REPORT ON FDM 3D PRINTING SKILL DEVELOPMENT PROGRAM

Volunteer report for 3d printing SDP conducted on dates 8th - 10th December, 15th - 17th December, 22nd - 24th December, 2025

Submitted by Sourav Thakkar, 25BIT205, B.Tech ICT. Date 10th January 2026

Acknowledgement

The successful execution of this Skill Development Program would not have been possible without the support provided by the AICTE-IDEA Lab jointly with the IIW-PDEU student chapter.

I would like to extend my gratitude to **Dr. Vishvesh J. Badheka** (Department of Mechanical Engineering, School of Technology)**,** our mentor and faculty coordinator for the skill development program, for his guidance and mentorship throughout this initiative. His vision for technical skill development has been a driving force for us. Dr. Badheka also oversaw the smooth conduction of the workshop, ensuring that everything proceeded seamlessly. He guided the coordinators every step of the way, providing insights and support that were important to the success of the program.

A special thanks to the organizing team—**Raj Pandya**, **Megh Raval**, and **Kushagra Patel** for their planning and management of the resources, scheduling and coverage of all relevant topics and bridging the gap between design and physical object. I also thank our coordinators Shaili Gupta and Dax Savaliya for their seamless coordination which ensured the smooth operation of all three batches conducted on various dates.

Index and program overview

• Introduction & Objective

The FDM 3D printing skill development program was designed as a hands-on program to take participants from basic knowledge to application level proficiency. The primary objective was to equip students with industry-relevant skills in Design for Additive Manufacturing (DfAM), Advanced Slicing, and Hardware Maintenance. Unlike standard workshops, this program also focused on power user skills such as tolerance testing, diagnosing mechanical failures, and parametric modeling.

The workshop also aimed to provide an in-depth understanding of the currently available 3D printing technologies along with the specific variations of FDM 3D printing machines. The designated method for signing up for the workshop was through the website:
https://theteam404.github.io/FDM-Workshop/
Wherein, students were asked to pick the batch of their choice.

• Batch Schedule & Size:

The Candidates for the program were divided into three batches to ensure personalized attention (limited to 20 students per batch). All sessions were conducted in December 2025. Each of the three batches spanned 3 days with morning and afternoon sessions each day. The timings for the first and second sessions were fixed at 10:00 AM - 1:00 PM, and 2:00 PM to 5:00 PM. The content covered in the 3 batches was consistent and identical.

The first, second and third batches were conducted from 8th - 10th December, 15th - 17th December and 22nd to 24th December.

- ## Detailed Curriculum (Day-wise)

  - ### Modules Covered In Day 1:

1. Intro to 3D printing : FDM/FFF vs. SLA/DLP/SLS.
2. Machine Fundamentals : Machine Kinematics (Cartesian vs. CoreXY vs. Delta)
3. Parametric Modelling & DfAM : Intro to Parametric CAD (SolidWorks)
4. Slicing 101 : Intro to basic slicers (OrcaSlicer)
5. Initiating the First Layer : Setup to start the first layer

The first day began with an introductory session led by the Mentor **Dr. Vishvesh J. Badheka** for the coordinators **Raj Pandya**, **Megh Raval**, and **Kushagra Patel**. After completing the participant attendance, the batch moved to Computer Lab C007 to begin the technical modules. The aim of the first day was to address the spectrum of 3D printing, introducing students to both hardware and software components to provide a broad overview. This allowed the second and third days to focus on specific details, technical nuances, troubleshooting, and building a deeper understanding.

Module 1 : 3D Printing Basics (1.5 Hours)

The session started with an overview of additive manufacturing. The coordinators explained the distinctions between different printing technologies, such as FDM/FFF, SLA, and SLS, and introduced essential terminology like Slicing, Tolerances, and Infill.

Module 2 : **Machine Fundamentals**

We covered the theory and anatomy of a 3D printer. This included a breakdown of individual machine parts and a discussion on printer kinematics, specifically comparing Cartesian, CoreXY, and Delta motion systems, filament driving and retraction mechanisms namely bowden and direct drive and the advantages and disadvantages of each.

Module 3: Parametric Modelling & DfAM (4 Hours)

The second half of the day focused on hands-on design using SolidWorks. **Kushagra** guided us with basic 2D sketching and quickly transitioned to 3D modeling. Students learned to use essential tools such as Extruded Boss/Base, Extruded Cut, Mirror Entities, and sketching on specific contours.

After designing individual components, the session moved to the Assembly environment. Participants learned how to assemble their parts using features like Standard Mates, Coincident relations, and Concentric alignment for circular faces.

The key aspect of the 3rd Module was the practical approach: the specific parts chosen for the design tutorial were components of a single larger mechanism. This meant students weren't just designing random shapes; they were building parts that they immediately used in the assembly phase to create a final product.

After the break, attendance was taken and the participants were divided into five teams of four members each for a rapid prototyping competition. The goal was to see which team could translate a 2D into a 3D model the fastest.

The coordinators provided specific sketches for two pairs of parts. The challenge required the teams to design these parts so they would slot fit perfectly together in the SolidWorks assembly environment. Winning team was the one who achieved this the fastest. This exercise was designed to help students practice converting 2D sketches into 3D objects efficiently under time constraints.

The competition was highly engaging, with the winning team completing their designs in just 10 minutes. As a reward, they were given a coupon for a free 3D print.

Module 4: Slicing 101 : OrcaSlicer (1.5 Hours)

This module focused on the basics of slicing. Participants were guided through the installation of **OrcaSlicer (v2.3.1)** and the configuration of machine profiles for the available printers. The coordinators moved through the room to provide individual troubleshooting for students facing installation or setup issues.

Once the software was ready, the session covered the workflow from CAD to G-code. Key topics included:

⦿ **Exporting Files:** Best practices for exporting designs from CAD software in .STL and .3MF formats.

⦿ **Interface Navigation:** Understanding the three main views in OrcaSlicer: *Prepare* (for setup), *Preview* (for analyzing the layers), and *Device* (for monitoring).

⦿ **Model Manipulation:** Hands-on training with essential tools including Auto-Orient, Move, Rotate, Measure, and the "Lay on Face" tool to optimize printing angles.

⦿ **Slicing & Export:** The module concluded with generating the "Slice Plate" and exporting the final G-code file for the printer.

Module 5: Initiating The First Layer (1.5 Hours)

The final module of the day addressed the most critical part of a successful print: the first layer. This session was a mix of theory and planning.

We discussed how to identify the correct face of a 3D model to place on the build plate for high stability. The coordinators explained the theory behind bed adhesion, detailing why it fails and how to prevent warping. Practical strategies to prevent these were taught, including the use of **Skirts** (to prime the nozzle) and **Brims** (to increase surface area for better grip).

- ## Modules Covered In Day 2:

6. Slicer Power-User : Maximizing Quality & Strength, Managing supports, Infill Patterns
7. Mastering G-code Parameters : Adaptive Layer Height, Line Width, Ironing.
8. Calibration & Torture Testing : Printing & analyzing calibration objects.
9. Filaments 101 : Beyond PLA; PETG, TPU, CF infused filaments, ABS, ASA & Nylon

The second day started with attendance. **Dr. Vishvesh Badheka** briefed us on the plan for the day, highlighting which technical parts we needed to focus most on. We then moved to Computer Lab C007. Unlike the first day which was about basics, Day 2 was designed to get deep into the technical settings of the slicer software.

Module 6: Slicer Power-User

Raj briefed us on the need for advanced control and then we continued using OrcaSlicer, moving beyond the default settings. The students were taught how to tweak specific parameters to get better results. We broke this down into four areas:

⦿ **Quality:** Adjusting layer height, line width, and seam positions to make the print look better.

⦿ **Strength:** Changing the number of walls, top layers, and choosing the right infill patterns to make parts stronger.

⦿ **Speed:** Tweaking acceleration and travel speeds to print faster without losing quality.

⦿ **Supports:** We compared "Tree" vs "Normal" supports and showed how to use the "Support Painting" tool to manually place supports exactly where needed. We also looked at features like "Fuzzy Skin" and using Brims to help prints stick better.

Module 7: Mastering G-code Parameters In this session, we looked at the actual code that runs the printer. We opened G-code files in Notepad to understand the structure and how to read it. We then discussed tuning settings for specific materials—like adjusting retraction to stop stringing, finding the right bed temperatures, and managing fan speeds for cooling.

Module 8: Calibration and Torture Testing After the break and attendance, we moved from the computers to the actual 3D printers. Students got hands-on experience navigating the printer menus. They practiced:

- Auto and Manual Bed Leveling using the paper method.
- Setting the "Z-Offset" (getting the nozzle height perfect).
- Copying files to the memory card and starting a print.

To test the machines, we printed standard test models like the **3DBenchy** and other torture tests. These helped show how the printer handles overhangs, fine details, and stringing.

Module 9: Filaments 101 The final module of the session was about materials. **Megh** ran us through the basics of filaments, including their density and cost. We also discussed important factors like moisture absorption (hygroscopy), melting points, and safety regarding fumes (VOCs). While we mentioned engineering materials like ABS and Nylon, the main focus was on easy to access materials like PLA, PETG, and TPU.

- ## Modules Covered In Day 3:

10. Print Finishing Techniques : Support Removal, Sanding, Painting
11. Advanced Slicing : Slicing complicated models, print-in-place mechanisms
12. Maintenance & Diagnostics : identifying and fixing common failures
13. Hardware Deep Dive : Disassembly, Print head teardown

Day 3 was set up to be the most hands-on day of the workshop, ensuring students got familiar with the physical machines. The day began with attendance, followed by a practical guide from **Dr. Vishvesh Badheka** on how to progress after the workshop in CAD and 3D printing, how to select and buy a personal 3D printer.

To get the candidates focused, we organized a pop-quiz covering slicer features, brims, and filament types. The losing team was assigned the task of washing the printer build plates. This wasn't just a penalty; it taught another important segment: cleaning the print bed and how a clean bed, free of dust and skin oils, is essential for good adhesion. Throughout the day, the printers were running in the background, printing the actual parts that the students had designed in SolidWorks on their own.

Module 10: Print Finishing Techniques

Raj walked us through the post-processing phase. He demonstrated how to finish printed objects using sandpaper of various grits to get a smooth surface. We also looked at the appropriate tools for removing support material without damaging the model, highlighting how to use the sandpaper to reach smaller crevices and how not to damage thin extrusions, and discussed which chemicals work best as primers for painting and which ones to avoid.

Module 11: Advanced Slicing

Kushagra led the module on advanced slicer settings. The main focus was on "print-in-place" mechanisms—models with moving parts that are printed in one go. We learned how to select the right layer heights and tolerances to ensure these complex mechanisms work right off the printer.

Module 12: Maintenance & Diagnostics After the break, we moved to maintenance. This module covered the most common problems students might face. We discussed what to check before starting a print and how to troubleshoot issues like nozzle clogging, poor retraction, Z-offset errors, and bed adhesion failures. We also covered mechanical issues like vibration, layer shifting, and how to properly tension the belts.

Module 13: Hardware Deep Dive

For the final technical module, **Megh** disassembled his personal printer to give a live demonstration of the internal components. We learnt about the stepper motors, control mainboard, power supply unit (PSU), wiring, and thermistors. We also covered practical skills like changing a nozzle, checking bed leveling sensors, and the mechanical differences between Direct Drive and Bowden extruders.

We also went through the available printers in the Tinkering Lab to look at the different machines available, including the **Creality Ender 3 Neo**, **Ender 5 Plus**, **Raise3D N2**, **Anet E12**, and briefly looked at the resin printers from Creality and Elegoo.

Hardware And Software Used:

Hardware:

- **Printers:**

1. **Bambu Labs A1** : Courtesy Raj Pandya (Personal Printer)

2. **Anycubic Kobra 2 Neo**: Courtesy Megh Raval (Personal Printer)

3. **Creality Ender 3 Neo**: from Tinkering Lab (PDEU C block workshop)

4. **Elegoo Neptune 4 Pro**: Research printer Courtesy Dr. Vishvesh J Badheka (IIW Research Lab, C block workshop)

- **Filaments:**

1. Esun PETG: **AICTE** Idea Lab (PDEU)
2. Generic PLA: **AICTE** Idea Lab (PDEU)
3. Generic TPU: **AICTE** Idea Lab (PDEU)
4. Esun PLA + 10% CF infused: **IIW** Research

- **Computers For Running SolidWorks :** C Block Computer Lab C-007 (PDEU)

Software:

- **CAD software:** SolidWorks 2025

- **Slicer:** OrcaSlicer 2.3.1 (Primary), BambuStudio 2.04(Secondary for Bambu Lab A1)

Website to access pre-made testing models : makerworld.com

Gallery, Outcomes & Conclusion:

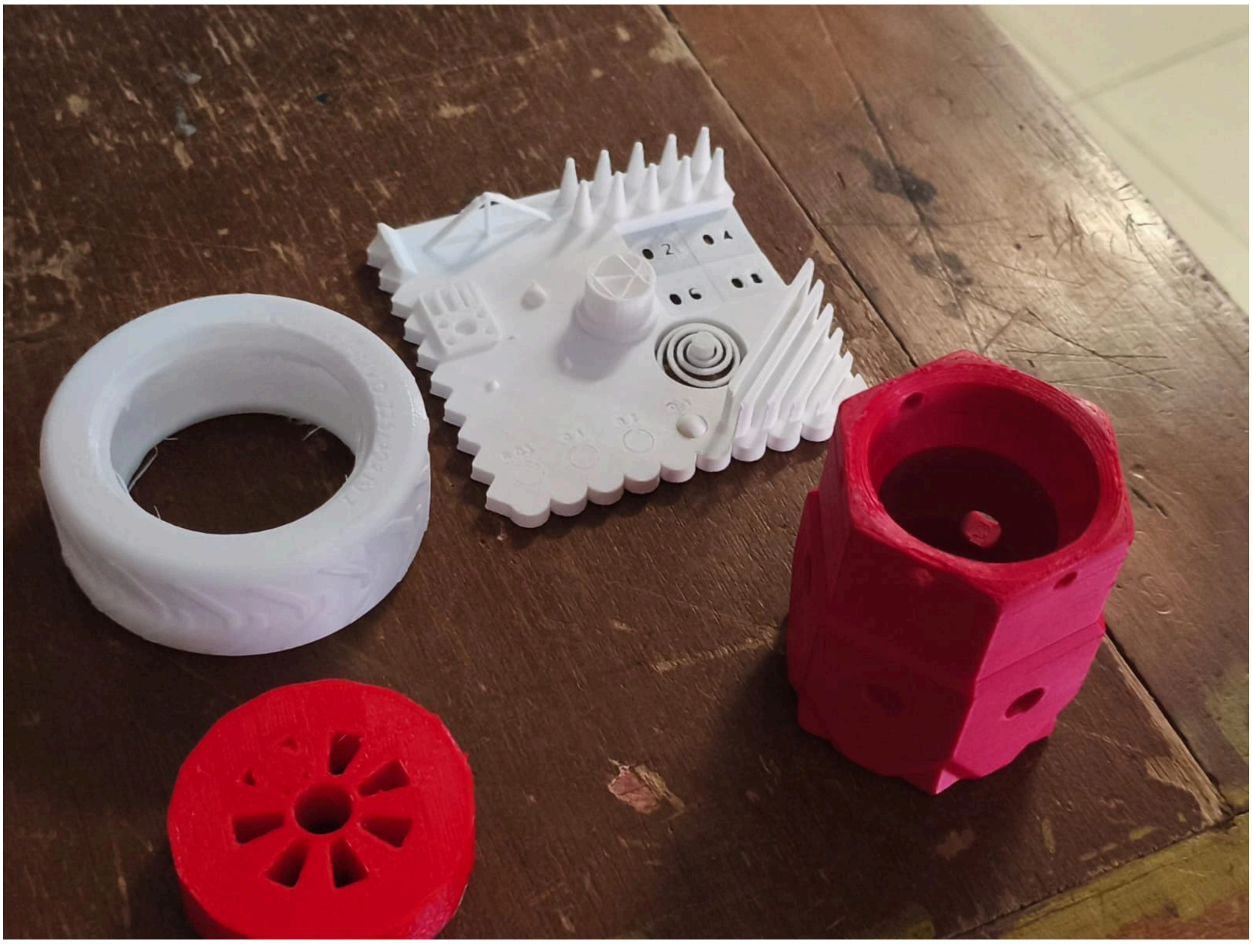
Gallery:

Photo Of Batch 1

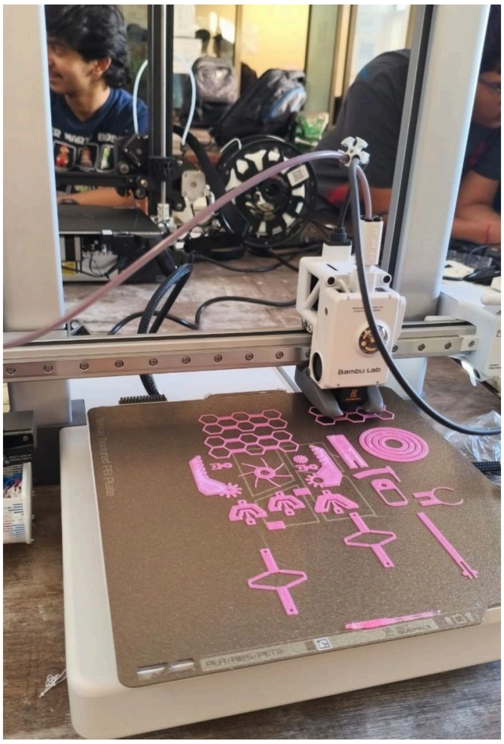
Photo Of Batch 2

Photo Of Batch 3

Photo of students coordinating to fix a problem in the slicers



Results of the Calibration and Torture Testing in Module 8



Left: Coordinator Kushagra Setting up the Elegoo Neptune 4 Pro for printing.`

Right: Bambu Lab A1 printing a variety of mechanisms made by the students.

Outcomes:

Participant Diversity One of the biggest successes of this Skill Development Program was the diversity of the participants. We didn't just have Mechanical Engineering students; the workshop hosted students from **Biotechnology, Computer Science, Chemical Engineering, and ICT**.

It was also a mix of experience levels, with participants ranging from 1st-year undergraduates all the way to M.Tech scholars. We were particularly proud to host **two students from GEC Patan**, who traveled to Gandhinagar specifically to attend this workshop, highlighting the demand for high-quality technical training.

Skill Acquisition By the end of the program, the participants had acquired extensive knowledge in the entire 3D printing workflow—from digital design to physical product. They moved past the basics and gained a deep understanding of prototyping.

Confidence The most significant outcome was the shift in confidence. Students who had never touched a 3D printer before left the workshop with the ability to independently design a part, slice it with the correct settings, and operate the machine to successfully print it.

Conclusion:

The workshop wrapped up with students collecting their own self-designed 3D prints, confident in their ability to design parts. Aligning with the workshop's motto:
"CAD it! Print it! Hold it!".