the diversity of 3D printing technologies and existing facilities, to extend the virtual room of 3D printing by completing the virtual laboratory of BRIGHT and resources offered in the BRIGHT virtual platform also with specific resources that are related to TUCN and are different in terms of 3D printing solutions being offered as compared to the existing ones from Poznan University of Technology (e.g. Selective Laser Sintering and Selective Laser Melting technologies are available exclusively at the Technical University of Cluj-Napoca at the level of BRIGHT consortium).

Accessing of the TUCN virtual laboratory rooms can be done in the same manner like the PUT 3D printing virtual room it is accessed from the main interface of the BRIGHT virtual laboratories shown in Figure 3. Selecting the link related to Virtual laboratories shown in Figure 3 and by opening of the interface (located at https://bright-project.eu/?page_id=320) containing the map of Europe, pin representing laboratories of TUCN has to be selected (see Figure 23). To access the 3D printing laboratory rooms of TUCN is possible also to be made by accessing the following link: <https://nessy2022.viewin360.co/share/collection/79pbg>



Figure 23. Access to 3D printing room of Technical University of Cluj-Napoca (TUCN)

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Starting point of this Virtual laboratory is in the front of the TUCN main building (see Figure 24), while after entering into the building (main corridor) it is possible to get inside the 3D printing laboratories of TUCN (see Figure 25).

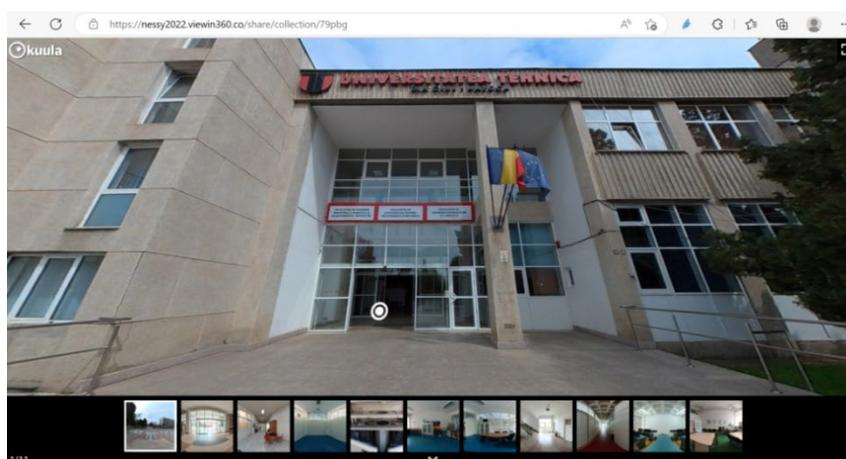


Figure 24. Main entrance of TUCN

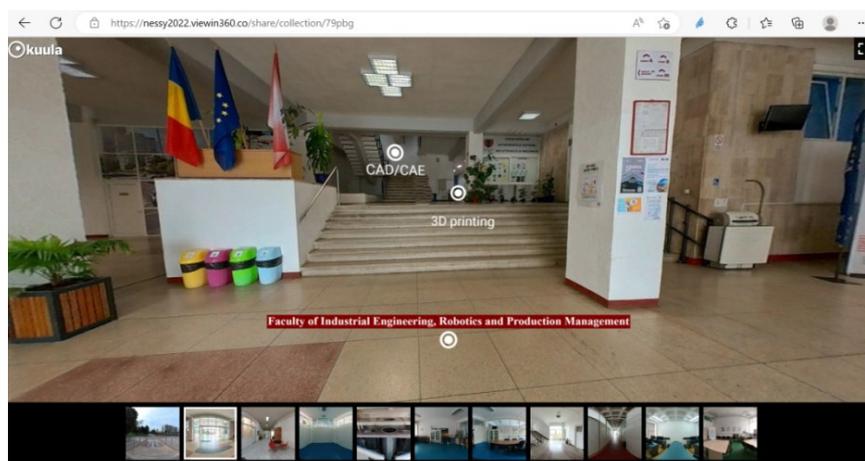


Figure 25. Main entrance corridor of TUCN

Virtual 3D printing laboratory rooms of TUCN have been created using Insta 360 camera and processed images that have been done using Kuula software, in which, in similar manner like in the case of PUT 3D printing virtual laboratory room, there have been integrated teaching resources in relation with the specific types of 3D printing equipment items that are different as compared to the ones of PUT and are available in different laboratories at TUCN.

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As compared to PUT partner which has all equipment items gathered in one single laboratory room, at TUCN the 3D printing equipment items are split in 3 different laboratories, as following:

- 1) 3D printing main printing laboratory, located in other room at the lower floor of the building, where FDM, SLA and SLS 3D printing equipment are being placed (Figure 26)
- 2) SLM 3D Printing laboratory (Figure 27), located at the lower floor of the building,
- 3) medical 3D printing laboratory (Figure 28), located in a separate building.

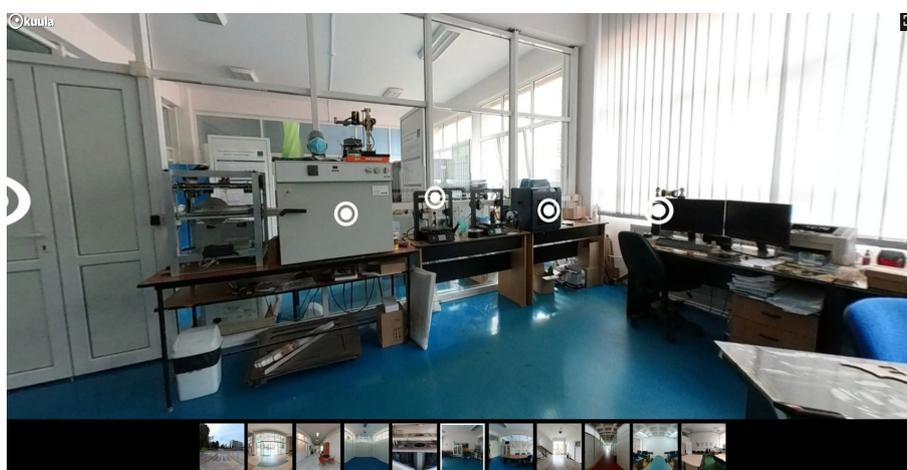


Figure 26. 3D Printing laboratory (FDM / SLA and SLS room) at TUCN

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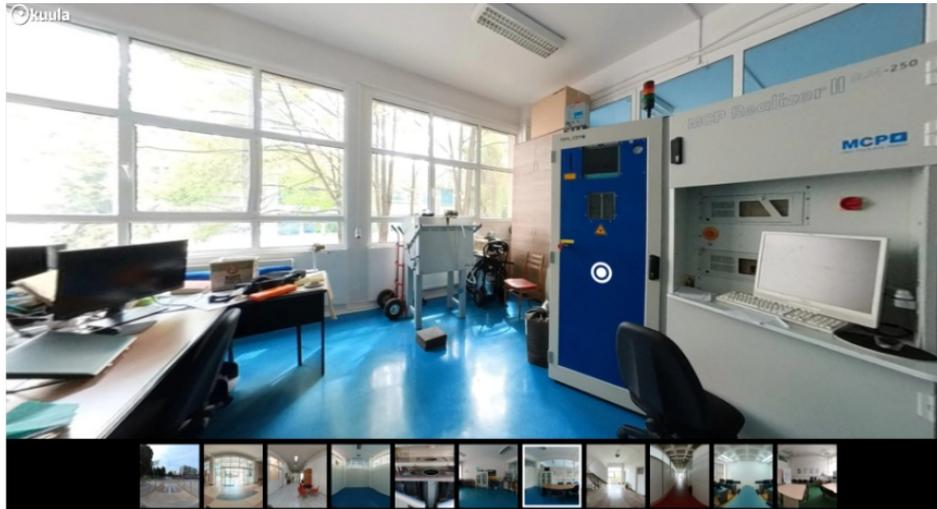


Figure 27. SLM 3D printing room at TUCN

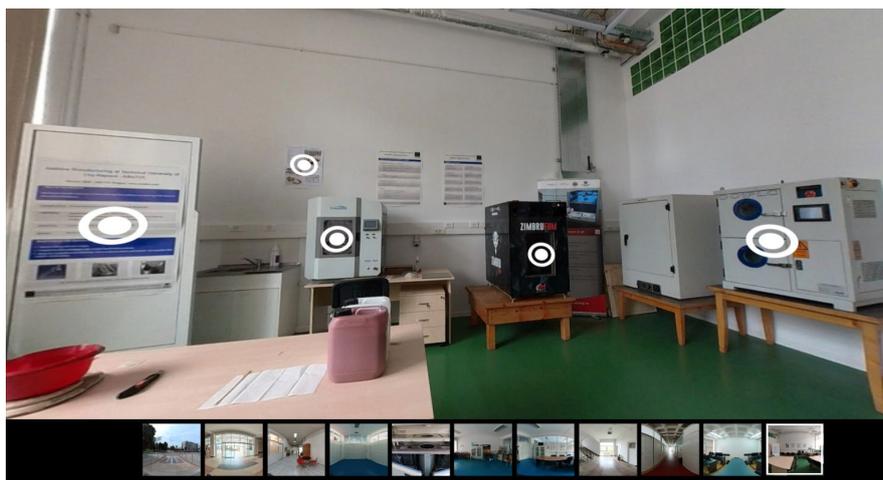


Figure 28. 3D Printing for medicine laboratory at TUCN, where 3D printing equipment for PEEK material is being located

In terms of facilities provided in the BRIGHT 3D printing laboratory rooms, there are provided specific for all these 3D printing methods that are different as compared to the ones that are available at PUT, in the same manner like in the case of PUT, video materials or photos that are providing instructions and training materials in relation with specific types of 3D printing equipment items realized by specific producers of these types of machines, along with specific instructions in relation to the characteristics of specific type of equipment (see Figure 29).

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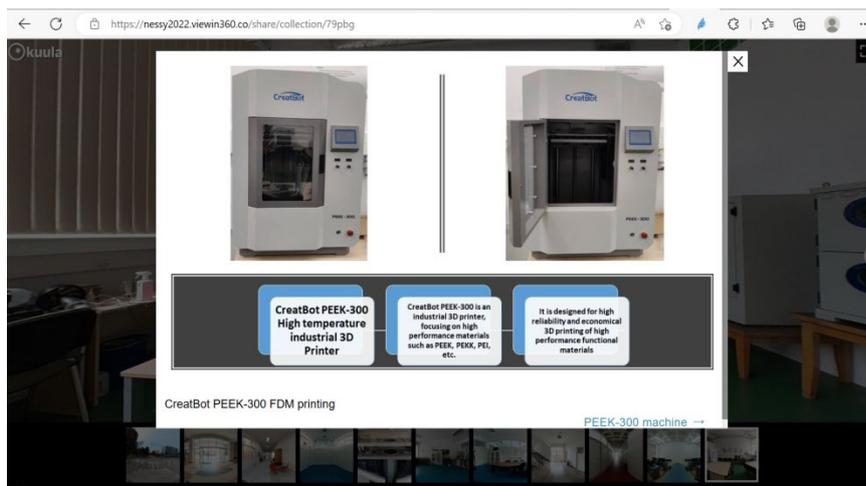
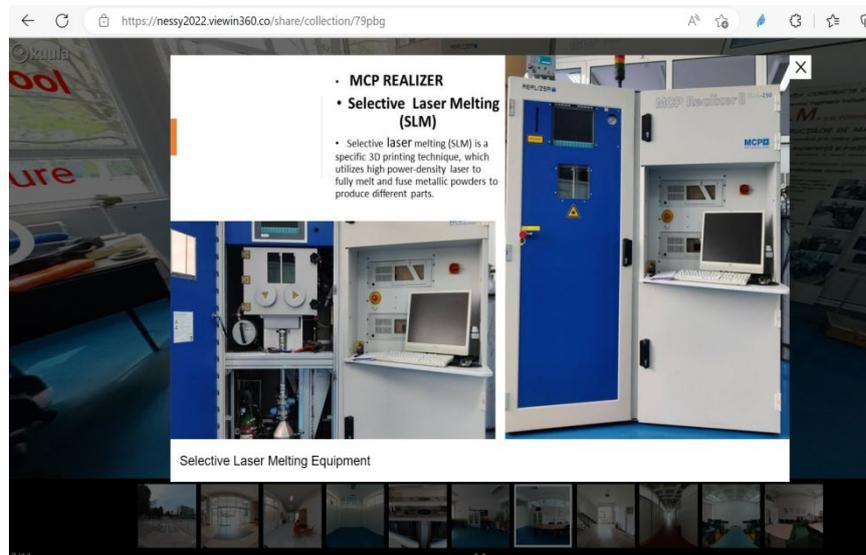


Figure 29. Videos and photos that are explaining the working principles of 3D printing technologies that are available at TUCN

There are provided also videos related to BRIGHT international summer school parts that have been realized by professors in cooperation with students and also videos related to the realized BRIGHT webinars (see Figure 30). Examples of photos with medical case studies that have been produced using specific 3D printing technologies to support patients in time of pandemic are emphasized in the rooms (see Figure 31).

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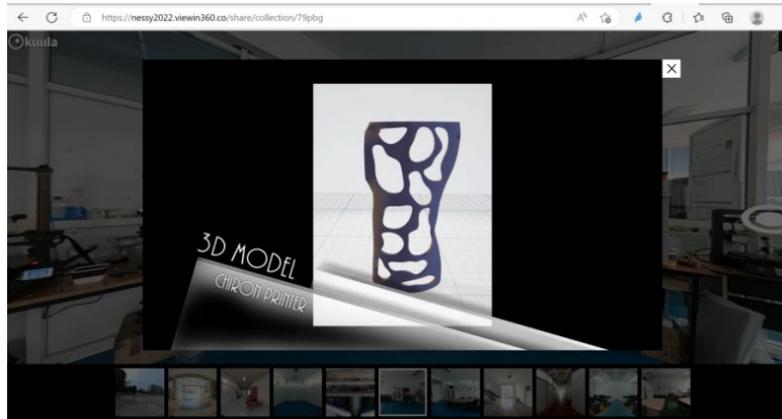


Figure 30. Video materials realized by the professors and students working for an orthosis that has been produced by 3D printing at TUCN during BRIGHT Summer School 2021



Figure 31. Examples of medical parts realized using different types of 3D printing technologies at TUCN provided in Virtual laboratory rooms

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Presentations that were held during summer school about 3D printing technologies, 3D printing toolkit manual and 3D printing toolkit laboratory modules (BRIGHT teaching resources) have been integrated within the virtual 3D printing laboratories of TUCN in the rooms that are specific to the case studies / type of 3D printing technologies that were used for producing the specific case studies / medical parts described in the toolkit manuals / webinar etc (Figure 32).

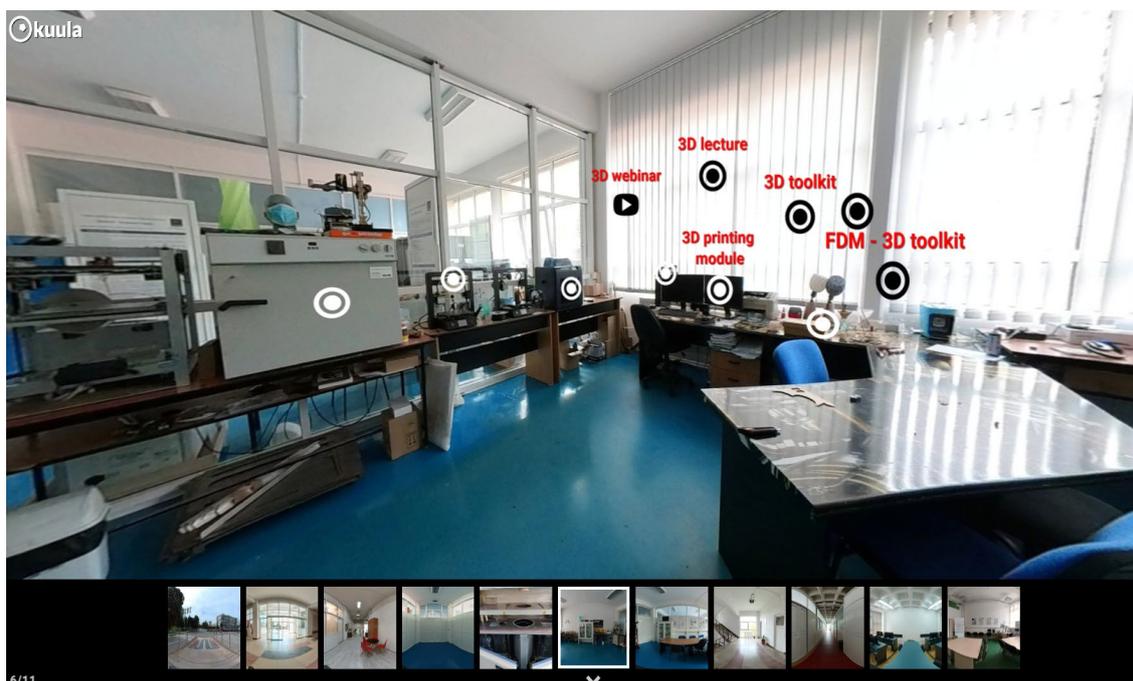


Figure 32. Pinning teaching laboratory resources (course module, toolkit laboratory modules within the 3D printing laboratory rooms of TUCN)

Last, but not least, promoting materials related to the BRIGHT project or events organized within the BRIGHT project, that are guiding users to the link of the events (e.g. BRIGHT summer schools) on the BRIGHT project website (reports, resources, etc.) have been included /integrated also in the BRIGHT laboratories of TUCN within the realized platform, along with one e-library of 3D printed models that have been realized by professors and students during the organized events (BRIGHT summer schools) (see Figure 33).

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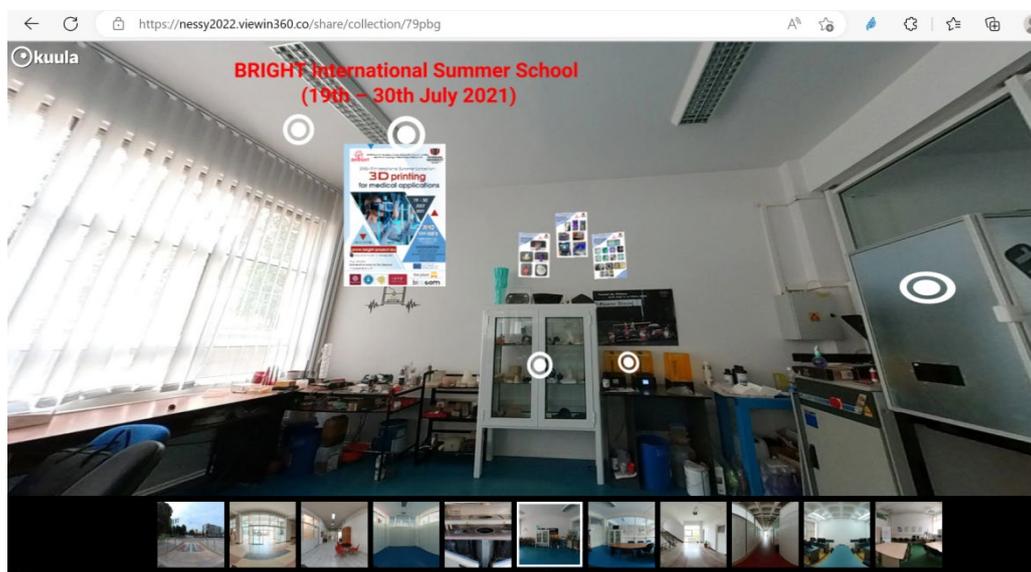


Figure 33. Bright project events promoted within the BRIGHT virtual laboratory rooms of TUCN

3. Conclusions

The 3D printing virtual laboratory rooms realized by PUT and TUCN partners as part of the BRIGHT virtual platform that has been developed within O3 of the BRIGHT project contains most of knowledge developed during the project regarding 3D printing and Rapid Tooling technologies (e.g. Vacuum casting), being extensively used during the BRIGHT project activities, including the summer school and Multiplier Event carried out after the platform was finished. 3D printing virtual laboratory rooms that are available at PUT and TUCN and can be accessed easily through the web platform of BRIGHT project represents an important teaching resource that was used and will be used in continuing in any form of remote learning, when access to laboratory is restricted or when conducting remote classes for international students online. The teaching resources provided within the 3D printing laboratory rooms of PUT and TUCN gives a new insight to the students that can remotely visit different laboratories rooms that are available at these institutions, having the chance to get familiarized with how different types of 3D printing equipment items and technological methods can be used for producing different types of medical parts using such methods. The educational content of 3D printing virtual laboratory rooms can and will still be added, even after ending of the BRIGHT project, by adding or updating teaching resources with the aim of expanding it with results of student diploma theses for further references.

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