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3D STEAM

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Accelerating STEAM-related Knowledge and Skills via 3D Modelling and 3D Printing

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3Dsteam Lesson Planner Tool for Teachers

This document is a partial result of the project *Accelerating STEAM-related Knowledge and Skills via 3D Modelling and 3D Printing (acronym: 3D STEAM)*

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This particular work package was led by Johannes Kepler University, Linz, Austria

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Summary and Instructions for Teachers

How to Use this Template to Transform Your Lessons into STEAM Projects with 3D Modeling and 3D Printing

Welcome, educators! This template is your guide to transforming your subject-based lessons into exciting, multidisciplinary STEAM (Science, Technology, Engineering, Arts, Mathematics) projects using 3D modeling and 3D printing. Whether you're working solo or as part of a dynamic teaching team, this tool will help you create engaging, hands-on learning experiences for your students.

Let's Get Started:

1. **General Information**: Start by filling out the general information about your lesson, including the related subjects, grade recommendations, and total activity time. This sets the stage for your lesson.
2. **Learning Objectives**: Clearly define what you want your students to learn both during and after the lesson. Focus on the short-term goals for the lesson itself and the long-term goals that extend beyond it, especially those involving 3D modeling and printing.
3. **Overview**: Introduce the topic and purpose of your unit. Include any prerequisite knowledge your students need. This section should capture their interest and explain why the activities are relevant.
4. **3D Modeling and 3D Printing Integration**: Describe the tools and software you'll use for 3D modeling and the steps involved in the 3D printing process. Specify the learning objectives related to these technologies and ensure they align with the overall goals of your project.
5. **STEAM Elements**: Break down your unit into its STEAM components, explaining how each subject area is integrated and contributes to the overall learning experience. Highlight how 3D modeling and printing play a role in each element.
6. **Syllabus**: Outline the lessons in your unit, specifying the subjects, topics, and learning objectives for each one. Emphasize how 3D modeling and printing will be used to achieve these objectives.
7. **Instructional Plan by Lesson**: For each lesson, provide a detailed plan that includes time allocation, teaching and learning activities, materials needed, and specific learning objectives. Make sure to include dedicated sections for 3D modeling and printing activities.
8. **Evaluation Plan by Lesson**: Define each lesson's evaluation criteria and methods, focusing on assessing your student's understanding and skills in 3D modeling and printing.
9. **Additional Resources**: List any additional notes, activity sheets, evaluation materials, and references that can support your lesson.

Dive In and Get Creative:

Following this template, you'll create structured and engaging lessons that turn traditional subject-based teaching into dynamic STEAM projects. Use 3D modeling and printing to inspire your students and foster a deeper understanding of integrated STEAM concepts. Let's bring those ideas to life!

Introduction to 3D Design and 3D Printing

AUTHORS (NAMES / SCHOOL / COUNTRY):

PHILIPPE KIRSCH / LYCÉE ALINE MAYRISCH / LUXEMBOURG

LESSON PLANNER

General Information

- **RELATED SUBJECTS:**
  Mathematics, Physics, Chemistry, Material Sciences, Arts
- **GRADE RECOMMENDATIONS:**
  Ages 13 -16
- **TOTAL ACTIVITY TIME:**
  90 minutes

Learning Objectives

- **THE IMPORTANCE OF LEARNING OBJECTIVES DURING THE LESSON:**

  Understand the process of 3D fabrication from the first idea to a finished object.

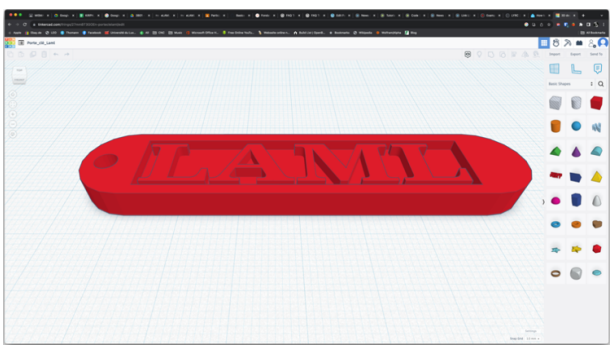
- **THE VALUE OF LEARNING OBJECTIVES AFTER THE LESSON:**

  Introduction to learning Objectives after the lessons, e.g. goals for follow-up (long term).

Overview

- **TOPIC & PURPOSE:**

  In this unit, the students will get a theoretical and practical introduction to 3D printing and the complete preceding design process. Starting from an existing keyring, students will learn how to create a basic 3D computer model of the desired object. Basic geometry knowledge, but also the ability to imagine objects in 3D are required. The use of a computer design software (Computer Aided Design, CAD) and the navigation in a 3D computer environment are necessary to achieve the proposed goal.



- **ACTIVITY PRE-REQUISITES:**
  None

3D Modeling and 3D Printing Integration

- **3D MODELING TOOLS AND SOFTWARE:**
  Three ways to create:
  - Participants can design their own 3D object using software on a computer or tablet, such as TinkerCAD, Shapr3D, Blender, OpenSCAD, or Fusion 360.
  - Participants can scan an existing object to create a copy (Qlone, ScandyPro).
  - Participants can download an object created by someone else (Thingiverse, Thangs, etc.).

- **3D PRINTING PROCESS:**
  Export and save – STL, OBJ, 3MF formats:
  - Once the CAO / CAD design is complete, the object can be saved or exported in an appropriate format. The most common file format for 3D printing is called STL.
  - The more advanced alternatives to STL are .OBJ and .3MF.
  - These file formats do not contain color information. For 3D color printing, you need to use file formats such as .X3D, .WRL, .DAE, .PLY, etc.

  Slicing:
  - Process of translating the 3D file into instructions that the 3D printer must follow using special software! Basically, slicing involves dividing the 3D model into hundreds or thousands of horizontal layers, telling the machine exactly what to do, step by step. Once the files are sliced, a new file format is generated, called G-code, with the extension .GCODE.

- **LEARNING OBJECTIVES RELATED TO 3D MODELING AND PRINTING:**

  The students will be capable of designing a 3D object from A to Z, by considering all different aspects (size, design, material properties and choices, function) of another object by transferring the learned skills to a new creation.

STEAM Elements

- **SCIENCE:**
  Physics- Chemistry (Material Sciences): different types of plastics with different properties (melting point, resistance to UV, acids, etc.)

- **TECHNOLOGY:**
  3D manufacturing using FDM printers.

  Geometry in 3D: orientation.

  Use of CAD software to design a 3D computer model.

Use of CAM software to translate the 3D model into program code the 3D printer can use to produce the actual part.

- **ENGINEERING:**
  Interaction of dimensions in the keyring, e.g. where to put the hole for the metal ring, so that it can freely move even with keys attached to the ring.
- **ARTS:**
  Design aesthetics

  Color of the finished part

  Elements of symmetry or asymmetry

  Size and aspect ratio of the keyring
- **MATHEMATICS:**
  What are the geometrical properties of the design of a keyring?

  Geometry: parallelism, shapes, aspect ratios

  Calculating dimensions base on constraints

Syllabus

- **LESSONS:**
  1), 2)
- **SUBJECTS:**
  1) Mathematics, Physics-Chemistry

  2) CAD-CAM software, 3D printer manipulation & control
- **TOPIC OF THE UNIT:**
  1) Introduction to 3D printing

  2) Do your own design in 45 minutes!
- **LEARNING OBJECTIVES DURING THE LESSON:**

  1) Understand the whole design and fabrication process in order to be able to take the necessary design decisions at the right moment.

  Which materials are suited for which applications?

  2) The students learn how to use the required computer tools to produce their own personal design of a keyring.

  Changing and adapting the design on the computer will let them decide about the aesthetics of the final product.
- **LEARNING OBJECTIVES AFTER THE LESSON:**

  1) The students are able to produce more complex structures and objects by themselves through understanding the whole process.

They are able to model their ideas using a combination of basic geometric shapes.

2) The students will be capable of designing a 3D object from A to Z, by considering all different aspects (size, design, material properties and choices, function) of another object by transferring the learned skills to a new creation.

Instructional Plan by Lesson

- **LESSON [1]:**
    - **TIME PLAN:**
      a) INTRODUCTION (10 minutes)

      b) LEARNING ACTIVITIES (35 minutes)
    - **TEACHING & LEARNING ACTIVITIES:**

      a) Quick presentation of the complete 3D design and production process.

      b) Details about each step of the design process. Which decisions must be made at what point? What are their implications?
    - **MATERIALS:**
      a) Presentation (PDF attachment, slides 1 to 8)

      b) Presentation (PDF attachment, slides 9 to 23)
    - **LEARNING OBJECTIVES:**
        - **INTRODUCTION:**
          Understanding the overall process and the order of the different steps.
        - **LEARNING ACTIVITIES:**
          Understanding the process more in detail and the importance of the different steps with their impact on the final result.
        - **WRAP-UP & EVALUATION:**
          /
        - **3D MODELING ACTIVITIES:**
          /
        - **3D PRINTING ACTIVITIES:**
          /
- **LESSON [2]:**
    - **TIME PLAN:**
      a) HANDS-ON ACTIVITIES (35 minutes)

      b) WRAP-UP & EVALUATION (10 minutes)
    - **TEACHING & LEARNING ACTIVITIES:**

      a) Use the learned guidelines to design and produce a physical object.

b) Optical inspection of the produced parts (keyrings), comparison of the students' work and discussing the differences (aesthetics, function, etc.).

- **MATERIALS:**
  a) A computer, a CAD software (TinkerCAD), a CAM software (PrusaSlicer), a 3D Printer (Prusa i_3 MK_3S+ & OctoPrint) and filament in different colors

  b) 3D-printed keyrings

- **LEARNING OBJECTIVES:**

  - **INTRODUCTION:**
    /

  - **LEARNING ACTIVITIES:**

    (Hands-on activities) Manipulate the technology (computer software, 3D printer) to produce the desired output.

  - **WRAP-UP & EVALUATION:**

    Critical analysis of the preceding choices for the final product, changing different aspects in order to get a better (smaller, nicer, lighter(?), etc.) product in the next iteration cycle. Self- improvement.

  - **3D MODELING ACTIVITIES:**
    Three ways to create:

    - Participants can design their own 3D object using software on a computer or tablet, such as TinkerCAD, Shapr3D, Blender, OpenSCAD, or Fusion 360.

    - Participants can scan an existing object to create a copy (Qlone, ScandyPro).

    - Participants can download an object created by someone else (Thingiverse, Thangs, etc.).

  - **3D PRINTING ACTIVITIES:**

    (Description of the 3D printing tasks, printer settings, and expected outcomes)

Evaluation Plan by Lesson

- **LESSON [1]:**

  - **EVALUATION CRITERIA:**
    Does the student understand / know the basic ideas of 3D design and printing?

  - **EVALUATION METHOD:**
    Questions & Answers

  - **3D MODELING AND PRINTING ASSESSMENT:**
    /

- **LESSON [2]:**
    - **EVALUATION CRITERIA:**
      Did the student make the desired product?
    - **EVALUATION METHOD:**
      Observation, comparing products, highlighting differences
    - **3D MODELING AND PRINTING ASSESSMENT:**
      /

Additional Resources

- **NOTES:**
  None
- **ACTIVITY SHEETS TO BE LINKED:**
  As attachment
- **EVALUATION MATERIALS TO BE LINKED:**
  None
- **REFERENCES / SUPPORTING MATERIALS TO BE LINKED:**

TinkerCAD: https://www.tinkercad.com/

PrusaSlicer: https://www.prusa3d.com/de/page/prusaslicer_424/

Prusa i_3 MK_3S+:

https://www.prusa3d.com/product/original-prusa-i3-mk3s-3d-printer-kit/

LAML Makerspace
3D Printing

Une introduction à l'impression 3D en 100 minutes.

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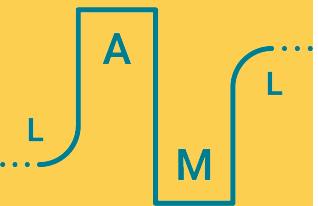
Lycée Aline Mayrisch Luxembourg

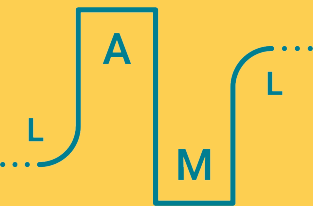
13 novembre 2023



0. Déroulement

Déroulement de l'atelier

1. Introduction : The LAML Makerspace
2. Généralités sur l'impression 3D
3. Principe du processus complèt
4. Création d'un objet 3D - Design
5. (P)réparation des données - Slicing
6. Impression 3D
7. Questions ?



1. Introduction

The LAML Makerspace

- Belle salle pour projets S32
- 8 imprimentes 3D Prusa i3 MK3/MK3S+
- 1 laser cutter Glowforge
- 1 foil cutter Brother Cameo4
- 4 stations de soudage
- 12 ordinateurs Mac mini
- Raspberry Pi's, Arduino's, Circuit Playgrounds, Kniwwelino's
- divers outils, pièces mécaniques et électroniques
- ...et notre propre page web :
  `http://makerspace.laml.lu`

Attention :

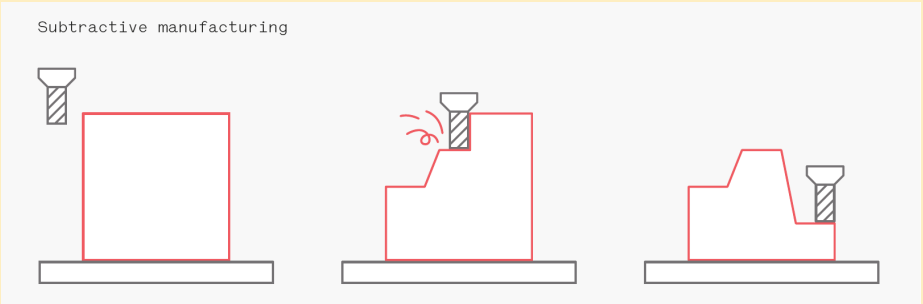
Le LAML Makerspace est ouvert tous les mercredis de 12 :00 à 13 :50 !

2. Généralités sur l'impression 3D

Fabrication soustractive

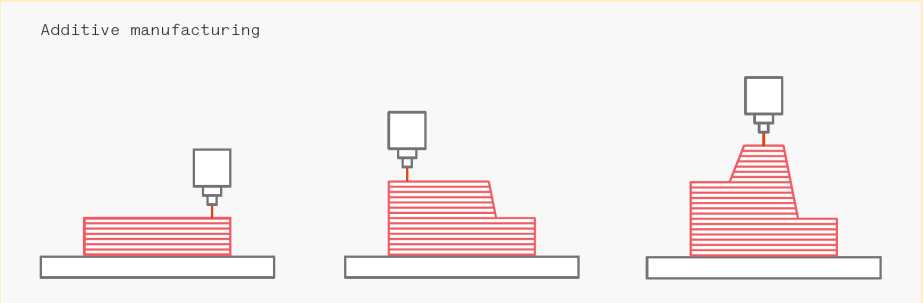
L'usinage CNC est une technologie de fabrication soustractive courante.

Contrairement à l'impression 3D, le processus commence généralement par un bloc de matériau solide et enlève de la matière pour obtenir la forme finale requise, à l'aide d'une variété d'outils rotatifs tranchants ou de fraises.



Fabrication additive

Les procédés de fabrication additive ou d'impression 3D permettent de fabriquer des pièces en ajoutant de la matière couche par couche. Les procédés de fabrication additive ne nécessitent pas d'outillage ou d'installations spéciales, de sorte que les coûts d'installation initiaux sont réduits au minimum.



Types d'impression 3D

- Stereolithography (SLA)
- Selective Laser Sintering (SLS)
- **Fused Deposition Modeling (FDM)**
- Digital Light Process (DLP)
- Direct Metal Laser Sintering (DMLS)
- Electron Beam Melting (EBM)

Matériaux utilisables [1]

- ABS
- TPE, TPU [2]
- **PLA** [3]
- HIPS, PVA [4]
- PETG [5]
- ASA [6]
- PC, PP
- PEEK [7]

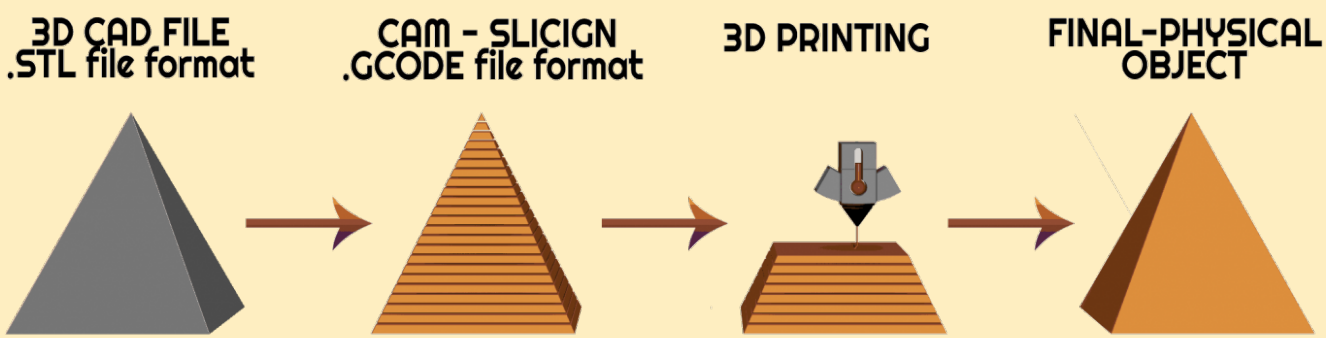
1. https://www.simplify3d.com/support/materials-guide/
2. **flexible**
3. **facile à imprimer, bon marché**
4. **solubles dans l'eau**
5. **convient pour la nourriture**
6. **résiste aux températures élevés et aux UVs**
7. **aussi résistant que de l'aluminium**

3. Principe de l'impression 3D

Étapes d'une impression 3D

1. Création (concevoir, numériser ou télécharger)
2. Exportation du fichier généré (.STL ; .OBJ ; .3MF ;)
3. Slicing (CAM - Computer Aided Manufacturing)
4. Impression
5. Enlèvement des supports, post-processing

Schéma



Imprimate 3D

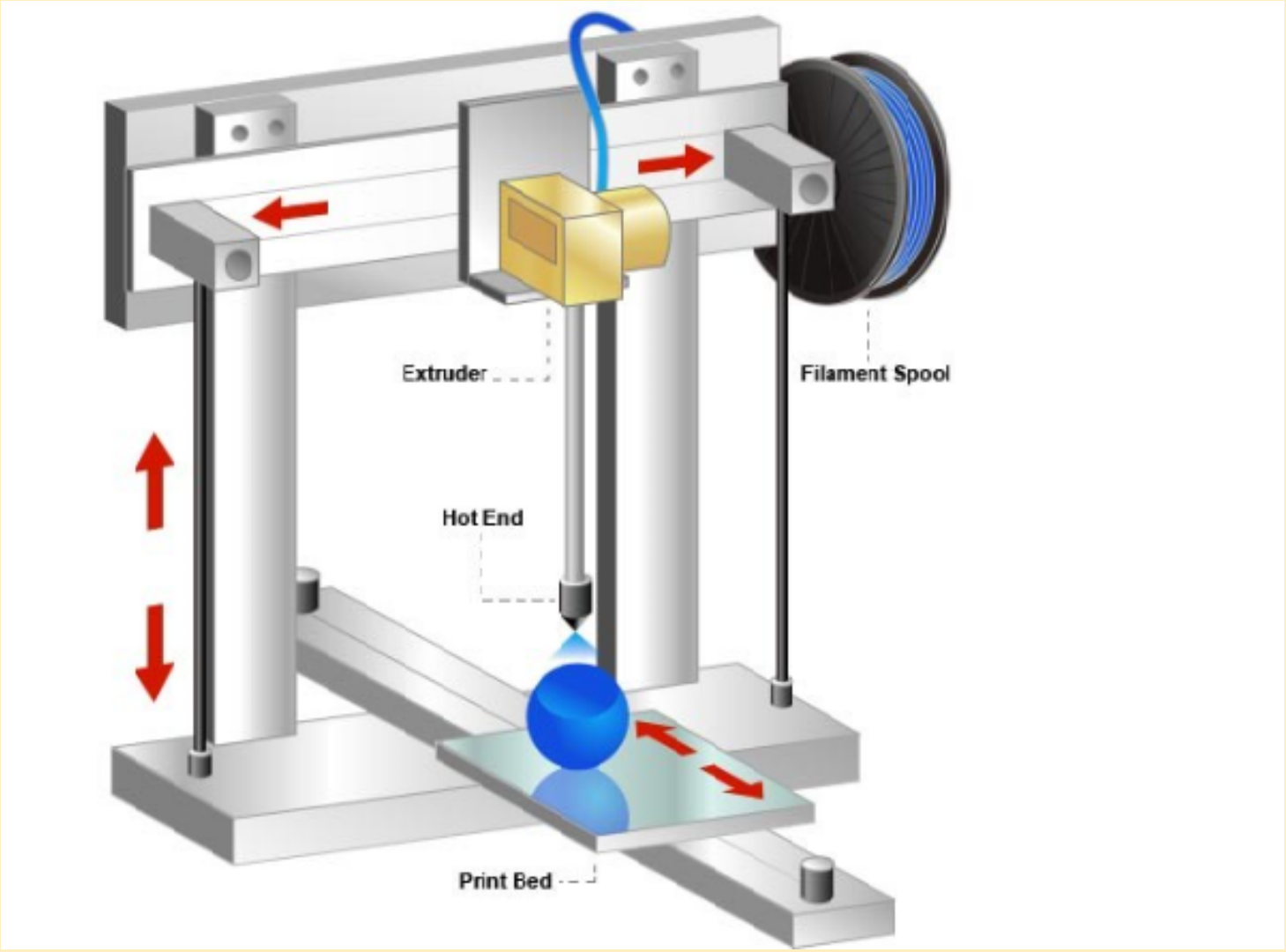


Figure – Schéma d'une imprimante 3D.

Tête d'extrusion

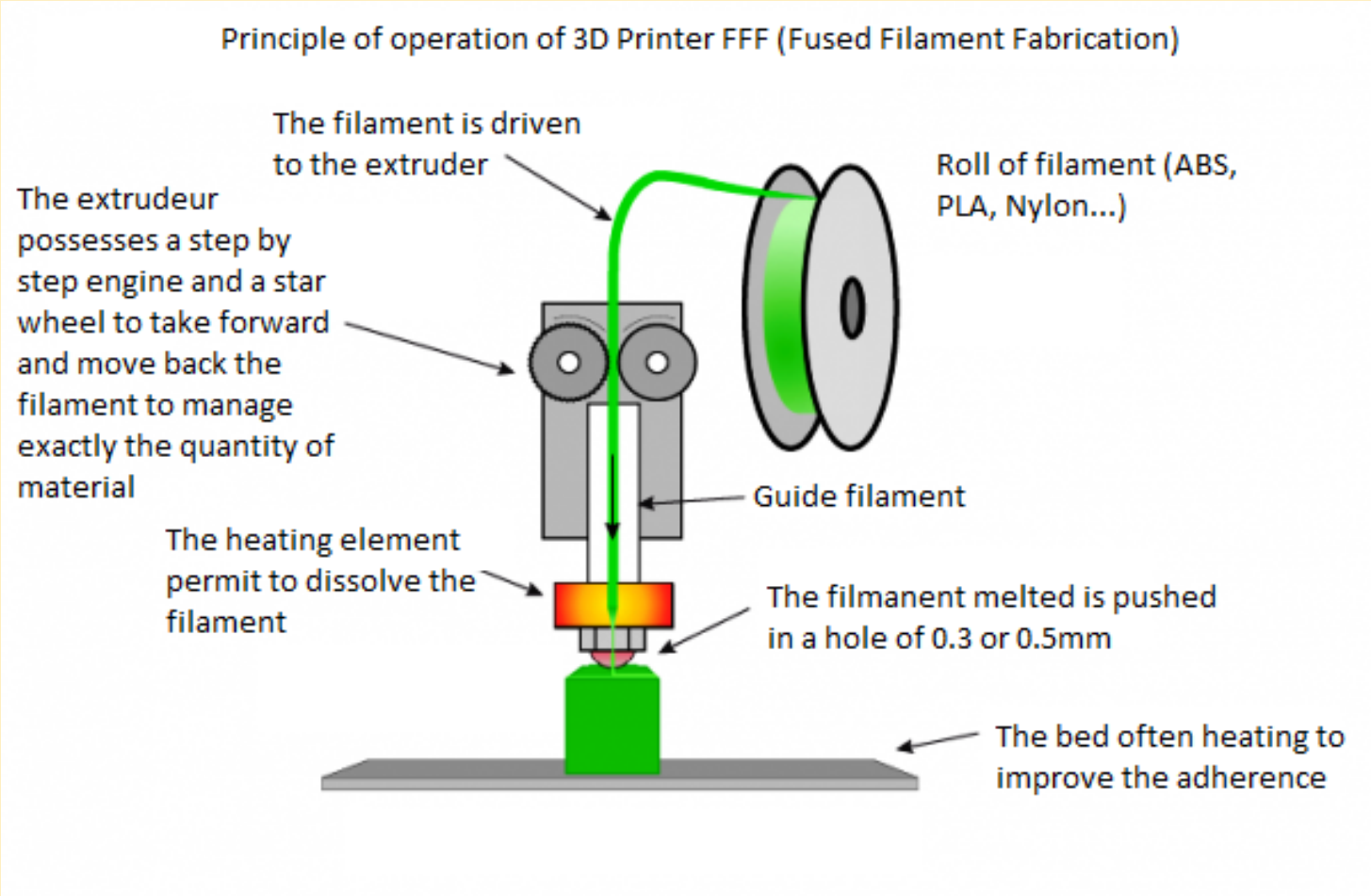


Figure – Schéma d'une tête d'extrusion (extruder).

4. Création d'un objet 3D

Création - 3 possibilités

- concevoir un objet 3D soi-même à l'aide d'un logiciel sur ordinateur ou tablette (TinkerCAD, Shapr3D, Blender, OpenSCAD, Fusion 360)
- numériser un objet existant pour en faire une copie (Qlone, ScandyPro)
- télécharger un objet réalisé par une autre personne (Thingiverse, Thangs, etc.)

Exportation, sauvegarde - STL, OBJ, 3MF

- Une fois terminé la conception CAO/CAD[8], il sauvegarder/exporter l'objet dans un format approprié. Le format de fichier le plus courant pour l'impression 3D est appelé STL[9].
- Les alternatives plus performantes à STL sont .OBJ et .3MF.
- Ces formats de fichier ne contiennent pas d'informations sur les couleurs. Pour l'impression 3D en couleur, vous devez utiliser des formats de fichier tels que .X3D, .WRL, .DAE, .PLY, etc.

8. Conception Assisté par Ordinateur / Computer Aided Design
9. STL signifie STereoLithography, du nom du tout premier procédé d'impression 3D.

5. Préparation des données - Slicing

Slicing

C'est le processus qui consiste à traduire le fichier 3D en instructions que l'imprimante 3D doit suivre à l'aide d'un logiciel spécial pour faire cela ! En gros, le découpage consiste à diviser ou à découper le modèle 3D en centaines ou milliers de couches horizontales, indiquant à la machine exactement ce qu'elle doit faire, étape par étape. Une fois les fichiers découpés en tranches, un nouveau format de fichier est généré, appelé G-code, avec l'extension .GCODE [10].

Logiciels de Slicing

- Slic3r [11]
- **PrusaSlicer** [12], dérivé de Slic3r
- SuperSlicer [13], dérivé de PrusaSlicer
- Cura [14]
- *Symplify3D* [15]

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10. Le code G est le langage de programmation principalement utilisé pour contrôler les machines-outils automatisées comme les imprimantes 3D et les CNC (Computer Numerical Controls). En un mot, le code G est le langage de la machine et ce que nous utilisons pour communiquer avec elle !

11. https://slic3r.org/

12. https://help.prusa3d.com/en/downloads/

13. https://github.com/supermerill/SuperSlicer

14. https://ultimaker.com/software/ultimaker-cura

15. https://www.simplify3d.com/

PrusaSlicer : Importation

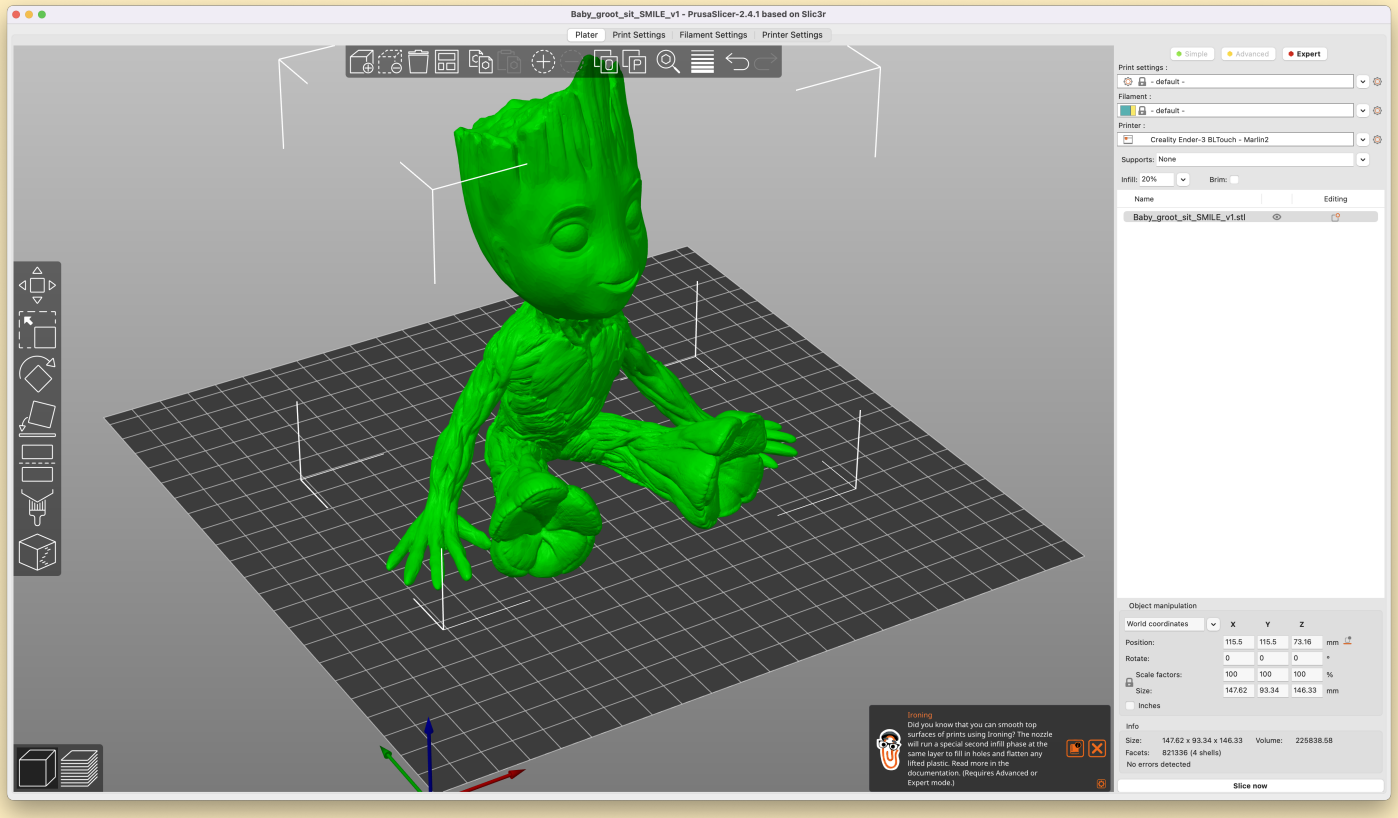


Figure – Fichier STL importé dans PrusaSlicer.

PrusaSlicer : Découpage

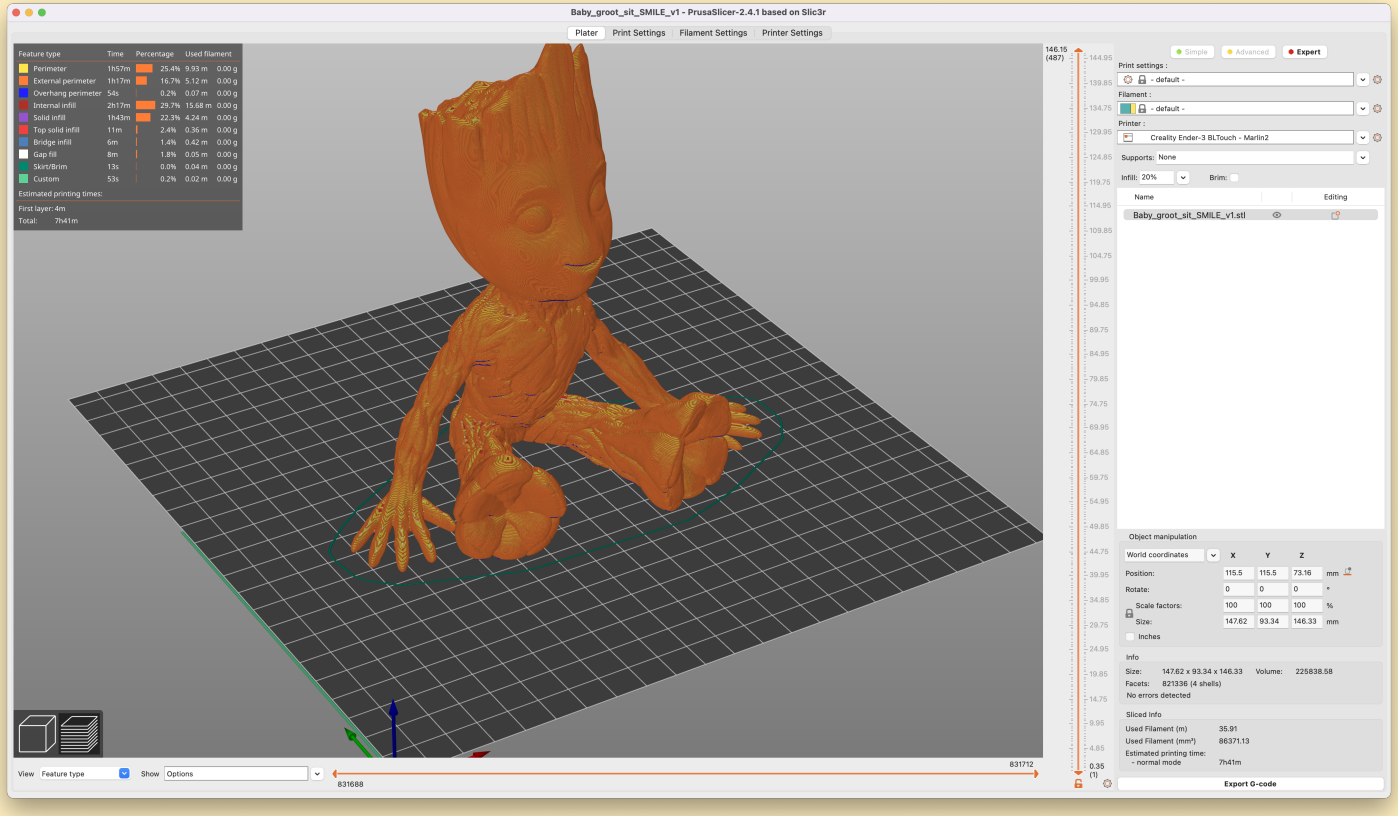


Figure – Fichier STL découpé par PrusaSlicer.

Prusaslicer : Vue en coupe

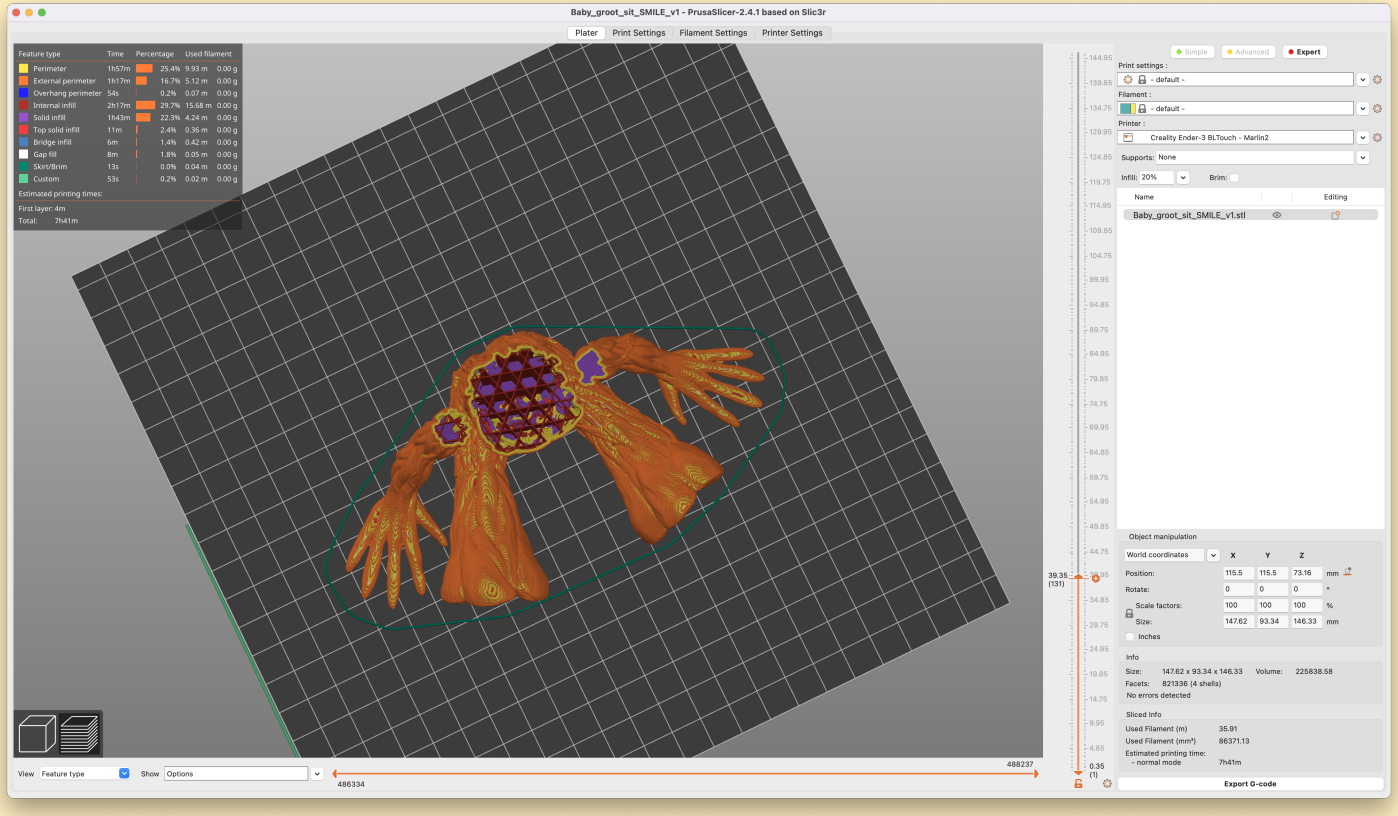
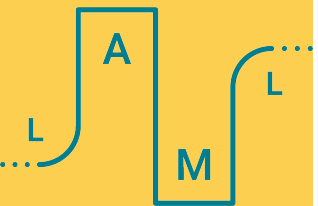


Figure – Coupe à travers le découpage.

6. Impression 3D



Impression via OctoPrint (Interface Web)

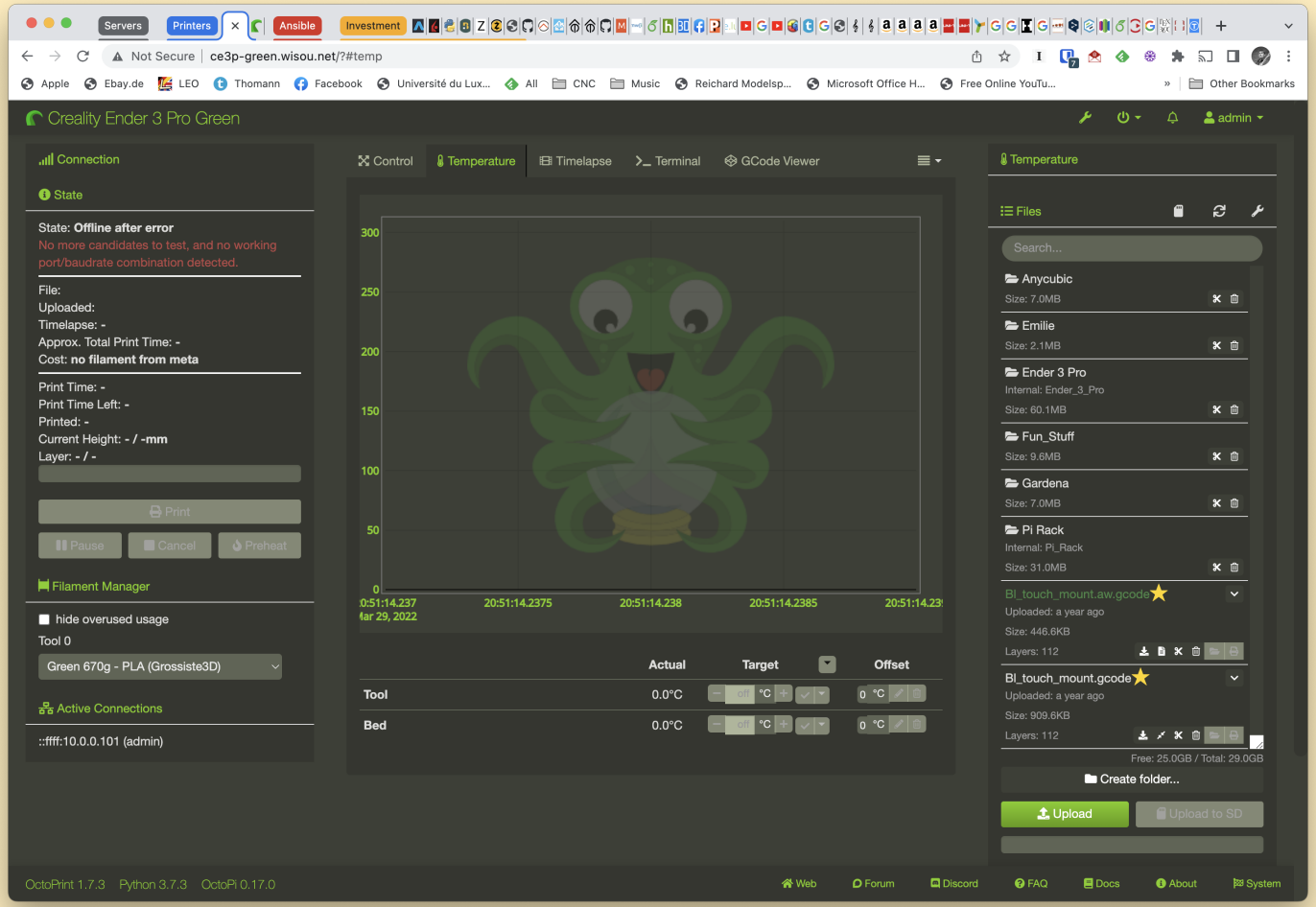


Figure – Interface web de OctoPrint.

Nos imprimantes 3D

- Prusa 01 : Prusa i3 MK3S+ (http://prusa01.local/)
- Prusa 02 : Prusa i3 MK3 (http://prusa02.local/)
- Prusa 03 : Prusa i3 MK3 (http://prusa03.local/)
- Prusa 04 : Prusa i3 MK3 (http://prusa04.local/)
- Prusa 05 : Prusa i3 MK3S+ (http://prusa05.local/)
- Prusa 06 : Prusa i3 MK3S+ (http://prusa06.local/)
- Prusa 07 : Prusa i3 MK3S+ (http://prusa07.local/)
- Prusa 08 : Prusa i3 MK3S+ (http://prusa08.local/)

Données de connexion

- Login : prusa
- Mot de passe : prusa

7. Questions - Divers

Merci pour votre participation !