Co-funded by the Erasmus+ Programme of the European Union

BRIGHT

Erasmus+ strategic partnership for Higher Education

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

O3 - BRIGHT CAD 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 CAD virtual laboratory room and supporting capabilities**
Date of Delivery	**July 2022**
Authors	**Filip Gorski, Răzvan Păcurar, Miloš Simonović, Peter Koštál**
Version	**FINAL VERSION**

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Content

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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.

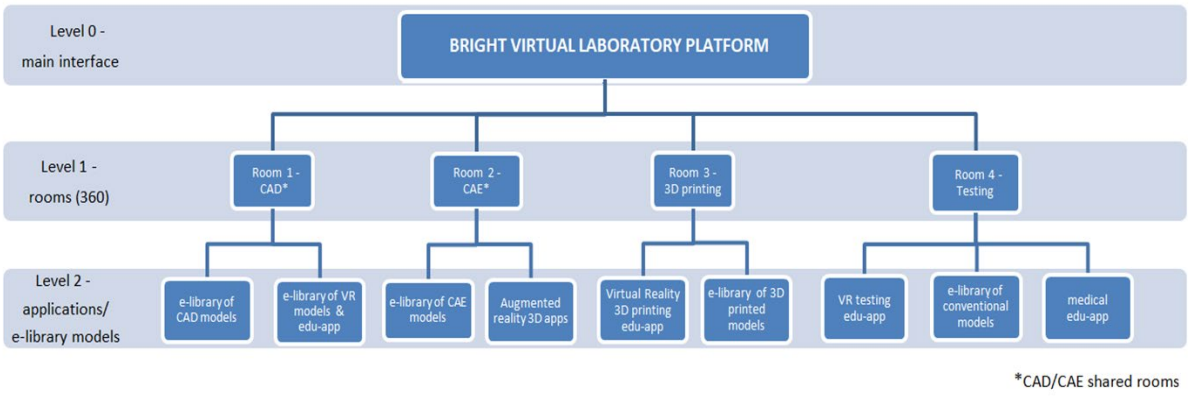


Figure 1. Initial concept of the Virtual Laboratory platform in the BRIGHT project

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

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

In this report there are provided details about **the thematic CAD virtual laboratory room (room number 1)** which is relying on basic main room that has been constituted at TUCN partner, being completed with the supporting capabilities in PUT, UNI and STU rooms, 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. First step in the conceiving process of medical parts is CAD (Computer Aided Design) step, as one my notice in the scheme presented in Figure 2.

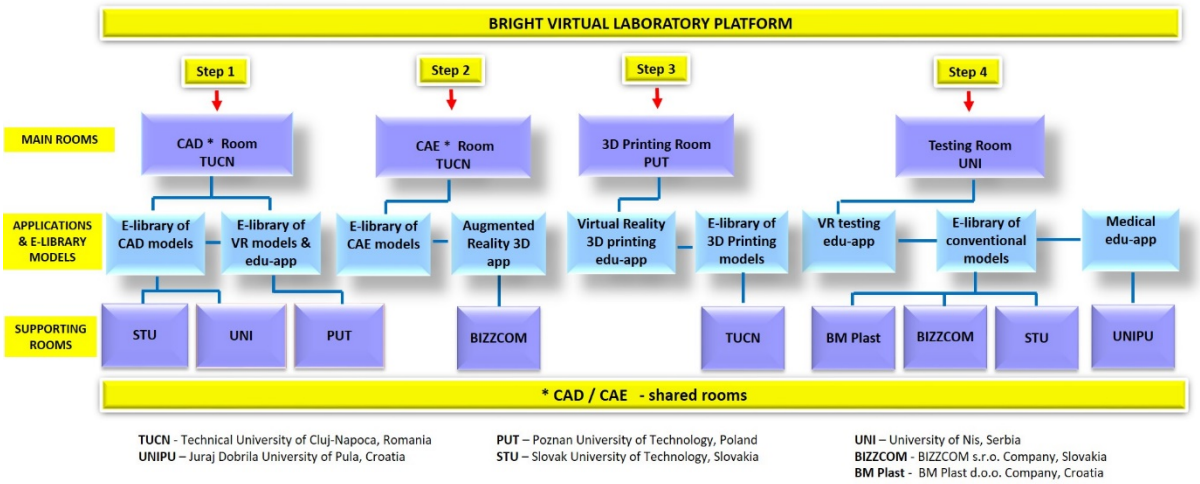


Figure 2. Main concept of BRIGHT virtual laboratory platform in terms of thematically rooms and apps

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 2021 edition held in Cluj-Napoca and 2022 edition 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 (including the ones in the CAD room).

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

2. Virtual CAD laboratory room description

2.1. Accessing the virtual CAD 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).

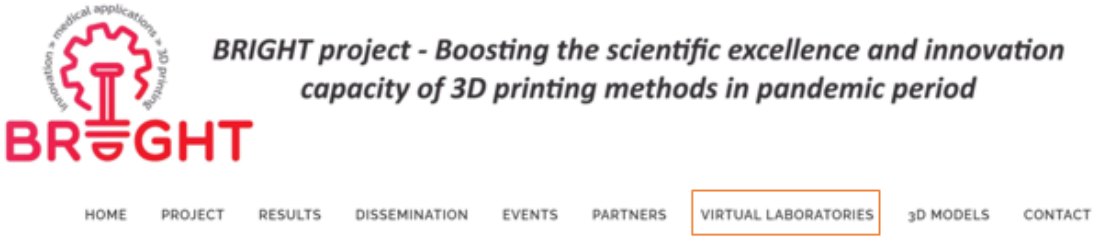


Figure 3. BRIGHT project website – access to WWW interface of Virtual Laboratory

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 CAD laboratory room of Technical University of Cluj-Napoca

Virtual laboratory of TUCN has been assigned as main room related to CAD topic, as one may noticed in Figure 2. Accessing of the TUCN virtual laboratory rooms can be done after selecting the main interface of the BRIGHT virtual laboratories shown in Figure 3 (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 4). To access the CAD laboratory room of TUCN is possible also to be made by accessing the following link: https://nessy2022.viewin360.co/share/collection/79pbg

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

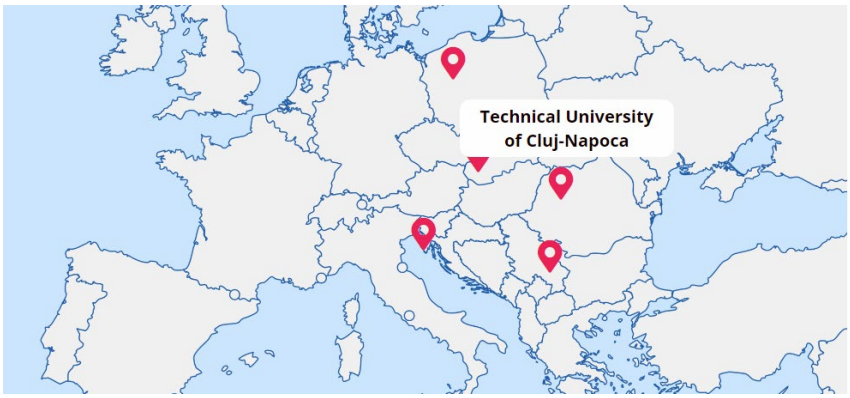


Figure 4. Access to CAD room of Technical University of Cluj-Napoca (TUCN)

Starting point of this Virtual laboratory is in the front of the TUCN main building (see Figure 5), while after entering into the building (main corridor) it is possible to get inside the CAD / CAE virtual laboratory of TUCN (see Figure 6).

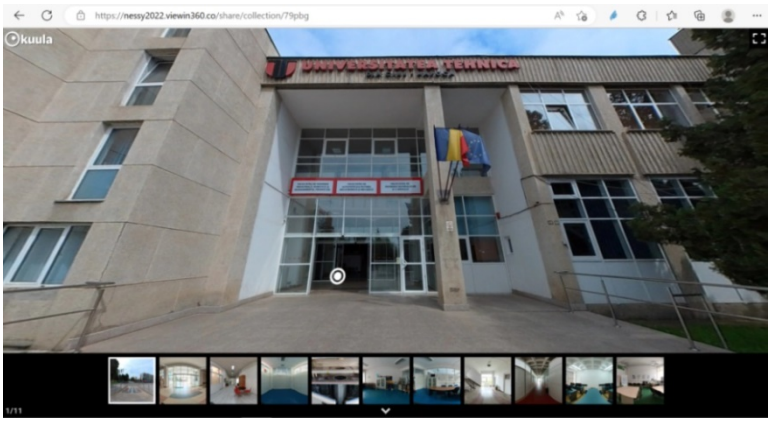


Figure 5. Main entrance of TUCN

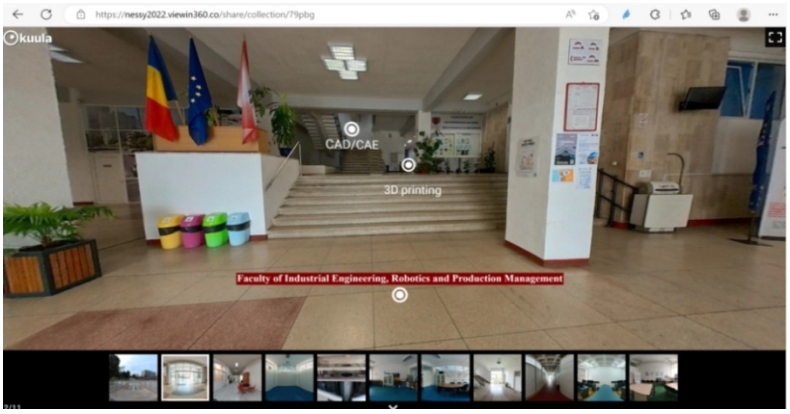


Figure 6. Main entrance corridor of TUCN

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Virtual CAD laboratory room of TUCN (which is shared commonly with CAE room at the level of TUCN as shown in Figure 2) has been created using Insta 360 camera and processed images have been processed using Kuula software, integrating in this way teaching resources in relation with CAD of the medical models that have been realized within the BRIGHT project.

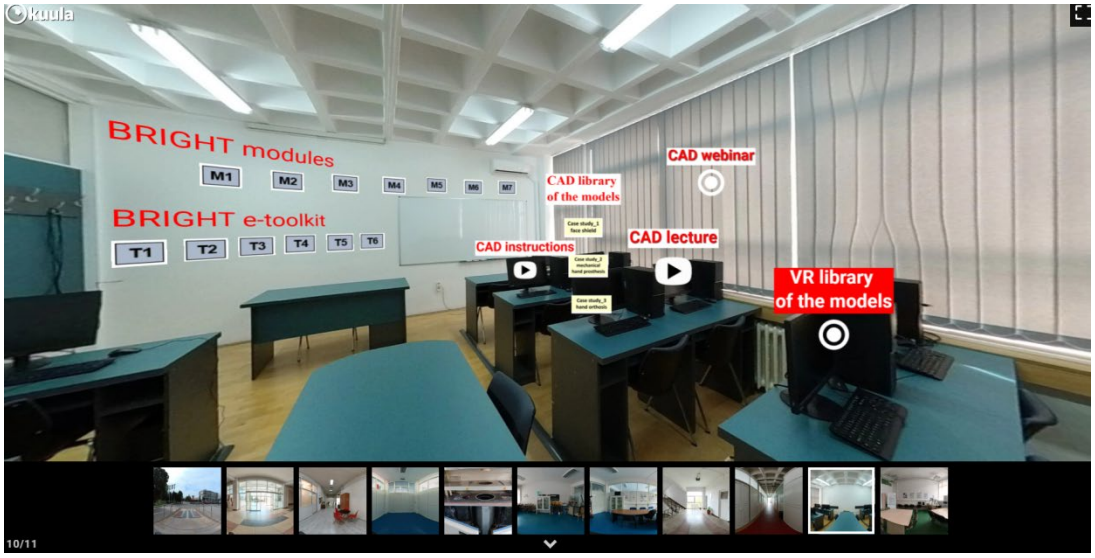


Figure 7. Main content of the resources provided within CAD Virtual room of TUCN

As one may notice in Figure 7, the first category of teaching resources is represented by the teaching resources (course modules + laboratory toolkit modules) realized by the BRIGHT project consortium within O1 and O2. They can be freely accessed and downloaded from this room of the platform without any restriction by every user that is accessing the platform.

In continuing, in this virtual room there have been integrated videos that have been produced during different types of events (like BRIGHT International Summer school) in terms of CAD, since beside the course modules and toolkit laboratory modules, within the realized presentations there are provided important information based on experience of BRIGHT consortium professors in relation to specific case studies that have been designed in concordance with the medical applications that have been produced by 3D printing for specific patients in time of pandemic (see Figure 8).

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Figure 8. Video presentations that can be accessed through the CAD Virtual room of TUCN

CAD webinar and CAD instructions for students (in video format) based on the teaching materials that have been used during the BRIGHT Summer school event activities realized by the BRIGHT professors for students have been also integrated into the platform since it has been considered as being one valuable resource in relation to anyone who wants to get familiarized with the steps that are required in developing of specific medical parts that are needed to be produced by 3D printing technologies, like face shields, orthoses, etc. (see Figure 9).

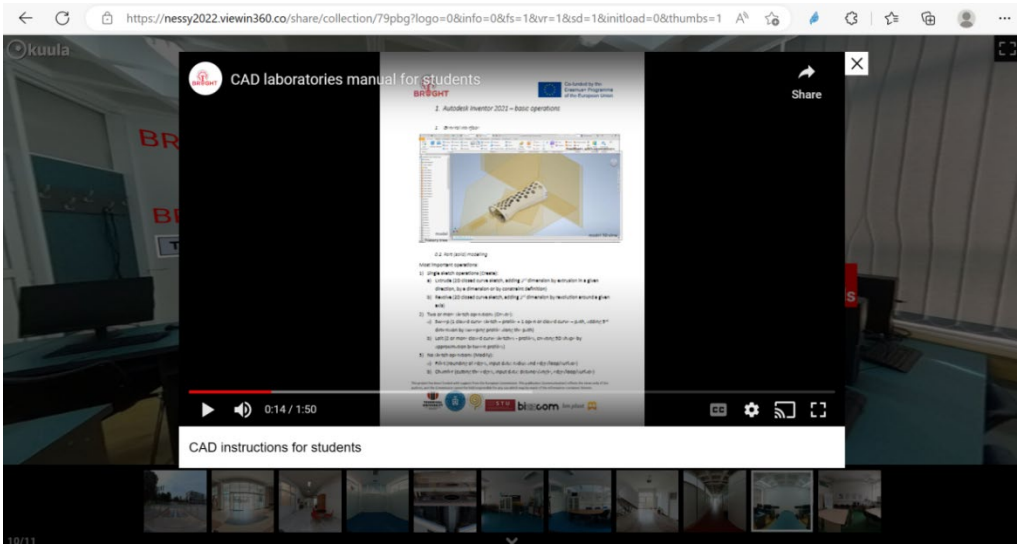


Figure 9. Video teaching resources related to the designing of specific medical products to be made by 3D printing technologies included into the CAD Virtual laboratory room

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

CAD e-library of the models has been included into the CAD virtual laboratory platform, as one may notice being presented in Figure 10. Along with the CAD models that can be downloaded and uploaded by the user in specific CAD programs, like SolidWorks or Autodesk Inventor, there have been included also important descriptions in pdf format about the particularities of the models in close correlation to the 3D printing technology recommended to be used for realizing of the each type of model (medical part) presented.

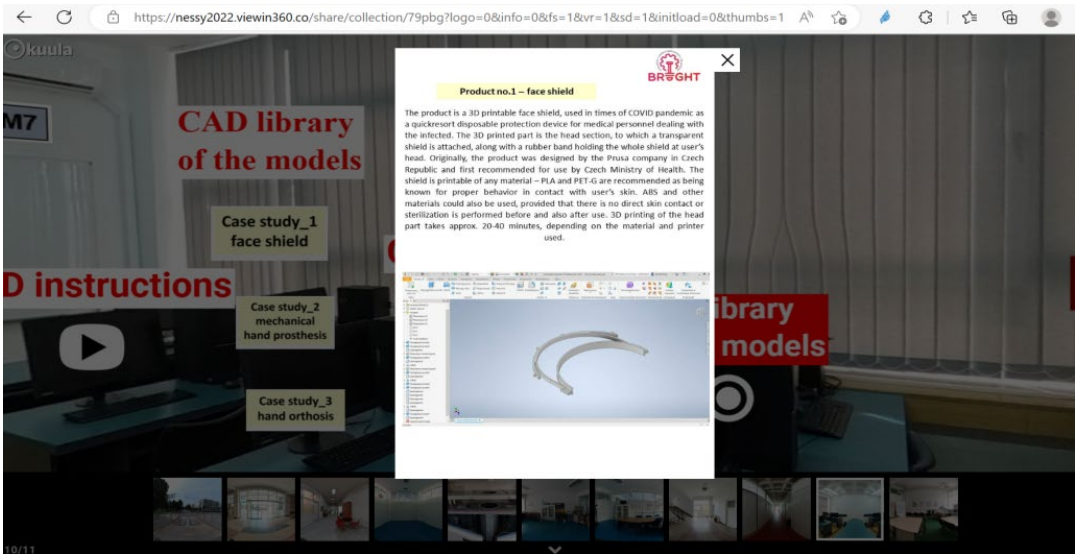


Figure 10. CAD library and pdf descriptions of the medical models to be made by 3D printing

Besides the already presented teaching resources, one important application that has been associated to the CAD virtual laboratory of TUCN is represented by the VR applications that have been realized for presenting selected 3D models of medical parts that are corresponding to the 3D models library that is accessible in the CAD Virtual Laboratory (see Figure 11).

The library contains more than a dozen models, with possible expanding. The library has not been created entirely anew – Sketchfab platform was utilized in this case, besides the Virtual laboratory of CAD (TUCN), the models being embedded also on the BRIGHT project website, to be accessed directly from the WWW interface by accessing the following link: https://bright-project.eu/?page_id=329 (see Figure 12). The examples of models contained in the VR library include, but are not limited to hand orthosis, tongue, face shield, robotic prosthesis, mechanical bicycle prosthesis, implants, anatomical models (body parts), etc.

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

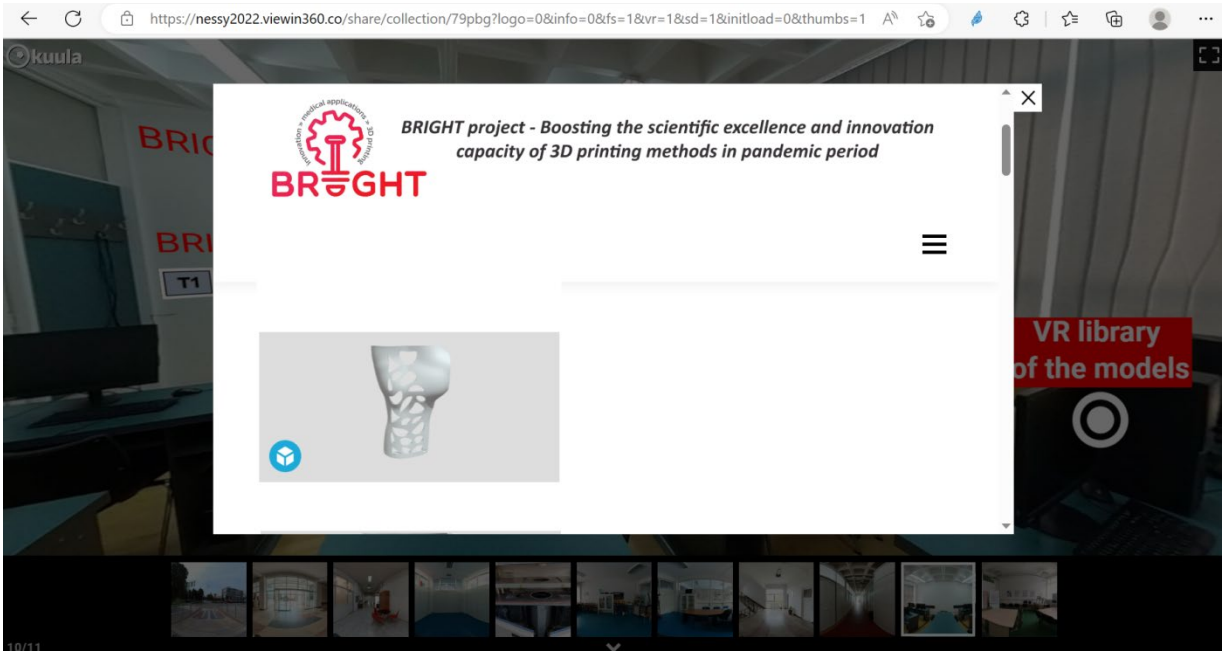


Figure 11. VR models which are accessible through the CAD Virtual laboratory of TUCN

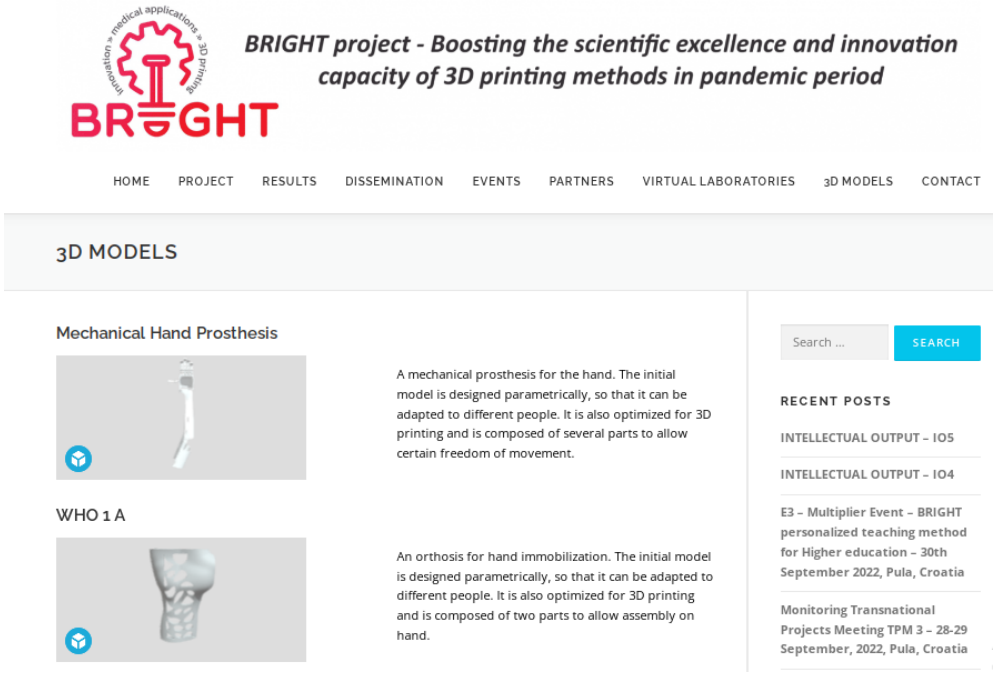


Figure 12. WWW interface of the 3D models library

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

The models can be further on freely opened and visualized in Sketchfab (see the example provided in Figure 13). Models can be also freely downloaded and used for own educational processes in design, 3D printing and others by anyone who is interested in using them for teaching purposes or for realizing them by 3D printing technologies, like FDM.

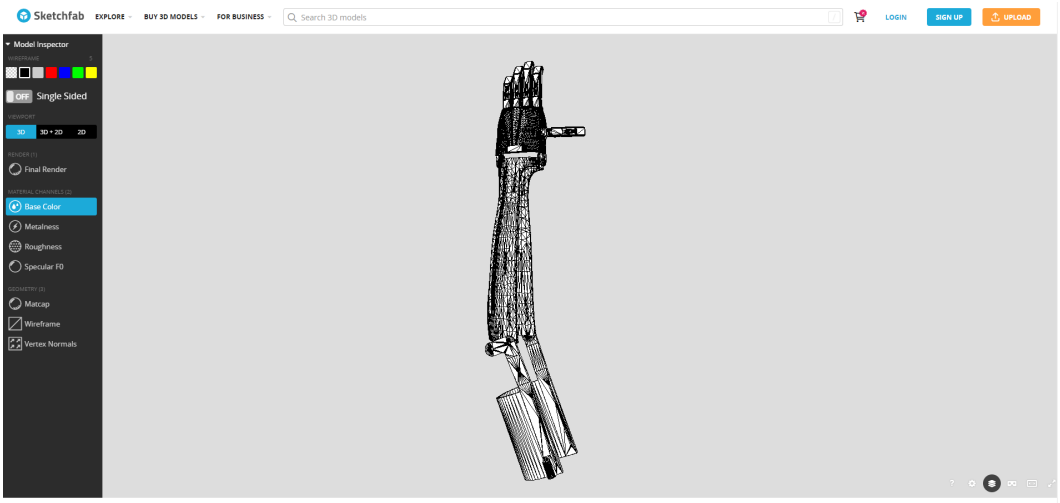


Figure 13. 3D model of a prosthesis opened in SketchFab platform

2.3. Additional supporting capabilities at University of Nis and STU Trnava

Additional support related to CAD virtual laboratory main room of TUCN has been provided by University of Nis and STU Trnava in their virtual laboratory rooms (like shown in Figure 2) who have been included few of the resources that have been provided also in the CAD virtual laboratory of TUCN, but with an expansion of the facilities offered regarding to this topic, in terms of e-library of CAD models, that have been completed with few extra CAD models which have been realized by these partners in their work with their students on medical parts they were developing to in terms of CAD. Accessing of the University of Nis and STU Trnava virtual laboratory rooms (Figure 14) can be done after selecting the main interface of the BRIGHT virtual laboratories shown in Figure 4 (by opening of the interface (located at https://bright-project.eu/?page_id=320).

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Figure 14. Accessing of the CAD virtual laboratories of the University of Nis (Serbia) and STU Trnava (Slovakia)

In Figure 15 is being showed how there have been integrated all the above mentioned teaching resources about CAD within CAD laboratories of STU Trnava (Slovakia) and University of Nis (Serbia) (course modules, toolkit laboratory modules, video presentations, reports, case studies), which had in their facilities at the level of institutions involved in the BRIGHT project, computer laboratory rooms that are specifically related to CAD topic and were used for CAD activities that were associated and used within the BRIGHT project (see Figure 15).

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

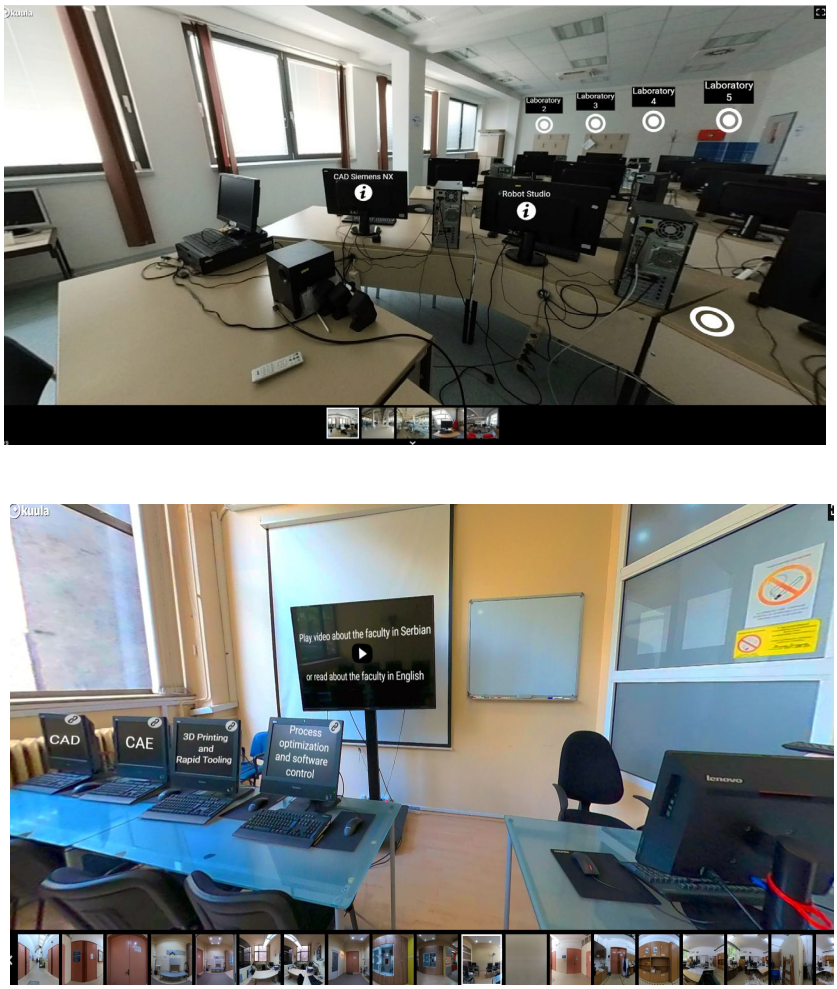
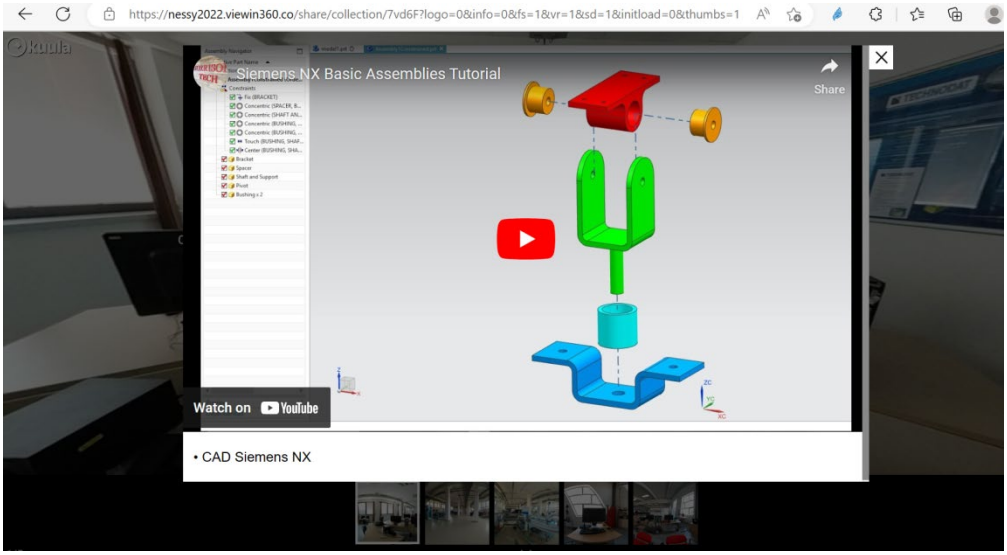


Figure 15. CAD Virtual laboratories of University of Trnava (Slovakia) and University of Nis (Serbia)

Beside the existing teaching resources that are mostly common to the existing ones in the CAD virtual main laboratory of TUCN, within the STU Trnava CAD laboratory, there have been added also some additional important resources in terms of teaching like Basic Assembling tutorials that were done using specific software programs (these resources being available and unique at STU partner), like Siemen NX, RobotStudio, etc. Provided additional resources were provided in the STU CAD virtual laboratory relying on the specific resources in terms of software programs and logistics that are available in relation with CAD at STU Trnava (see Figure 16).

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.



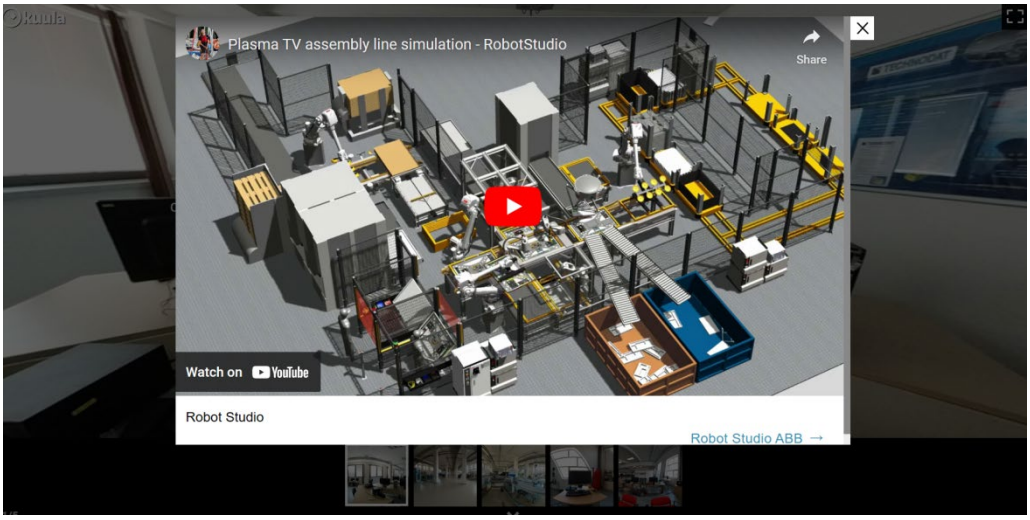


Figure 16. Additional teaching resources in terms of CAD provided by STU partner in their virtual laboratory of CAD

2.4. Additional supporting capabilities realized by PUT partner in VR

Additional supporting capabilities in terms of CAD were realized by PUT within their virtual laboratory in terms of VR edu-application as shown in Figure 2. At the level of PUT there haven't been associated multiple rooms, like in the case of the other partners in which for CAD or for 3D printing or for testing there have been assigned specific rooms. Therefore

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

the main applications that have been realized at the level of PUT in relation with CAD have been integrated within their Virtual laboratory of Rapid Manufacturing presented as being associated with the Virtual 3D printing room (main room that has been assigned to PUT according to Figure 2). The VR application that has been developed by PUT is associated to CAD process, but also to the simulation process in terms of 3D printing and post-processing of the 3D printed models as well (this is the main reason why in Figure 1 the VR applications realized by PUT partner was linked to 3D printing process in the end, since the VR application includes also part of the CAD process in the beginning of simulating the process). For accessing the VR application, accessing of the PUT (Poland) virtual laboratory room must be done first like in the case of the other partners, after selecting the main interface of the BRIGHT virtual laboratories as shown in Figure 17 (by opening of the interface (located at https://bright-project.eu/?page_id=320).

Figure 17. 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 17), the virtual room which is one faithful representation of PUT's laboratory of Rapid Manufacturing is opening. 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 18). Then, the view starts outside, on a corridor of building of Faculty of Mechanical Engineering of PUT (Figure 19). The whole VL Room is representing a single, advanced and packed laboratory of Rapid Manufacturing.

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

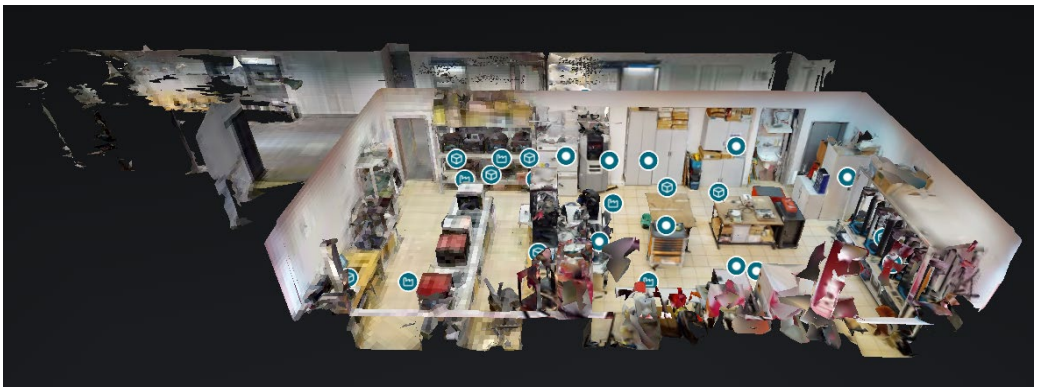


Figure 18. Virtual Laboratory of Rapid Manufacturing at Poznan University of Technology (PUT) – outside view

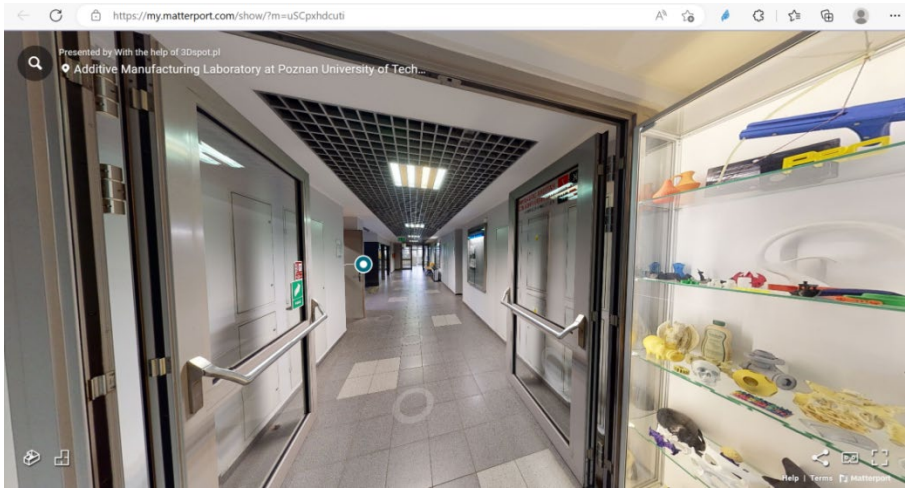


Figure 19. Corridor of building of Faculty of Mechanical Engineering of PUT

After entering into the Virtual laboratory room shown in Figure 19, the pin shown in this figure is leading the user to the entrance of the Virtual laboratory of PUT (Figure 20) from where the user can have one nice perspective of the entire virtual laboratory, comprising lot of resources gathered in the same room in terms of CAD, 3D printing, etc.

By walking through the Virtual laboratory and by accessing the exact spot of the link presented in Figure 21, one immersive Virtual Reality application that has been created by the PUT team which is available also to be downloaded can be accessed in this mode. The annotation shown in Figure 21 also contains a short YouTube video presenting the functions and operation of the VR application.

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Figure 20. Virtual Laboratory of Rapid Manufacturing at Poznan University of Technology – inside view

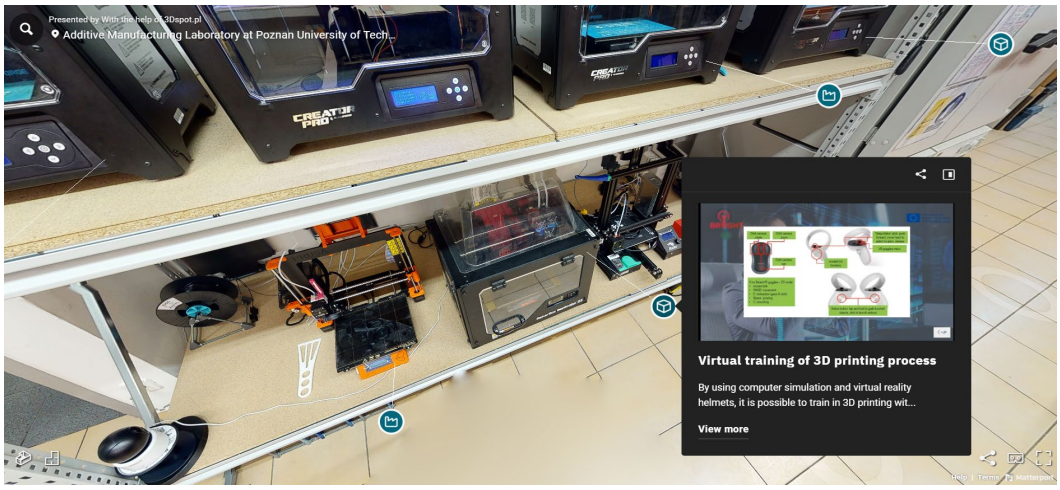


Figure 21. Virtual Reality application for design and 3D printing of a medical product available through Virtual Laboratory of Poznan University of Technology

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)

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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 CAD thematic virtual room, in this presentation have been included details about the simulation realized in VR mode about CAD topic (steps 1, 2 and 3 given above), the rest of the steps being presented and included in the thematic room related to 3D printing virtual laboratory room (that has been assigned to PUT 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 22. 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 IO3,
- quit – this turns off the application

Figure 22. Main menu of the Virtual Reality application for 3D printing teaching

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

After launching the training, the student is placed in a simulated environment – a large room, with AutoMedPrint scanning equipment in the middle, also containing a TV model (for displaying instructions) and some laboratory equipment (3D printer, cabinet with materials, working table with manual tools etc.). In the VR mode, movement around the environment is realized partially on user's own legs (on a short distance) and by teleporting (Figure 23). In desktop mode (without goggles) movement is smooth, using WASD keys.

In the main window, there is a basic user interface with text windows and buttons. This is not visible to the student who has VR goggles, but can be operated by the instructor. The UI contains buttons for two camera modes (first-person which is preview of what user in VR goggles sees and orbit, which allows rotating and zooming to various places, independently on movements of the user). It also contains a text box with current instruction, and the quit button.

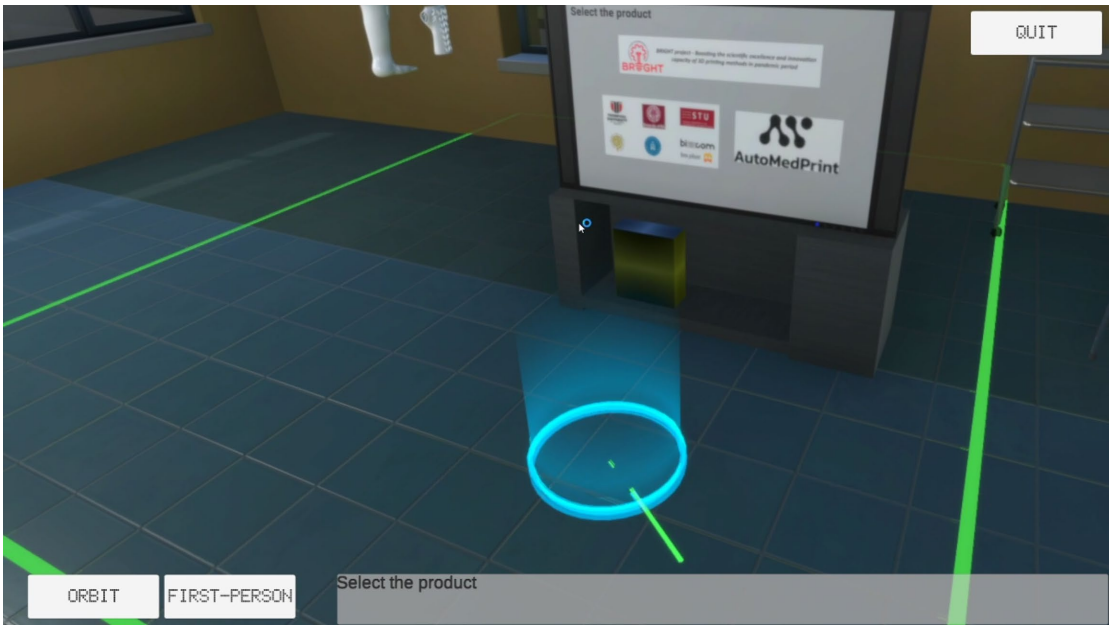


Figure 23. Movement on a distance in VR - teleporting

The initial step is product selection. After touching or clicking on a product, its description will be presented on the TV. The second step is patient scanning. The digital avatar is shown and the student must first invite the patient to the chair (see Figure 24).

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Figure 24. The initial step – product selection

The second step is patient scanning. The digital avatar is shown and the student must first invite the patient to the chair (Figure 25) and then he can start the scanning by clicking on the laptop at the scanning workplace in VR (like shown in Figure 26)

Figure 25. Selecting of the product and 3D scanning of the patient in VR

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

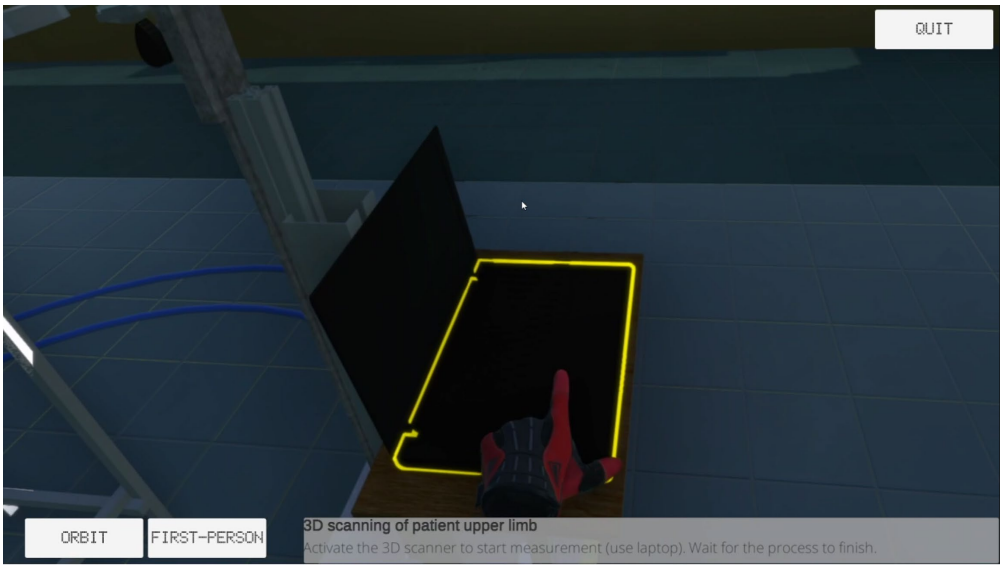


Figure 26. Activation of 3D scanning procedure

As in the real AutoMedPrint system, the scanning is realized automatically (Figure 27). The user must wait for the process to finish, which takes approximately half a minute (the process is sped up in relation to the real scanning). After the process, the student must ask the patient to get off the chair and next task begins.

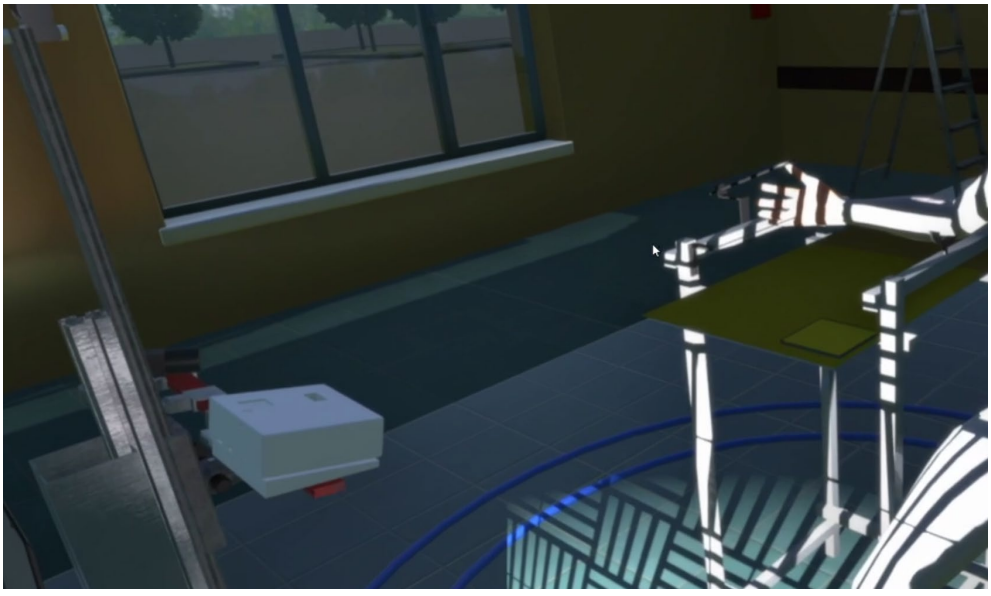


Figure 27. Simulated 3D scanning of patient's upper limb

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

The next steps consist in the configuration of the variant of the selected orthopedic product, assigning of CAD design features in VR as shown in Figure 28. The application continues to show students how the rest of procedure of realizing one part by 3D printing and realize post-processing is happening. These aspects will be described in the thematic virtual room related to 3D printing process that has been assigned to PUT as shown in Figure 2, since these steps that are following in continuing in the applications are more related to 3D printing instead of CAD.

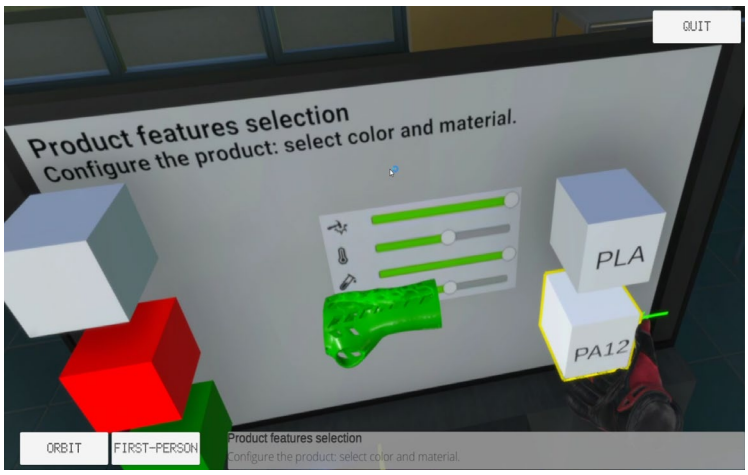


Figure 28. CAD product configuration and technological setup for the 3D printing process

3. Conclusions

The teaching resources provided by the BRIGHT project consortium partners in terms of CAD virtual laboratory room are extremely important since they are providing in a very comprised manner how different principles and methods of CAD designing must be taken into consideration when specific medical parts for concrete patients have to be realized by using different types of 3D printing technologies and equipment items that are available on the market. The teaching resources provided within the CAD virtual laboratory rooms of TUCN partner, completed with the supporting capabilities given in the UNI, STU and PUT rooms 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 the CAD methods and principles that can be used for producing medical products that are aimed to be realized by 3D printing technologies in particular. Many of the presented and realized CAD resources have been produced by professors and students within the BRIGHT project

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

(O1, O2, O4 and O5 in particular), being completed by the results and activities that have been performed by the BRIGHT professors and students during the BRIGHT international summer school editions in 2021 and 2022. Using Virtual Reality and applications developed in VR for teaching has proved to be very effective in education, as the collected feedbacks from the attendees of summer school event organized in 2022 and Multiplier event organized in 2022 in Croatia has emphasized. The main benefits of the created VR application consists in a better comprising on behalf of the students in terms of CAD. CAD laboratory room that is available at TUCN partner, completed with the supporting capabilities given in the UNI, STU and PUT can be accessed easily through the web platform of BRIGHT project and 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 educational content of CAD virtual laboratory rooms that are available on the BRIGHT virtual laboratory platform on the BRIGHT project (https://bright-project.eu/?page_id=320) can and will still be developed even after ending of the BRIGHT project, being aimed to be used in continuing in teaching purposes by anyone who is interested in producing medical products to be made by 3D printing technologies to support patients hospitals in time of pandemic or by anyone who is interested on research activities related to the designing methods and producing of new medical products by using different types of 3D printing technologies.

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.