IO4 – Report and tools for immersion of 3D printing in European education and training

O4A4 - Evaluation of the pilot report.

E3D+VET

ERASMUS+
3D PRINTING
VET CENTRES

ERASMUS3D+

For the immersion in 3D printing of VET centres.

Project Agreement Number

2017-1-DE02-KA202-004159

PARTICIPANT ORGANIZATIONS:

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- O4A4 -

Evaluation of the pilot report

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Introduction

The purpose of this report is to give a complete overview of the pilot test of the E3D+VET project, conducted in the two countries involved: Italy and Germany.

The document shows the results of the pilot and its impact on teachers, students and VET centres. It gives, also some feedback on the previous products (IOs) and it allows the consortium partner to fix possible problems on the tools developed and if necessary, it allows to apply mitigation actions.

In particular, this document contains quantitative and qualitative data, a clear description on how the test has been organized and conducted and a description of the tools created, used and tested during this test phase.

Thanks to the pilot it was possible to understand if the project was functional in all its aspects, in which way the 3D printing technology can be implemented in the European VET institutes, what is the current scenario on the use of 3D printing and what could be the future developments in the teaching process according the use of the new technologies.

The pilot phase was also possible thanks to the collaboration of several European schools and associations that had voluntarily decided to test, for the first time, the new methodology and tools developed by the consortium partners.

1. General Information about the pilot phase

Schools involved in the pilot

During the pilot phase of the E3D+VET project, 3 schools and 1 psychoeducational association that works with disabled students and people with SpLD, were involved.

The choice of schools has been linked both to the nature of the project and partners of the consortium but also to those associated partners who gave the full availability in testing the tools made.

In particular the schools and the association involved are the following:

- **Ludwig-Erhard-Schule Karlsruhe**

Address: Englerstraße 12 - 76131 Karlsruhe

Web site: http://www.les-ka.de

Country: Germany

- **Carl-Hofer-Schule Karlsruhe**

Address: Adlerstr. 29 - 76133 Karlsruhe

Web site: https://www.carl-hofer-schule.de

Country: Germany

- **Istituto Tecnico ed Economico per il Turismo Pio La Torre**

Address: Via Nina Siciliana, 22, 90135 Palermo PA

Web site: https://www.iisspiolatorre.edu.it/

Country: Italy

- **Si.da Associazione psicoeducativa di Daniela Leto e Simona Valenti**

Address: Piazza stazione San Lorenzo 16 a Palermo

Web site: https://www.facebook.com/www.danielaleto.it/

Country: Italy

Classes involved in the pilot

In general, the target audience of the E3D+VET project is composed of VET school, students, teachers, educators, and so on...

In Italy, in a first phase of the pilot, the test has been carried out in the upper secondary school classes, with students aged 13-15 years old that they are attending the professional institute of arts and teachers of VET institute.

In a second moment the test phase has been conducted with students aged 12-16 years old with SpLD disorders who are attending the psychoeducational association to improve their skills and some educators of this association. This phase gave the opportunity to experiment and test the tools with students with SpLD.

In the German VET schools, the pilot phase has been carried out with students aged 15-20 years old and VET teachers. In particular with two classes of medical assistants. The students are in training for about a year. They are two days a week in school, three days a week in a doctor's surgery. And two classes of media designers. The students are in training for about a year. They are two days a week in school, three days a week in a company.

These classes were specifically chosen because 3D models and exercises studied and designed were included in the plan of the didactical training offer of the European schools involved.

Teachers and students involved in the pilot

During the pilot, 17 members of the training staff were involved and specifically teachers and educators. In particular, were involved 6 German teachers (3 from each school) 8 Italian teachers, that teach: computer, technology, chemistry, geometry, science, marketing, graphic and professional techniques of public administrative services, and 3 educators from Si.da association.

It was important to have such a wide variety of teachers in order to have different results on several fronts. For example, it was possible to evaluate the exercises performed from the interdisciplinarity of the subject, technical and non-technical point of view.

On the other hand, a total of 111 students of VET institution were involved.

- 81 students from German schools:

    1. D2MT1 (Carl-Hofer-Schule): 18 students
    2. D2MT2 (Carl-Hofer-Schule): 18 students
    3. 1MF3 (Ludwig-Erhard-Schule): 20 students
    4. 2MF5 (Ludwig-Erhard-Schule): 25 students

- 20 students from Istituto Tecnico ed Economico per il Turismo Pio La Torre (Italy).
- 10 Students from Si.da association (Italy).

Period when the pilot test has been performed

The period in which the pilot phase of the E3D+VET project has been conducted was included in the academic year of each school participating in the project.

For the Italian VET school "Istituto Tecnico ed Economico per il Turismo Pio La Torre" according to the suggestions of the teachers involved in the pilot, the test started during the school year "2019-2020", in the beginning of November 2019 till the end of the same month, so as to integrate this activity in the annual didactics plan.

For the VET German schools the pilot test, for the same reason of the Italian one, started in November 28th till December 11th, 2019.

2. Organisation of the pilot

The pilot was organized by following a common methodology in all the schools and associations that took part in the test. This methodology is titled "Define methodology for pilots" and it has been given to teachers and educators at the beginning of the pilot phase so they could learn some formal and non-formal techniques in order to conduct, in a best way, the lesson with the new tools.

During the pilot, teachers and students experimented a lot of different tools. These tools and methods increased the student's skills and knowledge and at the same time kept the student's attention high.

In addition to the traditional techniques, teachers had to interact with digital tools in order to carry out the exercise and complete the pilot phase.

The guide, "O1 – A1. Transfer of knowledge about basic of 3D printing concepts to the VET teachers", took an important role in this phase, because it allowed the transfer of technical knowledge to teachers or staff involved in the test phase.

Another important tool considered in the test phase, a digital one, was the networking community platform. The aim of this platform is to develop a web community for 3D printing professionals and people form the educational fields. The platform is an open source tools, the user can download some exercises and contribute with other ones to update and enrich the web Library. The exercises are divided in different categories such as: subject, difficulty of printing, materials, etc.

The platform can be reached through the following link:
https://app.e3dplusvet.eu/it/exercises/

PILOT IN GERMANY

The pilot, in German schools was carried out in 5 different steps:

Step 1 (2 to 3 hours of 45 minutes):

In a first moment, both students and teachers filled in the self-evaluation questionnaire before the pilot test to understand the pre-existing knowledge of the target group involved. In a second moment teachers took some exercises developed in IO1 of the E3D+VET project and they introduced them in their daily school lessons.

All the models tested were printed in advance by CETEM and SEMKA, partners involved in the project.

The exercises tested were:

- Head lice - https://app.e3dplusvet.eu/exercises/head- lice-2 /
- Fertilization of the ovum and maturation - https://app.e3dplusvet.eu/exercises/fertilization -of-the-ovum-and- maturation-2 /
- Neolithic goseck circle and nebra sky disk - https://app.e3dplusvet.eu/exercises/time- neolithic-goseck-circle-and-nebra- sky-disk /

Step 2 (2 to 3 hours of 45 minutes):

In the second step, there was the training of teachers who took part in the test phase, on the use of 3D printing. This training was supported by the materials developed in both IO1 and IO4. In particular, teachers have been provided with a guide to be able to print in 3D and some digital media such as videos and power points to better understand the topic at technical level.

Step 3 (4 hours of 45 minutes):

During this stage he student' training at SEMKA took place in Carl-Hofer-Schule facilities.

An introduction to 3D printing for the four school classes was done. They learned how 3D printing works and which steps are necessary to perform from an idea to a printed object.

By using different 3D-models from several companies, the students obtained an idea about how important the new technology is for their future jobs.

After the trainings, the students completed the survey "Student self-evaluation after the pilots".

Step 4 (2 to 4 hours of 45 minutes, homework):

In order to validate and understand if the methodology and tools developed have been useful, SEMKA's staff asked to the teachers for creating new ideas (exercises) to be printed with 3D technology and to be included in their schools' curricula.

In total, German teachers developed 3 new exercises:

- Animal Cell (Biology) - https://app.e3dplusvet.eu/exercises/variability-of-cell-structure-using-the-example-of-an-animal-cell-1/

- Compound bodies in the "Architects Office Geometry (math) - https://app.e3dplusvet.eu/exercises/compound-bodies-in-the-architects-office/

- Presentation of the principal sin "pride, vanity, pride" (Superbia) as part of the seven main sins (Religion) - https://app.e3dplusvet.eu/exercises/presentation-of-the-principal-sin-pride-vanity-pride-superbia-as-part-of-the-seven-main-sins/

Step 5 (30 minutes):

The last step of the pilot concerned about the compilation of the final self-evaluation questionnaire by the teachers, to understand if the test phase and the results were satisfactory or if they required improvements and also if the knowledge transmitted was perceived and acquired.

PICTURES OF THE PILOT IN GERMANY

Fig. 1 - Teacher is explaining technical information about how to print in 3D.

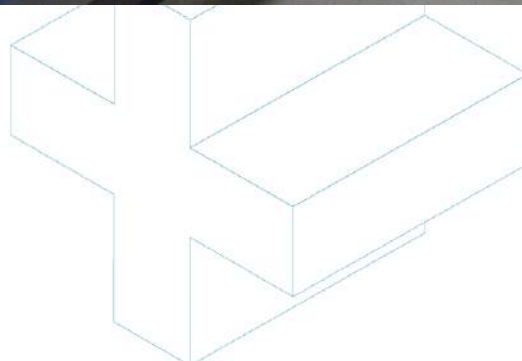Fig. 2 - Models printed in 3D.

Fig. 3 – Students that are testing the exercises.

Fig. 4 – Students that are experimenting the 3D model software.

Fig. 5 – Students that are testing the exercises.

Fig. 6 – Students that are experimenting with the 3D model software.

Fig. 7 - Teacher that explaining technical information on how to print in 3D.

Fig. 8 – Students that are experimenting with the E3D+VET platform.

Fig. 9 – Students that are experimenting with the E3D+VET exercises.

PILOT IN ITALY

The pilot in Italy has been carried out in 4 different sessions in the school involved IISS Pio La Torre and in two sessions in Si.da association.

- **Pilot in IISS Pio La Torre school.**

The pilot has been organized in 4 different afternoons at IISS Pio La Torre school.

The sessions have been planned in the following way:

1st Session (4 hours) – At the beginning, CEIPES' project managers involved only teachers. They explained to them the main aims of E3D+VET project and some basic contents on how to print in 3D. This was possible thanks to videos and slides presentations that the consortium partner developed during the implementation of the project and thanks to this little preview session it was possible to clarify all doubts that they had.

It is important to underline that the teachers involved in the test phase, already had some 3D printing skills, because the consortium partners transferred some notions on how to print in 3D thanks to the technical guide developed in the IO1 of the project.

In addition, during this first phase the CEIPES's distributed the self-evaluation questionnaires before the pilot start. These tools were important to have the sum of both the expected and obtained results during the whole test phase.

2st Session (4 hours) – During this day, in addition to VET teachers, CEIPES' staff involved also VET students. Numerous non-formal education activities have been implemented during this session. Students, together with teachers, were divided into groups and through some brainstorming and mental map activities, CEIPES' staff asked to them to summarise the creation and the productive process of a 3D printed model.
These kinds of activities were very important, both to create a solid team building during the pilot sessions among students and teachers, to transfer 3D printing knowledge to students and also to identify pre-existing knowledge in them.

In this session the CEIPES' project managers also distributed among the students initial self-evaluation questionnaires.

3rd Session (4 hours) - In the third part of the pilot, students and teachers tested the exercises given to them by the consortium partner. The teachers performed some lessons by interacting with the models and experimenting with multisensory techniques.

In particular the Italian school tested the following exercises:

- Assembled Pieces - https://app.e3dplusvet.eu/exercises/assembled-pieces-3/
- Pyramids - https://app.e3dplusvet.eu/exercises/pyramids-2/
- EU borders - https://app.e3dplusvet.eu/it/exercises/eu-borders/
- Fibonacci's spiral -https://app.e3dplusvet.eu/exercises/fibonaccis-spiral/
- Car_4_Mobile - https://app.e3dplusvet.eu/exercises/car_4_mobile/
- Balance System - https://app.e3dplusvet.eu/exercises/balance-system/
- Wind turbine - https://app.e3dplusvet.eu/exercises/wind-turbine/
- Coordinates Verification - https://app.e3dplusvet.eu/exercises/coordinates-verification/
- Archimedes' Principle - https://app.e3dplusvet.eu/exercises/archimedes-principle/
- 2D Chemical Formulation - https://app.e3dplusvet.eu/exercises/2d-chemical-formulation/
- 3D Chemical Formulation - https://app.e3dplusvet.eu/exercises/3d-chemical-formulation/
- Simple Structures Connections - https://app.e3dplusvet.eu/exercises/simple-structures-connections/

Not only considerable feedback was been given by the students but also by the teachers who saw in a practical way the possible advantages that the experimentation with these tools have.

Furthermore, in a second phase, CEIPES' project managers showed which are the most important steps to print in 3D, (1-the creation of the 3D model, 2 - the exportation in STL format, 3 - the generation of the G-code, 4 - the creation of the 3D printing object.

After the self-evaluation questionnaire after the pilot phase was given to the students in order to collect the feedback about the pilot performed.

3rd Session (4 hours) – During this last phase, only teachers were involved. CEIPES' staff explained to them the methodology for creating new exercises to be uploaded on the web platform developed by the consortium of partner.

This phase was very pleasant exciting because the teachers gave us their feedback together with many new ideas. In total, the Italian teachers developed 5 new exercises:

- The animal cell – (Biology) - https://app.e3dplusvet.eu/exercises/discover-the-animal-cell/

- A design bookshelf – (Design) - https://app.e3dplusvet.eu/exercises/a-module-of-a-library/

- The VSEPR molecular theory – (Chemistry) - https://app.e3dplusvet.eu/exercises/the-shape-of-molecules/

- An exercise in geometry with surfaces and solids – (Geometry) - https://app.e3dplusvet.eu/exercises/from-the-point-to-the-three-dimensional-space/

- The Platonic solids – (Geometry) - https://app.e3dplusvet.eu/exercises/platonic-solids/

These exercises were developed by following the "methodology for creating new didactic 3D printing design" that consists of the following points:

• Some information about additive manufacturing.

• Benefits of using 3D printing in the classroom.

• How to define 3D exercise?

At the end, final self-evaluation questionnaires have been given to teachers and they filled in them to collect also their point of view on the pilot phase realised. In addition, teachers voluntarily registered on the E3D+VET platform and shared their first experiences through the forum section.

To know more about the Italian pilot phase, you can click on the following link https://www.facebook.com/CEIPES/videos/3243383795732141/ and watch the video.

- **Pilot in Si.da association.**

The pilot at the Si.da association was developed in two sessions.

Si.da, is not an associated partner of the project but they wanted strongly to test the tools and the exercises with their students with SpLD.

The need arose because Si.da's Staff wanted to see if it was possible to develop some exercises to help the learning process of their students with SpLD and to make this process as simple and fast as possible.

During the first day, CEIPES' staff introduced students and educators to the E3D+VET project and gave to them some basic notions regarding the use of 3D printing.

After that, all the project materials were presented, including the web platform, where educators had the possibility to register, to download and to upload exercises developed with the 3D printing technology.

During the second day the exercises were tested. The educators performed short lessons in which they explained the learning objectives of each model and they tested the real efficiency of the materials in a practical way.
All feedback was collected through the initial and final self-assessment questionnaires.

PICTURES OF THE PILOT IN **ITALY**

PIO LA TORRE SCHOOL

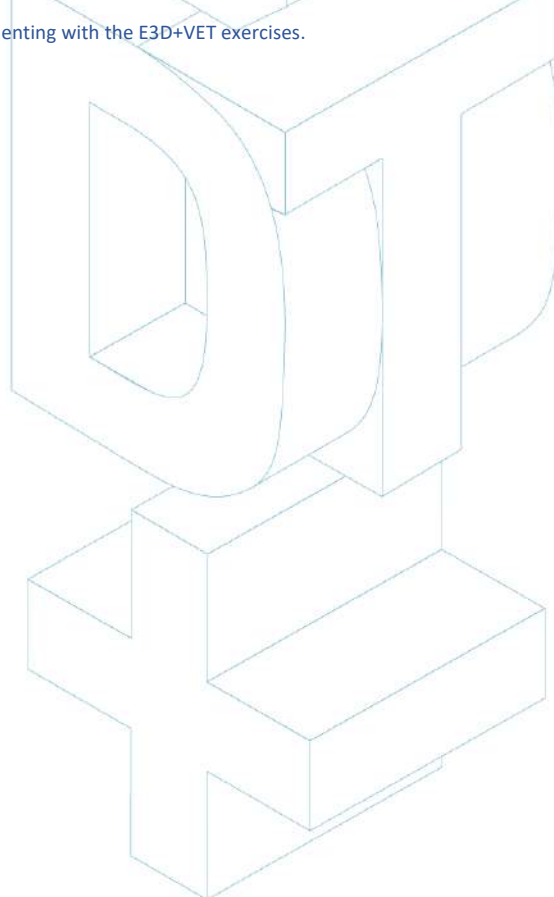Fig. 1 – Students that are experimenting with the E3D+VET exercises.

Fig. 2 – Teachers that are experimenting with the guide on how to print in 3D (IO1).

Fig. 3 – CEIPES'staff that are explaining how a 3D printer works.

Fig. 4 – Students and teachers that are experimenting with non-formal tecniques.

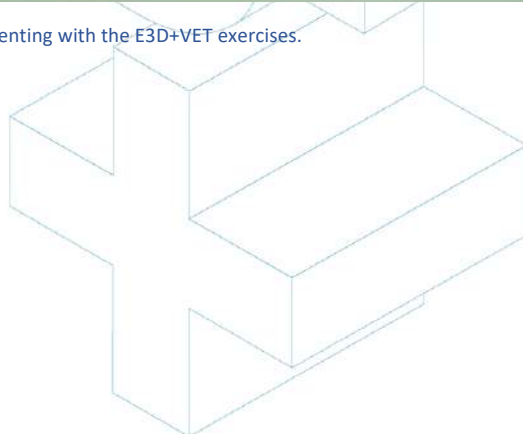Fig. 5 – Students that are experimenting with the E3D+VET exercises.

Fig. 6 – CEIPES'staff that are explaining how a G-code software works.

Fig. 7 – CEIPES'staff that are explaining how a 3D model software works to teachers.

Fig. 8 – Teachers that are performing lessons with the E3D+VET models.

Fig. 9 – Students and teachers that are experimenting with non-formal tecniques.

Fig. 10 – Students and teachers that are experimenting with the E3D+VET exercises.

Fig. 11 – CEIPES'staff that are explaining how a 3D printer Works thanks to non-formal activities.

SI.DA ASSOCIATION

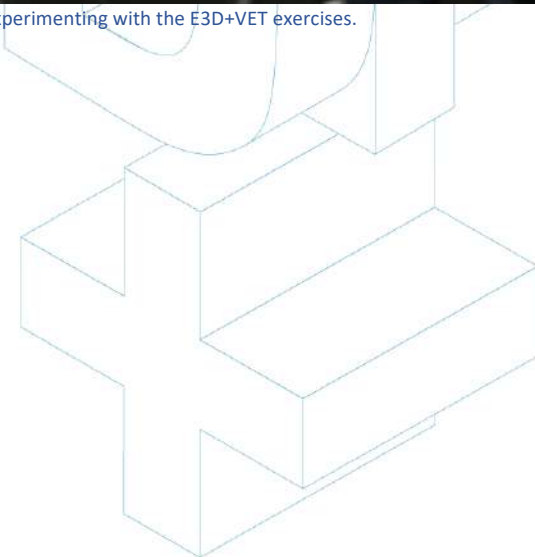Fig. 1 – CEIPES'staff that are explaining how a 3D printer works.

Fig. 2 – Students with SpLD that are experimenting with the E3D+VET exercises.

Fig. 3 – Students with SpLD that are experimenting with the E3D+VET exercises.

Fig. 4 – Students with SpLD that are experimenting with the E3D+VET exercises.

3. Quantitative and qualitative results

The evaluation phase was very important. During the test phase, some initial and final self-assessment questionnaires were given, both to students and teachers. In this phase it was possible to have some feedback of both the expected and obtained results. These results were obtained thanks to a template that the consortium partners distributed during the test phases. The template was composed by multiple choice and open questions. It was very simple to fill in. The template of the all the questionnaires are in the "IO4A2- Creating a methodology for the pilot".

Below, there is a summary of the results obtained.

Student results from the self-evaluation questionnaires.

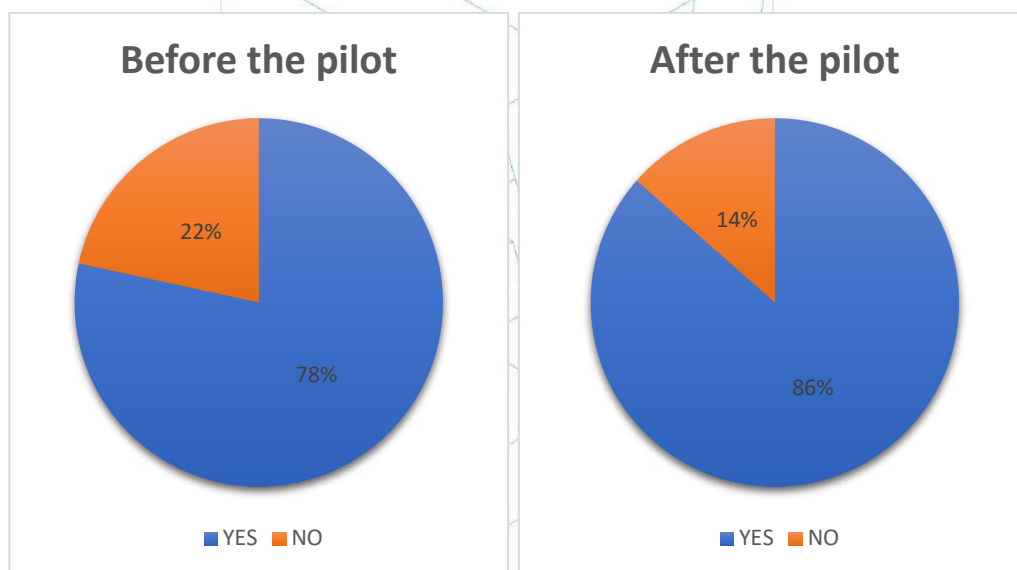- **Do You Know the 3D printing technology? (1: a bit, 5: a lot).**

(Results compared before and after the pilot)
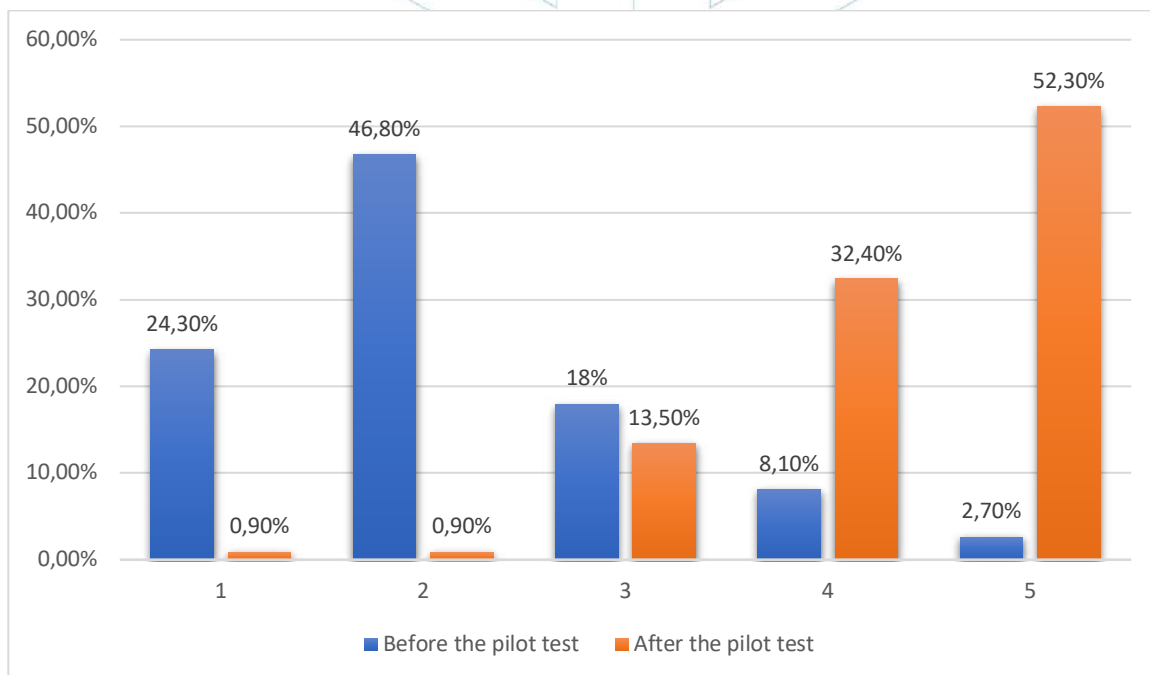
GENERAL COMMENT: As shown in the graph after the pilot phase, the students who participated in the course increased their knowledge of the 3D printer.

- **Do you Know how a 3D Printer Works?**

(Results compared before and after the pilot)

GENERAL COMMENT: Many of them, already in the initial phase of the test, said that they knew how a 3D printer works. A small percentage increased after the pilot phase.

- **If YES, please describe it below:**

(Results compared before and after the pilot)

Before the pilot phase	After the pilot phase
- I use it in my previous school to create a new brand identity - In the laptop we create a 3D picture and then the printer prints it - Print object in 3D - Heats the plastic and uses a coordinate given by a computer to design an object - I know how it works but I don't know how to use it - I have never tried one - I have one at home - I never see one - I saw it on YouTube - I saw it on a video - My brother has one	- Design 3D models with 3D software; export and adapt print files (STL files); Test, alignment and further processing of the G code; Using the 3D printer; Remove models from the printer after printing; Post-processing the model; - Thanks to a digital model we can create a G-code and pass to the 3D printer - Design on paper; Design on digital programs; Insert the SD card into the printer; The printer takes the instructions to make the desired object. - Thanks to a plastic filament we can create a 3d object layer by layer.

GENERAL COMMENT: Many of them before the course knew what a 3D printer was. They saw it in the videos, but nobody knew how it worked. After the pilot the description o how a 3D printer works became very clear and correct.

- **How much can be useful the 3D printing in your learning process? (1: not useful, 5: very useful).**
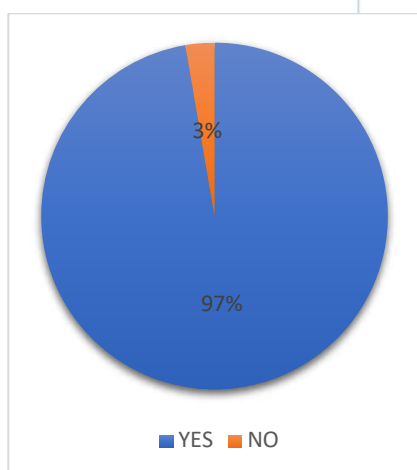
(Results compared before and after the pilot)
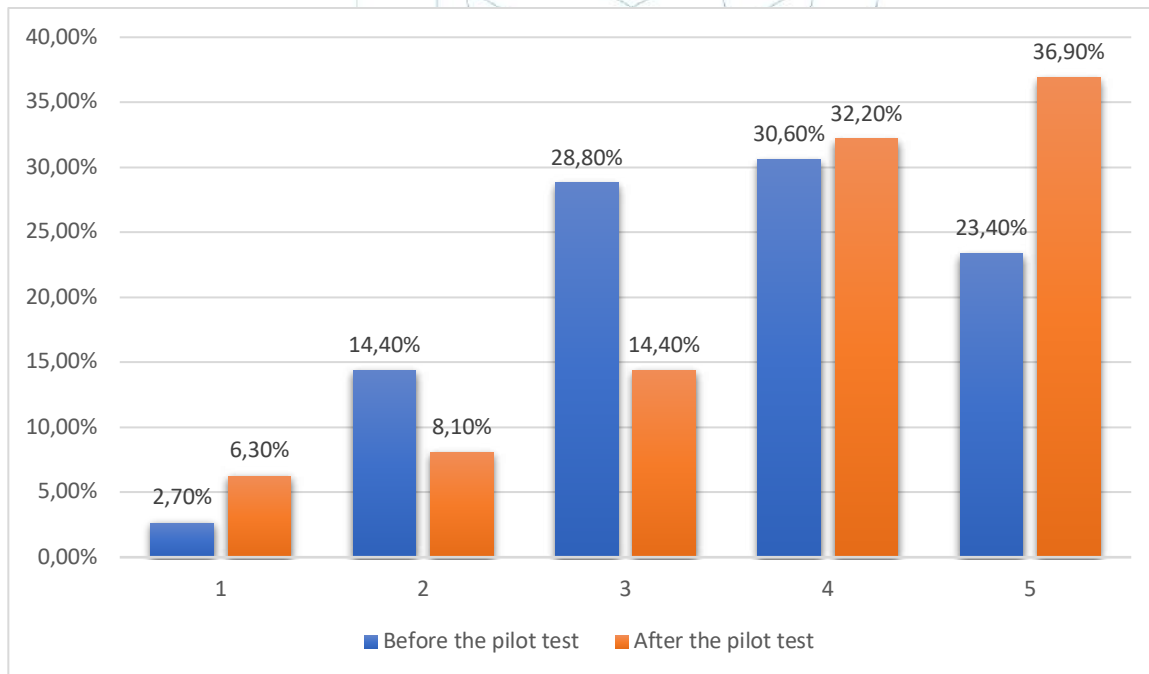
GENERAL COMMENT: In both the initial and final self-assessment many students recognised the usefulness of using this technology

- **Would you like to have educational exercises developed with 3D printing technology? Please motivate your answer.**

(Results before the pilot)

- I want to learn 3D printing, how it works because I think that is very useful
- It is very interesting
- I love to know new technology
- We can learn how to use it correctly
- Because I really like the technology
- To learn new thing
- It could be interesting
- I can learn how it works
- Because you learn a lot of thing

GENERAL COMMENT: almost 100% said they wanted to have exercises developed with 3D printing technology.

- **How the educational exercises developed with the 3D printing technology have been useful in your learning process? Please describe it below:**

(Results after the pilot)

- Because, I understood difficult concept
- I can see what I learn
- To enrich the knowledge of the subjects according to the object
- It was interesting
- Actually, I did not understand a lot. This is a new era for me
- They were very useful for understanding how to design an object
- This is a new thing for me I don't have any idea
- It was confusing
- They help a lo,t especially in school learning
- It makes lessons more exciting
- Makes lessons more clear
- Thanks to the solid figures, the teachers were able to explain more easily and we understood it better

- **Do you think that during the lesson can be useful having educational models printing in 3D? Please develop your answer.**

(Results before the pilot)


14%

86%

■ YES ■ NO
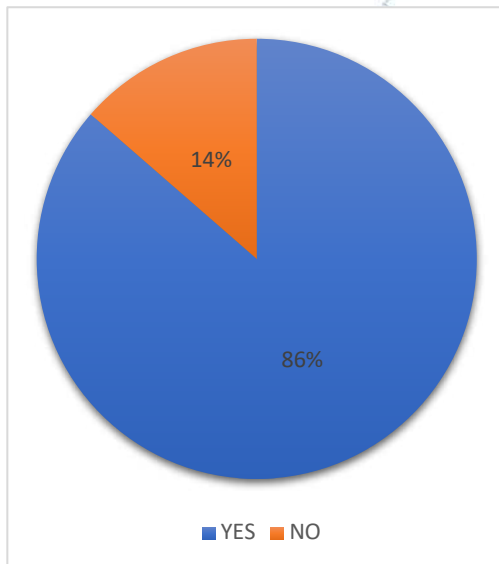
- It is very useful
- They help me to learn more
- We can know all characteristic of one thing that is virtual in the real life
- We can learn faster
- To develop better for my work
- To learn more how to use 3d print
- To learn new methods of learning
- It could be interesting
- No, I don't like plastic
- Because we can create some models useful for our learning process
- It is very useful

GENERAL COMMENT: more than 80% said they wanted to have exercises developed with 3D educational models.

- How useful have been the 3D models shown and used during the lesson? (1: not useful, 5: very useful) In which way?

(Results after the pilot)
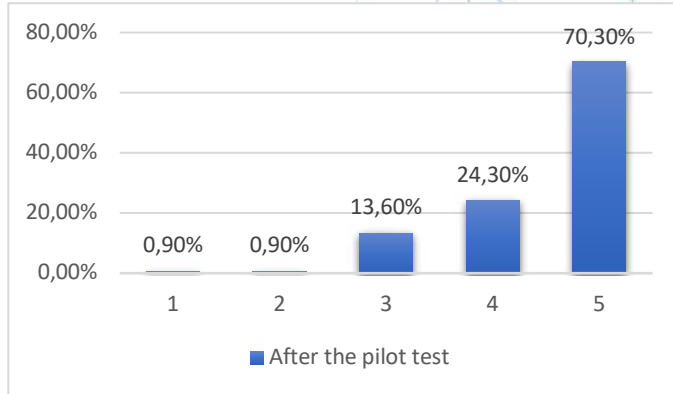
- We had chance to practice
- They are going to be more useful
- We used them to assemble the various pieces of Europe and to understand how DNA is formed
- Because I really enjoyed studying in this way
- Lessons became more interesting
- Funny and instructive
- In geometry with solids in science with bonds

GENERAL COMMENT: More than 70% of students after the pilot phase recognised that the models shown during the lesson where very useful.

- Do you think experimenting with 3D printing technology and 3D models can make the lesson more pleasant?

(Results before the pilot)
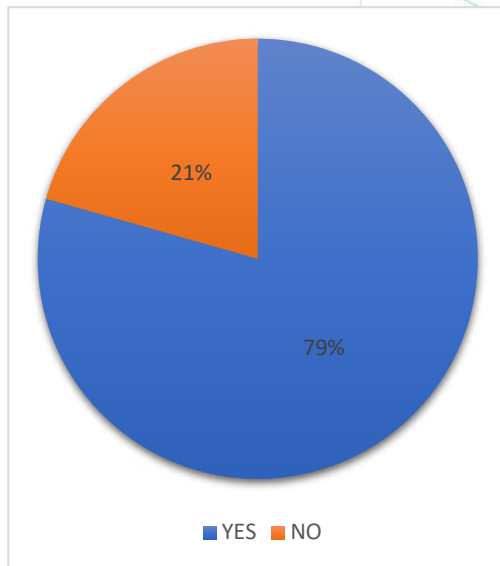
- It will be more interesting and funny
- The wonderful thing is to know the features of the objects
- We can enjoy ourself in the meanwhile we learn
- It's always nice to learn new things especially related to the technology that is important today to find a job
- I don't like it
- I believe that the 3D printer is not useful for the study
- It could be interesting
- It could be funny
- It is very useful

GENERAL COMMENT: More than 75% of students before the pilot phase recognised that the lesson could be more attractive with the 3D printing models and technology.

(Results after the pilot)
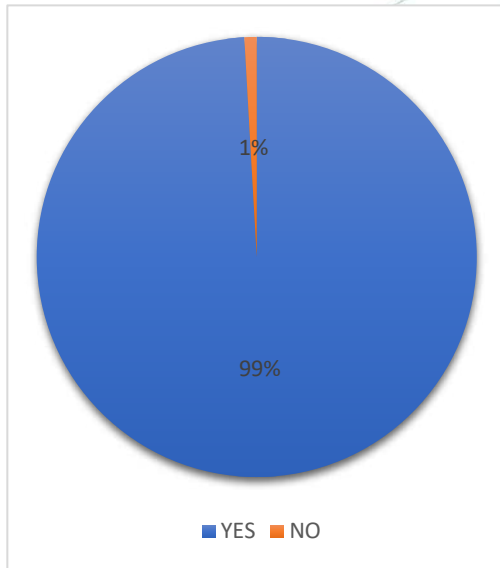
- Time passed fast
- I understand difficult concept
- we can print a lot of theoretical concept
- We can understand better
- To discover something new and to learn something that will be useful for our future.
- If there is something without letters or texts in the lesson I can learn better
- It improves our creativity
- Because it helped me to understand how things are designed
- The lesson became more visual
- I was excited
- Help in a practical and simple way to learn and in a pleasant way

GENERAL COMMENT: After the pilot phase the 99% of students recognized that it was more attractive using 3D printing models and technology.

- **Would you like to learn how to use a 3D printer?**

(Results before the pilot)
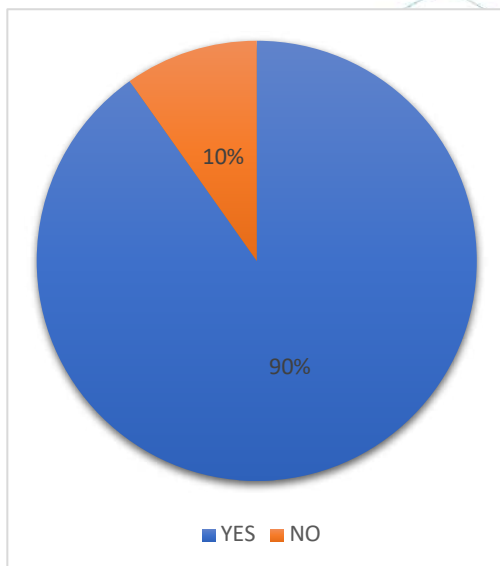
- Because can be useful in my future job
- I want to have a new experience It could be useful in the future year
- I'm so curious
- it is very interesting
- It is interesting
- I don't think it is useful in my sector
- I don't think it's useful in my field
- It could be useful, funny and innovative
- Yes, it is very useful for my future
- It could be my future job
- Because this will be the future
- To know more
- Want to learn new things

(Results after the pilot)

- YES - NO
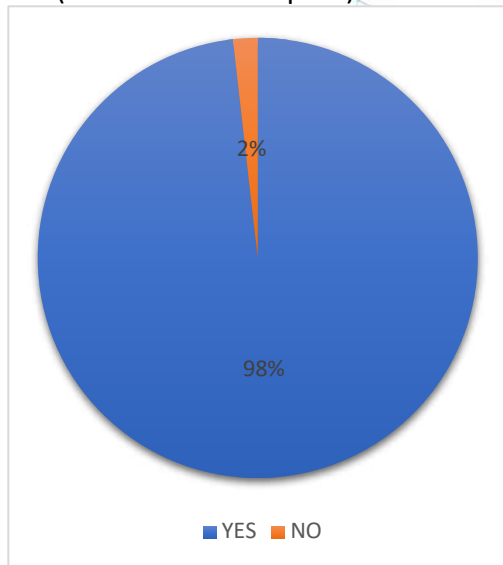
- I want to use in my life
- I can use it in my future work
- to print more things
- It is interesting
- I can use it in my job
- for my future
- It is very boring
- It is very funny
- It is very good
- I like it

GENERAL COMMENT: All students before and after the pilot wanted to learn about how to use a 3D printer. The reasons were various.

- **How satisfied are you with the contents of the training course received? (1: a bit, 5: a lot). Please comment your answer**

(Results after the pilot)

- After the pilot test
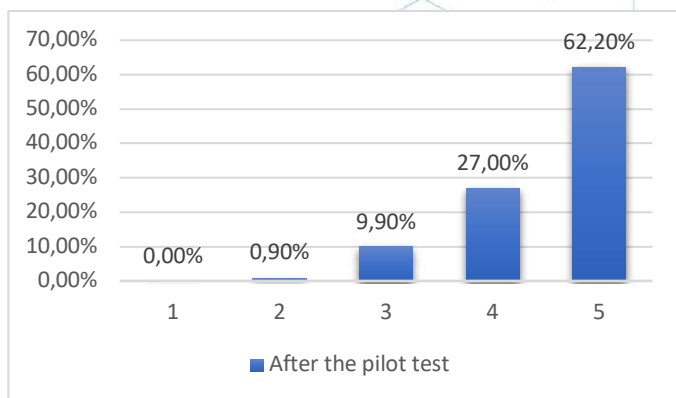
- Interesting
- Really exciting, thank you very much!
- Perfect, was great.
- It was very useful and also, we learn a lot of things
- The content was clear and simple
- It was funny
- Very satisfied also to exchange ideas with others
- Wonderful
- It was interesting
- I am very satisfied because what we have been taught has been done clearly

GENERAL COMMENT: More than 60% of the students found the course interesting and satisfactory in content.

- **How satisfied are you with the methodologies used during the training course? (1: a bit, 5: a lot). Please comment your answer**

(Results after the pilot)
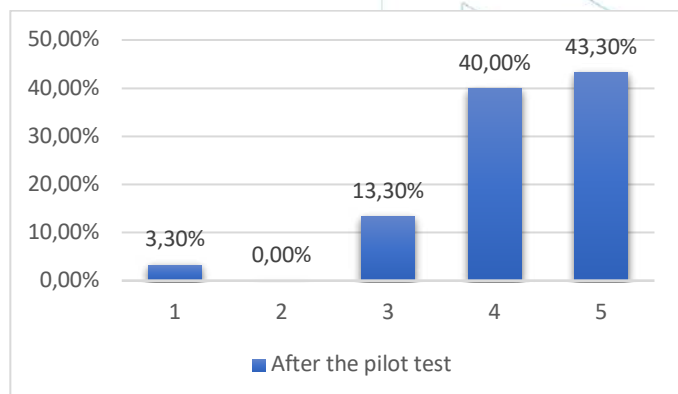
- A new way on how we can learn
- new way of learning
- It was a little bit confusing
- Very satisfied also to exchange ideas with others
- No idea but good
- I have to learn more things about what methodology is
- I am very satisfied because what we have been taught has been done clearly
- It could be more interesting
- You can see in above
- Very interesting
- It was perfect

GENERAL COMMENT: The 80% of the students stated that the methodologies used during the course were interesting in a range from 4 to 5.

- **In which sector do you (want to) work?**

(Results compared before and after the pilot)

Before the pilot phase	After the pilot phase
- Air Force - I want to be photographer - Video, but learn more thing it's a good way - Hairdresser - I want to be a Youtuber - Design - Computers - Teaching - I dont' Know - Designer	- Medical assistants - Media designer - I don't know - Architecture - Health service - Designer - Dermatology - Graphic design - Video maker - Advertising - Technology

- **How could 3D printing be used in the sectors you are interesting on?**

(Results compared before and after the pilot)

Before the pilot phase	After the pilot phase
• Design everything in 3D • In drawing • Much in the development of miniatures and in the furnishing of houses • Creating model houses • Time safe • I don't know yet • It can be provide us more time • Drawings • Online drawings • In my designs	• Design of the buildings • To built a lot of things • To create 3D models of my projects • To teach to kids how the object are made • Not yet • X-raying • No role haha but hopefully someday leg prostheses • Imminent not quite as big • Currently none in my area. • Not yet in my practice. • Medicine research

- **What are the general results you expect from this course?**

(Results before the pilot)

Before the pilot phase
• How 3D printing works and how helpful it can be in medicine • What role pressure plays in medicine. • How 3D printing works. • More experience in 3D printing • I want to know what it is this new technology and I want to learn to use it • I want to learn it • to know how it work and why • The general results are many but I want to learn how to use this new technology • Get out of school knowing something more • Learn what the 3D printer is if you have to use it in the classroom • use the 3d printer for classroom work

- **What are the general results that you had from this course?**

(Results after the pilot)

After the pilot phase
• It was very interesting • This test was useful to understand the potential of a 3D printer • 3D printers will be most important of technology • Learn the function of the 3D printer and apply it in the reference subjects • New generation technology will be 3D printing

- I know more things on 3D printing
- I have to learn this
- It is very important and useful
- I learned a lot and enjoyed myself
- Technology is developing

- **Suggestions for future training course on the 3D printing**

(Results after the pilot)

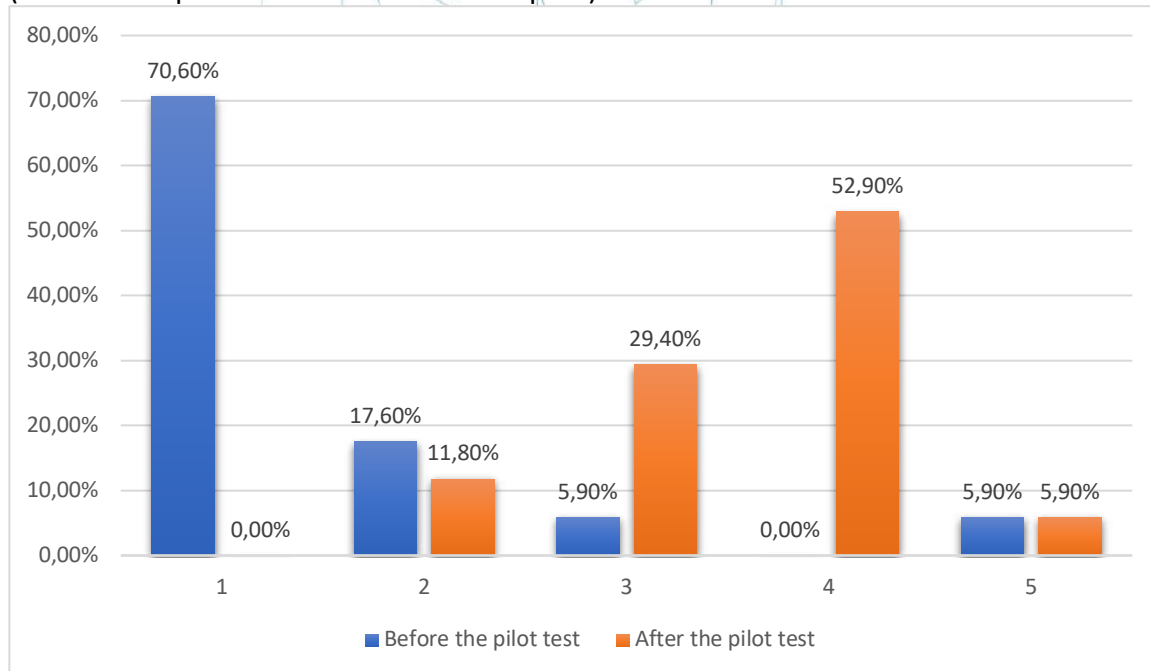| After the pilot phase |
|---|
| Everything was great, thank you! Thank you! Everything great Use the printer at the beginning so that the result can be shown at the end :) That the print is finished towards the end Let students try printing ❤️❤️❤️❤️ Print make up Start printing earlier so that you have the result in the end Was very good I learned a lot, thanks! Everything was good |

The complete results of questionnaire before the pilot phase are available on the following link:
https://docs.google.com/spreadsheets/d/1myKsH0SHbjTM2JibUfFQm8iAnVIqpm6ocGrYe1yb0E0/edit?usp=sharing

The complete results of the questionnaire after the pilot phase are available on the following link:
https://docs.google.com/spreadsheets/d/1UcBnf6KcmH-PdB1tXX-a7f6GpXMmyIRlnIjic8_lUcI/edit?usp=sharing

Teacher results from the self-evaluation questionnaires

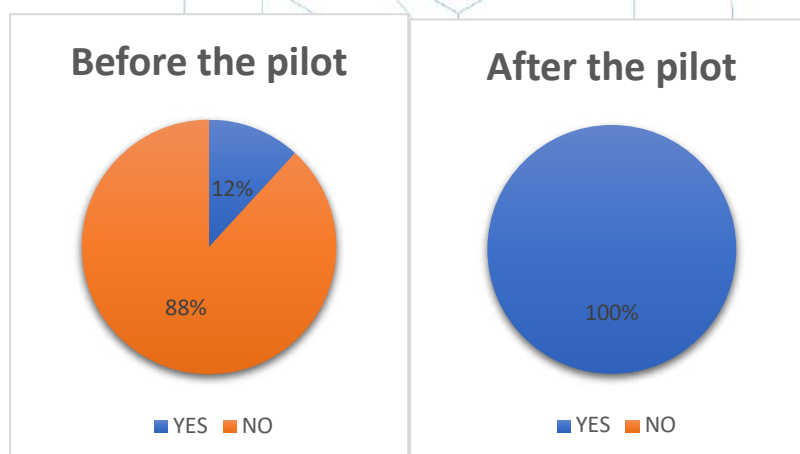- **Do You Know the 3D printing technology? (1: a bit, 5: a lot).**

(Results compared before and after the pilot)

GENERAL COMMENT: More than 70% of teachers involved in the pilot didn't know the 3D printing technology before the pilot phase. After the pilot phase they stated that they, right now, know the technology in a range of 4.

- **Do you know how a 3D printer works?**

(Results compared before and after the pilot)

GENERAL COMMENT: More than 85% of teachers involved in the pilot didn't know how the 3D printing technology worked before the pilot phase. After the pilot phase, all 100% of teachers Know it.

- **If YES, please describe it below:**

(Results compared before and after the pilot)

Before the pilot phase	After the pilot phase
• By creating mesh objects. • I'm very able to use a 3D printer. I love the software Rhinoceros and also I have a 3D printer	• We create a 3D model or we can download one from a repositories then we import in a software that generate the G-code and we pass all the information to the 3D printer. • With an stl file I can import in the g-code software and give the information to the printer • After creating a digital model it is exported to STL. The G-code is generated from the STL file. Through a memory medium it is transferred from the computer to the printer. The printing process is then started. • A wire of a thermoplastic material with a specific section is thermally transformed through an extruder. One plate moves in a Cartesian plane and the extruder is positioned on a binary carriage that moves along the z axis, because it is raised vertically with the help of two motors.

GENERAL COMMENT: From the comments it is possible to note that the preparatory course and the guide IO1 provided were in effective allowing teachers to acquire digital skills regarding 3D printing and CAD modeling.

- **How much can be useful the 3D printing technology in your teaching process? (1: not useful, 5: very useful).**

(Results compared before and after the pilot)
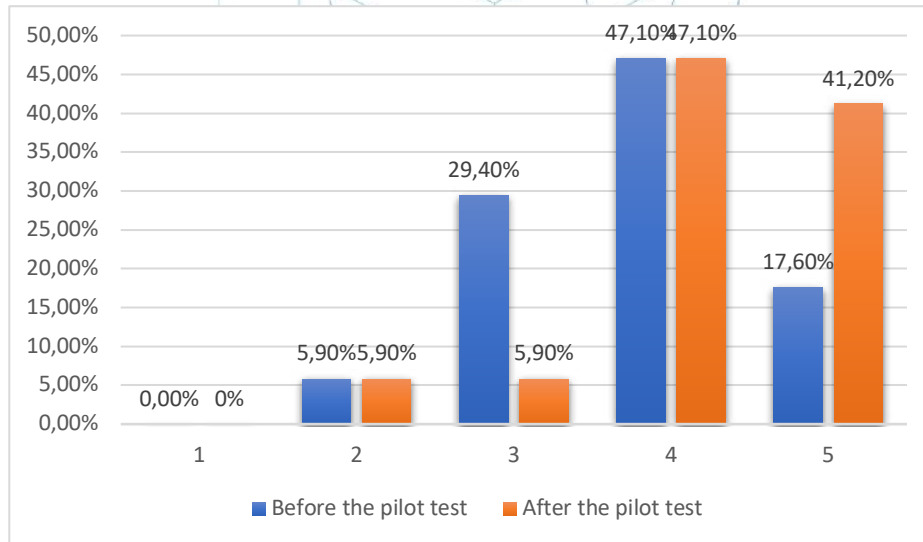
GENERAL COMMENT: Since the beginning, the teachers said that 3D printing technology can be very useful in teaching process.

- **Do you think that during the lesson can be useful having educational models printing in 3D? (1: not useful, 5: very useful) Why? Please motivate your answer below**

(Results before the pilot)
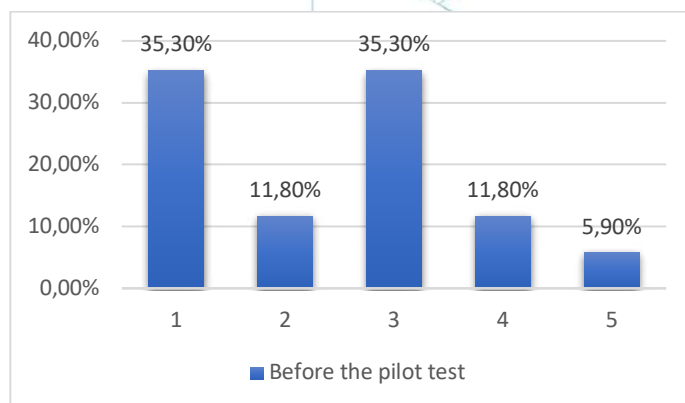
- The use of a 3D model can facilitate the learning process of the students
- To facilitate learning
- I don't Know
- The knowledge of the 3D printer is not necessary in the school's computer science courses
- Because I think I will participate in the course for 3D printing and not learn new educational models
- It is an additional teaching tool

GENERAL COMMENT: At the begininng, the teachers were a little bit skeptical about the true potential of 3D printed models.

- **How the educational exercises developed with the 3D printing technology have been useful in your learning process? Please describe it below:**

(Results after the pilot)

- They have made the children to understand the theoretical contents and have encouraged motivation
- There weren't exercises of computer technology
- The exercises developed can be used as support in future lessons.
- I could not understand well applied to my discipline
- Until now never used
- Visual and tactile learning of theoretical exposure
- Students could learn more and in an active way
- They motivate students and teacher to learn
- In a very useful way
- The students were very interested on them more than our traditional methods
- Fantastic model and exercises useful for students with SpLD
- Very helpful! There have never been such models before!

GENERAL COMMENT: After the pilot they said that the use of these models was very important because it facilitates the understanding of some difficult theoretical concepts that became more simple.

- **Do you think experimenting with 3D printing technology and 3D models can make the lesson more pleasant? Why? Please motivate your answer below**

(Results before the pilot)

18%

82%

■ YES ■ NO
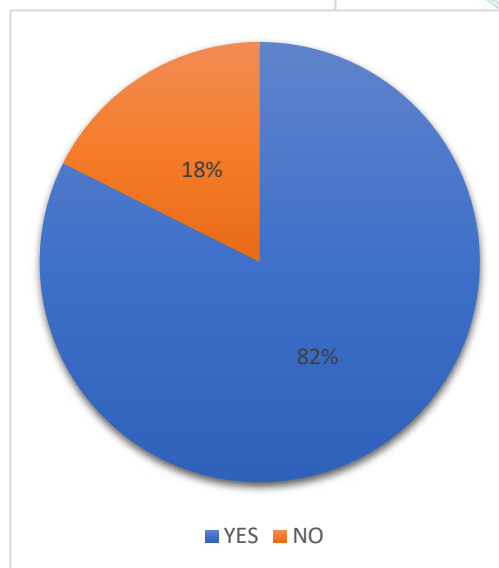
- Students can experiment through the construction of a 3D model which previously learned
- To get more feedback from reality
- It is widely used in advertising for making gadgets.
- It is not possible to experiment with the 3D printer in computer courses
- Very much. Because I believe that in traditional teaching is a lack of ability to generate further engagement to tye student. I have experienced 3D printing during lessons and it has generated many empathies
- It would serve to imagine the students' capacity for interest and instrumental skills

- **Do you think that experimenting with 3D printing technology and 3D models made the lesson more pleasant? Why? Please, develop your answer below**

(Results after the pilot)
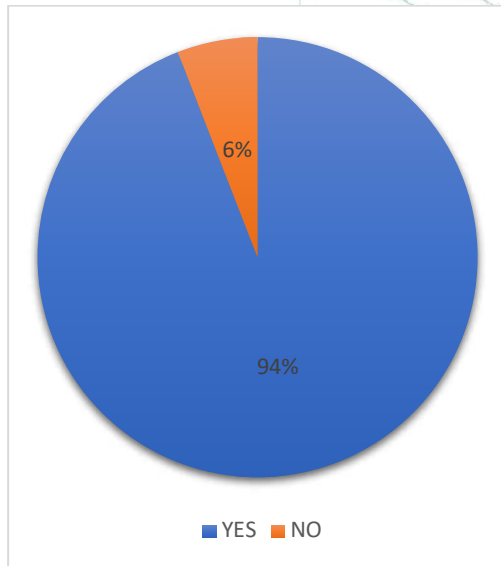
- Suggestion: Raise interest in class to learn in a different way
- Students could learn more and in an active way
- Because difficult concept could be simplifying
- They help students in the learning process
- We can develop a lot of tools that are not in the market
- Thanks to the 3D object we can transform our lesson in game
- 3D printing is playing an increasingly important role in many companies, particularly in the medical field.
- Current technology
- Already helpful, although it takes a lot of time.

GENERAL COMMENT: Many, however, from the beginning recognised the potential of the technology and tools provided.

- **How useful have been the 3D models shown and used during the lesson? (1: not useful, 5: very useful). In which way? Please comment your answer below:**

(Results after the pilot)
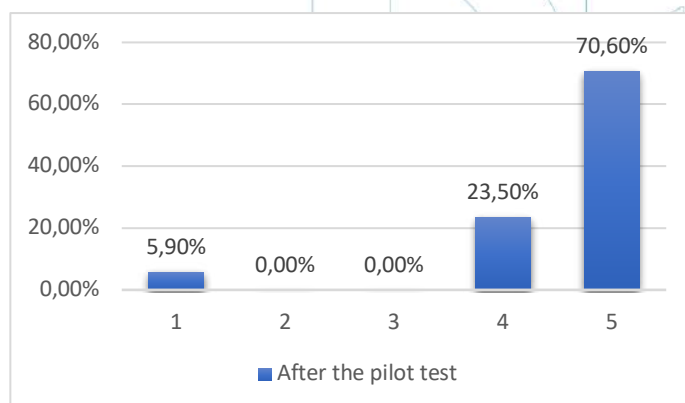
- The made to the children to understand the theoretical contents and have encouraged motivation
- There weren't exercises of computer technology
- The 3D models allow to solve some problems that involve the real visualisation
- I noticed that the students quickly understood the geometrical contents that are more difficult to understand and that generate confusion if they are explained only theoretically.

GENERAL COMMENT: After the pilot they said that the use of models was very important because it facilitates the learning process.

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- How interesting was the lesson with the new methods and tools? (1: a bit, 5: a lot)
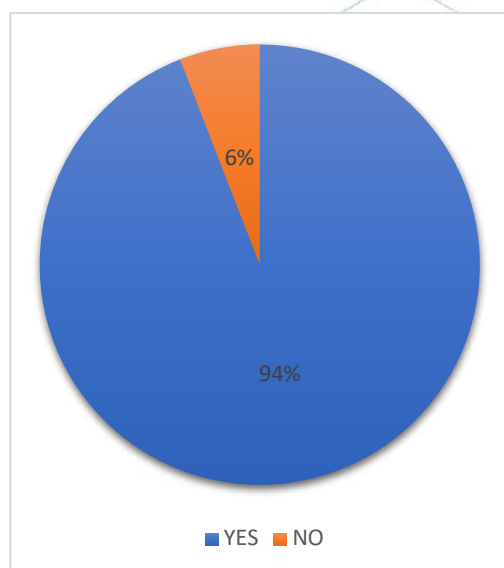
(Results after the pilot)
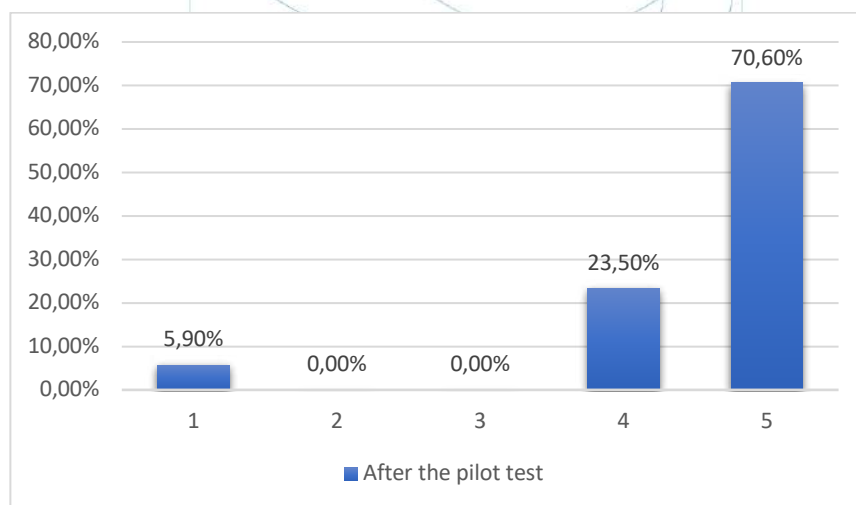
GENERAL COMMENT: More than 70% said that the tools and methodology used made the lesson more interesting.

- **Do you think that the materials supplied (guides, methodologies, platform and exercises) are useful to carry out the pilot phase? Please motivate your answer below**

(Results before the pilot)

- They were very easy to understand
- They are very useful and clear
- They were useful to understand all 3D process and how to conduct the pilot phase
- Everything is useful if well-coordinated
- The material provided is a good start for learning to experiment
- I think so ... I can be precise at the end of the course
- So far they have given me good learning bases

(Results after the pilot)
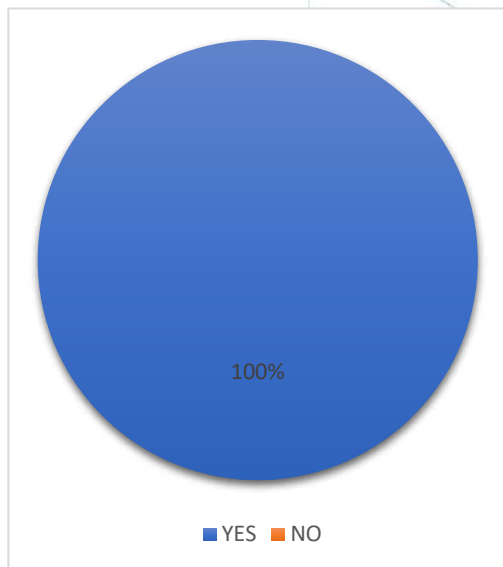

- They allowed us to better understand the process
- All the training material and tools have been useful for experimenting with new teaching methods
- The materials are very simple to use.
- We have seen a different educational approach that includes an easy intersection with other disciplines
- I find that they were very pleasant and clear
- They were useful
- They were very clear
- They were very simple and clear

GENERAL COMMENT: Both before and after the pilot the teachers said that the materials provided have been very useful and easy to understand.

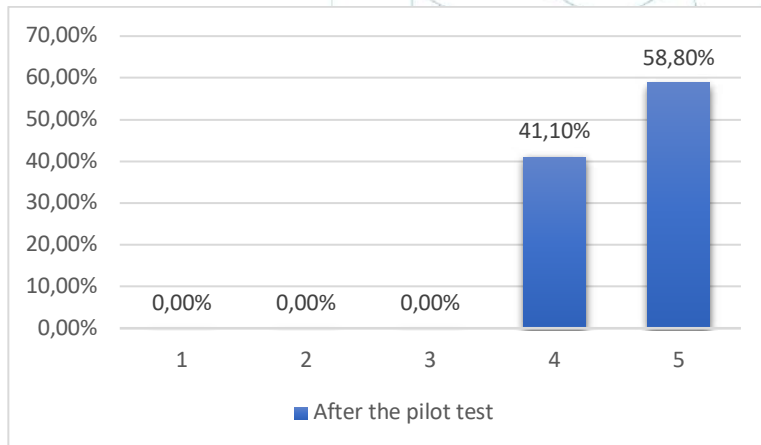- **Which 3D printing skills would you like to develop in the pilot phase?**

(Results compared before and after the pilot)
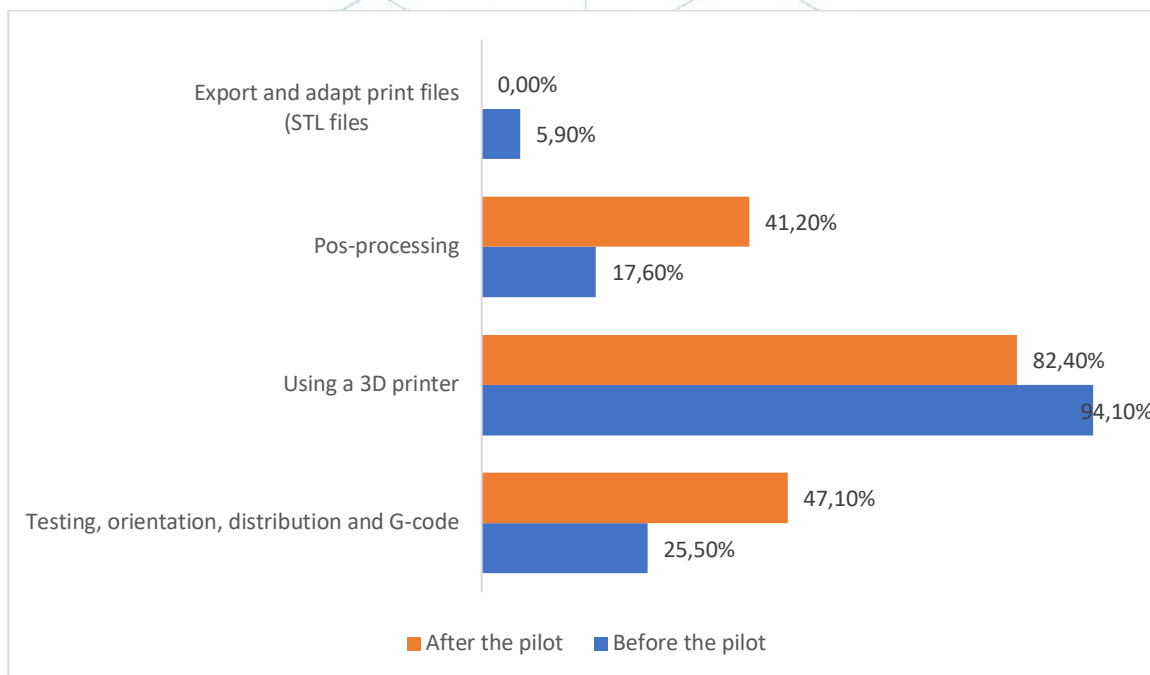
GENERAL COMMENT: More than 90% of teachers want to learn in a practical way how to use a 3D printer.

- **How satisfaced are you with the methodologies and tools used during the pilot phase? (1: a bit, 5: a lot)? Please comment your answer.**

(Results after the pilot)

- The tools are adequate as well as the methodology that allowed us an active participation.
- The satisfaction was to see the students respond positively to the test
- The tools used and the methodology allowed us to actively participate
- It shows me different way to conduct the lesson
- It has been shown another way to teach the lesson
- They were very simple and clear

GENERAL COMMENT: More than 90% of teachers confirmed that they are satisfied with tools and methodology given to them in a range between 4-5.

- **Please, write a general feedback about the guide: "Transfer of knowledge about basic of 3D printing concepts to the VET teachers**

(Results after the pilot)

After the pilot phase
• Very useful • It was easy to aunderstand • Very clear • Very good • They were easy to understand • Useful and easy to understand • Materials are very well designed and very informative! • Very good, but too long. • Good help. • Clear Informative. It makes sense. • Complicated. Maybe it would have been shorter. • Very helpful for getting started.

- **Please, write a general feedback about the methodology: "Develop methodology for creating new didactic 3D printing design"**

(Results after the pilot)

After the pilot phase
• The methodology provides key concepts that are easy to understand
• Excellent methodology
• The methodology explains the basics in a simple way to create a new 3D printing didactic model
• Good
• Very useful
• Content very clear
• Very clear and useful
• Very good
• They were easy to understand
• Useful and easy to understand
• Materials are very well designed and very informative!
• I didn't use it.
• Can you work with.

- **Please, write a general feedback about the exercise developed**

(Results after the pilot)

After the pilot phase
• Very good but I need more and different exercise for my subject
• The exercises allowed the multidisciplinary lessons to be experienced in a creative and innovative way, capturing the students' attention and making them actively participate
• The exercises allowed the active participation of the students who took part in the course
• Good
• The exercises performed allowed us to actively participate in the training
• Very useful
• Exercise well done
• Very very important models
• Very good
• They were easy to understand
• Wonderful

- **Please, write a general feedback about the web platform developed**

(Results after the pilot)

| After the pilot phase |
|---|
| • Very user-friendly |
| • The platform is very well developed for searching for available resources. |
| • The platform is useful for sharing materials, educational experiences and opinions of others |
| • Good |
| • The platform is useful for sharing the materials of educational experiences and opinions |
| • Very useful |
| • Very user-friendly the graphic is ok |
| • Very clear and simple |
| • Very good |
| • Very user friendly |
| • Wonderful we can develop new exercises |
| • Looks great. Unfortunately, I have not been able to create any models and exercises there myself. |

- **How useful the platform was for finding 3D exercises and models? (1: not useful, 5: very useful)**

(Results after the pilot)
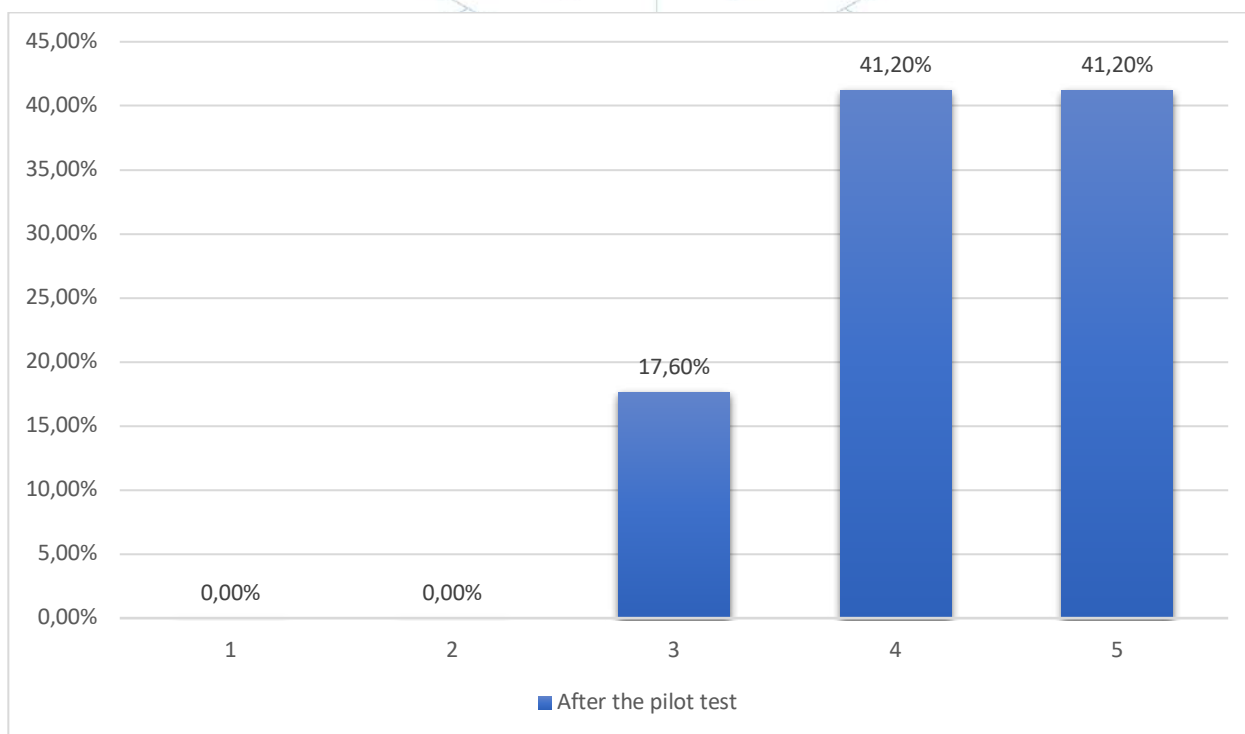
- How would you rate the design of the platform and its usability? (1: very poor, 5: very good). Please comment your answer

(Results after the pilot)
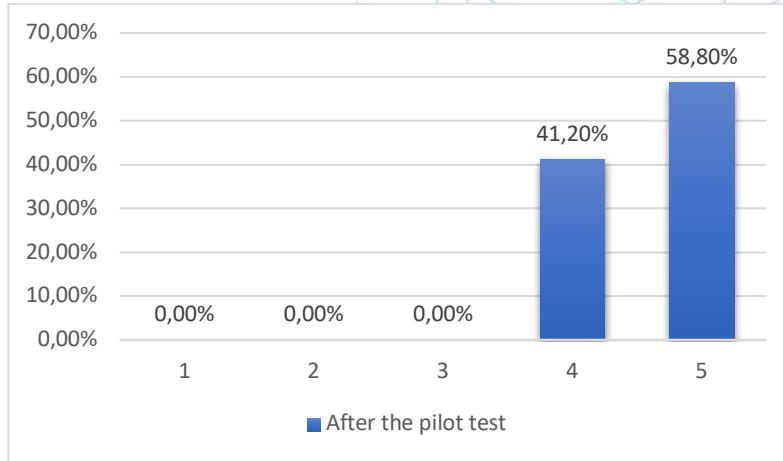
- Very user-friendly
- The platform allows you to identify the exercises and 3D models quite easily
- We can easily take inspiration from existing models
- It is very intuitive and easy to use for teaching
- You can easily find exercises and models to develop
- Very user-friendly
- Improve the translation
- Very clear
- Well done
- Modern

GENERAL COMMENT: More than 90% of teachers confirmed that the platform was very good in a range between 4-5 and its design too.

- In which sector do you work?

(Results compared before and after the pilot)

Before the pilot phase	After the pilot phase
- Teacher/ Advertising graphic and degree in architecture - Teacher and researcher - Architect and teacher of advertising graphics and graphic design - Teacher - Teacher - geologist - SCHOOL - Educator in s SpLD association - Educators in si.da association - Psychology - Media technology - Teacher media technology and math - Religious instruction	- Medicine and biology - I'm a teacher - IT sector - I'm a teacher - Teacher - Educators in SpLD environment - Educator in the si.da association - Psychologist - Media technology - Layout - Religion - Biology, medicin

- **How could 3D printing be used in the sectors which you are interesting on?**

(Results compared before and after the pilot)

Before the pilot phase	After the pilot phase
• For educational purposes it is perfect for a course in advertising graphics • Software development useful for learning 3D or other subjects • In various contexts: industrial design, advertising gadgets and medical prostheses • Reproduction of economic models • To make models of minerals, fossils, etc. • For the creation of customised brands and gadgets aimed at a corporate coordinated image • To develop more skills on the way of teaching • To develop new exercises • to help students to acquire some skills that are difficult for them • Would be nice if the subject were included in the curriculum. • You can make a connection to medical technology and show the students where this technology is already used everywhere. • Print models and show students where 3D printing plays a role in medicine.	• For the teaching activity • To create some exercise where number are transformed in shapes • To create prototypes of designed objects • To develop new exercises • To stimulate the learning process • We can develop a lot of specific tools based on the needs of our students • Can help us and students to teaching and learning • Use classroom models for illustration; Explain 3D printing and show possible applications in the field of medicine • Develop models • Show current developments • Illustrate complex relationships (time)

- **What are the general results you expect from this course?**

(Results before the pilot)

Before the pilot phase
• Knowing how to use a 3D printer • Basic skills of the 3D printer and design • I expect a greater assessment of the personal skills acquired • Expand my professionalism • To learn how to use a software CAD and a 3D print • To understand new technology • To experiment new tools • Get ideas for class. • I personally want to learn about 3D printing and see how to use it in class. • Learn a lot about 3D printing. • Learn more about 3D printing. See how to bring 3D printing closer to students.

- Exciting lessons
- "More knowledge for the students.
- For teachers, more concrete ideas for models that are basically used in class.

- **How satisfied are you with the general pilot phase? (1: a bit, 5: a lot)?**

(Results after the pilot)
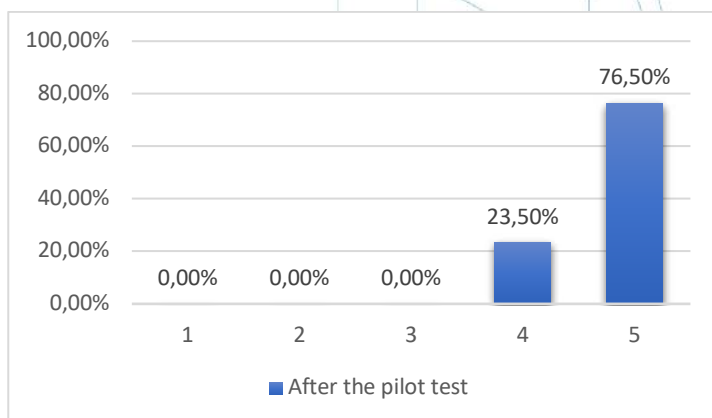
- It was very short
- The course was very interesting
- I believe it has been carried out in such a way as to give useful indications to those who teach
- I liked it
- Very useful
- Very innovative way of teaching
- Very useful test to understand different way to teach
- Fantastic
- It was perfectly organized.
- Competence made.
- Perfectly explained, very useful and entertaining.
- Thumbs up! Thank you very much!

GENERAL COMMENT: More than 76,50% of teachers confirmed that they are satisfaced with the pilot phase conducted.

- **What are the general results that you had from this pilot phase?**

(Results after the pilot)

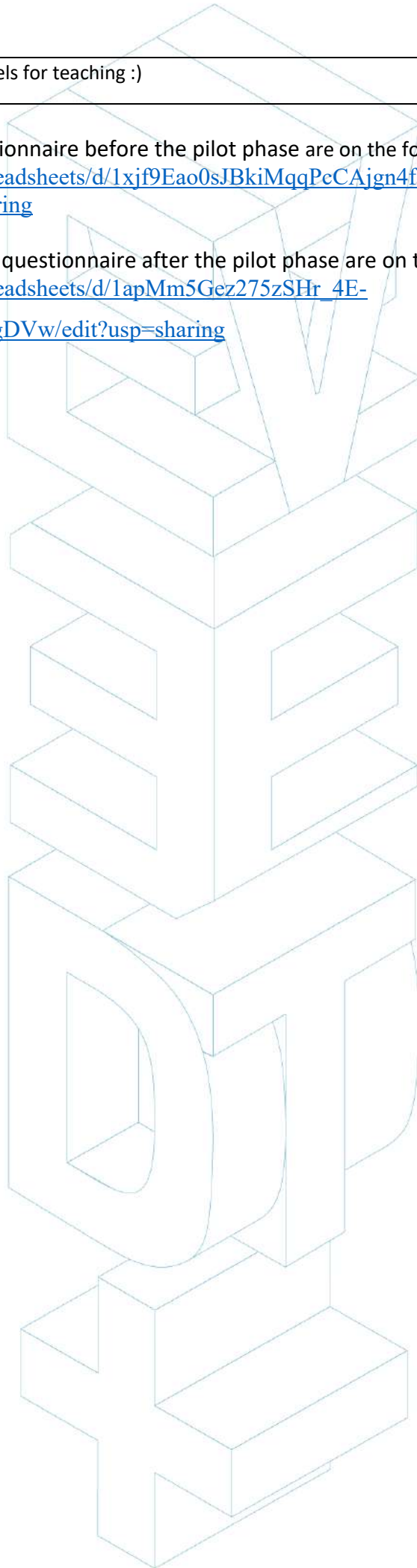| After the pilot phase |
| --- |
| Satisfactory Know valid and pleasant project managers able to broadly interest on the proposed topic Very interesting course Very good I understood that with technology our lesson can be more pleasant Very useful Models, handouts, ideas for lessons and a good mood :) Perfect! Thank you very much!!! Much. New knowledge about 3D printing and use in class. Lots of new ideas. |

- Ideas, materials, models for teaching :)

The complete results of questionnaire before the pilot phase are on the following link:
https://docs.google.com/spreadsheets/d/1xjf9Eao0sJBkiMqqPcCAjgn4f1V0psqJ-sZG85BzY0g/edit?usp=sharing

The complete results of the questionnaire after the pilot phase are on the following link:
https://docs.google.com/spreadsheets/d/1apMm5Gez275zSHr_4E-bAxxaBEL0T_J86cNoO5vgDVw/edit?usp=sharing

Conclusion

The pilot phase of E3D+VET states what the partner consortium, that implements the various activities envisaged by the project, supported since the beginning: the introduction of 3D printing in VET institutes and other kind of association, brings a lot of benefits not only from a teaching point of view but also above all from learning process.

3D printing technology, therefore, enhances both the development of logical skills and spatial orientation, and the scientific process of building a hypothesis (design) and then using errors for verification (creation of objects and improvement / correction of errors; creation of a new object).

Obviously, we must fill in all the gaps that our school systems have, from the rigidity of the curricula, to the lack of technological skills of the teachers. Above all else, the expansion of STEM subjects in schools should be supported with practical and engaging workshops. We should innovate our didactic system.

From the data collected, thanks to the test phase, the tools and methodologies created by E3D+VET partner consortium was a success for the institutes and the associations involved, raising interest and opening eyes to panoramas that until now had not yet been discovered.

It also emerged that "digital" technologies do not replace traditional expressive languages, but they are an added value which allow students to experiment in new learning environments equipped with (technological) tools capable of supporting and expand their hypotheses, theories and knowledge.

The results obtained are traceable, according to our experience, due to the fact that the students had the opportunity to experiment freely, discovering independently the potential of the tools provided.

Obviously, some tools made by the consortium, need some improvements, which can only be discovered through the various tests.

One of the strongest difficulties of the pilot phase of the E3D+VET project was to convince teachers to put aside traditional teaching techniques and learn new ways of teaching. For this reason, the consortium partner of the project believe that teachers' training courses in VET institutions, regarding new technologies, must be increased in order to ensure that teachers don't have only the role of director of the entire lessons they become the true and proper actor together with the students.