

# BRIGTH

Erasmus+ strategic partnership for Higher Education

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

## O3 – BRIGTH virtual laboratory testing room

<b>Project Title</b>	<b>Boosting the scientific excellence and innovation capacity of 3D printing methods in pandemic period 2020-1-RO01-KA226-HE-095517</b>
<b>Output</b>	<b>O3 - BRIGTH e-learning virtual laboratory platform - description of testing room + supporting capabilities</b>
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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.

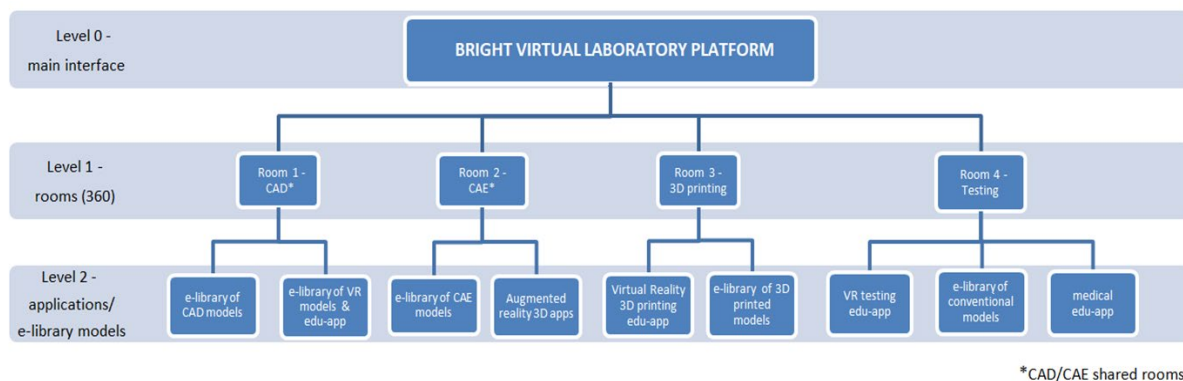


Figure 1. Initial concept of the Virtual Laboratory in the BRIGHT project

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 virtual laboratory testing room (room number 4)** which is relying on basic main room that has been constituted at University of Nis (UNI) partner, completed with the additional supporting capabilities that are being offered at STU, UNIPU, BIZZCOM and BM Plast in their Virtual rooms in relation to the realized medical products, 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](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. As one my notice in the scheme presented in Figure 2, testing room was placed according to the last step (4<sup>th</sup> step in the chain) that it is necessary to be followed when one medical product has been designed by CAD, validated through CAE analyses and finally it was 3D printed.

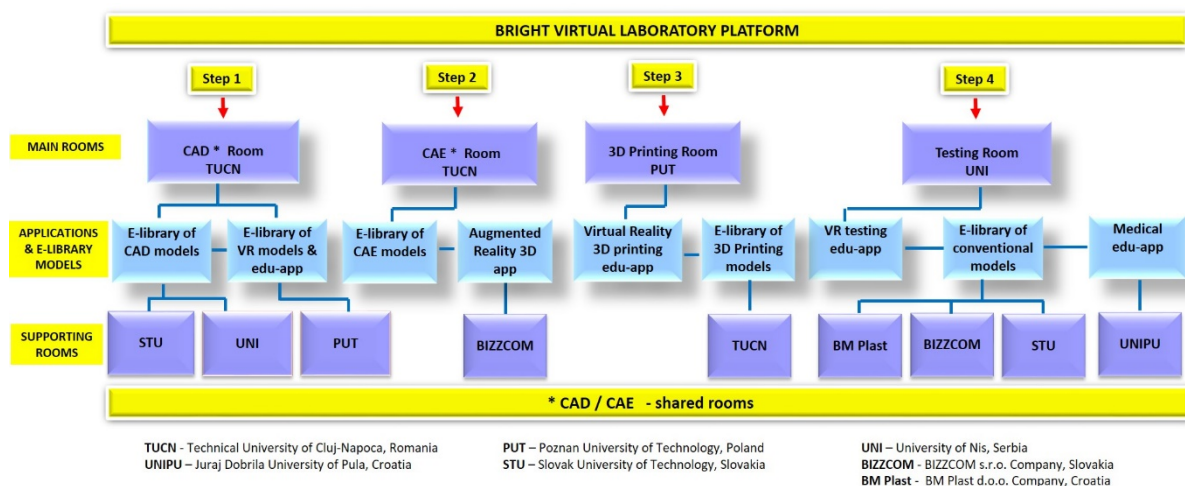


Figure 2. Main concept of BRIGHT virtual laboratory platform in terms of thematically rooms and apps

Therefore the testing room has been focused mainly on facilities that are referring to the testing facilities that have been identified among the BRIGHT partners at University of Nis (Serbia), this institution being assigned mainly to take care about the mechanical testing

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procedures description in terms of teaching, being completed by the additional capabilities that were identified at STU, UNIPU, BIZZCOM and BM Plast in their Virtual rooms, the presented resources being variable and coming in completing the process of designing, manufacturing and testing of medical products made by 3D printing technologies, by offering additional solutions related to quality control of the products (STU), medical procedures that are necessary for the standardization (Juraj Dobrila) or other conventional manufacturing / processing / post-processing steps like the ones that are being used by BIZZCOM and BM Plast in relation to the realized parts made by conventional technologies like CNC, injection molding, etc .

## 2. Virtual testing laboratory rooms description

### 2.1. Accessing the virtual testing 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).

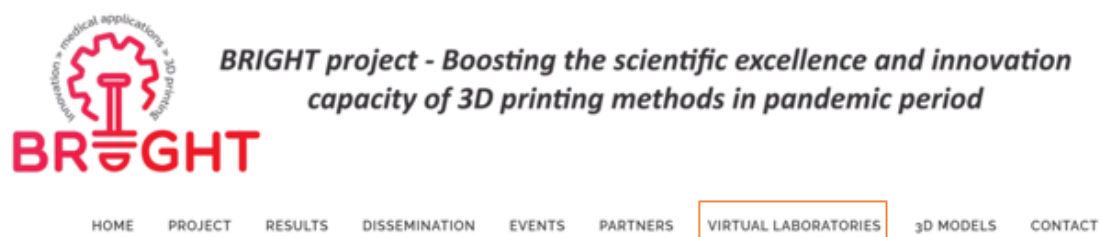


Figure 3. BRIGHT project website – access to WWW interface of Virtual Laboratory

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](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.

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## 2.2. Virtual testing laboratory room of University of Nis – UNI (Serbia)

As has been mentioned in the Introduction section of this report, Virtual laboratory of the University of Nis has been assigned as main room related to testing topic, as one may notice in Figure 2. Accessing of the UNI virtual laboratory room can be done after selecting the main interface of the BRIGHT virtual laboratories shown in Figure 2 (by opening of the interface (located at [https://bright-project.eu/?page\\_id=320](https://bright-project.eu/?page_id=320)). Containing the map of Europe, pin representing laboratories of UNI has to be selected (see Figure 4). To access the virtual testing laboratory room of UNI is possible also to be made by accessing the following link: <https://nessy2022.viewin360.co/share/collection/7vT3c>



Figure 4. Access to virtual testing room of University of Nis – UNI (Serbia)

Starting point of the laboratory is inside the building, where there is possibility to either select the CAD route (University of Nis has provided supporting capabilities to the CAD main virtual laboratory of the Technical University of Cluj-Napoca, as one may notice in Figure 2) or the material testing route, to have access to the testing infrastructure and the equipment items related specifically to this topic (see Figure 5). The main functionality and purpose of the University of Nis virtual laboratory has been focused in the BRIGHT laboratory platform in the field of material and parts testing.

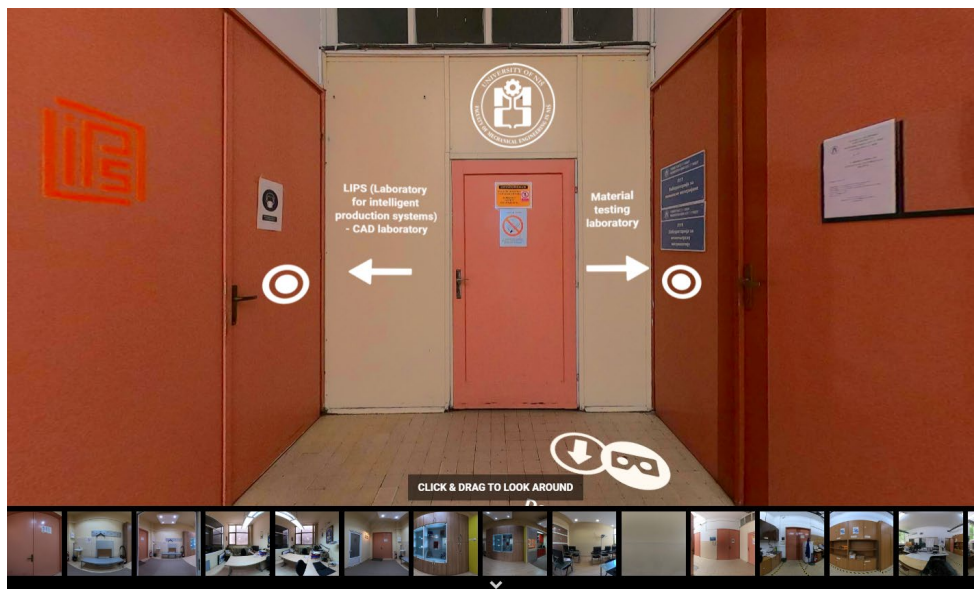


Figure 5. Virtual Laboratory of University of Nis – starting point

The laboratory contains the following locations:

- the Universal Testing Machine room (Figure 6)
- the material testing laboratory, with multiple locations (Figure 7)

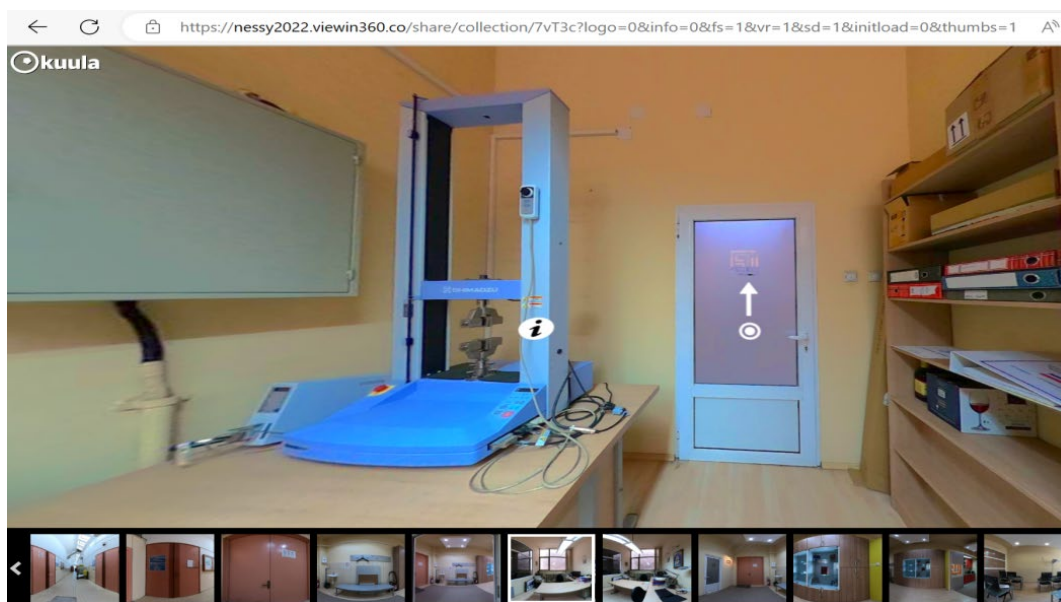


Figure 6. Universal Testing Machine room at VL of University of Nis

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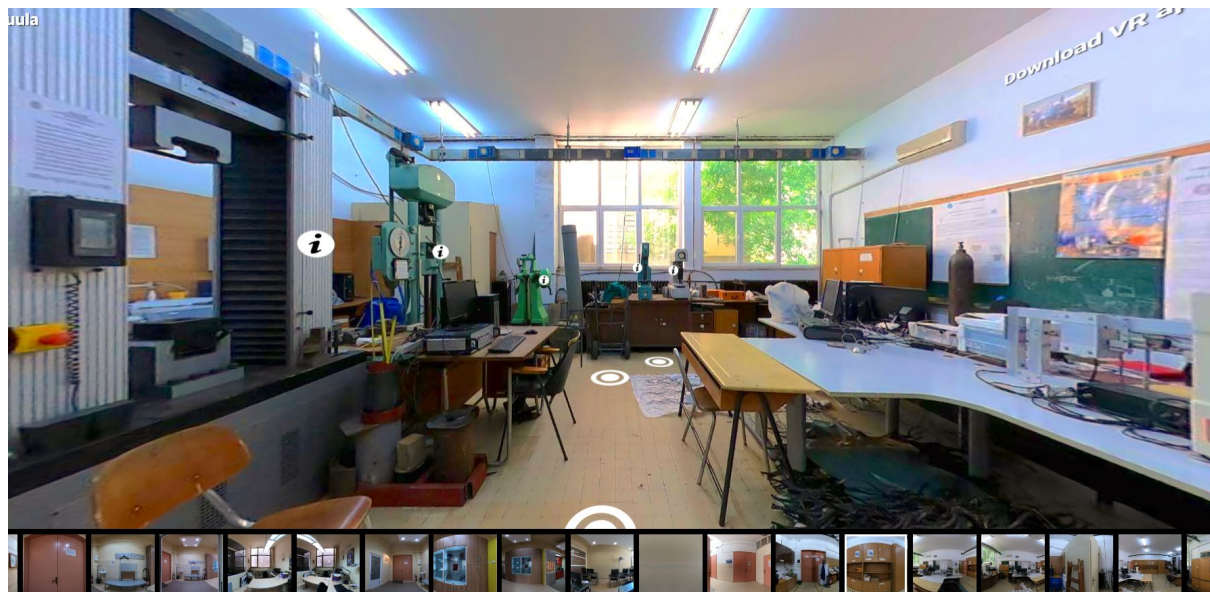


Figure 7. Material testing laboratory at VL of University of Nis

The educational content available at the laboratory contains educational videos of testing of medical parts (including O1 course modules, especially the one related to Mechanical Strength and Science of Materials (see Figure 8))

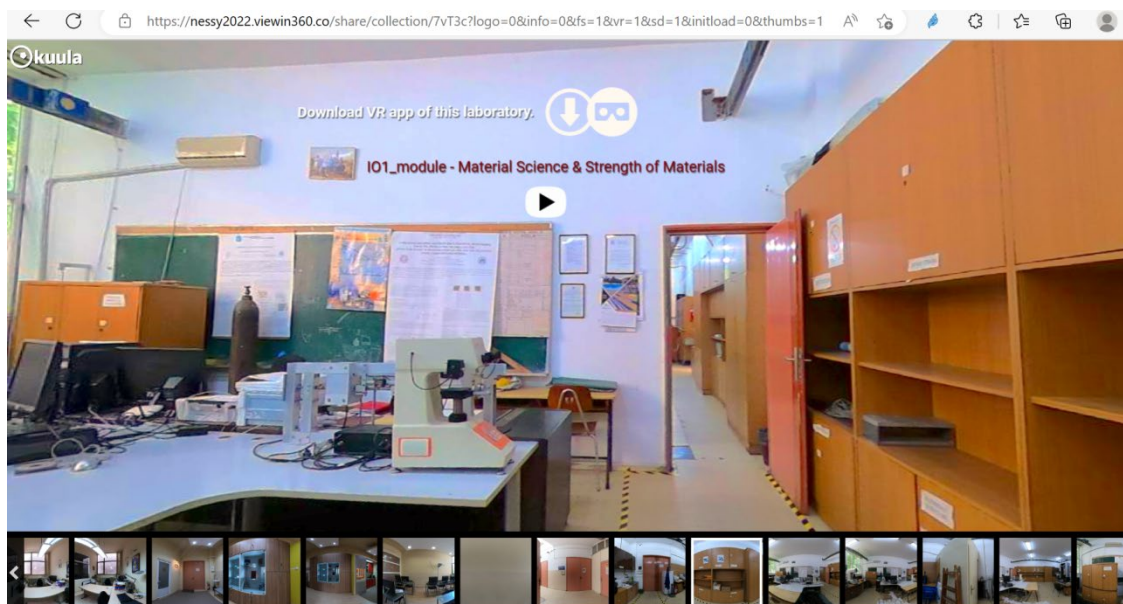


Figure 8. Educational teaching materials regarding the mechanical testing of medical parts

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Within the virtual laboratory of testing there are provided details educational descriptions of most basic material testing procedures, such as Charpy impact test, tensile / compression, hardness test, etc. as shown in Figure 9.

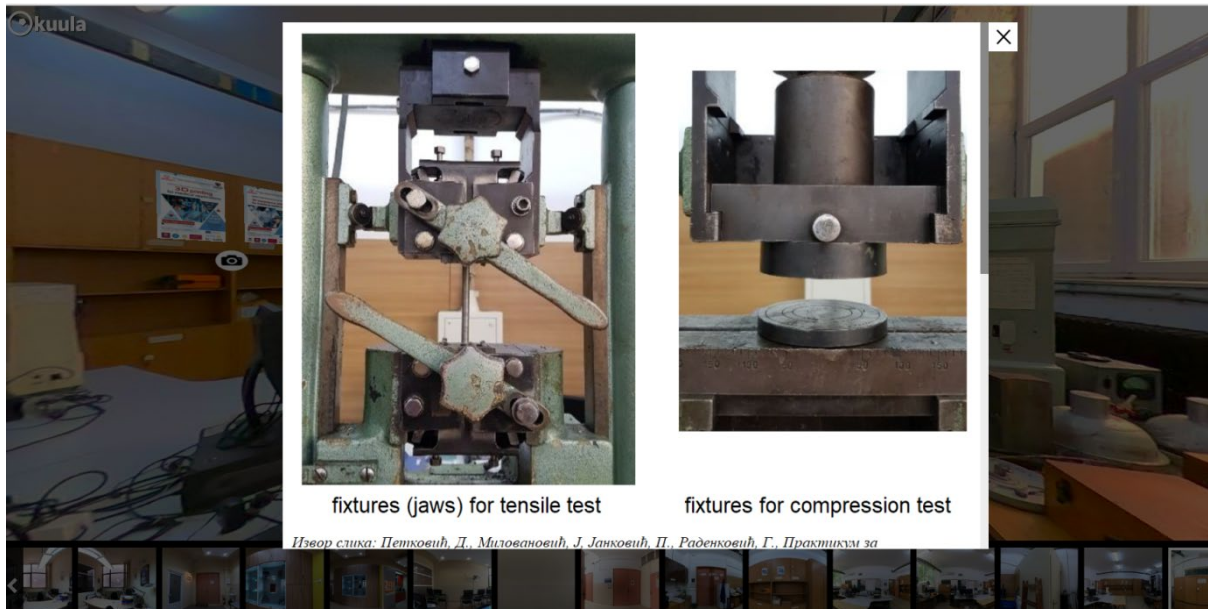
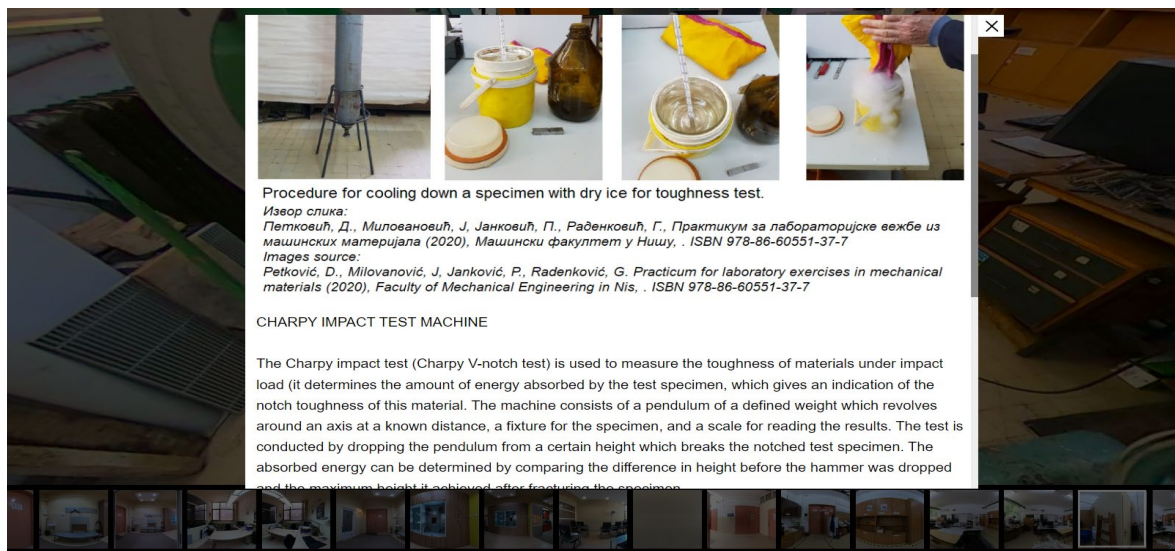


Figure 9. Description of Charphy and tensile / compression tests in Virtual testing laboratory of Nis

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Also within the virtual laboratory room at the University of Nis there are provided link to BRIGHT webinar #4 on testing which has been realized by the University of Nis based on specific case studies (medical products realized by 3D printing (University of Nis has one DLP 3D printer) and tested finally on the mechanical testing laboratories of the University of Nis (see Figure 10).

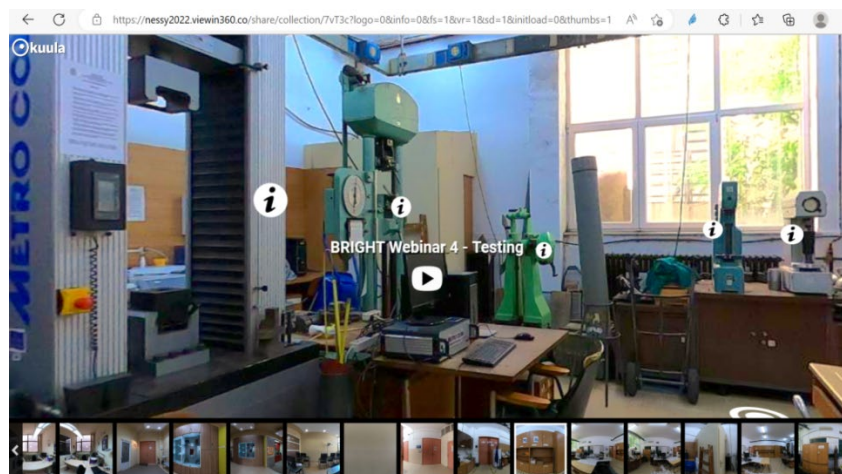


Figure 10. Webinar integrated as teaching resource in the Virtual testing laboratory room

Within the virtual laboratory of testing at the University of Nis there have been integrated also specific links to selected scientific publications that have been realized by the team of University of Nis in terms of testing. These links can be accessed free of charge and resources can be downloaded without any restriction from the University of Nis virtual testing laboratory (see Figure 11).

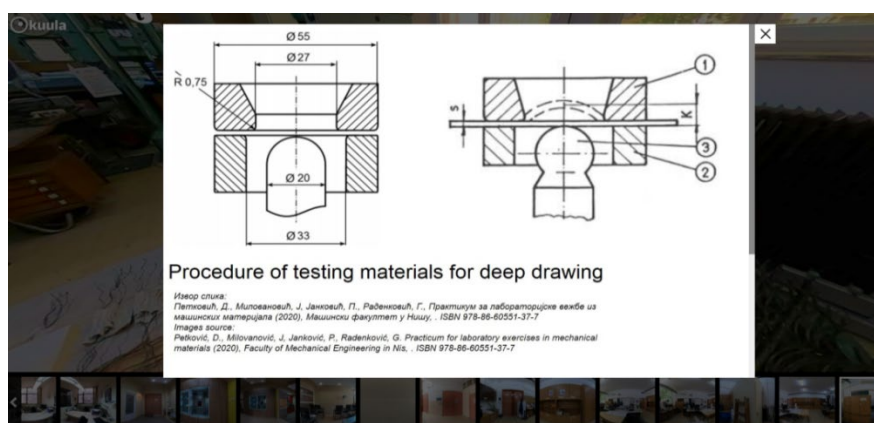


Figure 11. Scientific publications that have been realized by the team of University of Nis

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Within the Virtual laboratory testing at the University of Nis there have been introduced videos and pdf presentations from the BRIGHT International summer school, in which mechanical tests were performed for the student (e.g. in the case of orthoses) and were recorded in the laboratories of the University of Nis in summer of 2021 (see Figure 12).

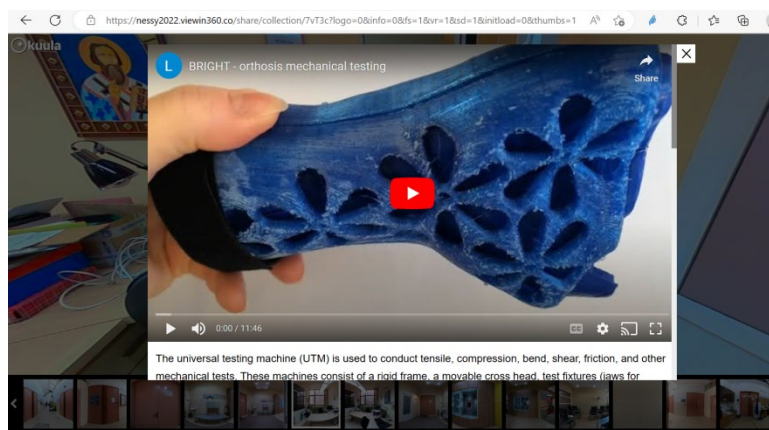


Figure 12. Mechanical testing of 3D printed orthoses for BRIGHT project realized at UNI

Last, but not least, within the Virtual testing laboratory of the University of Nis (Serbia) it is provided one link to an educational interactive Virtual Reality application that was made at UNI for the BRIGHT project, allowing to take part in the process of material testing of medical part in VR mode (see Figure 13).

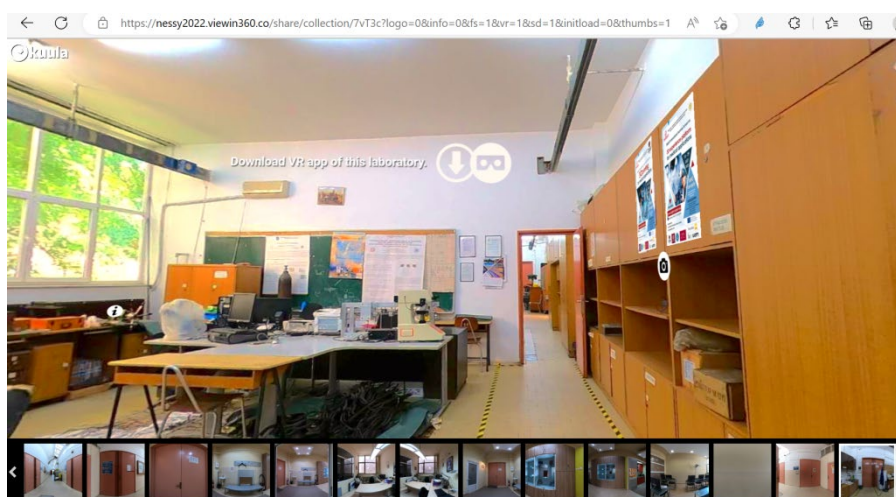


Figure 13. VR application (simulation) integrated within virtual testing laboratory of UNI

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The laboratory is a simplified representation (“digital twin”) of a real material testing laboratory at University of Nis. When starting the application, the user is placed directly inside the laboratory and is able to walk around and explore all the machines. The interactive part is the tensile test. A specimen can be placed inside jaws of the universal testing machine and the process can be started by using a red button. Then, an animation is played and the process is simulated (Figure 14).

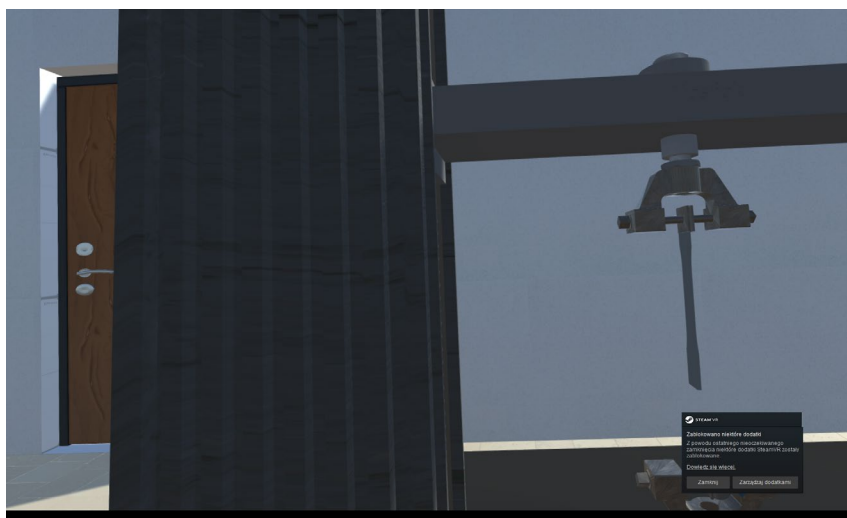


Figure 14. Simulation of tensile test in the VR testing application

In terms of showing the testing procedure through VR application, this allows students to explore the virtual lab, see real testing machines and uses them in the “learn by doing” manner. As such, it is an important asset and extension of the BRIGHT virtual laboratory platform.

### 2.3. Supporting capabilities in STU, UNIPU, BIZZCOM and BM Plast

Additional support related to testing virtual laboratory main room of the University of Nis (Serbia) has been provided by STU Trnava, University Juraj Dobrila of Pula, Bizzcom and BM Plast companies in their virtual laboratory rooms (like shown in Figure 2), these additional resources being included in their rooms along with teaching resources, libraries of models or apps to support virtual laboratory of the University of Nis and BRIGHT platform in terms of testing.

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Accessing of all the supporting institutions (STU Trnava, UNIPU, BIZZCOM and BM Plast) virtual laboratory rooms (Figure 15) 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](https://bright-project.eu/?page_id=320)).

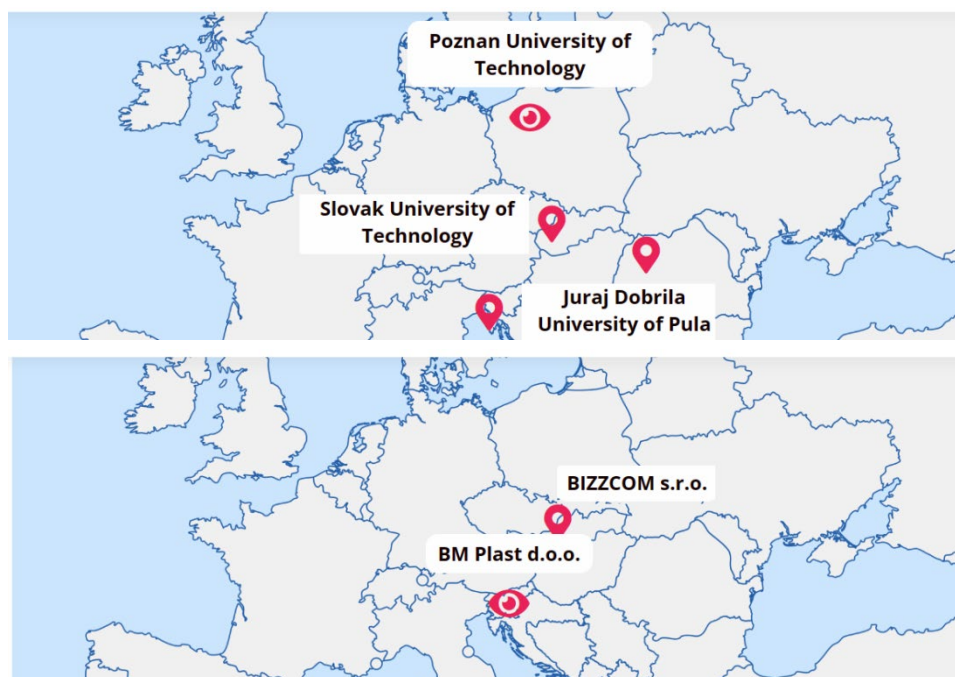


Figure 15. Access to virtual laboratory of PUT, STU Trnava, UNIPU, BIZZCOM and BM Plast

Therefore in terms of supporting rooms, virtual Laboratory of Slovak University of Technology / Faculty of Materials Technology in Trnava is offering additional, but valuable solutions in terms of quality control an flexible manufacturing systems: (<https://nessy2022.viewin360.co/share/collection/7vd6F>).

At the level of BRIGHT consortium this was the only partner who has been identified as having experience and logistic facilities on flexible manufacturing systems that can be integrated together with 3D printing systems in case such systems are needed to be realized to produce medical parts by modern technological methods (e.g. hybrid manufacturing), but also about quality control (3D scanning, metrological measurements, with CMM machines or Computer Tomographs (CT). Quality control methods as CMM or CT are very important steps that are required to be realized in the end of the process for testing of medical products

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besides the mechanical tests procedures that have been already presented and are available at University of Nis (Serbia) for different types of mechanical testing, like tensile, hardness, etc. One representative image about the Virtual hall for assembly and quality control operation that is provided by STU Trnava is shown in Figure 16.

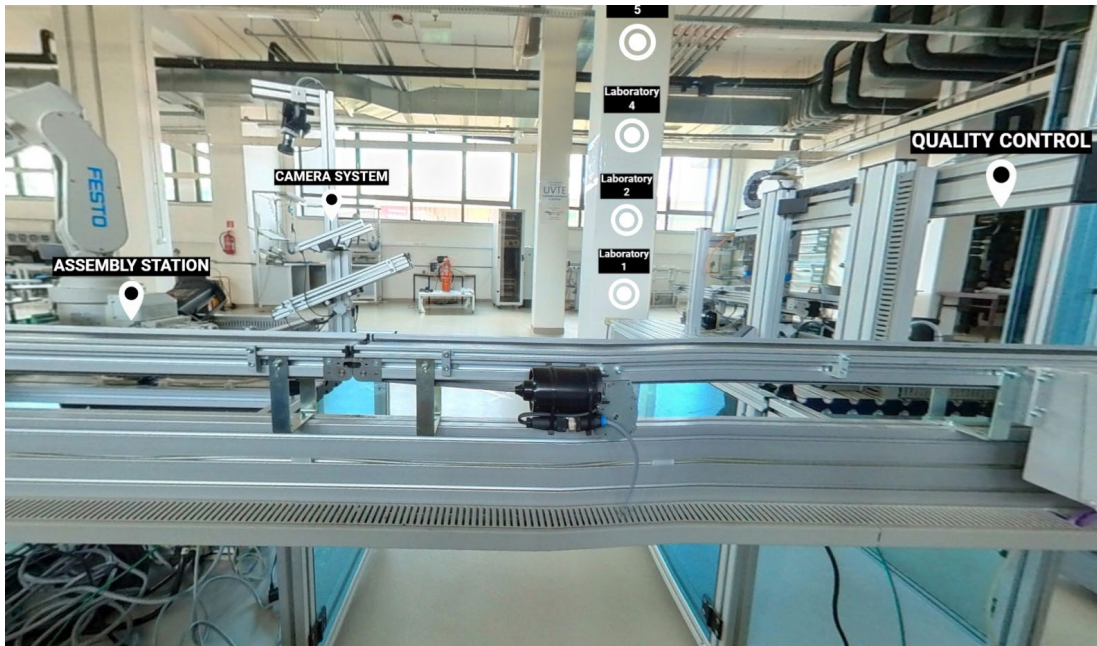


Figure 16. Virtual hall for assembly and quality testing (STU)

The educational content comprised in the virtual room for testing at STU Trnava contains like in the case of the other Virtual laboratory rooms: videos that are explaining different methodologies used for CAD (STU has been supporting also CAD virtual room of Technical University of Cluj-Napoca in terms of resources and mainly CAD e-library of the models that have been produced (as shown in Figure 2), but also there are integrated into these rooms special videos about testing or scanning, specific tutorials in relation with these topics, other documents in which information about specific equipment items that are used for scanning / quality control testing, etc., so the users who are visiting their room could easily familiarize with this field of testing (quality control done by 3D scanning and CMM methods in principle) (see Figures 17 and Figure 18).

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Figure 17. Virtual coordinate measurement machine workplace (STU)

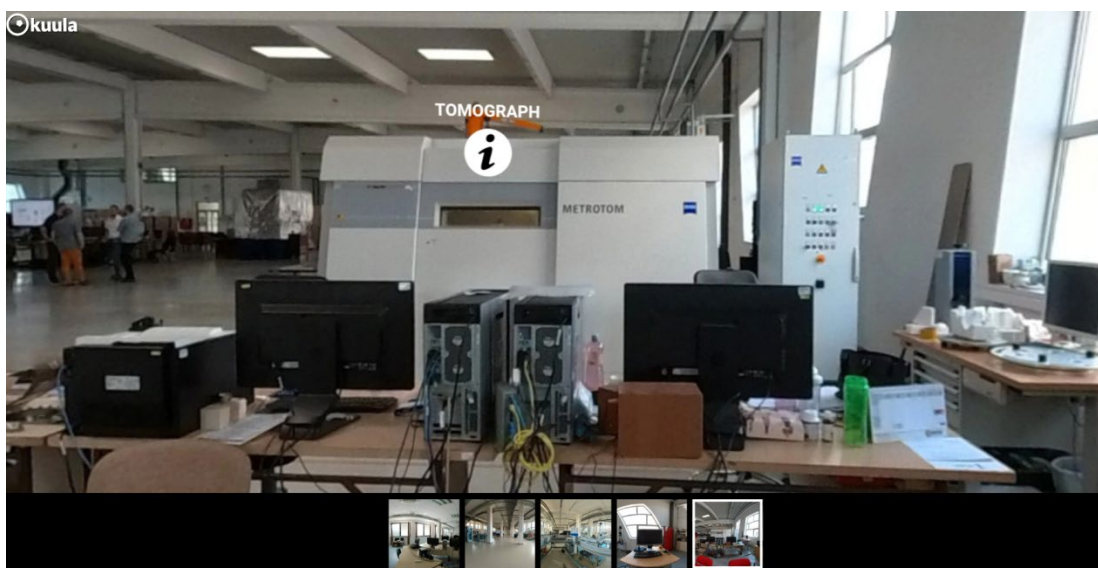


Figure 18. Zeiss Metrotom equipment used for CT scanning of products (STU Trnava)

Virtual laboratory of the Juraj Dobrila University of Pula is offering support in terms of capabilities for the testing main room realized by the University of Nis, by completing it with one set of resources that are linked with the medical standard procedures that are required to be followed additionally to the mechanical tests that have been performed.

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In this sense, Juraj Dobrila University partner presents a broader picture different than the one provided in the other virtual laboratory rooms of BRIGHT Higher Educational institutions. The virtual tour of the University can be accessed through the following link: <https://kuula.co/share/7sXgY/collection/7PzR7>

By walking through the Virtual technical laboratories rooms that are available at Juraj Dobrila University of Pula (Croatia), one interesting laboratory that the users of the BRIGHT platform can find is the one related to medical simulations (see Figure 19).

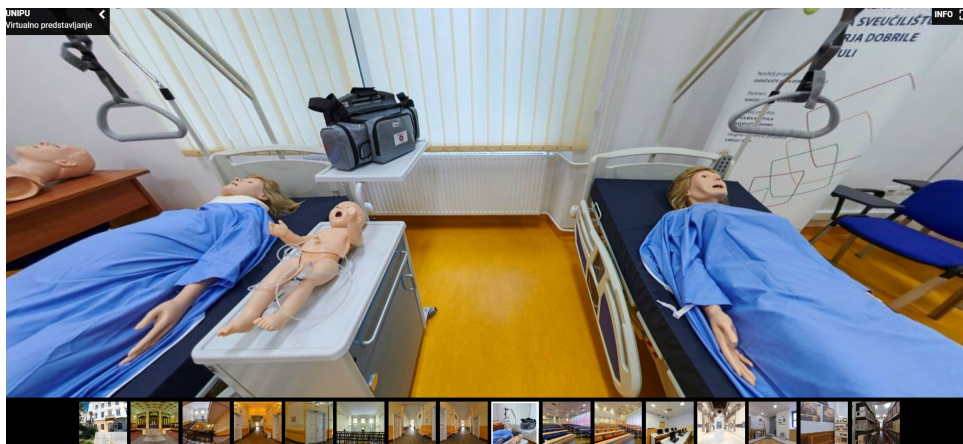


Figure 19. University of Pula – medical simulation laboratory

One other important facility that the Juraj Dobrila University of Pula (Croatia) is offering is related also to the laboratory of programming in which there are explained how medical applications in terms of simulations can be conceived and realized and the importance of such applications not just for the engineers, but also for the medical side (medical institutions, surgeons / medical doctors in general in principle) (see Figure 20).

Such medical application has been integrated into one of the Virtual laboratory rooms of the Juraj Dobrila University of Pula (Croatia), among other types of mobile robots, that there are presented like virtual showcase, as they were realized by professors and students of Juraj Dobrila in time of pandemic (Figure 21). Few of the robot models shown in this room have been developed with the aim to be used for medical purposes (social robots, robots used for therapeutically issues faced by patients with special needs, etc).

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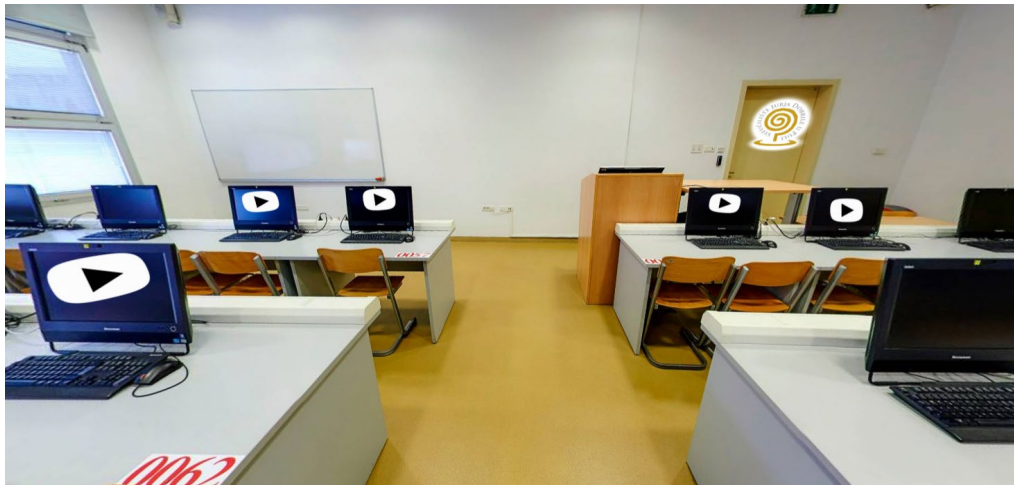


Figure 20. Laboratory of programming (Juraj Dobrila University of Pula)

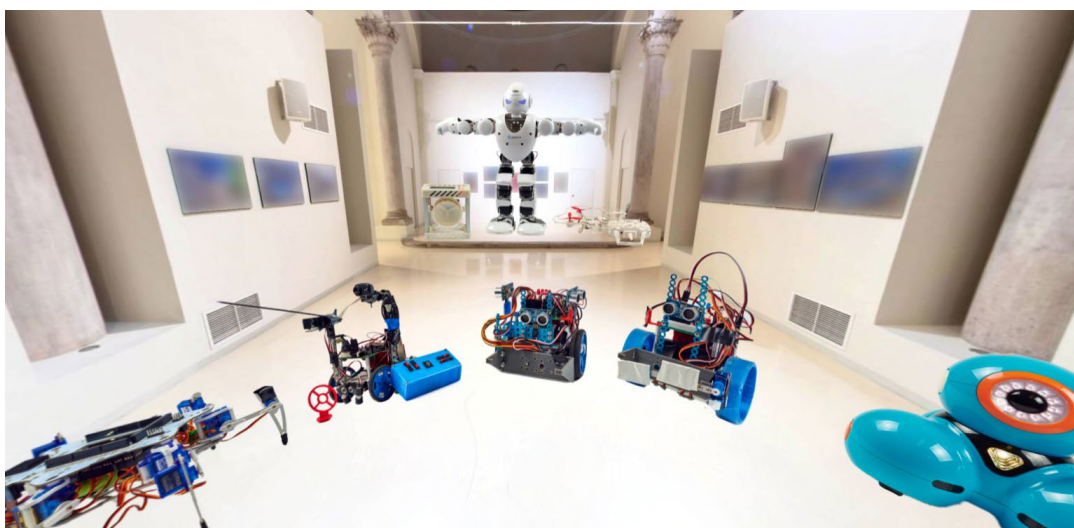


Figure 21. University Juraj Dobrila of Pula (Croatia) – robot showcase

Going further to the industrial partners, in case of BIZZCOM which was involved in the BRIGHT project in developing Augmented Reality applications to sustain the CAE virtual laboratory rooms and applications which have been assigned to the Technical University of Cluj-Napoca, like shown in Figure 2, in the virtual laboratory of of Bizzcom company in relation to the supporting capabilities that are related to Virtual laboratory testing that has been realized by the University of Nis (Serbia) in terms of mechanical testing, in their virtual rooms that can be accessed through the interface shown in Figure 3 or by accessing directly

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the following link: <https://nessy2022.viewin360.co/share/collection/79pDP>, there have been identified, included and finally integrated into the BRIGHT virtual laboratory platform unique capabilities of this industrial partner to the BRIGHT consortium, consisting in Prototyping, testing, assembly and transporting equipment items that the BIZZCOM company mainly has in terms of conventional technologies (like punching, CNC pressing, etc, (see Figure 22), along with one set of virtual models in one e-library that they are producing using these technologies (and also by 3D printing) as one may notice in Figure 23.

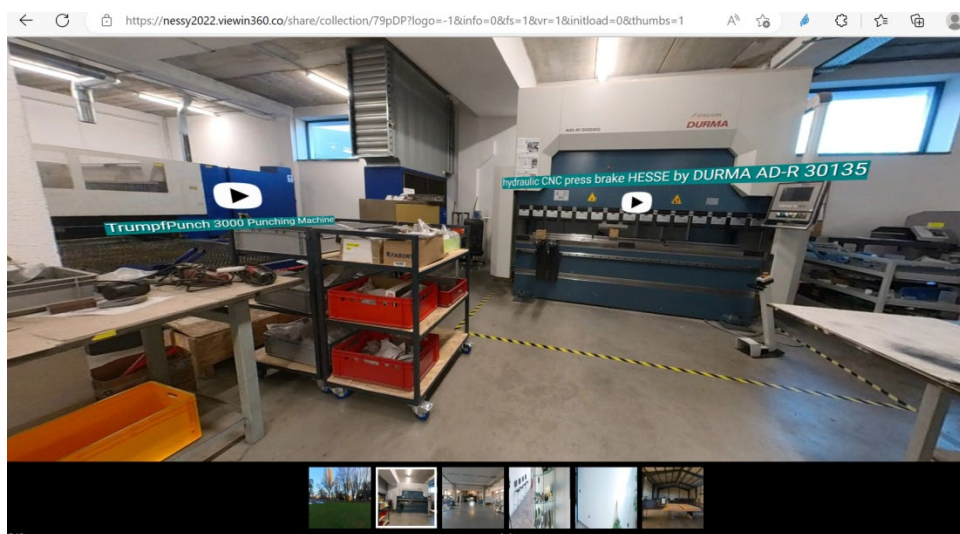


Figure 22. Punching machine and CNC press available at Bizzcom company (Slovakia)

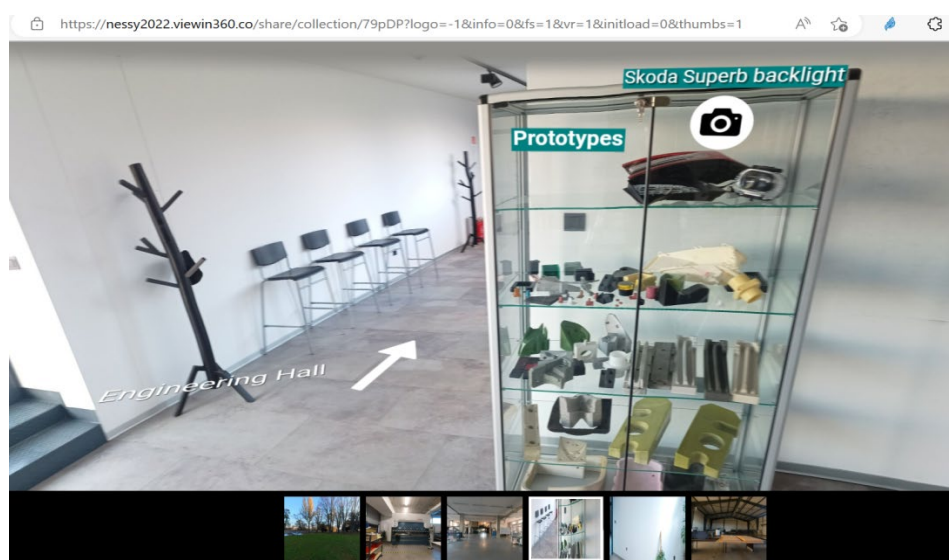


Figure 23. Examples of prototypes produced at BIZZCOM (Slovakia)

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Overall and generally speaking, by having a real imagery of most of facilities of a specific production company like BIZZCOM integrated within the BRIGHT Virtual laboratory platform brings value in the educational process of the students who are able to get and comprise much better in this way the company itself. The virtual laboratory of BIZZCOM represents the organizational structure of the company, processes realized there and equipment used. The students can get familiarized in this way with how a modern company is involved in using digitalized methods (including AR) in their operating technologies.

Last, but not least, as in the case of Bizzcom, the virtual laboratory of the second industrial partner to the BRIGHT project (BM Plast company) which can be accessed from the main platform of BRIGHT Virtual laboratory interface provided on the BRIGHT project website like shown in Figure 3 or by accessing directly the next following link [:https://nessy2022.viewin360.co/share/collection/79p1c](https://nessy2022.viewin360.co/share/collection/79p1c) , enables students to see how a production company dealing with polymers is organized and working. The virtual laboratory presents the various production processes related to polymers (useful when 3D printing prototyping stage is finished and a given medical product is directed into real production), such as injection molding and extrusion processes (Figure 24) or material preparation process (Figure 25). The equipment available at the production site is presented and described from educational point of view, emphasizing the most important aspects of the processes and devices the BM Plast company is using, along with one e-library of models that are produced by using injection moulding process of medical parts to be made on a larger batch series (serial production).

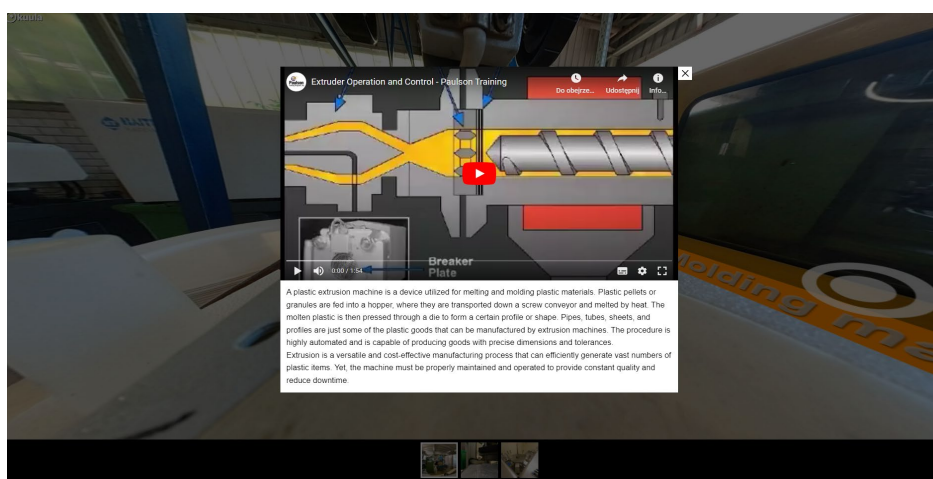


Figure 24. Polymer processing description at BM Plast Virtual Laboratory

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Figure 25. Material making process explained within BM Plast Virtual Laboratory

### 3. Conclusions

The virtual testing laboratory room realized by UNI partner as part of the BRIGHT virtual platform that has been developed within O3 of the BRIGHT project, being completed with the supporting capabilities of STU, UNIPU, BIZZCOM and BM Plast, contains most of knowledge developed during the project regarding main mechanical methods that are used for testing the medical parts made by 3D printing (like Charpy / tensile / compression / hardness tests) that have been presented within the Virtual testing laboratory of UNI being completed with other additional testing methods that are required to be followed in this case like quality control testing (3D scanning, metrological control, etc.) these methods being extensively presented by STU Trnava partner in particular. The other capabilities which are emphasized by Juraj Dobrila partner are referring to specific equipment and methods that are available at this University, in relation to medical standard tests that are necessary to be performed additionally to the ones that are being performed mechanically, along with teaching resources on programming which are emphasizing how medical applications in terms of simulations can be conceived and realized and the importance of such applications not just for the engineers, but also for the medical side (medical institutions, surgeons / medical doctors in general in principle), such example of application being integrated into one of the Virtual laboratory rooms of the Juraj Dobrila University of Pula (Croatia), among other types of mobile robots, that there are presented like virtual showcase, as they were realized by professors and students of Juraj Dobrila in time of pandemic.

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Last, but not least, the additional supporting capabilities and facilities that are being presented in the case of specific production companies like BIZZCOM and BM Plast, that have been integrated within the BRIGHT Virtual laboratory platform brings value in the educational process of the students who are able to get and comprise in this way much better the organizational structure of the companies itself, along with the processes and equipment items that these companies are using for realizing of parts using conventional methods, including one e-library of models that these companies have been produced in pandemic using the conventional technologies, like punching, CNC pressing, injection molding, etc. The resources realized regarding the Virtual testing laboratory of BRIGHT platform as part of O3 have been extensively used during the BRIGHT project activities, including the summer school and Multiplier Events. Virtual testing laboratory realized by University of Nis (Serbia), along with the other supplementary capabilities that are integrated within the laboratories of STU, Juraj Dobrila, BIZZCOM and BM Plast partners can be accessed easily through the web platform of BRIGHT project ([https://bright-project.eu/?page\\_id=320](https://bright-project.eu/?page_id=320)) 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 is being required. The teaching resources provided within the virtual testing laboratory room of UNI along with the other supplementary capabilities that are integrated within the laboratories of STU, Juraj Dobrila, BIZZCOM and BM Plast 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 different types of methods that can be used for testing of different types of medical parts using such methods. The educational content of virtual testing laboratory room 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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