

The 21st Century Students Project - Promoting Digital Manufacturing and Design in European Schools, towards the Fourth Industrial Revolution

The present work presents the activities which are performed in the “21st Century students” project. The main target of this project is to assist students to improve their Science, Technology, Engineering, and Mathematics (STEM) skills through digital manufacturing and design, in response to Industry 4.0. The primary target group of the project is Key Stage (KS) 3 students and their educators. The “21st Century students” project is implemented through a close collaboration of partners from various European countries, providing complementary backgrounds, aiming to:

- *Create a transnational network of 7 educators and digital manufacturing experts to promote effectively STEM learning in school's sector.*
- *Prepare students for Industry 4.0 revolution, developing a Learners Academy, that is focused on attributing to pupils expert-led learning experiences on Digital Modelling, Fabrication, and Automation.*
- *Develop an open Digital Manufacturing Learning Lab to support the effective delivery of education both within and beyond the classroom and support groups of educators to grow their skills.*
- *Strengthen the capacity of all organizations working in secondary education to provide quality STEM knowledge, thus enabling them to lead the way in Industry 4.0 education.*

Keywords: *STEM education, Industry 4.0, Digital Manufacturing, Digital Design, Digital Fabrication*

Introduction

The relatively low attractiveness of Science, Technology, Engineering, and Mathematics (STEM) studies and careers, and the demanding labor-market needs in STEM-related disciplines raise a challenge throughout Europe. The number of STEM students has been dwindling in recent years. Since 2000, the rate of European graduates in STEM disciplines has been reduced by 3%, as a result of the common perception that STEM subjects are too difficult or complex (Scientix, 2016). As we move on to the fourth industrial revolution (Industry 4.0), manufacturing companies are rapidly harnessing revolutionary digital design, fabrication, and automation technologies. Cutting-edge and new manufacturing techniques and tools are continuously introduced to industry, exerting extra pressure on educators to remain agile and industry relevant in a continuously changing environment.

This gap between education and the labor market is exacerbated by limited innovation in learning systems and inability to keep up with the pace of advances in industry. Without any action the next generation will be unprepared for the needs of the future, risking both productivity and social cohesion. According to the

World Economic Forum (World Economic Forum, 2018), there is a growing disconnect between education systems and labour markets, and many of today's children will work in new job types that do not yet exist. Subsequently, the 'Education 4.0' initiative calling was launched for all stakeholders to act in transforming the primary & secondary education system.

Thus, focus is needed on shifting the content of learning and the mechanisms through which it is delivered, to meet the needs of the future; hence, to upskill also the teachers whose adaptation will have a multiplier effect on next generation. To cope with the fast pace of technological innovation, education systems need to foster deeper and more diverse partnerships to drive curriculum and, most importantly, pedagogical innovations in favour of Science, Technology, Engineering, and Mathematics (STEM) (Scientix, 2018) and to ensure nations can supply a sufficient talent pipeline for the technologically orientated careers of the future, providing the necessary flexibility for economy in order to cope with the continuous technological advancements and challenges.

The "21st Century students" project moves towards this direction. It is grounded on the premise that students of all abilities can improve their STEM skills through digital manufacturing and design (DM&D), in response to cover the needs and challenges of Industry 4.0 (Lee et al., 2018), being prepared for a rapidly developing digital-driven world of work. The project fosters the creativity and innovation skills of pupils, mainly through hands-on and technology-based digital manufacturing tools, to drive STEM education in non-conventional ways. The project promotes teaching experiences that are aligned to the modern workplace, by the use of technologies and tools that are endemic to Industry 4.0. It will create novel teaching resources and professional development materials to support the schools sector to keep up with the pace of advances in manufacturing, facilitating the use and comprehension of digital tools. In the long term this will contribute significantly to the maintenance of the European manufacturing industry strong position globally, which currently accounts for almost 15% of the EU's GDP (Eurostat 2018).

Previous Erasmus+ KA2 projects on the theme of Digital Manufacturing & Design are largely focused on the Vocational Education and Training (VET) sector and often did not fully succeed to encourage schools to also embrace alternative models of instruction and learning in support of ascertaining 'Education 4.0'. Although there is a realization that education needs to develop students to meet the challenges and needs of today industry and society, projects did not fully succeed to recognize the value of early integration of practical and enjoyable DM&D learning experiences as a support tool to raise students' interest in STEM subjects. Previous KA2 projects such as the 'European Robotic Laboratory' (2014-1-FR01-KA201-008671) and 'ERASMUS3D+: Training material for developing 3D printers' (2015-1-DE02-KA202-002496) contain elements useful for this project through the provision of in-depth educational materials for upskilling learners in the area of Robotics and 3D printing. However, they presented an element of 'over-specialization' and could not fully provide a holistic educational package aimed at promoting a basic understanding of a variety of Digital Manufacturing technologies.

The 21st Century partnership is aligned to the opinion that school students would benefit more from a wider range of introductory resource focused on the various technologies associated with Digital Modelling, Digital Fabrication and Manufacturing Automation. 21st Century Students encapsulates and builds on previous good practice but seeks to go further through the creation of an Intellectual Output (IO) ‘Learning Academy’ (IO1) that will provide a suite of ‘taster’ teaching resources categorized across the following three thematic ‘mini toolkits’: Digital Design, Digital Fabrication and Manufacturing Automation. This will be supported by the Intellectual Output ‘Digital Manufacturing Learning Lab’ (IO2) acting as an openly accessible platform to support the effective delivery of DM&D education both within and beyond the classroom learning environment. Schools leaders will be supported in the implementation of the ‘21st Century Student’ resources, through the creation of the Intellectual Output ‘Implementation Handbook’ (IO3) and the Intellectual Output ‘Teachers 4.0 – Training Programme’ (IO4) which will provide both the pedagogical and technical skills required to use DM&D technologies as a tool to raise students’ interest in STEM subjects, and confidently endorse the concepts of “learning by doing” and “flipped classroom” approaches.

Aims and Objectives

Driven by the rapidly changing needs of employers and the demand for new skills for the fourth industrial revolution, ‘21st Century Students’ will place a premium on motivating students to become ‘creators’ and ‘innovators’ through exposure to high-tech digital manufacturing facilities and expertise. The “21st Century students” project relinquishes the classical approach that the educator is the only source of information, and the classroom is the only place where knowledge can be disseminated. It endorses a technology-based and student-centric approach that enables pupils to learn from different sources and educators than what they were traditionally exposed to. The primary target group of the project is Key Stage 3 students and their educators. The “21st Century students” project is implemented through a close collaboration of partners from various European countries, providing complementary backgrounds, aiming to:

- ✓ Create a transnational network of 7 educators and digital manufacturing experts to promote effectively STEM learning in school’s sector, working collaboratively to promote effective STEM learning in the schools sector, subsequently driving the skills and capabilities required to deal with industrial complexities..
- ✓ Prepare students for Industry 4.0 revolution, through the development of a 21st Century Students ‘Learner Academy’, focused on exposing school students to digital manufacturing environments and expert-led learning experiences on Digital Modelling, Fabrication and Automation.
- ✓ Develop an open Digital Manufacturing Learning Lab to support the effective delivery of DM&D education both within and beyond the

- 1 classroom learning environment and provide a forum for supporting
- 2 groups of educators to grow their craft in collaboration with one another.
- 3 ✓ Strengthen the capacity of all organizations working in secondary
- 4 education to provide quality STEM knowledge, thus enabling them to lead
- 5 the way in Industry 4.0 education & meet the needs of an increasingly
- 6 digital manufacturing sector.

9 Methodology/Direct project Implementation

11 The 21st Century Student project direct implementation includes four
 12 Intellectual Outputs, six multiplier events and a range of various dissemination
 13 activities. Each of the above will directly target individuals to a new understanding
 14 of different perspectives and approaches in STEM education, and on the impact of
 15 using practical Digital Manufacturing & Design technologies as a support tool to
 16 raise students' interest in STEM subjects.

17 More specifically, details for each one of the mains activities are presented
 18 below for each one of the Intellectual Outputs.

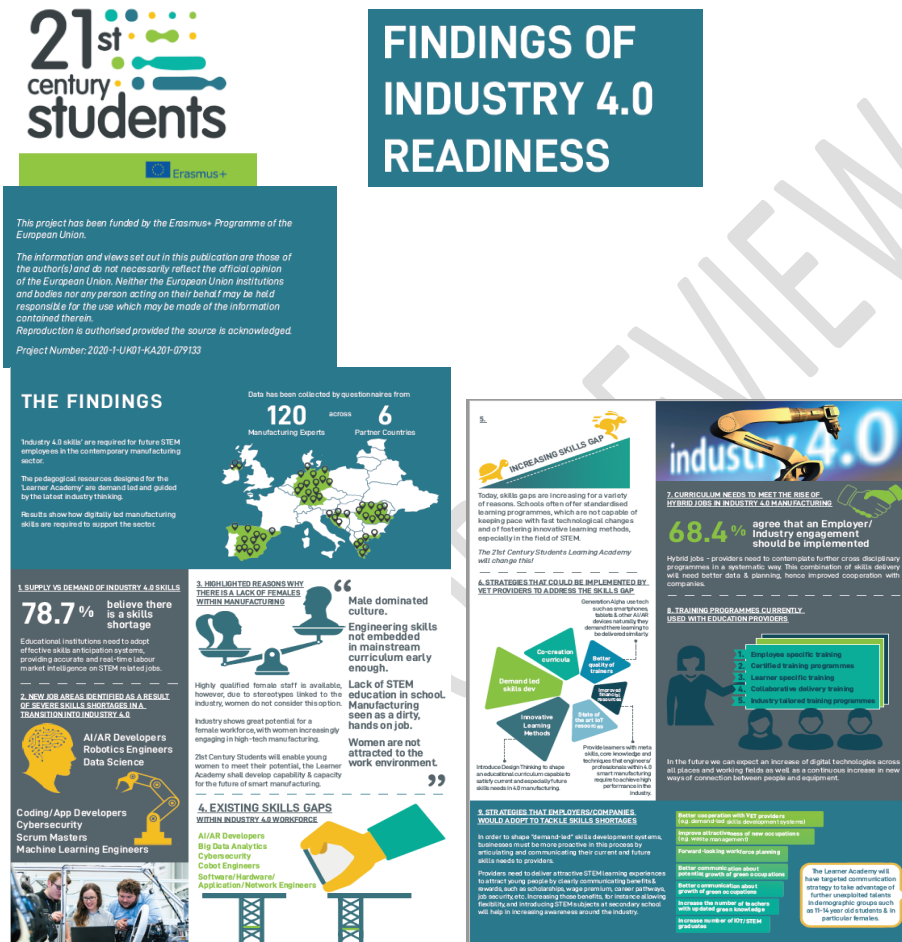
- 20 • Intellectual Output IO1: 21st Century Students: Learner Academy
 - 21 ○ IO1 will undertake data collection with 120 industry leaders across 6 EU
 - 22 countries to determine the primary Industry 4.0 skills and techniques
 - 23 required by the future talent pipeline to support the next generation of
 - 24 industrial revolution. This will ensure the pedagogical resources designed
 - 25 for the 'Learner Academy' are demand-led and guided by the latest
 - 26 industry thinking.
 - 27 ○ Infographic Report: summarizing the fundamental 'Industry 4.0 skills'
 - 28 required for future STEM employees in the contemporary manufacturing
 - 29 sector. This data will be collected through a primary research exercise with
 - 30 120 manufacturing experts from across the six partner countries.
 - 31 ○ A collection of 30 'taster teaching resources' categorized in three thematic
 - 32 'mini toolkits': Digital Design, Digital Fabrication and Manufacturing
 - 33 Automation will be created.
 - 34 ○ IO1 will pilot the 3 toolkits that constitute the Learner Academy to 150
 - 35 KS3 students (30 per DM&D facility). The project consortium partners
 - 36 will reach out to their secondary school network or relevant platforms to
 - 37 recruit 30 KS3 learners to participate in 'Experience Days' in which they
 - 38 will gain first – hand experiences with the latest DM&D equipment,
 - 39 resources, and expertise. The 150 learners will evaluate the 'Learner
 - 40 Academy' resources following the pilot to inform the continuous
 - 41 refinement & development of the resources prior to going 'live' on the
 - 42 'Digital Manufacturing Learning Lab' in Intellectual Output IO2.
- 43 • Intellectual Output IO2: Digital Manufacturing Learning Lab
 - 44 ○ In IO2 school leaders will have the opportunity to voice their ideas and
 - 45 opinions for the final design of the Digital Manufacturing Learning Lab
 - 46 through a feedback session coordinated by all partners following the initial

- 1 conceptual design of the online platform. This will be completed prior to
- 2 the technical development.
- 3 ○ An openly accessible platform will support the effective delivery of
- 4 DM&D education both within and beyond the classroom learning
- 5 environment and provide a forum for supporting groups of educators to
- 6 grow their craft for STEM education in collaboration with one another.
- 7 ○ In IO2 120 school educators across 6 EU countries will be involved in the
- 8 Learning Lab pilot through live demonstration sessions to gauge feedback
- 9 on usability from an educators perspective.
- 10 ○ The learning lab will be disseminated to 350 school educators (50 per
- 11 partner).
- 12 • Intellectual Output IO3: 21st Century Students: Implementation Handbook
- 13 ○ In IO3 a ‘how-to’ manual providing the nuts and bolts for implementing
- 14 the 21st Century pedagogical resources and online tools will be created
- 15 and piloted to 120 school educators. A group of 20 educators in each of the
- 16 6 partner countries will be conducted to assess the guidance on materials,
- 17 planning & delivery both within and outside the classroom. The
- 18 Implementation Handbook will also provide the technical guidelines for
- 19 using the ‘Digital Manufacturing Learning Lab’. The intended audience
- 20 includes program leaders, teachers, and instructional staff working to adapt
- 21 and implement the 21st Century Student resources, and wider STEM
- 22 initiatives.
- 23 • Intellectual Output IO4: Teacher 4.0 Training Programme
- 24 ○ In IO4 60 school educators will participate in the pilot of the ‘Teacher 4.0’
- 25 teacher training programme which will consist of both technical and
- 26 pedagogical CPD to ensure teachers have the correct theoretical and
- 27 practical skills to deliver effective DM&D education. This will focus on
- 28 the use DM&D technologies as a tool to raise students’ interest in STEM
- 29 subjects, and confidently endorse the concepts of “learning by doing” and
- 30 “flipped classroom” approaches.
- 31
- 32 It worths to be mentioned that in order to efficiently cover the requirements
- 33 and needs for the preparation of the above-mentioned Intellectual Outputs, the
- 34 ‘21st Century Students’ consortium combines partners of different, yet
- 35 complementary backgrounds, that bring in the project the following advantages:
- 36
- 37 ○ Latest expertise and facilities in digital design & manufacturing
- 38 ○ Schools educators with access to digital fabrication laboratories
- 39 ○ Close links to school networks
- 40 ○ Experience working with industry stakeholders to identify future skills
- 41 requirements in the Manufacturing Sector
- 42 ○ Excellence in the design and delivery of professional development
- 43 programs of STEM education
- 44 ○ Geographical coverage to ensure a transnational approach.
- 45 ○ Designing digitally based pedagogical resource development and
- 46 deployment.

Methodology/Examples of the created Educational Resources

In the following figures, an indicative presentation of typical examples of the Intellectual Outputs resources (in the form of PowerPoint detailed presentations) are presented below is shown.

Figure 1. Infographic Report summarizing the fundamental Industry 4.0 STEM required skills (IO1)



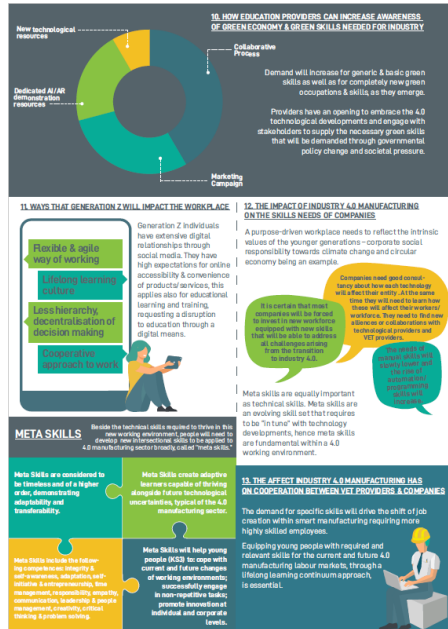
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Figure 2. Indicative screenshots of the 3D Printing in Manufacturing resource (IOI)

Definitions






3D printing (3DP)
Technologies that can create physical objects from digital files by adding material layer after layer

3D printer
Equipment used for 3D printing

Slicer
Software that generates the instructions needed by the 3D printer to make an object

Benefits of 3D printing

- Unique creative freedom.
- It produces less waste than other technologies.
- Reduces the time, effort and costs required to create new products.
- Reduces the risk of launching new products.
- Customizing objects can be made much easier and cheaper than with other methods.



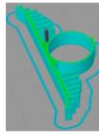


3D PRINTING IN MANUFACTURING

3D printing in manufacturing - typical workflow

1. Part design using CAD (Computer-aided Design) software
2. Conversion of the 3D model in a 3D printing file (such as STL)
3. 3D printing file preparation using a slicer software
4. 3D printing – the operator loads the file and the raw material, and launch the printing






3D model
CAD Software
CAD designer

3D model conversion
CAD Software
CAD designer



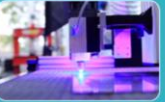
3D printing file
Slicer
3D printer operator

3D printing
3D printer
3D printer operator

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1 **Figure 3. Indicative screenshots of the Laser cutting resource (IO1)**

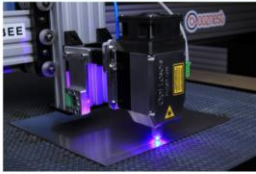
Definitions

		
Laser an instrument that can produce a powerful beam of light	Laser cutter a CNC machine that uses laser technology to cut materials	Laser cutting a digital manufacturing technology that transforms a 2D file into a physical object, using a laser cutter

2

Benefits of laser cutting

- Extreme precision
- Very complex shapes can be cut
- Contactless cutting
- Holding the piece is easy
- Repeatability
- High production speed
- Smooth edges
- Versatility - suitable for a lot of different materials and profiles.
- Does not require exchange of tools.
- Can be automated
- Wide range of supported materials
- Requires less energy for cutting metals than other traditional methods



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Laser cutting

Laser cutting applications in manufacturing

Laser cutting is used to cut or engrave a wide of range of materials: plastics, metals, wood, leather, textiles, paper, foam, etc. Consequently, it is used in a large variety of applications in manufacturing.

Manufacturing possibilities of laser cutting:

- Cut many types of materials into various shapes and sizes
- Production of various parts
- Prototyping
- Surface Texturing
- Engraving/marketing
- Cutting patterns for clothing, leather and footwear industry
- Fashion Design
- Jewelry



Picture courtesy of www.retail-works.co

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1 **Figure 4. Indicative screenshots of the CNC machining resource (IO1)**


Definitions



Computer Numerical Control (CNC)
the automated control of machine tools through the use of a computer.







CNC machine
a computer-controlled machine tool



CNC machining
a manufacturing process using a CNC machine to produce a part out of plastics, metals, wood and many other solid materials

The CNC machining workflow

- Part design in CAD software
- Converting the CAD file to CNC code, using CAM (computer-aided manufacturing) software.
- CNC machine preparation - the operator load the CNC code and attaches the appropriate workpieces and tooling
- Process execution







CAD file
CAD software

CNC program
CAM software

Machine preparation
CNC Machine


Process execution
CNC Machine



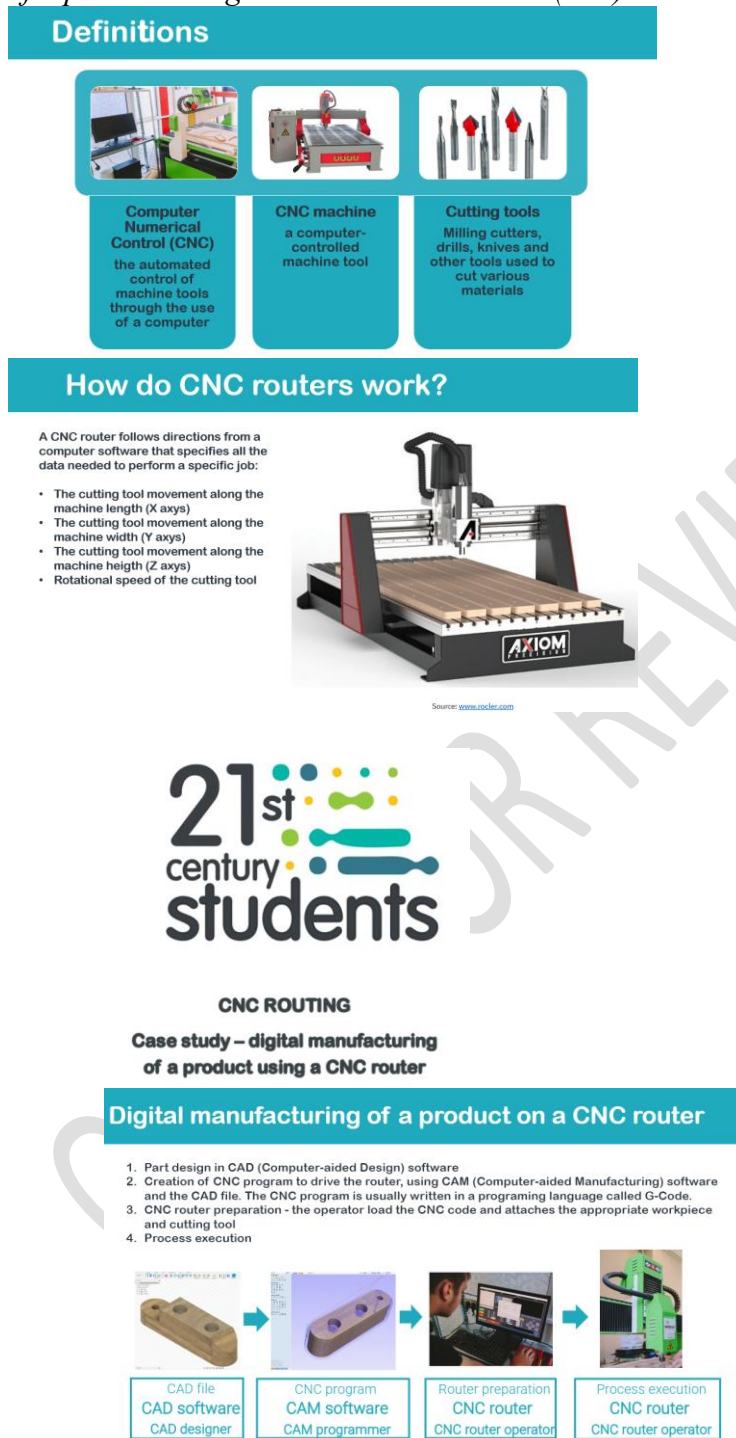
CNC MACHINING

Benefits of CNC Machining

- Improved accuracy of the machining process, thus ensuring consistent product quality
- High production speed
- Efficiency
- Increased safety during machining
- Cost effectiveness
- Reduced changeover time
- High production volume
- Enables flexibility in manufacturing

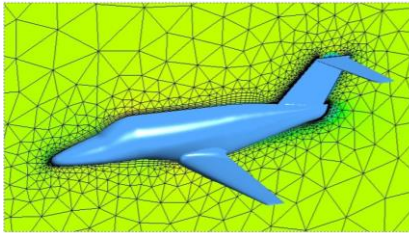


1 **Figure 5. Indicative screenshots of the CNC routing – Digital manufacturing**
 2 **of a product using a CNC router resource (IO1)**



- 1 **Figure 6. Indicative screenshots of the Digital Fabrication-Digital evaluation**
 2 **of an aircraft design resource (IO1)**

Case study – Digital evaluation of an aircraft design



Scope:

- To present the evaluation of an aircraft design, using the Digital - Computational approach!...

- 3 **How do the Engineers test and improve their designs?**

There are two paths an Engineer can follow, to improve his/her designs:

➤ The Experimental approach:

- The Engineers create real models of their design ideas.
- The real models are tested in laboratory conditions as close as possible to reality.
- The test results are further analysed, and conclusions are extracted.

➤ The Digital – Computational approach:

- Engineers create CAD and Digital models of their ideas using Computers.
- The Digital models are imported in special Computer Programs, called Numerical Solvers, that simulate Physics and reproduce real conditions.
- The results of the Numerical Solvers are analysed, and conclusions are extracted.

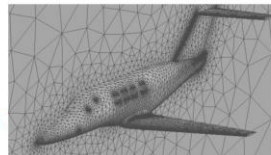
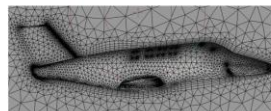
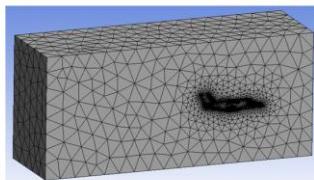
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- 6 **DIGITAL FABRICATION**

The Digital – Computational approach – 3

- The aircraft geometry and the space around it are divided into many smaller blocks-parts. These parts are connected to each other, to build the Digital model.




- The Digital model is now ready!
- The Digital model is a twin of reality!

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1 **Figure 7.** Indicative screenshots of the Digital Fabrication-Wind turbine digital
 2 fabrication resource (IOI)

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Case study – Wind turbine digital fabrication



Real Wind Turbine (40m diameter)

3D design of a real scale Wind Turbine (40m diameter)

Real 3D-printed My-Own Wind Turbine (0.25m diameter)

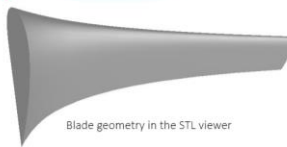
Royalty free pictures in slide: <https://pixabay.com/>

Hands-on – 1: My-Own Small-Scale Wind Turbine

- The blades can be easily designed using specific software (i.e., the Q-blade free software)
- The geometry can be further optimized (by using CFD software; thus, becoming a young Engineer)
- The resulting geometry can be evolved (in any CAD software) and constructed (in a 3D printer)

The outcome of such an analysis is now ready-to-be-used by students, to build My-Own small-scale wind turbine (Part 1: Blade)

- The blade geometry is downscaled to a length of 10cm = 100mm
- The final (optimal) blade geometry is used for My-Own small-scale wind turbine assembly (IGES file is included) (STL file is also included)



Blade geometry in the STL viewer

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21st century students

DIGITAL FABRICATION


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Hands-on – 3: My-Own Small-Scale Wind Turbine

- The resulting geometry (STL files or STEP files) can be 3D printed (in any commercial 3D printer)
- The blade geometry (Part 1) and the rotor geometry (Part 2) can be printed on a 3D printer. We need 3 blades and 1 rotor for My-Own small-scale wind turbine. (Please be cautious and print the 3D parts under the supervision of an adult: i.e., teacher or parent)
- The material and the printing conditions regarding various types of materials are user-defined!...

Suggested printing conditions (for the supervisor):

Material: PLA
 Fill density: ~20%
 Hot-end temperature: 200-210°C
 Bed temperature: 60-70°C
 Layer height: 0.1-0.2mm



Rotor and 3 blades on the 3D printer

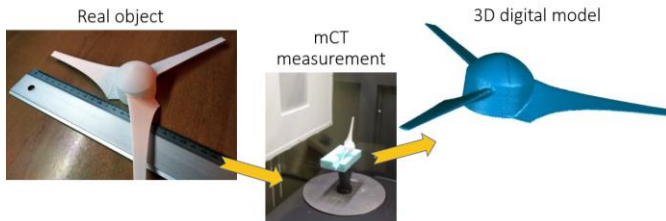
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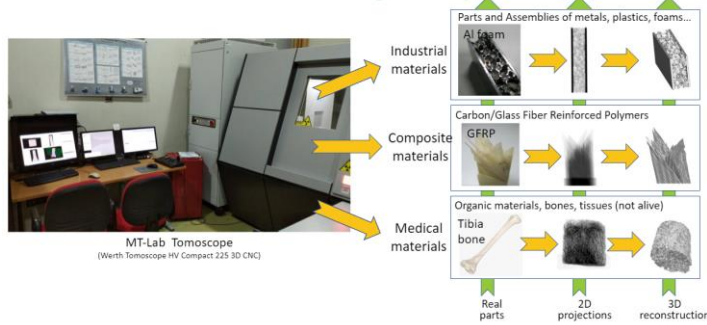
1 **Figure 8. Indicative screenshots of the Digital Fabrication-micro-Computed**
 2 **Tomography resource (IOI)**
micro-Computed Tomography (mCT)

- Can we create a digital model of a real object with just a single measurement?
- Yes, mCT can do it!...
- Is the result a detailed 3D digital model?
- Yes! Involving both the external and the internal geometry of the object!... Let's find out more...



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mCT measuring examples



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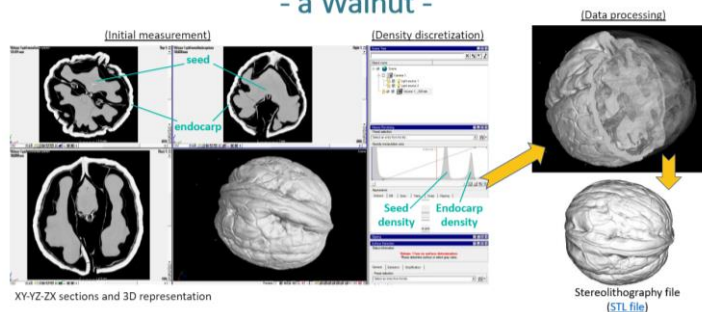
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DIGITAL FABRICATION

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mCT measuring example – 1
- a Walnut -



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- 1 **Figure 9.** Indicative screenshots of the Digital Fabrication-Digital Design of a
 2 Wind Turbine resource (IO1)

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Case Study – Digital Design of a Wind Turbine

SCOPE:

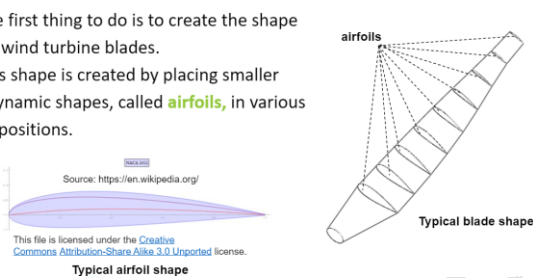
- A wind turbine blade model ready for fabrication, that could be designed in a simple and concise manner, by the students!...



4

How Wind Turbine Blades Are Designed – 1?

- The first thing to do is to create the shape of the wind turbine blades.
- This shape is created by placing smaller aerodynamic shapes, called **airfoils**, in various radial positions.



Source: <https://en.wikipedia.org/>
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Typical airfoil shape

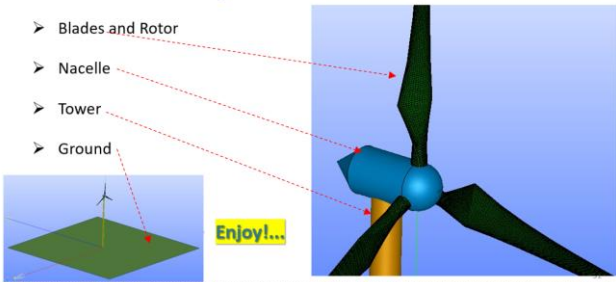
Typical blade shape

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DIGITAL FABRICATION

Hands-on: Wind Turbine Design (a Case Study)

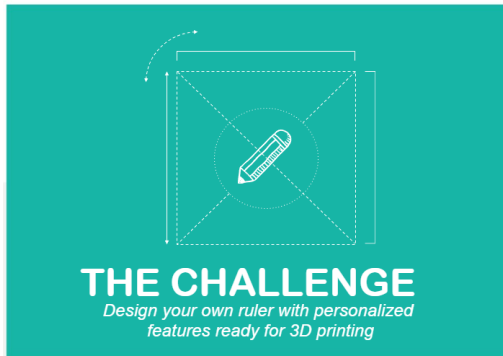
- The user can rotate and enlarge the associated CAD model, which includes:
 - Blades and Rotor
 - Nacelle
 - Tower
 - Ground



Enjoy!...

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1 **Figure 10.** *Indicative screenshots of the Digital Design-CAD Practical resource*
2 *(IOI)*



3 3D Printing – What is an STL File?

- An STL file is a special type of file used in 3D printing
- STL stands for 'stereolithography,' which is a type of 3D printing technology
- An STL file contains a 3D model of an object that is ready to be printed
- The 3D model is made up of many small triangles that form a mesh
- The STL file tells the 3D printer how to print the object by instructing it to lay down layers of material, such as plastic or metal, in a specific pattern
- The STL file is important because it ensures that the 3D printer creates an exact replica of the 3D model, down to the smallest detail



6 CAD PRACTICAL

Exporting STL Files

- To export an STL file for 3D printing, you need a 3D modeling software program
- Once you have created a 3D model in the software program, you can export it as an STL file
- To export the file, you typically go to the 'File' menu in the software program, choose 'Export,' and then select 'STL' as the file type
- You may also need to adjust some settings, such as the size and scale of the model, before exporting the file
- Once the STL file is exported, you can load it onto a 3D printer and start the printing process

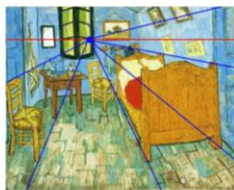
1 **Figure 11.** *Indicative screenshots of the Digital Design-CAD intro resource (IO1)*



1 **Figure 12.** *Indicative screenshots of the Digital Design-Drawing Practical*
 2 *resource (IO1)*



3 **Understanding Perspective**



For years artists have used perspective in their drawings to create depth and space within their art. Vincent Van Gogh famously used single point perspective to create his piece, 'The Bedroom', 1888.

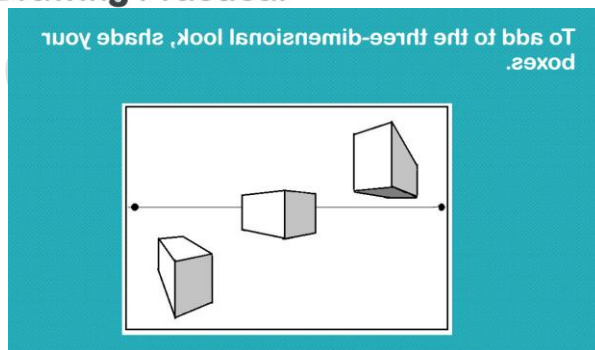
Examples of this style of art go back to the 13th Century and was discovered by a man named Filippo Brunelleschi. Shown here is a renaissance painting by Raphael named 'School of Athens', 1509



Both examples shown here are commonly known as 'Single Point Perspective'.




6 **Drawing Practical**



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- 1 **Figure 13.** *Indicative screenshots of the Manufacturing automation-Intro to*
2 *Manufacturing automation resource (IOI)*

Definitions




Automation
the use of automatic equipment in a process or facility to reduce human intervention and improve the process

Manufacturing automation
the implementation of automation to manufacturing processes and machineries

Manufacturing automation applications

- Automated production lines
- Numerical control of machines
- Automated assembly
- Robots in manufacturing
- Flexible manufacturing systems
- Computer process control



21st century students

Manufacturing automation

Skills needed in manufacturing automation

- Technological skills in different fields (mechanics, electronics, hydraulics, pneumatics, robotics, etc.)
- Troubleshooting abilities
- Digital skills
- Creative thinking and problem-solving skills
- Teamworking
- Attention to detail




Figure 14. Indicative screenshots of the Manufacturing automation-Robotics arms in manufacturing resource (IO1)



Dissemination Activities

The partnership delivers tools and materials for the dissemination of project activities and outcomes in order to achieve the following:

- inform, promote, and build a solid case for the uptake of outputs by sectoral stakeholders.

- stimulate the cross-sectoral adaptation of outputs and/or the development of corresponding materials in the field of training and education.

The “21st Century students” project includes the following dissemination and project visibility activities:

- 6 Multiplier Events attended by a minimum of 160 target group representatives attending Events.
- 3 email campaigns with 500 recipients addressed to target groups and stakeholders all across Europe, aiming to inform, motivate, and promote involvement in project activities.
- 6 press releases
- 3 Erasmus+ Guest Blogs/Case Study
- 21st Century Students Twitter Page
- 100 Partner website/social media update
- Attendance at 80 3rd partner events
- Project website to extend the reach of dissemination efforts by exploiting the appeal of new media, especially to younger individuals and those not reached by other project dissemination activities.

Innovation of the project

The partnership will develop a novel 21st Century Student ‘Learner Academy’ consisting of a suite of 30 bespoke ‘taster’ learning resources developed by digital manufacturing experts from industry and academia.

The non-formal learning resources are innovative in nature and include virtual demonstrations of DM&D technologies & equipment, industry case-studies/podcasts, project-based learning exercises, bite sized eLearning videos, interactive games. These resources will assist learners to understand the fundamental principles of Industry 4.0 through an ‘experimental learning’ rather than traditional “chalk-and-talk” approach. Significantly, it will bring the world of Industry 4.0 to schools with no digital manufacturing equipment or facilities.

The ‘21st Century Students’ project is driven by non-formal learning approaches and exposing both school students and their educators to non-traditional forms of learning and learning environments. The project will place a premium on motivating students to become ‘creators’ and ‘innovators’ through exposure to state-of-the-art digital manufacturing facilities and expertise available across the partnership. The project relinquishes the classical approach that considers the educator as the only source of information and the classroom as the only place where knowledge can be disseminated. The ‘21st Century Students’ project will design expert led pedagogical materials created by leading industry experts and academics in the Digital Manufacturing for the benefit of the school’s sector. Traditionally, schools have minimal engagement with Industry and this project will open up that opportunity for the benefit of

driving curriculum and pedagogical innovations in favour of STEM. School educators and learners from across 6 EU Countries will have the opportunity to collaborate with Industry 4.0 experts and visit digital fabrication laboratories and innovation centers that they would not traditionally be exposed to. Furthermore, the partnership in itself is an innovative feature of this application as it forms an entirely new cross-sectoral relationship, bringing both experienced and non-experienced Erasmus+ partners together.

Conclusions/Impact on Education and Society

The ‘21st Century project’ partners will focus on including students & educators with fewer opportunities during the pilot activities and through the multiplier events. It is anticipated that students and educators with cultural differences, economic, geographical obstacles and educational difficulties will be involved in the project's pilots and events.

Participants within the partners regions are facing the following situations:

- Cultural Differences: immigrants or refugees, people belonging to a national or ethnic minority, people with linguistic adaptation and cultural inclusion problems.
- Geographical Challenges: people from remote or rural areas, people from less serviced areas (limited public transport, poor facilities, villages with poor IT infrastructure/broadband)
- Educational Difficulties: people with learning difficulties/or disability, people with poor school performance
- Economic Challenges: People from economically deprived communities/families

The partners will take appropriate measures to avoid exclusion of specific target groups and to promote access to formal and non-formal education, active citizenship, empowerment, and inclusion in society. The ‘21st Century project’ project aims to empower and involving directly marginalized learners in its delivery while at the same time increasing the capacity of the partners to engage with the marginalized population.

Support activities will include the following supplementary activities:

- Virtual Connectivity: The ‘Learning Lab’ will include remote features to virtually connect schools with the project consortium expert, This will ensure schools with a lack of resources, limited or no access to facilities or face geographical barriers still can foster deeper and more diverse partnerships to drive curriculum and pedagogical innovations in favour of STEM.
- Resource Variation: The pedagogical resources within the ‘Learning Academy’ will be suitably designed for schools who have limited or no access to digital manufacturing facilities through the inclusion of

several ‘low-resource high impact’ resources (e.g., virtual equipment demonstrations, industry case studies / podcasts).

- Linguistic Support: Prior to the delivery of the ‘experience days’, the partners will engage with teachers/trainers to assess if a student who is participating in the pilot may have difficulty understanding the language of delivery. If required a translator or additional support staff will be used to ensure that the learner can fully participate in the pilot. Further, the translation of intellectual outputs will ensure that teachers / students face no linguistic barriers when implementing the resources.
- Accessibility: A number of pilot and dissemination events will be held throughout the project across the partners digital manufacturing labs & innovation centers. Partners will undertake prior risk assessments to ensure those with a disability or other health conditions can fully participate in the planned activities. Reasonable adjustments to these environments will be made if necessary such as adapting the layout of the room or equipment.

Through the creation and exploitation of our expert-led pedagogical resources, thousands of learners across Europe will be exposed to the latest Digital Manufacturing technologies, processes and learning resources to ensure they are ‘skilling today for tomorrow’. In the longer term this is expected to have a positive impact on addressing embedded STEM challenges & enhancing the competitiveness of the manufacturing sector to cope with future industrial revolutions. Teachers will recognize the value of deeper and more diverse partnerships across education & industry to drive industry relevant learning experiences that create tomorrow’s future-ready workforce. For all organizations working in the schools education field, there will be greater availability of innovative pedagogical materials and resources for educators to successfully instill quality DM&D education through virtual means, particularly those with a lack of resources or no access to facilities.

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