Chapter 1: Assessing Need

Introduction:
3D printing is a game changing technology that democratizes design, micro-manufacturing and education. 3D printing allows educators and students to transform ideas into rapid prototypes and to create effective, tactile learning aids.

When starting an initiative to bring 3D printing technology into an educational setting it is important to design the effort in the context of printer applications. Designing programs through the lens of perceived use will allow your effort to be successful.

Gauging Interest:
Before you begin to design an initiative to bring 3D printing to your school, and before you begin to research printers, curriculum and the exciting world of 3D printing, you must find an answer to the following question: "What sparked your (or your institution's) interest in 3D printing?" Once you have identified the origin of interest you can begin to establish the foundation for an effective integration effort.

Faculty Interest
If you envision 3D printing to be an addition to current course or extra curricular offerings it is important, at this early stage, to accurately gauge faculty interest in the technology and its integration into the curricula.

1. Speak with faculty members who know of 3D printing about their thoughts on applying the technology in the classroom.
2. Explain the educational benefits and power of 3D printing to important faculty members who are not familiar with the technology and gauge their support level. If certain faculty members are excited about the possibilities that a 3D printer would enable, consider collaborating with them when it comes time to talk to administrators.

Student Interest
You also may wish to consult relevant student groups and individual students whom you know will be enthusiastic about having a 3D printer on campus. Allowing students to take early ownership of the initiative will ensure student involvement in, and support, for future programing.

A grassroots integration effort of a groundbreaking technology, such as 3D printing, allows for a more successful and widespread adoption of the technology. Thus, it is critical to have students and faculty who are interested and supportive of the initiative.

Note- At this stage, it is only necessary to speak with a handful of faculty members whom you believe would be supportive of or be willing to help with the initiative.

Aligning with Institutional Goals:
In addition to understanding the root of your interest and the interest level of others, it is helpful to identify what you envision the role of 3D printer technology to be in your school. If you plan on using 3D printing to fill a curriculum gap, the road to obtaining a 3D printer and establishing effective organizational infrastructure throughout the printing program will be different and more involved than if you just plan to implement the printer as a tool to supplement a current curricular offering. Thus, clarifying the role of 3D printing in your institution is an essential early goal.

Before continuing brainstorm detailed answers to the following questions:

Why 3D printing as opposed to other new technologies?

Why is NOW a good time to create this program?

Understanding the directional motivations behind the initiative to bring 3D printing to your institution will allow for more effective and successful decision making in the steps to come.

Chapter 2: Taking Action-Gaining Support (I)

The Team:
In the previous chapter you identified students and faculty members who were supportive of your initiative to bring 3D printing to your school. Bring together a selection of these individuals and form a student-faculty team that will spearhead the effort.

1. Talk to the team about your interest in 3D printing and the applications you perceive the technology has within your institution.
2. Then let other team members share their interests and ideas. Work to identify popular printer applications and interest areas.
3. Use this information to break the team up into task groups.
4. Then decide if the 3D printer(s) will be integrated on a departmental level, serving just one educational concentration, or if the printer(s) will be integrated using an interdisciplinary, STEAM based approach. STEAM stands for science, technology, engineering, art, mathematics.
5. Once there is a team consensus on the initial role of 3D printing in your school, form team objectives. Create SMART. actionable goals to achieve short term objectives. SMART. goals should be realistic and achievable, while long term objectives can be more optimistic. SMART goals are specific, measurable, achievable, relevant, timely.
6. Draft these goals, along with the mission of your initiative in an initiative charter.

STEAM–Science, Technology, Engineering, Art, Mathematics

Initiative Charter
Vision
Mission
Objectives
Short
Action Items
Long
Action Items

Creating an Administrative Dialogue:
The first major step in any effort to bring 3D printing to a school is to create a dialogue with school administrators. Prior to administrative meetings, inform whomever you will be meeting with of the work completed so far and the excitement throughout academic departments. When meeting with administrators, be prepared to give simplified

explanations of 3D printing technology and its educational importance. It is also helpful to bring print samples obtained from 3D printer companies or a printing service, educational testimonials from other schools, and sample lesson plans. Also, be prepared to show why the purchase of a 3D printer is a logical step in modernizing the school and improving the quality of education enjoyed by students.

After initiative leaders meet with department heads and/or administrators, your team should reconvene and modify the initiative objectives and mission, if needed. Once the mission of the initiative is clear and supported by necessary administrators you are ready to move to the purchase process.

Chapter 3: Taking Action-The Purchase Process (II)

To begin the purchase process, clarify and prioritize the uses of 3D printing in your institution as a team. This will make accommodating all applications during the purchase and selection process very manageable. Then, bring together all of the perceived applications and wishes for printer implementation and begin to draft a budget.

Choosing the correct printer will allow for maximum effect in the classroom. There are hundreds of different printers currently for sale and lease that fill many areas of need. Spend time finding a printer or lease program that best matches your desired applications.

Some resources to utilize during your search are 3D Hubs' yearly user printer rankings and Make Magazine's annual guide to 3D printing.

- 3D Hubs has extensive ranking information based on verified user reviews. On an annual basis they put together a buyer's guide including printers with more than ten reviews. The guide considers print quality, ease-of-use, build quality, reliability, failure rate, customer service, community, running expenses, openness, software and value.
- Make Magazine annually tests and ranks a selection of top 3D printers considering the results of printer stress tests and overall statistics.

Description of Advanced Printer Features

Printer Feature	Description	Pros	Cons
Dual Extruders	Two print heads	Allows for multi-material and multi color prints with ease	Added complexity in printing procedures, second extruder may come into contact with prints when not in use
Heated Build Plate	Heated build platform	Allows for printing in materials that require a heated printing surface such as ABS, assists with print adhesion	Increased operating cost, build plate is non-removable
Network Capabilities	Ability for printer to be networked	Allows for wireless printing, some models allow for print monitoring via a networked, onboard, webcam	May not be compatible with school network or network policy
Proprietary Filament Cartridges	Printer only uses custom sized consumables	Simplified consumables purchasing	Very high consumables cost, limited material options
Onboard LCD Screen with USB/SD capabilities	A screen on the printer normally allows users to begin/monitor prints and access utilities	Computerless printing	

Through the entire selection, purchase and rollout processes, let the printer manufacturers work for you. Ensure that your 3D printing program is set up for success by hunting for lifetime value, not deals. Find a manufacturer that will work with you to best serve your school's needs and who will provide assistance through the entire roll out process. You are making a purchase for an educational institution and printer reliability, durability and customer service should be top priorities.

Chapter 4: Getting the Word Out

By this point in the process you have obtained at least one 3D printer for your institution. It is now important to begin to advertise the new resource and to teach the school community about the educational and creative powers of 3D printing. The most effective rollout approaches are multifaceted. A comprehensive roll out may include static advertisements, interactive advertisements, faculty meetings, student meetings, and all school innovation or 3D printing themed assemblies. Break out your team into task groups for each type of advertising. Additionally, at least for the rollout of the printer, locate the 3D printer with maximum accessibility and visibility in mind.

Advertisement Type	Explanation
Static	Static advertising encompasses all print and digital still formats. Printing minimalistic, yet enticing, posters and placing a story about 3D printing in your school newspaper are both effective advertising strategies.
Interactive	Interactive advertisements include responsive blast emails and informal printer demonstrations. Both types of interactive advertisements are impactful methods of increasing community interest in 3D printing. Interactive techniques are most successful when employed after a formal, all school announcement or assembly introducing the printer and 3D fabrication technology.
Faculty Seminar	Soon after your team announces that the school has purchased a 3D printer, begin to hold faculty seminars. In a seminar explain how 3D printing works and how 3D printing can be an invaluable educational tool. Give examples of classroom applications and then support faculty as they brainstorm 3D printer applications for their own classrooms. Main themes should include curricular integration, innovation in the classroom and interdisciplinary, STEAM learning. If possible, let teachers see the printer in action and give them 3D printed samples. Faculty excitement generated in seminars will transfer to students and lead to a more successful and well-utilized 3D printing program.

Advertisement Type	Explanation
Student Seminar	Student seminars should open with the same overview explanation of 3D printing technology used in the faculty seminar. Then, shift focus to original creativity and applications of the printer that will be interesting to students in your school. If possible, let students see the printer in action and give them 3D printed samples. At the end of the seminar tell students to be advocates for the use of the technology in their classes. Also, direct students to 3D model databases so they can explore the technology on their own.
Innovation Assembly	A very effective method to inspire and educate an entire school about 3D printing is an innovation assembly. The assembly can be its own event or a subsection of a larger school meeting. During the assembly, invigorate and inspire the school community through multimedia presentations. The predominant goal of an innovation assembly should be to display the inspirational side of 3D printing and not to explain technicalities. Main themes of the assembly can include creativity, design and the power students are granted by having access to high-technology.

Advertising Timeline

Day Number	Actionable
1	Unveiling of 3D printer and introduction via innovation assembly
2	Post static advertisements
2	Begin interactive advertisements
3	Run faculty seminar
4	Run student seminar

Chapter 5: 3D Printing as a Corroborative Tool

Note-This chapter is predominantly focused on 3D printing as a tool that will be applied in existing courses, not 3D printing as the center of a curriculum.

The best way to promote and integrate the 3D printing program you created into existing courses is by assisting students and educators in developing their own applications. Be the catalyst for organic printer applications by sparking community members' imaginations while not providing concrete applications. Through this method teachers and their students will be able to take ownership of 3D printing technology and apply it in their classrooms.

Once teachers create their first printer uses, work diligently with them to ensure that all runs smoothly and that 3D printing is an additive part of their course. Delegate a member of your team to each class experimenting with printing. If demand is high enough, you may consider training additional students and teachers to help with initial applications by following the training procedures outlined in chapter 7.

Chapter 6: Computer Aided Design Software

CAD:
Computer aided design (CAD) software is the main utility that students and teachers will use to design 3D printable models. There are many inexpensive or entirely free options when it comes to CAD software.

Common CAD Software Used in Classrooms

Tinkercad	Tinkercad offers an easy to use, cloud based CAD program and cloud model storage for free. Tinkercad is widely used in 3D printing courses and is easy to master using the built-in tutorials.
Sketchup	Sketchup is a free CAD software that allows users to draw 2D models and then "push" and "pull" the drawings into 3D forms. Sketchup is a great beginner software choice and has many available plugins and support resources.
Autodesk AutoCAD	AutoCAD is an advanced 3D modeling program. It is most useful in advanced courses. Students can download AutoCAD under a multi-year educational license for no cost.

(listed least to most complex)

Many other CAD programs are used in 3D printing and STEAM courses. Have your team explore other or more specialized CAD options if necessary.

Software like Meshmixer and NetFabb Online allow users to check their 3D models for unprintable "holes" and for part strength. Such software should be used to check and repair every model before printing to ensure successful 3D prints.

Chapter 7: Procedures and Programatic Centralization

It is beneficial to the success of your program for your team to develop or utilize centralized and intelligent operating procedures for your institution. Necessary procedures outlined in this chapter include printer use training, maintaining printer logs, creating print submissions forms, creating a print queue system and creating a centralized 3D printing information hub with print history.

Note- If your printer manufacturer offers operation and print queue solutions there is no need or benefit in developing your own.

Training:
3D printing is a such a valuable educational aid because it affords students hands-on learning opportunities. Thus, your printer use training program should be grounded in hands-on instruction and practice. After the rollout stage, begin to offer training seminars for students and teachers interested in having access to the 3D printer. The exact training necessary for printer use will be different in every institution but the following tips act as universal guidance points.

1. Before the seminar, have all participants watch online instruction videos supplied by the printer company and read printer operation materials.
2. When participants arrive at the seminar, first review basic printer operation, then give participants opportunities to practice printer use and basic maintenance procedures that they learned from the pre-reading and watching.
3. When it becomes time for participants to be “certified” for printer use, pass the proficiency measures enacted for your program, administer a scenario based test on the machine. A certification test may include a run-through of pre-print, print and post-print procedures and then error resolution tests.

Print Submission Forms, Print Queue and Print History Solutions:
Many 3D printers come with print queue and history solutions. If the printer your institution purchased did not come with such solutions it is wise to follow the simplistic print log template in Appendix A and to create an online time reservation form for each printer at your institution.

Maintenance Logs:
Your program may opt to require all printer maintenance to be documented. Even if your 3D printer manufacturer handles printer maintenance, a maintenance log can be a valuable document to store essential serial numbers, support contacts, and printer malfunction notes. A sample maintenance log can be found in Appendix B.

3D Printing Information Hub:
A print blog or information hub is not necessary for the successful rollout of your educational 3D printing program but can be a valuable later addition to your program. An information hub may include technological explanations of 3D printing, student and teacher design resources, a CAD model database, and print history blog, among other options.

Chapter 8: Thinking for the Future:

The mark of a successful educational 3D printing program is not just initial traction or ease of curricular integration but also how quickly the program grows. Your team's approach to planning your program's future should be multifaceted; your team should lend care to hardware system expansion, curricular expansion and the continual use of 3D printing as a catalyst for STEAM education.

Specialized Curricular Offerings:
Once 3D printing is implemented as a corroborative educational tool in your institution, a common next step is to offer 3D printing centered design and engineering courses. In most institutions, dialogue concerning course development and rollout may start a few years after printers are first implemented.

Either through specialized curricular offerings or curricular corroboration, your team should ensure that your institution's 3D printing program acts as a continual source of creative and technological inspiration to the entire school community. A successful program should use 3D printing to teach students how to employ a STEAM-based problem solving tool kit and your program should aim to give every student and faculty member the proper tools to unleash their creativity and to bring their original, innovative ideas to life.

Appendixes:

Appendix A:

Your team may wish to adapt the following example print log to fit your program's needs

3D-Printer Use Log

Before you print:

i. Inspect blue tape, flatten any air bubbles and remove all debris.
   i. If the blue tape is excessively worn completely remove all tape, clean off all adhesive and then apply new tape with minimal overlap using a credit card to lay the tape flush to the build plate. Record maintenance in the printer upkeep log.

ii. Level the build plate.
   i. If using printer paper there should be slight friction between the extruder head and the paper. If using a business card there should be moderate friction between the extruder head and the card.
   ii. Visually ensure that the extruder will not scratch the build plate or get clogged due to low clearance.

iii. If the filament must be changed jog the z-axis down (main menu>utilities>jog mode>z axis>down arrow) so that there is at least 5cm of room between the extruder head and the build plate. Replace filament on the work cart with the end of the spool secured.

iv. Start print and observe first layer adhesion. Record filename, materials, print time (record after print) and your name in the print long. If any maintenance was performed record in the printer upkeep log.

3D-Printer Use Log: If a problem occurs during printing pause or cancel the print and email email@yourschool.org.

User Name	File Name	Spool Color	Part Weight	Print Time	Date

User Name	File Name	Spool Color	Part Weight	Print Time	Date

Appendix B:

Maintenance Log: If a problem is not solved through basic maintenance call Printer Manufacturer: +1 (555) 555-6800 Monday-Saturday 9am - 6pm, EDT. **SN: ########**

User name	Date	Problem	Maintenance Conducted	Result
