Design Brief

Addressing Irregular Surface Finish in 3D Printing Operations

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Executive Summary

This design brief document outlines a thorough training program aimed at improving the surface finish quality of 3D prints, reducing failed prints, and consistently delivering high-quality results. The program targets operators, managers, and supervisors within the 3D printing divisional team and focuses on advanced slicer settings, troubleshooting techniques, filament handling, nozzle calibration, and bed leveling, along with coaching and mentorship skills.

The training program follows a blended learning approach, combining self-paced eLearning modules and face-to-face training sessions. Learners will have access to interactive multimedia lessons, simulations, and hands-on practice to enhance their understanding and proficiency in the targeted areas. The program is designed to be completed within a 4 week timeframe to ensure minimal disruption to daily work responsibilities.

The instructional strategy addresses irregular surface finish issues through four modules, each covering specific sub-topics and learning objectives. Operators will gain expertise in optimizing slicer settings, troubleshooting surface finish problems, and critical tasks such as filament handling and nozzle calibration. Managers and supervisors will develop coaching and mentoring skills to support their team members and ensure optimal printing conditions.

Assessments, including formative and summative evaluations, will be integrated throughout the program to monitor learners' progress and measure their comprehension and application of knowledge and skills. Confirmative assessments will validate the training program's effectiveness by collecting data on reduced failed prints and improved surface finish quality.

The implementation plan outlines a structured approach for the deployment of the training program. The training plan will begin on September 4, 2023 and will be delivered through a combination of online and offline methods. Communication channels such as email notifications, newsletters, bulletin boards, and team meetings will be utilized to ensure effective communication and support for learners.

Overall, this training program aims to equip operators, managers, and supervisors with the necessary competencies to address surface finish issues and consistently deliver high-quality 3D prints. By following the outlined instructional intervention, Company XYZ can expect improved performance and a positive business impact.

Purpose Statement

The purpose of this training program is to equip learners with the necessary knowledge and skills to improve the surface finish quality of 3D prints, reduce failed prints, and deliver high-quality prints consistently.

Instructional Goals

1. Operators will be able to analyse and apply advanced slicer settings to achieve desired print quality outcomes.
2. Operators will be able to actively engage in troubleshooting and resolving issues during the printing process, demonstrating increased initiative and problem-solving skills.
3. Operators will be able to apply best practices for filament loading, nozzle calibration, and bed leveling to ensure consistent and accurate 3D prints.
4. Managers and supervisors will be able to demonstrate effective oversight and support in ensuring the implementation of best practices, providing guidance, and assuring optimal printing conditions.

Design Strategy Overview

This design strategy will focus on the three instructional interventions outlined in the needs analysis report. The program will be a comprehensive training initiative delivered through a blended learning approach, combining face-to-face training sessions and online self-paced learning.

The training program aims to equip operators, managers, and supervisors with the necessary knowledge and skills to improve surface finish quality, reduce failed prints, and consistently deliver high-quality 3D prints. The program will focus on advanced slicer settings, troubleshooting techniques, filament loading, nozzle calibration, bed leveling, and lastly, coaching and mentorship for managers and supervisors. The high level outline is described below. (*See Appendix A for a detailed topic analysis.)*

1. Module 1: Advanced Slicer Settings
2. Module 2: Troubleshooting Techniques for Surface Finish Improvement
3. Module 3: Filament Loading, Nozzle Calibration, and Bed Leveling Best Practices
4. Module 4: Coaching and Mentorship for Managers and Supervisors

From the learner survey, it was identified that the learners have received basic training on operating the printers but lack the advanced knowledge of slicer settings. Therefore, the program will not focus on introduction of basic slicer settings. The training program will be divided into four modules, each addressing specific sub-topics and learning objectives.

The program will be designed to be completed within a reasonable timeframe that allows learners to acquire the necessary knowledge and skills without disrupting their daily work responsibilities. Based on the complexity of the topics and the depth of the instruction, the program is estimated to be completed over a period of 4 weeks. This duration includes both face-to-face training sessions and online modules.

To accommodate different learning preferences and maximize learning outcomes, the program will utilize a blended learning approach, combining self-paced eLearning lessons and face-to-face training sessions. The online component will consist of modules that learners can access at their convenience, allowing them to progress through the material at their own pace. Face-to-face training sessions will be conducted to provide hands-on practice, interactive discussions, and immediate feedback. This combination of delivery strategies will ensure an engaging learning experience for the target audience.

Learner Audience

The target learners for this instructional intervention include 16 operators, 2 operation managers, and 4 shift supervisors who form the 3D printing divisional team. The learner analysis revealed varying types of experiences within this audience.

The operators have received basic training on operating the printers, but the analysis indicates potential knowledge gaps in advanced slicer settings, troubleshooting techniques, and critical tasks such as filament loading, nozzle calibration, and bed leveling. Therefore, it is important to focus on advanced slicer training, printing parameter best practices, and troubleshooting techniques to bridge these gaps and enhance their proficiency in these areas.

The managers and supervisors, on the other hand, are highly experienced technically but lack specific training in coaching and mentorship for the 3D printing team. They require tailored modules to develop their abilities to provide effective oversight, support, and guidance to the operators. Emphasizing intrinsic motivation, quality standards, and continuous improvement initiatives will be essential to their role in ensuring optimal printing conditions and facilitating knowledge transfer within the team.

Instructional Strategy

The instructional strategy for addressing irregular surface finish in 3D prints and reducing failed prints comprises four modules. Module 1 focuses on advanced slicer settings, teaching operators how to optimize print settings for surface finish quality through eLearning lessons and interactive simulations. Module 2 provides troubleshooting techniques for surface finish improvement, delivered through instructor-led sessions with demonstrations, group discussions, and hands-on exercises. In Module 3, operators learn proper procedures for filament loading, nozzle calibration, and bed leveling through hands-on training sessions. The final module, Module 4, targets managers and supervisors, offering eLearning lessons with branching simulations to enhance their coaching and mentoring skills, emphasizing effective communication, guidance, and adherence to quality standards.

(See Appendix B for a detailed breakdown of learning objectives, activities, and assessments.)

The training program encompasses a range of instructional delivery methods, including eLearning lessons, instructor-led sessions, hands-on practice, demonstrations, group discussions, and branching simulations. Learners have the flexibility to complete eLearning modules at their own pace, while instructor-led sessions provide face-to-face interaction and practical application. Throughout the modules, assessments will be conducted to evaluate learners' understanding and proficiency, ensuring they acquire the necessary knowledge and skills to address surface finish issues effectively.

By following this comprehensive instructional strategy, operators will gain expertise in optimizing slicer settings, troubleshooting surface finish problems, and performing critical tasks like filament handling and printer calibration. Managers and supervisors will also develop coaching and mentoring skills to support their team members. The blended delivery approach and ongoing assessment will enhance the knowledge and capabilities of its operators, leading to improved surface finish quality and a reduction in failed prints.

Assessment Strategy

The assessment strategy for the training program will include both formative and summative assessments to evaluate learners' understanding and proficiency in addressing the irregular surface finish issue and improving the quality of 3D prints.

Formative assessments will be conducted throughout the training program to provide ongoing feedback and support to learners. These assessments may include knowledge check questions, in-class activities, group discussions, and practice simulations. The purpose of formative assessments is to gauge learners' progress, identify areas of improvement, and provide immediate feedback to guide their learning journey.

Summative assessments will be administered at the end of each module topic to evaluate learners' overall comprehension and application of knowledge and skills. These assessments will consist of quizzes, image-based identification tasks, case studies, and problem-solving scenarios. The summative assessments will evaluate operators, managers, and supervisors' ability to apply advanced slicer settings, troubleshoot print quality issues, perform filament loading, nozzle calibration, and bed leveling accurately, and demonstrate effective coaching and mentorship skills, taking into account their respective roles and responsibilities within the 3D printing process.

In addition to formative and summative assessments, confirmative assessments will be utilized to validate the effectiveness of the training program. Confirmative assessments involve collecting data to verify the impact of the training on reducing failed prints and improving surface finish quality. This data may include post-training quality reports, performance metrics, and feedback from the Quality Control (QC) department. The confirmative assessments will provide valuable insights into the effectiveness of the instructional interventions and help determine the success of the training program in achieving the desired outcomes.

The assessment strategy aims to provide an extensive evaluation of learners' knowledge and skills while also validating the impact of the training program. By utilizing formative, summative, and confirmative assessments, Company XYZ can ensure that learners are equipped with the necessary competencies to address the irregular surface finish issue effectively and consistently deliver high-quality 3D prints.

Implementation Plan

The deployment of the solution will follow a structured approach to ensure effective delivery and successful implementation. The training program will be launched on September 4, 2023, with a phased approach to accommodate different groups of learners.

The general delivery methods will encompass a blend of online and offline approaches to cater to diverse learning preferences and logistical considerations. eLearning lessons will be developed to provide learners with self-paced learning opportunities. These lessons will include interactive multimedia elements, simulation activities, and knowledge check questions to engage learners and assess their understanding.

Instructor-led sessions will be conducted to provide hands-on practice, demonstrations, group discussions, and practice exercises. These sessions will allow learners to apply their knowledge and skills in a practical environment under the guidance of experienced instructors. The instructor-led sessions will be scheduled at regular intervals throughout the implementation period.

The expected delivery and completion dates for the training program will depend on the specific timeline set for each module. Each module will have a defined duration, taking into consideration the length of the topics and the required practice time. It is estimated that the entire training program will be completed within 4 weeks from the launch date.

Communications will be delivered through various channels, including email notifications, internal newsletters, bulletin boards, and team meetings. Additionally, a dedicated support channel will be established to address any queries or concerns raised by the learners during the implementation process.

Overall, the implementation plan aims to ensure a smooth and effective deployment of the training program, considering the different delivery methods, the phased approach, the expected completion dates, and the communications strategy. Through careful planning and execution, the training program will enable operators, managers, and supervisors to enhance their skills, improve their performance in 3D printing processes, and contribute to the overall success of the instructional intervention.

(See appendix C for a detailed breakdown of the implementation plan.)

Appendix A

Table 1 Training Program Outline

Module	Outline	Topics	Delivery	Audience
1	Advanced Slicer Settings	• Understanding slicer software and its advanced features • Optimizing print settings for surface finish quality	• eLearning lessons • Simulation activities	16 Operators
2	Troubleshooting Techniques for Surface Finish Improvement	• Identifying common issues related to surface finish • Analysing and resolving print quality problems	• Instructor-led sessions • Hands-on practice • Demonstrations, group discussions, and practice exercises	16 Operators
3	Filament loading, Nozzle Calibration, and Bed Leveling	• Proper procedures for filament loading and unloading • Calibrating the nozzle for precise extrusion • Leveling the print bed for consistent adhesion	• Instructor-led sessions • Hands-on practice • Demonstrations, group discussions, and practice exercises	16 Operators
4	Coaching and Mentorship	• Effective communication and guidance • Promoting intrinsic motivation and adherence to quality standards • Creating a culture of continuous improvement	• eLearning (branching simulation) lessons	2 Operation managers 4 Shift supervisors

Appendix B

Table 2 Instructional Strategy

Module 1: Advanced Slicer Settings			
Topics	**Learning Objectives**	**Activities**	**Assessment**
Understanding slicer software and its advanced features	Given interactive tutorials and presentation slides, learners will be able to identify the advanced features and functionalities of slicer software with 80% accuracy.	• Engaging video highlighting the importance and impact of slicer software in achieving high-quality prints. • Multimedia slides with interactive tutorials. • Step-by-step instructions and real-life examples in lesson content slides.	**Formative**: Knowledge check questions within the eLearning lesson. **Summative**: Conduct a final quiz on the presented content at the end of lesson.
Optimizing print settings for surface finish quality	Given a set of print specifications in the demo slicer software, learners will be able to stimulate a print that has a surface finish rating of 5.	• Brief review of the advanced features of the slicer software and print settings. • Step-by-step instructions in the demo slicer software. • Visual aids and examples of a successful print. • Practice simulation task.	**Formative**: Test learners on their ability to generate a successful print in the practice simulation task. **Summative**: Conduct a final quiz on print specifications at the end of lesson.
Module 2: Troubleshooting Techniques for Surface Finish Improvement			
Topic	**Learning Objectives**	**Activities**	**Assessment**
Identifying common issues related to surface finish	Given a failed print, learners will be able to identify common surface finish issues with 80% accuracy.	• Showcase of a series of failed 3D prints with various surface finish issues, such as layer lines, rough surfaces, or inconsistent texture. • Brief discussion with Q&A session. • Interactive presentation with clear explanations and examples of surface finish issues. • Demonstration of specific techniques for identifying common issues. • Present a series of failed prints and ask learners to identify specific issues present and document them in a worksheet.	**Formative**: Assess learner's worksheet from the in-class activity for accuracy. **Summative**: Conduct an end of lesson quiz which can include multiple choice questions or image-based identification tasks.

Analysing and resolving print quality problems	Given a failed print, learners will be able to analyse and troubleshoot print quality problems with 80% accuracy.	• Brief discussion to recall fundamental concepts of layer adhesion, dimensional accuracy and surface defects. • Demonstration of common problems, including examples of under extrusion, over extrusion, warping, and layer shifting. Followed by the explanation of potential causes behind these issues. • Step-by-step guidance on how to analyze and troubleshoot print quality problems systematically. • Hands-on activity. Learners are presented with multiple print quality scenarios and are required to analyze and troubleshoot the problems.	**Formative**: Evaluate the in-class activity for learners' accuracy in identifying the problems and selecting appropriate solutions. **Summative**: Conduct an end of lesson assessment which can include a case study or image-based problem solving.
Module 3: Filament loading, Nozzle Calibration, and Bed Leveling			
Topic	**Learning Objectives**	**Activities**	**Assessment**
Proper procedures for filament loading and unloading	Given a 3D printer and filament material, learners will be able to load and unload filament, following proper procedures and guidelines.	• Short video demonstrating the importance of proper filament loading and unloading. • Brief discussion to recall previous experiences. • Step-by-step instructions and guidelines for filament loading and unloading, using visual aids and demonstration videos. • Presentation slides on tips and best practices to ensure proper filament feeding and alignment. • Hands-on activity. Practice loading and unloading filament on a 3D printer under the guidance of an instructor.	**Formative**: Evaluate the in-class activity for learners' ability to load and unload the filament correctly. **Summative**: Conduct a final quiz on filament loading/unloading procedures, guidelines and best practices.

Calibrating the nozzle for precise extrusion	Given a 3D printer and an uncalibrated nozzle, learners will be able to calibrate the nozzle, under conventional circumstances.	• Short video demonstrating the importance of calibrating nozzle. • Brief discussion to recall previous experiences. • Step-by-step instructions and guidelines for nozzle calibration, using visual aids and demonstration videos. • Presentation slides on tips and best practices to ensure proper nozzle calibration. • Hands-on activity. Practice nozzle calibration on a 3D printer under the guidance of an instructor.	**Formative**: Evaluate the in-class activity for learners' ability to calibrate the nozzle precisely. **Summative**: Conduct a final quiz on nozzle calibration procedures, guidelines and best practices.
Leveling the print bed for consistent adhesion	Given a 3D printer, learners will be able to level the print bed, under conventional circumstances.	• Short video demonstrating the importance of leveling the print bed. • Brief discussion to recall previous experiences. • Step-by-step instructions and guidelines for leveling the print bed. • Presentation slides on tips and best practices to ensure proper leveling of the print bed. • Hands-on activity. Practice leveling the print bed on a 3D printer under the guidance of an instructor.	**Formative**: Evaluate the in-class activity for learners' ability to level the print bed correctly. **Summative**: Conduct a final quiz on print bed leveling procedures, guidelines and best practices.
Module 4: Coaching and Mentorship			
Topic	**Learning Objectives**	**Activities**	**Assessment**
Effective communication and guidance	Given a branching scenario activity, managers and supervisors will be able to demonstrate effective communication and guidance techniques under real-life simulated circumstances.	• This will be a soft skills training so an eLearning lesson with a branching activity is used. • Learners will experience the consequences of their decisions in a low risk, real-life scenario, while learning the necessary soft skills for effective communication and guidance.	Assess the learners based on their branching decisions throughout the lesson. Design the lesson to keep a track of learners' decisions on each branch and evaluate based on the number of right decisions made throughout the scenario activity.

Promoting intrinsic motivation and adherence to quality standards	Given a branching scenario activity, learners will be able to reinforce intrinsic motivation and adherence to quality standards among operators, under real-life simulated circumstances.	• This will be a soft skills training so an eLearning lesson with a branching activity is used. • Learners will experience the consequences of their decisions in a low risk, real-life scenario, while learning the necessary soft skills for promoting intrinsic motivation and adherence to quality standards.	Assess the learners based on their branching decisions throughout the lesson. Design the lesson to keep a track of learners' decisions on each branch and evaluate based on the number of right decisions made throughout the scenario activity.
Creating a culture of continuous improvement	Given a branching scenario activity, learners will be able to foster a culture of continuous improvement, under real-life simulated circumstances.	• This will be a soft skills training so an eLearning lesson with a branching activity is used. • Learners will experience the consequences of their decisions in a low risk, real-life scenario, while learning the necessary soft skills for creating a culture of continuous improvement.	Assess the learners based on their branching decisions throughout the lesson. Design the lesson to keep a track of learners' decisions on each branch and evaluate based on the number of right decisions made throughout the scenario activity.

** Instructional activities can be further detailed using Gagne's nine events but for the sake of assignment, activities are only described briefly.*

**Confirmative assessments can be elaborated in Instructional Strategy but for the sake of assignment, it has been only highlighted briefly in overall Assessment Strategy.*

Appendix C

Table 3 Implementation Plan

Module 1: Advanced Slicer Settings				
Topics Covered	**Time Frame**	**Delivery**	**Communication Method**	**Resources Needed**
• Understanding slicer software and its advanced features • Optimizing print settings for surface finish quality	September 4 – 29 (4 weeks)	eLearning lessons, Simulation activities (45 minutes per lesson) (Self-paced)	Email notifications, Internal newsletters, Bulletin boards, Team meetings	eLearning content slides, Demo slicer software, Personal laptop, LMS Platform, VPN access
Module 2: Troubleshooting Techniques for Surface Finish Improvement				
Topics Covered	**Time Frame**	**Delivery**	**Communication Method**	**Resources Needed**
• Identifying common issues related to surface finish • Analysing and resolving print quality problems	September 11 -15 (1 week)	Instructor-led sessions (3-hour sessions) (2 sessions per topic) (4 sessions in total) (8 Operators per session)	Email notifications, Team meetings	Access to training premises, Failed 3D prints for demonstration, Presentation slides, Videos for demonstration, Practice worksheets, Handouts, Visual aids
Module 3: Filament loading, Nozzle Calibration, and Bed Leveling				
Topics Covered	**Time Frame**	**Delivery**	**Communication Method**	**Resources Needed**
• Proper procedures for filament loading and unloading • Calibrating the nozzle for precise extrusion • Leveling the print bed for consistent adhesion	September 18 – 27 (1.5 weeks)	Instructor-led sessions (2.5-hour sessions) (2 sessions per topic) (6 sessions in total) (8 Operators per session)	Email notifications, Team meetings	Access to training premises, Access to 3D printers, Surplus filament material, Calibration tools, Failed 3D prints for demonstration, Presentation slides, Videos for demonstration, Practice worksheets, Handouts, Visual aids

Module 4: Coaching and Mentorship				
Topics Covered	**Time Frame**	**Delivery**	**Communication Method**	**Resources Needed**
• Effective communication and guidance • Promoting intrinsic motivation and adherence to quality standards • Creating a culture of continuous improvement	September 4 – 29 (4 weeks)	eLearning lessons (25 minutes per lesson) (Self-paced)	Email notifications, Internal newsletters, Team meetings	eLearning content, Personal laptop, LMS Platform, VPN access

** The communication strategy can be extensively detailed including pre-launch, launch, and post-launch plans, but for the sake of assignment, only communication methods are briefed.*