Co-funded by the European Union

ErgoDesign

ErgoDesign

Improving digital skills for Ergonomics and Bioengineering Innovations for inclusive Health Care

Project number: 2021-1-PL01-KA220-HED-000031182

A report for the development of the dynamic toolkit

NTUA Scientific Responsible: Angelos Markopoulos

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the National Agency (NA). Neither the European Union nor the NA can be held responsible for them.

Contents

1 Toolkit's structure

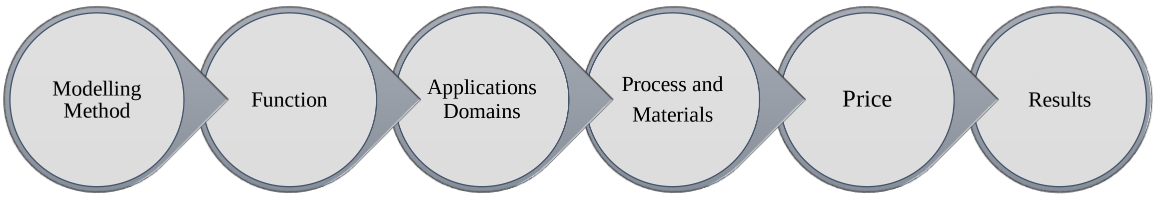
NTUA is PR1 leader: 'Specialized software/digital tools for design in the Health Care sector dynamic toolkit'. The aim of PR1 is to present several software tools for booting digital competencies of health education lecturers/ Academics and students. The purpose of Dynamic Toolkit (DT) is:

1. to increase the pedagogical digital skills of health education lecturers in the fields of 3D design and production of healthcare
2. to increase the digital skills of HE students for healthcare applications in prosthetics and implantology
3. to increase the knowledge on projects topics, to learn how to deal with patients with special needs.

Moreover, the medical device manufacturing industry is growing rapidly in order to keep up with the increased demand. Therefore, medical device product designers must create innovative medical products. Plenty of challenges are to be considered during the manufacturing of medical equipment, with the most important among them being patient safety. Efficiency, effectiveness, and cost containment are also very important to be considered. So, in order to manage product development risks, DT will help product designers to make the process of producing 3D printed implants more efficient, cost reduction, and product customization.

The DT is to put in order the various digital tools that can be used for designing and producing 3D printed models of any kind of medical implants, to systemize them according to a common format and to create a tool that can help the users to select the suitable tool for the right purpose.

All digital tools will be described according to a template considering different aspects: general description of the software/tool, specific purpose, functionalities, pros and cons, price (free software preferred to other tools), availability of the tool to one of the Partner University. The toolkit will not include user-experience aspects of computer-aided design (CAD) software, e.g., computational power, ease of use, or



other. The user will be able to choose, e.g., by ticking selections, from four different criteria and results will be provided in the form of a Table with proposed solutions. According this criteria NTUA designed the structure of the toolkit. Toolkit's basic structure is a 5-stage process:

Stage 1: Modelling Method

Digital tools for designing 3D printed models allow the user to create drawings using solid, surface, and mesh objects which offer different functionality.

Stage 2: Function

Several tools are perfect for medical use and come with numerous of advanced functions such as: simulation, 3D visualization, analysis of molecular structures, finite element analysis, generative design (GD)-generated suggestions for optimization, ergonomics analysis, direct import of 3D scanning data for reverse engineering, motion analysis, interference detection for assemblies and, preparing models for 3D printing,

Stage 3: Applications Domains

3D modelling has helped the most in the customization of the implants. Data is provided, which can help design prosthetics with the help of software, and customized prosthetics are made at a lower cost and with greater precision. Some of the applications of 3d printing are craniofacial implants, dental, cardiology, orthopedics, exoskeletons, prostheses, drug delivery.

Stage 4: Process and Materials

3D printing, a part of additive manufacturing (AM) process, 3D printing permits the manufacture of customized parts from various materials (like titanium, nitinol, hydroxyapatite, etc.). There are different methods of AM which require different materials. Although material selection depends on the application, the two most used methods are fused deposition modeling (FDM) and selective laser sintering (SLS).

Stage 5: Price

Subscription cost of the software.

Results

According to previous stages, the output will be the most appropriate digital tool for the user’s purpose. The selective software will be described considering different aspects: a general description of the software, specific purpose, functionalities, pros and cons, price. Furthermore, 3D design software will empower the user to use more than one of the 3D tools to demonstrate how the synergies between some of them can allow reaching the highest results.

Since all the partners agreed with the proposed structure, the next step was to made a list with possible tools, which could be included in the Toolkit. All the partners agreed for the final list of CAD software, as can be seen in Table 1, to be included in the toolkit.

Table 1. List of CAD software.

CAD Software
Fusion 360
SolidWorks
Inventor Professional
CREO
MeshLab
Siemens NX
MeshMixer
Solid Edge
Maya
Blender

With the use of HTML, CSS and JavaScript NTUA prepare the digital Toolkit's first version. The DT is illustrated in Figure 2. The main part of the DT consists of parameters which are divided into four main categories. There is also a table with the CAD software. From this table the users can choose software, and then, they can read a short description for each of 3D CAD software before their final selection. The users have the option to select the desired parameters and then the toolkit "recommends" the most suitable 3D CAD software (Figure 3).

ErgoDesign

Improving digital skills for Ergonomics and Bioengineering for inclusive Health Care

Welcome to Ergodesign Dynamic Toolkit
A collection of 3D CAD softwares used for dental and orthopeadic applications

Home | Dynamic Toolkit

On this page:

About this Toolkit

What is a CAD software

3D CAD Softwares used in Healtcare

Steps required in the creation of 3D printed model.

About this Toolkit

The Dynamic Toolkit is to put in order the various digital tools that can be used for designing and producing 3D printed models of any kind of medical implants, to systemize them according to a common format and to create a tool that can help the users to select the suitable tool for the right purpose.

All digital tools will be described according to a template considering different aspects: general description of the software/tool, specific purpose, functionalities, pros and cons, price (free-software preferred to other tools), availability of the tool to one of the Partner University. The toolkit will not include user-experience aspects of computer-aided design (CAD) software, e.g., computational power, ease of use, or other. The user will be able to choose, e.g., by ticking selections, from four different criteria and results will be provided in the form of a Table with proposed solutions.

Dynamic Toolkit is organised as an open online tool with searchable and downable items.

The language of the Dynamic Toolkit is English.

What is a CAD software

3D CAD, is a three-dimensional computer-aided design tool used to by designers, engineers, and architects to create industrial objects that iclude complex mechanisms. It helps to create functional, virtual prototypes of three-dimensional designs. A CAD software can be very specific, whether it is for industrial, mechanical, architectural or aeronautical engineering design.

CAD software tools allow designers to investigate design ideas, modify designs easily, visualize concepts through renderings, simulate how a design performs in the real world and draft documentation. Moreover, using cad software designers can share designs for feedback, and allow companies to get to market faster.

The benefits of 3D CAD softwares are the following:

- Rapid concept development
- Specialization
- Visualization
- Optimization
- Rapid manufacturing

3D CAD Softwares used in Healtcare

The medical device manufacturing industry is growing rapidly in order to keep up with the increased demand. Therefore, medical device product designers must create innovative medical products. Plenty of challenges are to be considered during manufacturing of medical equipment, with the most important among them being patient safety. Efficiency, effectiveness, and cost containment, are also very important to be considered.

Recent years have been marked by a growing interest in the creation of open science. This applies not only to the free sharing of content and research experience, but also in particular to the benefits of using open source systems. Many of the leading commercial software products have an analogue of open source software.

CAD software tools allow designers to investigate design ideas, modify designs easily, visualize concepts through renderings, simulate how a design performs in the real world, and draft documentation. Moreover, using cad software designers can share designs for feedback, and allow companies to get to market faster. In the biomedical field, CAD software is used for accurate modeling of complex geometries, customization, and patient-specific solutions, iterative design processes, simulation and analysis, collaboration, and communication, as well as facilitating manufacturing and production. More specifically CAD is necessary for the following reasons:

- Precise Design: Biomedical technology often involves intricate and complex designs, such as medical devices, implants, and prosthetics. CAD software allows engineers and designers to create precise and detailed 3D models of these components. It enables accurate representation of complex geometries, dimensions, and specifications, ensuring the design meets the required standards and functional requirements.
- Visualization and Simulation: CAD software provides visualization tools that allow designers to see the virtual representation of their designs in 3D. This visual feedback helps in assessing the aesthetics, ergonomics, and functionality of biomedical devices. Additionally, CAD software often includes simulation capabilities, allowing engineers to test the performance and behavior of the devices under different conditions. This simulation helps identify potential design issues and optimize the performance before physical prototyping.
- Customization and Personalization: Biomedical technology often requires customized and patient-specific solutions. CAD software enables the creation of personalized designs based on patient data, such as medical imaging scans. With CAD, engineers can precisely model and modify the design to fit the unique anatomy and needs of individual patients. This customization enhances the effectiveness and comfort of biomedical devices, leading to improved patient outcomes.
- Iterative Design Process: CAD software supports an iterative design process, where designers can make changes and refinements to their designs based on feedback and testing. The software allows for easy modification of design parameters, enabling rapid prototyping and evaluation of design iterations. This iterative approach leads to the development of optimized and efficient biomedical devices.
- Collaboration and Documentation: CAD software facilitates collaboration among multidisciplinary teams involved in biomedical technology development. It allows for the sharing and exchange of design files, enabling effective communication and feedback from clinicians, researchers, and manufacturers. Additionally, CAD software enables the creation of comprehensive design documentation, including detailed specifications, measurements, and material information. This documentation is essential for regulatory compliance, manufacturing, and quality control.
- Integration with Manufacturing Technologies: CAD software plays a crucial role in the integration of design with manufacturing technologies in biomedical engineering. The CAD models generated using the software can be directly used in various manufacturing processes, including additive manufacturing (3D printing), CNC machining, and mold fabrication. This integration ensures accuracy and consistency between the designed model and the manufactured product.

In summary, CAD is essential in biomedical technology for accurate design, visualization, and simulation, as well as for customization, iterative design processes, collaboration, documentation, and integration with manufacturing technologies. It boosts efficiency, accuracy, and innovation in developing biomedical devices, resulting in better healthcare outcomes.Some of the most used 3D CAD softwatres in the field of healthcare are MeshLab, SolidWorks, Blender, etc.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the National Agency (NA). Neither the European Union nor the NA can be held responsible for them.

Co-funded by the European Union

Figure 1. Initial page of Dynamic Toolkit.

Figure 2. The main structure of DT.

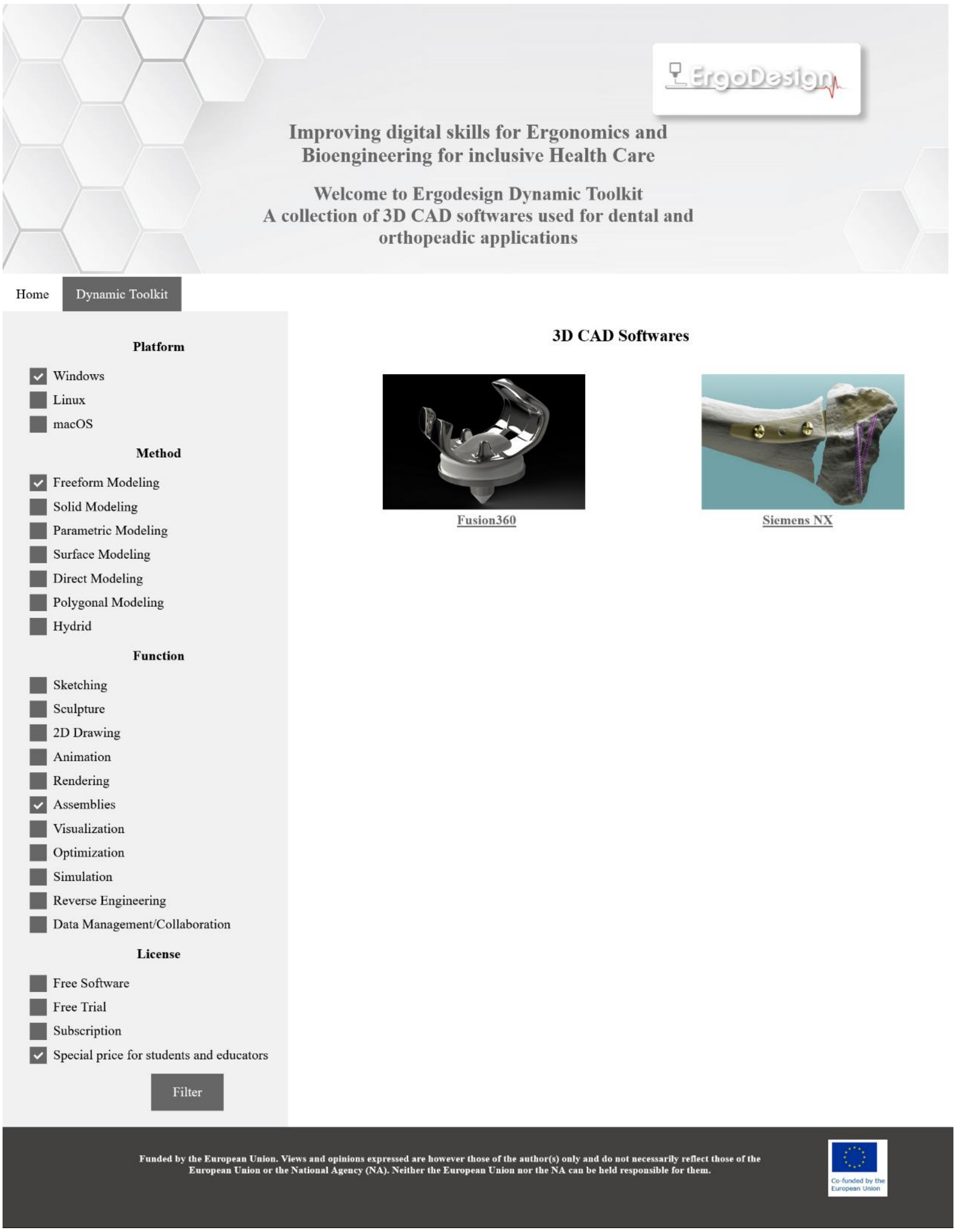
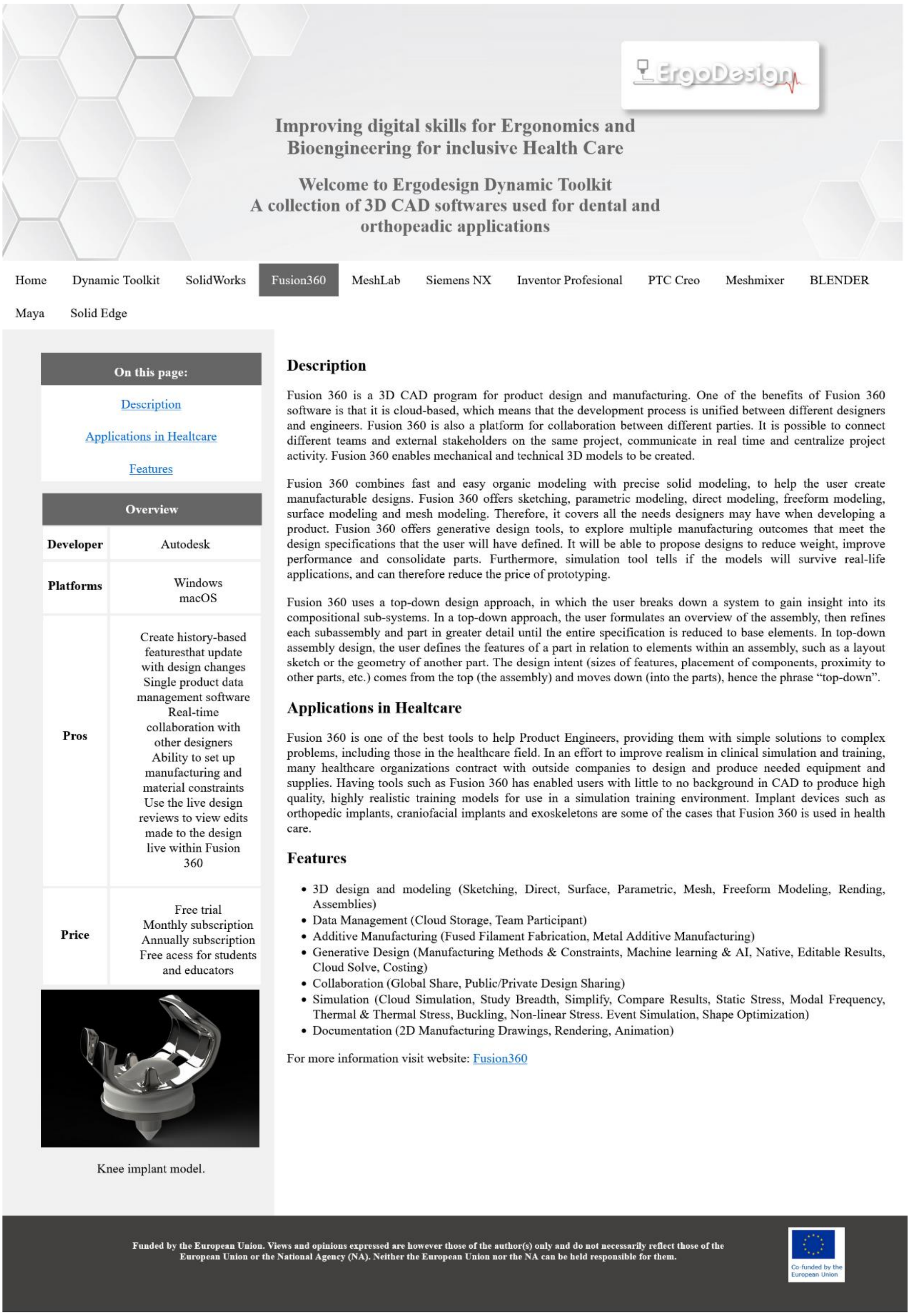


Figure 3. The results after a random selection of parameters.



ErgoDesign

Improving digital skills for Ergonomics and Bioengineering for inclusive Health Care

Welcome to Ergodesign Dynamic Toolkit
A collection of 3D CAD softwares used for dental and orthopeadic applications

Home | Dynamic Toolkit | SolidWorks | Fusion360 | MeshLab | Siemens NX | Inventor Profesional | PTC Creo | Meshmixer | BLENDER | Maya | Solid Edge

On this page:

Description

Applications in Healtcare

Features

Overview	
Developer	Autodesk
Platforms	Windows macOS
Pros	Create history-based featuresthat update with design changes Single product data management software Real-time collaboration with other designers Ability to set up manufacturing and material constraints Use the live design reviews to view edits made to the design live within Fusion 360
Price	Free trial Monthly subscription Annually subscription Free acess for students and educators

Knee implant model.

Description

Fusion 360 is a 3D CAD program for product design and manufacturing. One of the benefits of Fusion 360 software is that it is cloud-based, which means that the development process is unified between different designers and engineers. Fusion 360 is also a platform for collaboration between different parties. It is possible to connect different teams and external stakeholders on the same project, communicate in real time and centralize project activity. Fusion 360 enables mechanical and technical 3D models to be created.

Fusion 360 combines fast and easy organic modeling with precise solid modeling, to help the user create manufacturable designs. Fusion 360 offers sketching, parametric modeling, direct modeling, freeform modeling, surface modeling and mesh modeling. Therefore, it covers all the needs designers may have when developing a product. Fusion 360 offers generative design tools, to explore multiple manufacturing outcomes that meet the design specifications that the user will have defined. It will be able to propose designs to reduce weight, improve performance and consolidate parts. Furthermore, simulation tool tells if the models will survive real-life applications, and can therefore reduce the price of prototyping.

Fusion 360 uses a top-down design approach, in which the user breaks down a system to gain insight into its compositional sub-systems. In a top-down approach, the user formulates an overview of the assembly, then refines each subassembly and part in greater detail until the entire specification is reduced to base elements. In top-down assembly design, the user defines the features of a part in relation to elements within an assembly, such as a layout sketch or the geometry of another part. The design intent (sizes of features, placement of components, proximity to other parts, etc.) comes from the top (the assembly) and moves down (into the parts), hence the phrase "top-down".

Applications in Healtcare

Fusion 360 is one of the best tools to help Product Engineers, providing them with simple solutions to complex problems, including those in the healthcare field. In an effort to improve realism in clinical simulation and training, many healthcare organizations contract with outside companies to design and produce needed equipment and supplies. Having tools such as Fusion 360 has enabled users with little to no background in CAD to produce high quality, highly realistic training models for use in a simulation training environment. Implant devices such as orthopedic implants, craniofacial implants and exoskeletons are some of the cases that Fusion 360 is used in health care.

Features

- 3D design and modeling (Sketching, Direct, Surface, Parametric, Mesh, Freeform Modeling, Rending, Assemblies)
- Data Management (Cloud Storage, Team Participant)
- Additive Manufacturing (Fused Filament Fabrication, Metal Additive Manufacturing)
- Generative Design (Manufacturing Methods & Constraints, Machine learning & AI, Native, Editable Results, Cloud Solve, Costing)
- Collaboration (Global Share, Public/Private Design Sharing)
- Simulation (Cloud Simulation, Study Breadth, Simplify, Compare Results, Static Stress, Modal Frequency, Thermal & Thermal Stress, Buckling, Non-linear Stress. Event Simulation, Shape Optimization)
- Documentation (2D Manufacturing Drawings, Rendering, Animation)

For more information visit website: Fusion360

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the National Agency (NA). Neither the European Union nor the NA can be held responsible for them.

Co-funded by the European Union

Figure 4. A short description of each suggested software.

Then, NTUA send the DT to all partners for peer review by experts. The experts after the evaluation filled a questionnaire created by NTUA and NTUA collected all feedback. Finally, the DT was presented at the first transnational meeting of the project which was held on the 7th and 8th September at the Laboratory of Manufacturing Technology of the School of Mechanical Engineering – NTUA.

2 Methodology

2.1 Questionnaire

The purpose of the questionnaire is to check the functionality of DT. NTUA defined a structure for the questionnaire and suggested questions to be included in the questionnaire. The questionnaire started with some personal information about the experts: name and surname, e-mail address, country and University. The questionnaire continued with some general information about the experts: expertise sector, whether they use 3D CAD software and which one of the proposed software. Finally, the lasts questions concerned the opinion of the experts about DT: if they use the DT in their workplace, the structure of the DT, if the contents are sufficient, if they promote DT, and to suggest some improvements. Questionnaire structure is defined below:

Statement A1

Please write your e-mail address

Statement A2

Name and Surname

Statement A3

Please select your country

- ☐ Bulgaria
- ☐ Greece
- ☐ Hungary
- ☐ Italy
- ☐ Poland
- ☐ Slovakia
- ☐ Other:

Statement A4

Please add your affiliation

Statement A5

Please indicate your expertise sector

☐ Engineering

☐ Medicine

☐ Other:

Statement A6

Do you use 3D CAD software at your workplace?

☐ Yes

☐ No

Statement A7

Which of the following 3D CAD software do you use?

☐ Fusion 360

☐ SolidWorks

☐ Inventor Professional

☐ CREO

☐ MeshLab

☐ Siemens NX

☐ MeshMixer

☐ Solid Edge

☐ Maya

☐ Blender

☐ Other:

Statement A8

Would you use this toolkit in your workplace?

- ☐ Yes
- ☐ No
- ☐ Maybe

Statement A9

What is your opinion about toolkit structure?

Statement A10

Are the contents enough?

- ☐ Yes
- ☐ No
- ☐ Hard to say

Statement A11

Would you promote this toolkit?

- ☐ Yes
- ☐ No
- ☐ Maybe

Statement A12

Suggest some improvements

2.2 Questionnaire results for PR1

Initially, it is important to mention that the personal data and information collected from the experts (name and surname, university, e-mail address) was managed according to the regulations of the GDPR and the results of this study will be used for research purposes. The results of the assessment were given through the completion of a questionnaire completed by the experts.

The DT was tested by 21 experts (5 experts of each university) who were defined by the University's partners. The experts were HE Academics working in one of the project fields (Engineering, Biomedical Engineering, Medicine, Intercultural management, Innovation management, ICT, e-learning, and Information technologies) and were independent from project partners. Experts were selected based on their expertise sector with the largest percentage of respondents being engineers (Figure 5). The test of the DT is necessary to be carried out by experts from different scientific fields, such as engineers, due to their expertise in the technical work for design and production, experts from the IT sector, suitable for the control of the development of the toolkit, and also, by doctors.

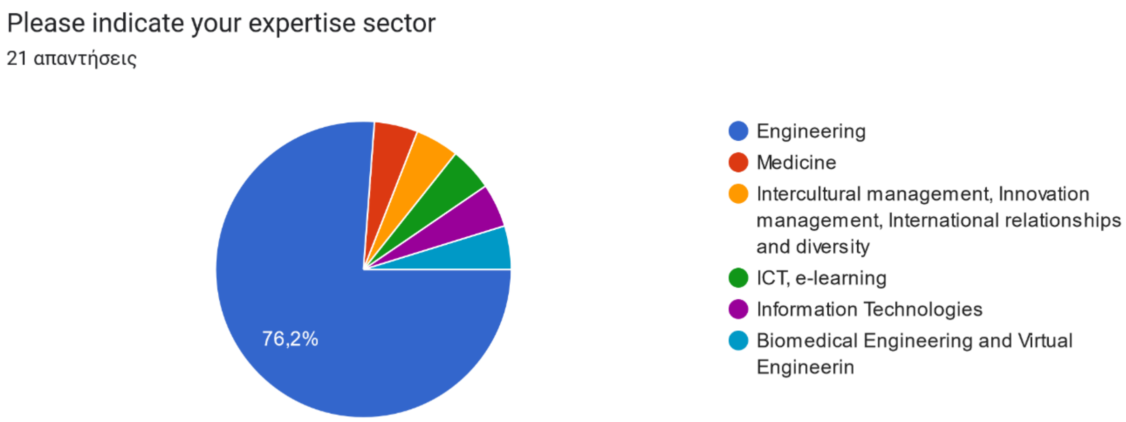


Figure 5. Expertise sector of the experts.

Based on the results, most of the experts answered that they use 3D CAD software, with 50% using SolidWorks and 16.7% using Inventor Professional, as illustrated in Figure 6 and Figure 7. According to the answers of the experts 71.4% will use the DT in their workplace and they will promote the DT, as shown in Figure 8 and Figure 9, respectively. Finally, Table 2 and Table 3 shows the opinion of the experts about the DT and their suggestions for improvements.

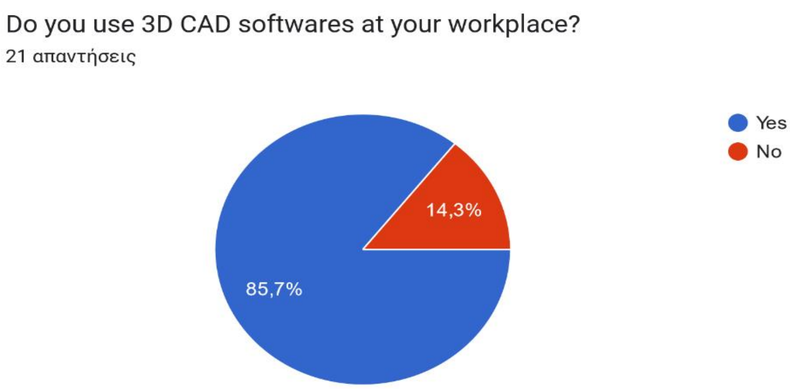


Figure 6. Percentage of experts using a 3D CAD software.

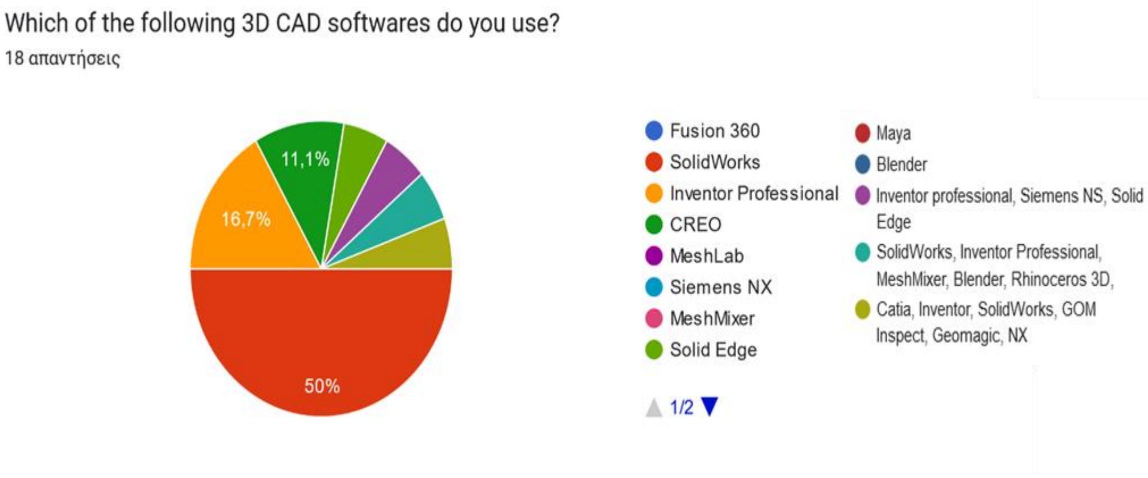


Figure 7. 50% of respondents use SolidWorks.

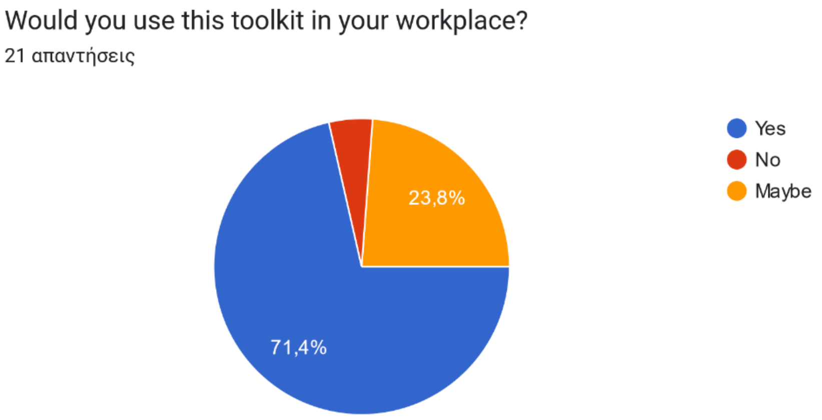


Figure 8. Percentage of use of the DT by the experts in their workplace.

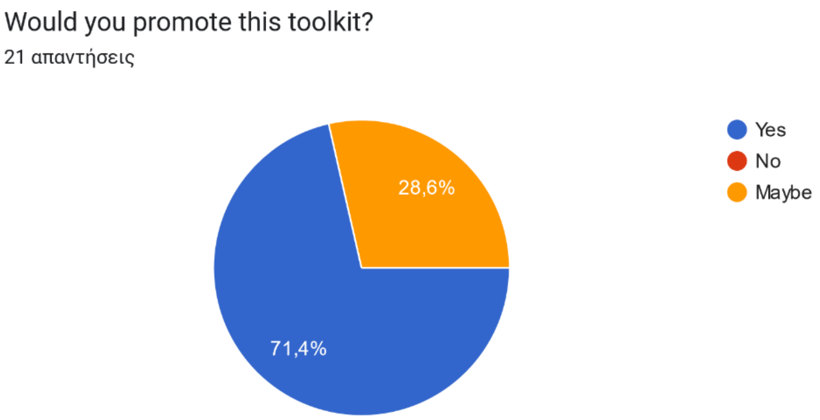


Figure 9. Percentage of promotion of the DT by the experts.

Table 2. Experts' opinion about DT structure.

Experts' opinion about DT structure
It looks like a great tool. My background and interest is the engineering simulation. In my previous workplace I simulated for a contractor some tooth (FEA), and I see some potential in the CFD side of bioengineering, so if you create some template e.g. for the nazal or the vein system or for the bone structure, it could be helpful for the simulation specialists/researchers
Great
Toolbox structure can be beneficial for designing in a CAD environment as it helps users choose the appropriate tool for a specific task
The structure seems right, but the filtering doesn't work and the overall aesthetics of the site is unsatisfactory (I am using up to date Opera browser)
User friendly
The structure is transparent and logical and includes different options for different groups of users.
User friendly structure, good overall performance
Structure looks promising
Simple to understand, but I assume it will continue to develop
It systematically filters our needs in a software or application for modelling, drawing, design etc. It is useful for beginners of 3D modelling
The structure is rather good, user friendly and easy to follow
User friendly and helpful for choosing the suitable tool
It systematically filters our needs in a software or application for modelling, drawing, design etc. It is useful for beginners of 3D modelling

Table 3. Experts' suggestions for improvements

Experts' suggestions for improvements
Program development for the future
Improvements could only be proposed after practical testing on a specific project.
Improve user friendliness, add more options
Add even more software, if they exist

I suppose this is just a platform that allows us to filter and select the software based on our needs. I think it is useful for beginners of the field. Perhaps it would be good to include even more software choices in the list. For instance, I did not see ANSYS listed. Also, I would think that a special score or index on usability or ease-of-use can be included in the filtering somehow (based on user feedback or online comments in general). People are often interested in which software or application would be the easiest to use or quickest to learn (apart from them being free of course). For instance, for non-engineering background users, it is normal for them to choose SolidWorks as the user interface is very usable, making it faster for the user to learn. But for engineering background users, many would opt for ANSYS as it renders more accurate output and clearer diagrams. Such info would only be known if we either familiar with the software, or if a few experienced people had shared this knowledge with us. If such information were to be quantified or made available in the toolkit, I'm sure it will help many users. Thank you.
1) The common format should be as simple as possible in order to facilitate non-engineers to use the toolkit without being too complicated. 2) Some predesigned components should be available.
Miss usability for visually impaired people here
Everything is ok, I don't have improvement.
Inserting videos with a similar theme, a comparison table would help the transparency of 3D software, which one is better or easier