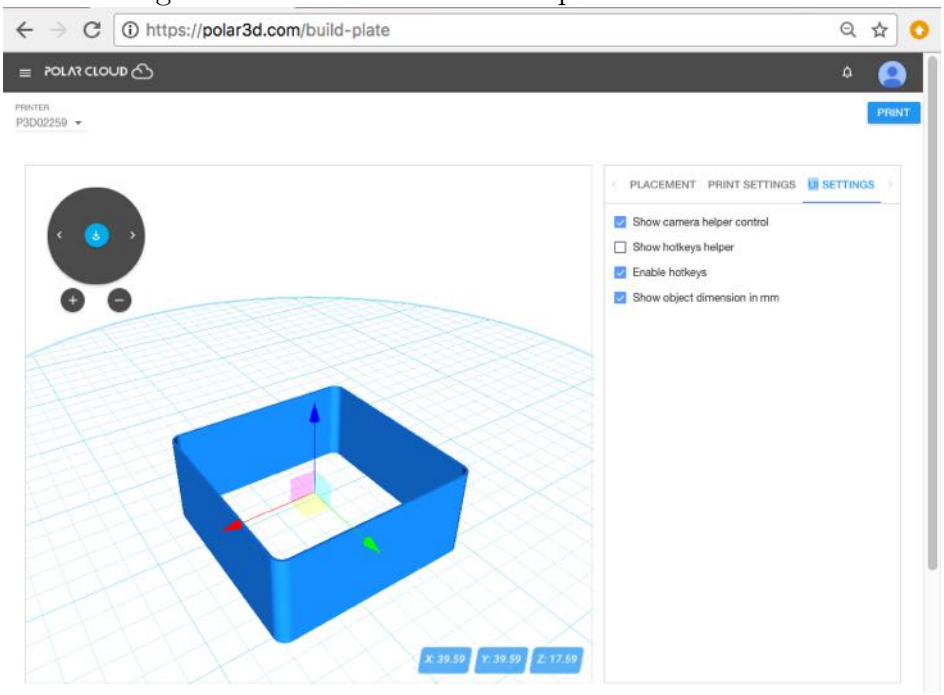
Figure 4.81: Polar Cloud build plate `UI SETTINGS`



4.6.1.1 The build plate screen: adding or extracting objects

You may load multiple objects to the build plate, adding objects from other print jobs you have queued, or adding objects accessible to you in the Polar Cloud, via the "`Load Objects from the Cloud`" or "`Load Objects from the Queue`" icon buttons, respectively.

When the build plate has multiple objects on it, stored in separate files, you may also select particular such objects to copy into your private collection of objects in the Polar Cloud: you may extract such particular objects to store in the Polar Cloud. See the "`Upload Objects to the Cloud`" icon button.

4.6.2 Submit your print job to a printer and begin printing

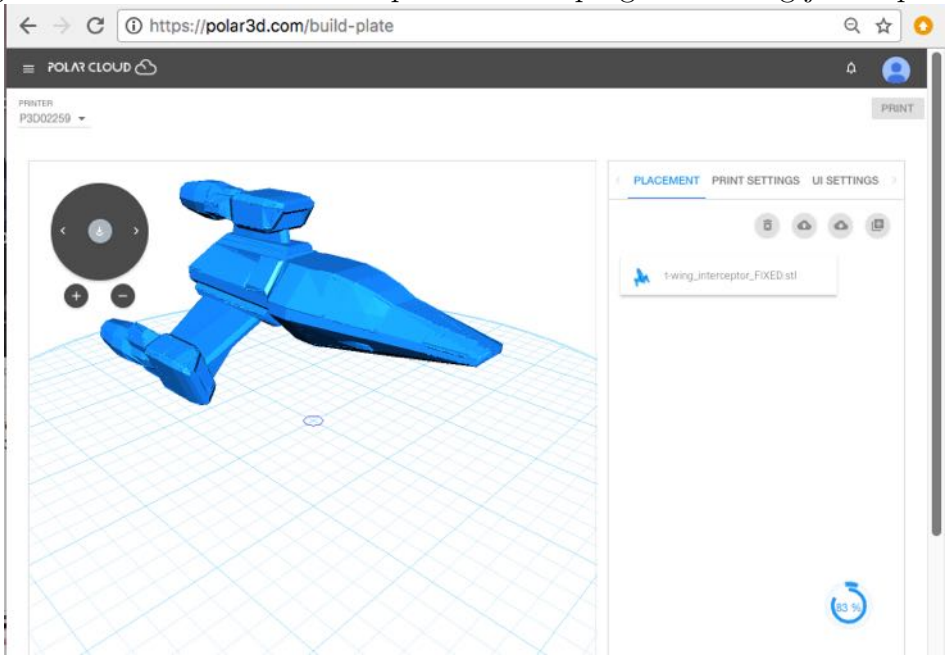
From the build plate screen, clicking the blue "PRINT" button (at the upper right of the screen) submits your print job to the currently selected printer (as shown in the upper left of the build plate screen); see for instance Figure 4.81 (or for additional discussion of build plate screen features, refer to Figure 4.78 in Section 4.6.1).

Especially if your object(s) have large .stl files, you may see a swirling blue icon (with a numeric progress value) towards the lower left of the build plate screen after clicking "PRINT", as the job is submitted to the printer; the numeric value and inner blue arc indicate how far the load has progressed, while the swirl of the outer blue arc shows progress occurring; see Figure 4.82.

Once your job is completely submitted, you will automatically be taken to the printer dashboard screen, where you will now see your job (as well as possibly other, previously submitted, jobs) in the print queue; refer to Figure 4.86.

To actually begin the print of your object, or whichever object is first in the queue, the printer owner or a printer manager (or a member of a group with control access to the printer) must click the "START" button on the printer dashboard screen (a blue button, towards the upper right); Section 4.6.3 will further discuss the printer dashboard control buttons such as "START" and "STOP". Of course, first you may want or need to perform some preparation tasks such as: remove any previously printed completed object off the build plate, touch-up the hair spray on

Figure 4.82: Polar Cloud build plate screen: progress loading job to printer



the build plate, load or change filament, *etc.*

Before your print job begins printing, you may also choose to modify it. And if you are a printer manager or have control access to the printer, you may modify the queued jobs of other members, perhaps shuffling the order of jobs, or merging jobs; Section 4.6.4 will further discuss such print queue management operations.

4.6.3 Printer dashboard control buttons

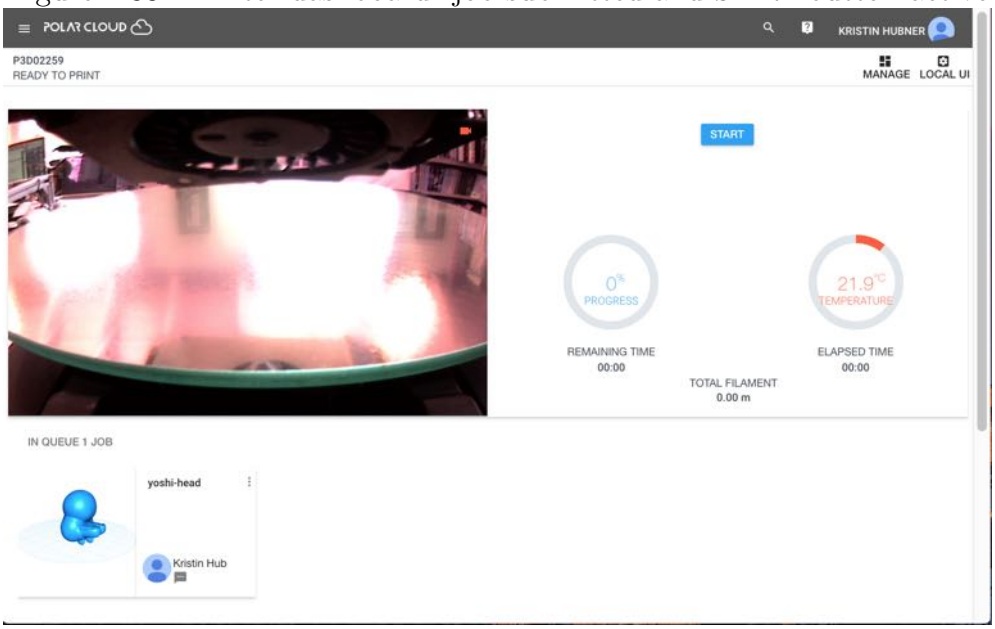
By default, the control buttons on the printer dashboard screen are only active for the printer owner and any additional printer managers, while members instead see these control buttons grayed-out. For such printers, only the printer owner and any additional

printer managers can trigger the actual start of a queued print job (or pause or stop a job that is currently printing).

However, when a printer is shared with a group, there is a group setting to allow members of the group to control the printer. When that switch has been set `ON`, then all members of the group sharing the printer can also make use of the control buttons.

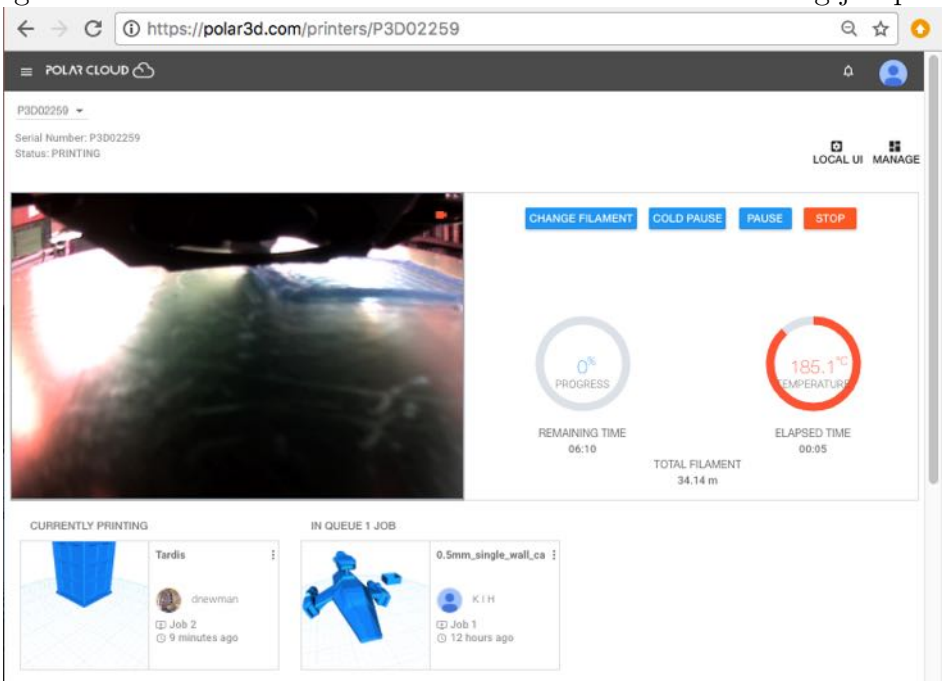
To trigger the start of the job at the head of the print queue, click the "`START`" button on the printer dashboard screen; see Figure 4.83.

Figure 4.83: Printer dashboard: job submitted and `START` button active



Once a job is printing, the control buttons "`CHANGE FILAMENT`", "`COLD PAUSE`", "`PAUSE`", and "`STOP`" appear; see Figure 4.84.

Figure 4.84: Printer dashboard: control buttons active during job print



The "`CHANGE FILAMENT`" button pauses the print (performs a "warm" pause), and backs out the current filament.

The "`COLD PAUSE`" button pauses the print, turning off the heating element in the extruder. A "cold pause" is appropriate when you do not wish to abort a partially printed object, but you need some significant time to check (or fix) something with the printer, or perhaps you need some time to obtain more filament.

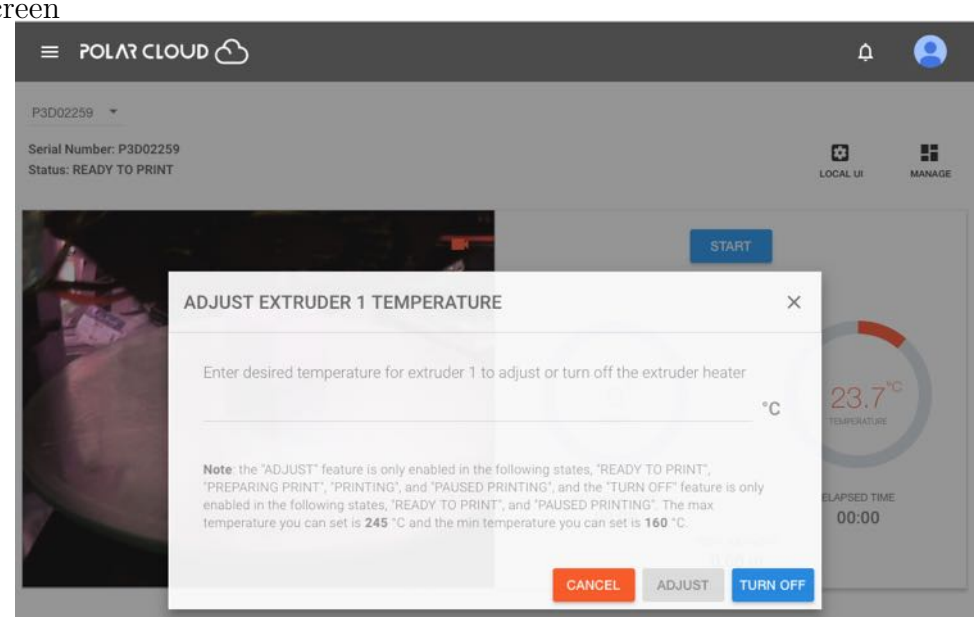
The "`PAUSE`" button performs a "warm" pause: it pauses printing but keeps the heater(s) on and does not back out the filament. As such, a "`PAUSE`" is appropriate when you want to quickly check (or fix) something. But leaving the printer in a "warm" pause for an extended period is not recommended:

since the filament remains in the still hot extruder, during an extended "warm" pause, melted filament may begin leaking onto your build plate.

The "STOP" button cancels the print job: printing of the current job stops, and all heaters are turned on. Note that the print job is left in the queue (should you later wish to make a fresh start on the print); if, however, you do not plan to ever re-attempt this print job, you should delete the job from the queue.

After performing a "CHANGE FILAMENT", "COLD PAUSE", or "PAUSE", the control buttons that become available are "RESUME" (to resume printing) and "STOP" (if you wish to turn your temporary pause into a permanent cancel of the print job).

Figure 4.85: Polar Cloud printer dashboard ADJUST EXTRUDER TEMPERATURE screen



In addition to the control buttons, the printer dashboard also allows controlling the printer temperature. Clicking on the temperature dial will bring up a screen with an option to adjust the printer temperature; see Figure 4.85.

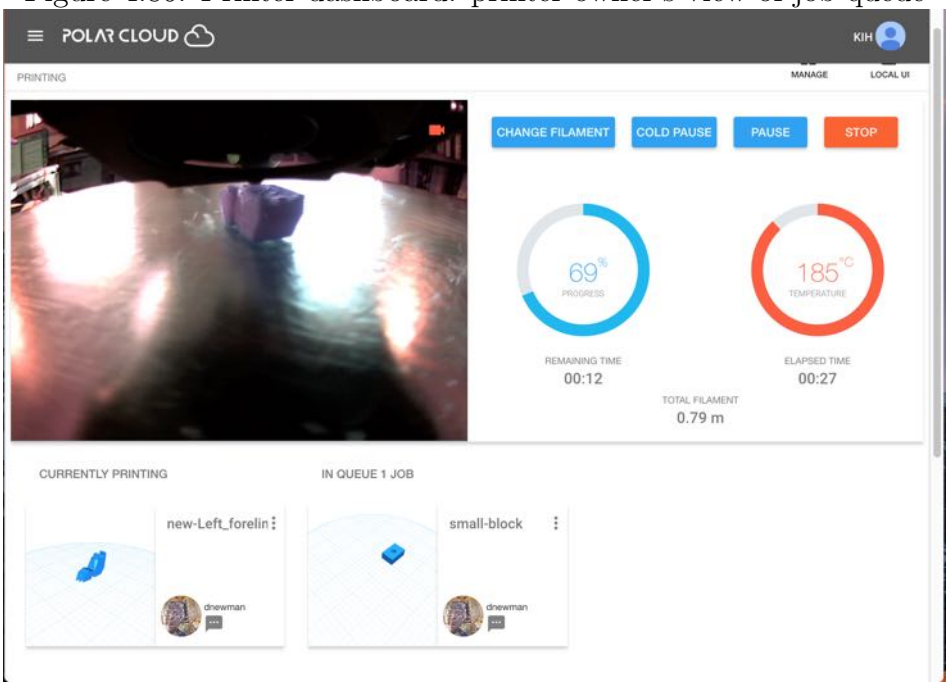
4.6.4 Print queues in the Polar Cloud

The Polar Cloud maintains a print queue for each printer, allowing multiple members (those Polar Cloud members authorized to use that printer; see Section 4.5.5) to submit print jobs to a printer; the Polar Cloud will submit each job in turn to the actual printer.

From the printer management screen, see Figure 4.60, clicking on "QUEUE" will show a display of jobs on the print queue. The owner or a manager of a printer will see *all* jobs; similarly, a member of a group configured to have printer control of any shared printers will also see *all* jobs. But a Polar Cloud member who is allowed to use the printer but who is neither the owner nor a manager, (nor a member of a group configured to have control of shared printers), will only see *his or her own* jobs.

Note that the printer manager(s) may view all jobs in a print queue, including jobs of other members; see Figure 4.86. The printer manager(s) may also modify jobs in a print queue, including those of other members; for instance, a printer manager may delete jobs from the print queue, or rearrange the order of the jobs in the queue. Clicking on the three vertical dots at the top right of the icon for a job will bring up the menu of available modifications; see for instance Figure 4.87.

Figure 4.86: Printer dashboard: printer owner's view of job queue



A Polar Cloud member (who is *not* the owner nor a manager of the printer, nor a member of a group with control access to the printer) can see and modify only those print jobs he or she submitted to the printer's job queue, as well as seeing through the printer dashboard a live view of whatever the printer is currently doing (which may be printing another member's job). Figure 4.88 shows an example of the printer dashboard screen presented to a member who has one queued print job of their own, waiting for another member's print job to finish.

Figure 4.87: Printer dashboard: printer owner's job modification menu

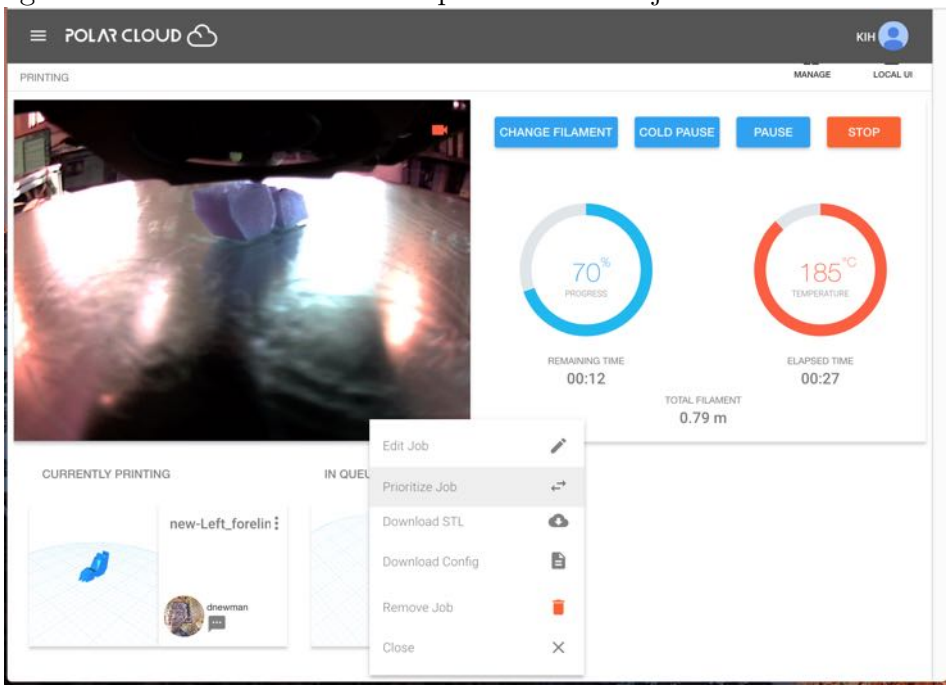
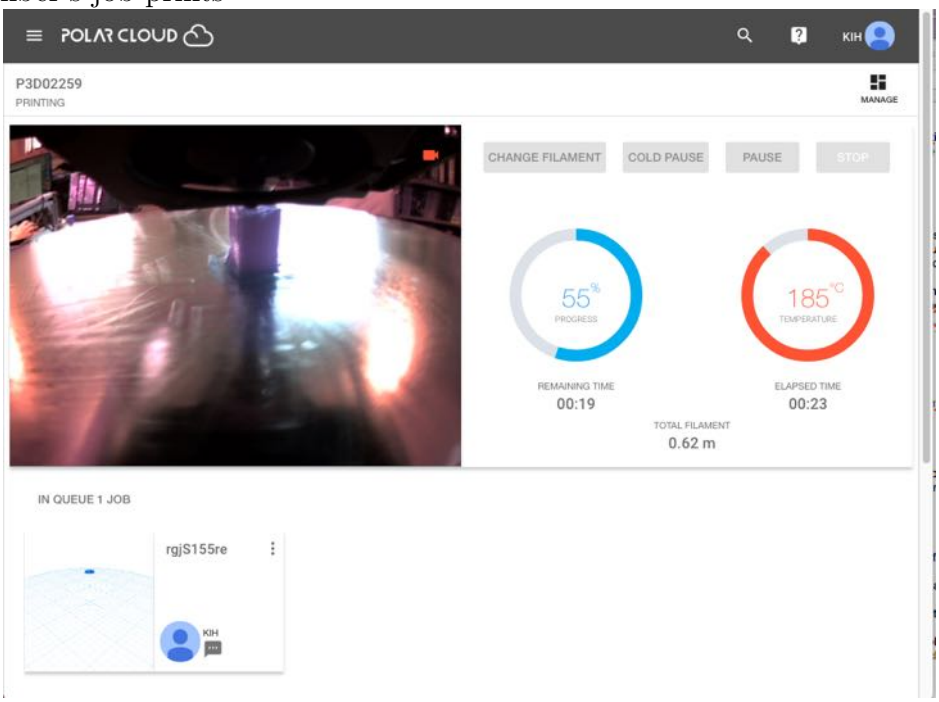
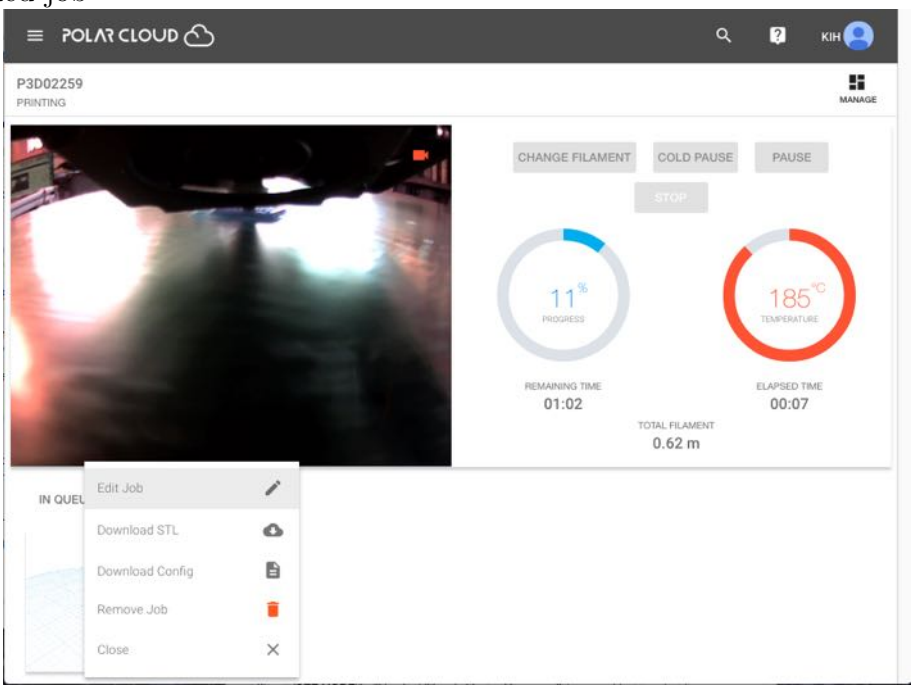


Figure 4.88: Printer dashboard: a member queued job waiting while another member's job prints



Note that the control buttons (towards the top right of the screen) are all grayed-out when a member is viewing the printer dashboard of a printer the member neither owns nor manages (nor has control access permitted through group membership): such a member cannot interrupt the printer's current job. Nor can such a member see what other jobs may be queued to the printer before his or her own job(s); the member can only perform operations on their own print jobs (before they begin printing), such as removing one of their own queued jobs, or editting/combining print jobs. Clicking on the three vertical dots towards the upper right of the queued job icon (see Figure 4.88) will bring up the options for modifying a queued job (see Figure 4.89).

Figure 4.89: Printer dashboard: member options for editting their own queued job



The Polar Cloud also maintains a history list of what has been printed on the printer. From the printer summary display screen, see Figure 4.60, clicking on "`HISTORY`" will show the history of what has been printed on the printer; see Figure 4.69.

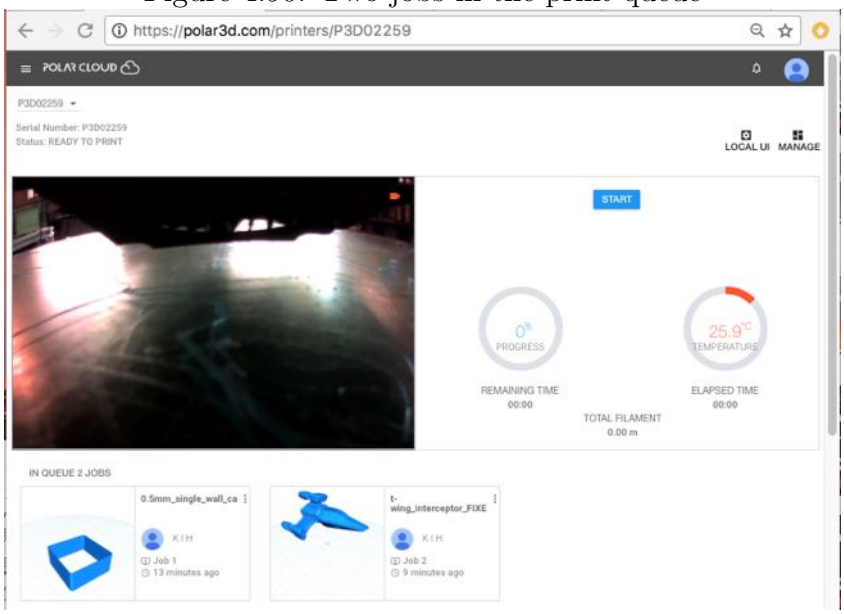
4.6.4.1 Merging print queue jobs

Sometimes it may be convenient to merge multiple print jobs – that is, to have the printer work on printing multiple objects at once. Especially for small objects, printing multiple objects at once (thus with built-in cooling time) may even yield better results. And for printers accessed by multiple Polar Cloud

members, printing multiple objects at the same time may lessen wait time and contention for the printer.

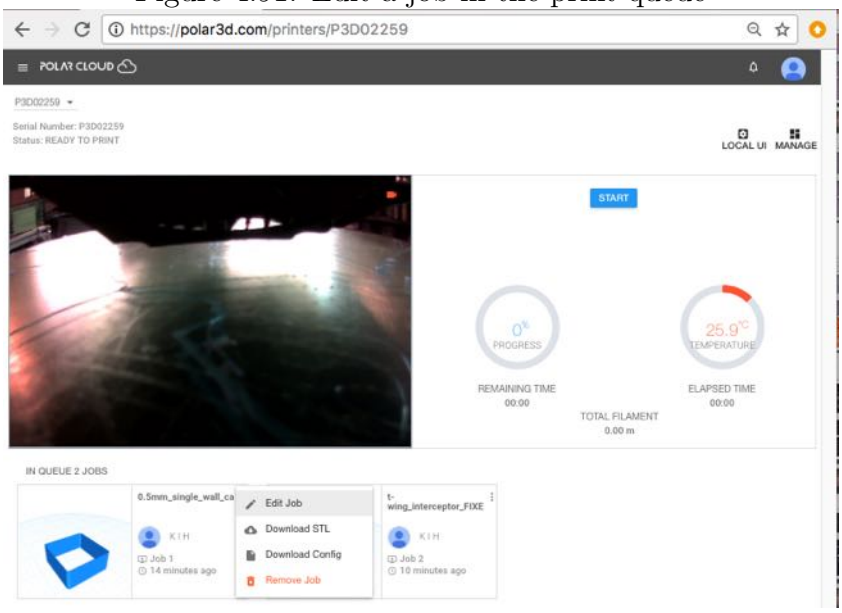
Suppose the print queue has multiple jobs queued; see Figure 4.90.

Figure 4.90: Two jobs in the print queue



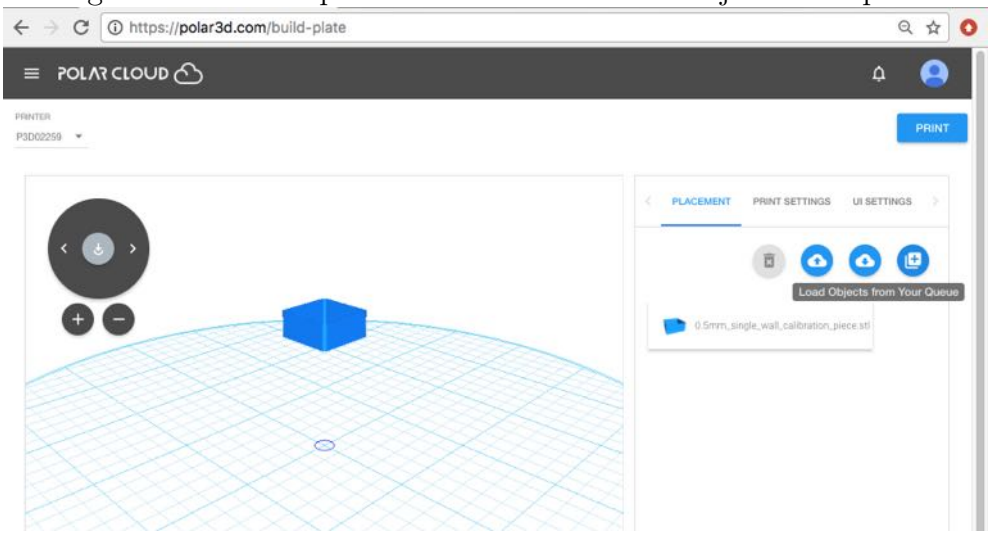
Click on the three dots at the upper right of the first job, and select "`Edit Job`"; see Figure 4.91.

Figure 4.91: Edit a job in the print queue



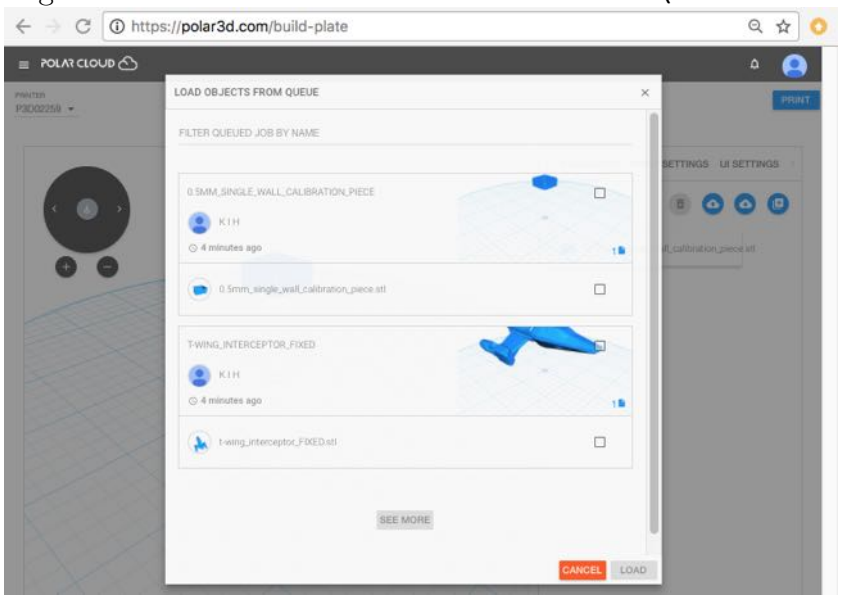
Editting a print queue job will take you to a build plate screen for that object; click the icon to the far right, "`Load Objects from Your Queue`" (underneath "`UI SETTINGS`"); see Figure 4.92.

Figure 4.92: Build plate screen: load another object from queue



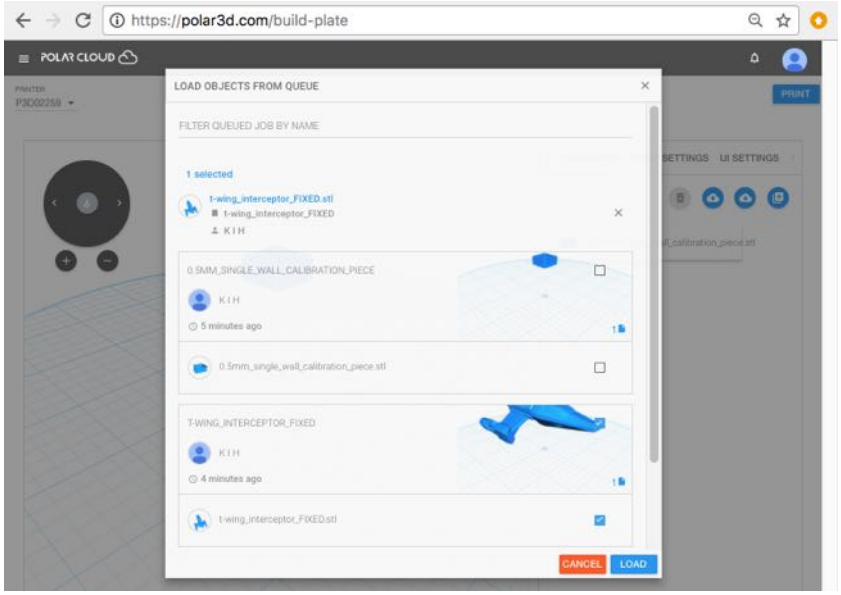
Clicking the load icon will bring up a "`LOAD OBJECTS FROM QUEUE`" screen; see Figure 4.93.

Figure 4.93: Polar Cloud `LOAD OBJECTS FROM QUEUE` screen



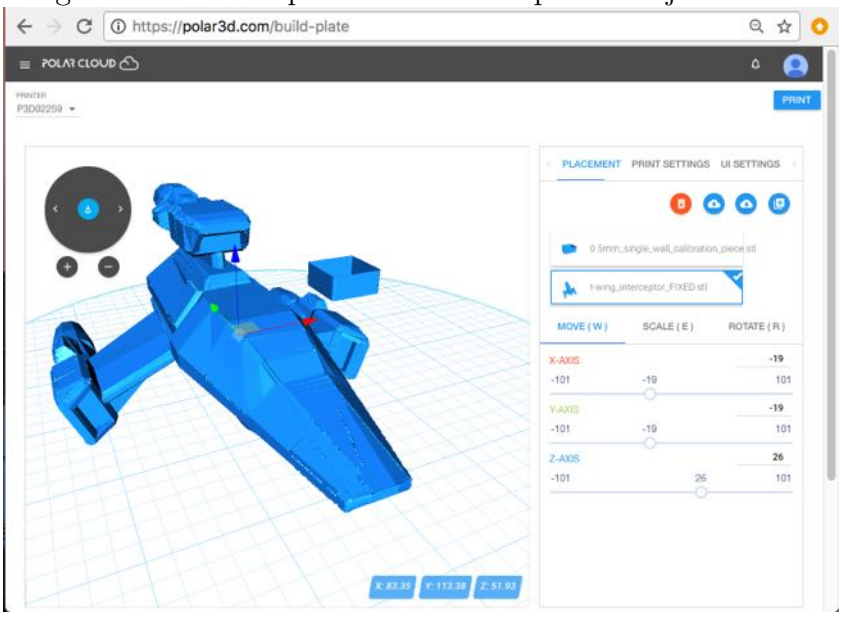
Check the box(es) for the jobs you wish to merge into the job you're editting, and then click the blue "LOAD" button (towards the lower right); see Figure 4.94.

Figure 4.94: Selecting which objects to load from the print queue



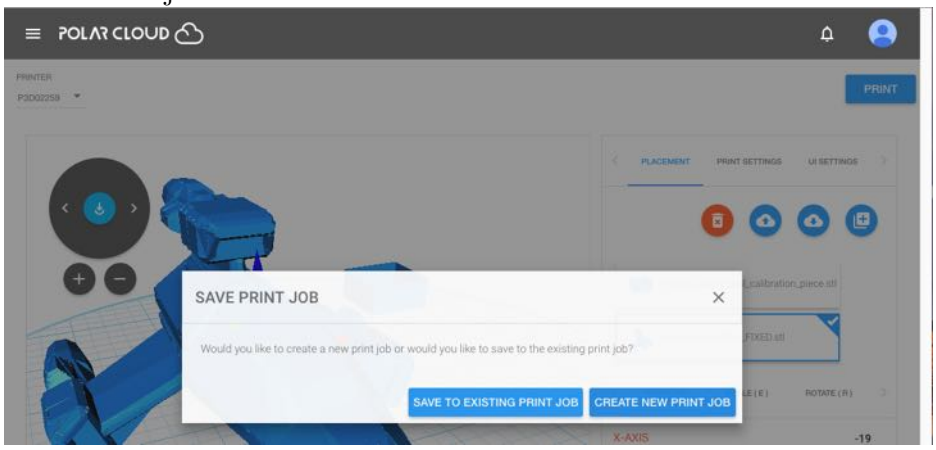
The additional object(s) will now also be loaded to the build plate; see Figure 4.95.

Figure 4.95: Build plate: additional queued object loaded



Click the "`PRINT`" button (towards the upper right) to submit this merged job to the printer; a pop-up "`SAVE PRINT JOB`" screen will ask whether you wish to "`SAVE TO EXISTING PRINT JOB`" (replacing the print job you originally chose to edit) or "`CREATE NEW PRINT JOB`" (submit a newly created print job in addition to your original print jobs); see Figure 4.96.

Figure 4.96: Build plate: choose whether merged job replaces original job or becomes a new job



If you click "`CREATE NEW PRINT JOB`", then at the printer dashboard you will now see three queued jobs, the two original jobs plus a third job which has both objects; see Figure 4.97. If you wish, you may now remove either or both of the original two print jobs: click on their three dots and select "`Remove Job`"; see Figure 4.98.

Figure 4.97: Merged job present in print queue

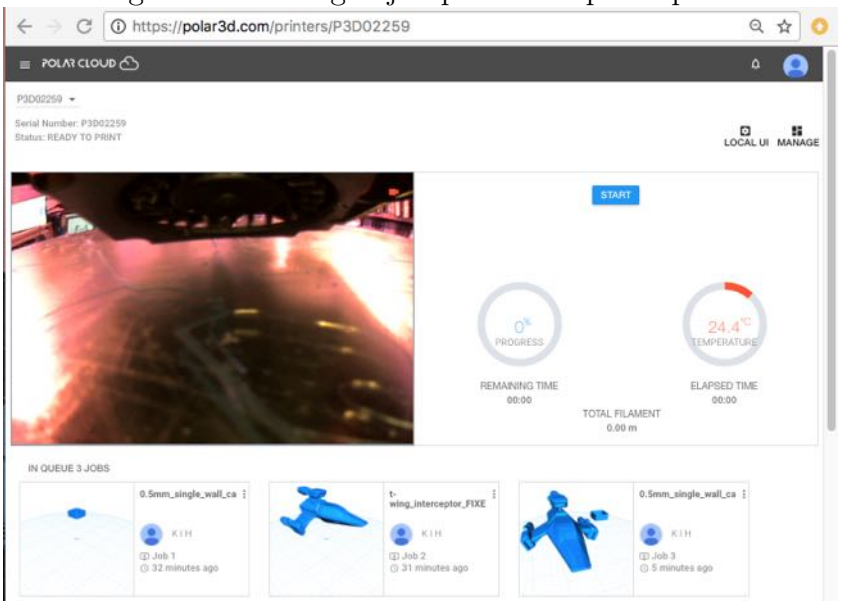
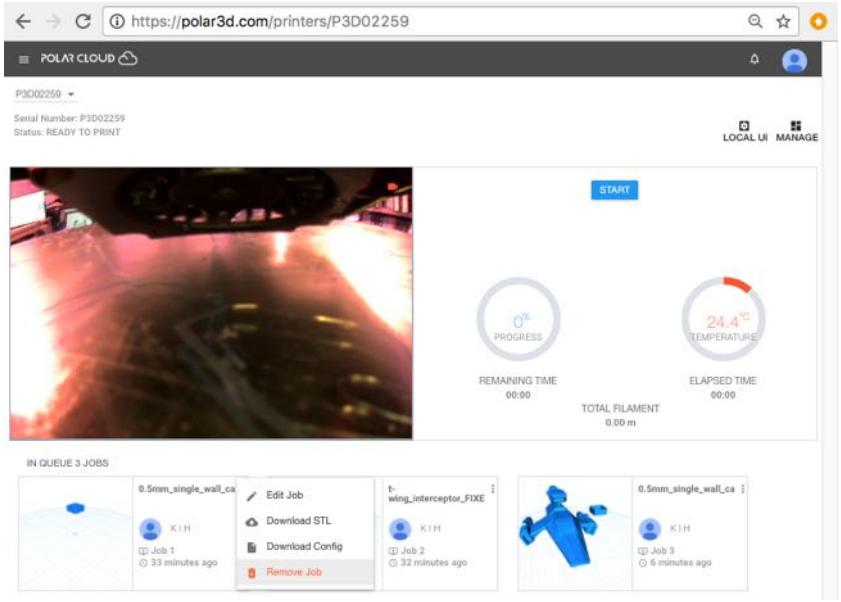


Figure 4.98: Remove redundant jobs from the print queue



4.6.4.2 Move a print job to a different printer

If you have access to multiple printers, then a print job that is pending in one printer's print queue may be moved to a different printer. To do this, go to the printer dashboard, click the three dots at the upper right of the print job icon, and click "`Edit Job`" to return to the build plate screen for the print job. Then select the desired printer from the printer drop-down menu (towards the upper left of the build plate screen) and click "`PRINT`" to resubmit the print job to the newly chosen printer.

Moving a print job is most often performed just for convenience and efficiency of managing printer use: *e.g.*, a different printer might be currently unused and ready to print, or might already have desired filament loaded. However, another case that can arise is when the printer local web interface "`Reset Printer on the Polar Cloud`" tab has been used to obsolete a prior use of the printer. When a printer has been obsoleted in the Polar Cloud, any print jobs that had been pending in its print queue remain in the Polar Cloud, not actively printing but instead assigned to the "obsolete" printer (re)named '`P3D`*`serial-digits`*`-deleted-`*`date`*, so that if desired, such print jobs may be editted to reassign them to a different printer.

4.6.5 Real-time video or updated snapshots of jobs in-progress

When you submit an object to be printed (press "`PRINT`" on the "`3D PRINT`" screen), the Polar Cloud display will automatically

go to the dashboard screen for your selected printer, showing what the printer is currently doing.

If you are connected to the same local network to which the printer is connected, the printer dashboard will show live video of what the printer is currently doing. If you are connected to the Polar Cloud through a different local network, the printer dashboard will instead display frequently updated (updated about every five seconds) still snapshots of what the printer is currently doing.

If your job is at the head of the printer's job queue, you will see your job printing. Once your job has begun printing, a "`STOP`" button will appear; you may press that button if you wish to stop (abort) the print job.

If you are the owner or a manager of the printer, you will see on the printer dashboard "`START`" button; press that button to begin your print.

Note that time-lapse video of the print job is also available later in the printer history; see Section 4.5.7.

4.7 Notifications in the Polar Cloud

Hovering over the bell icon, towards the upper right of a Polar Cloud screen, will display a summary of any notifications (such as invitations to access a printer or join a group) that you may have. When a number appears on the bell, it represents how many pending notifications are awaiting your attention; see Figure 4.100.

Figure 4.99: Polar Cloud notifications

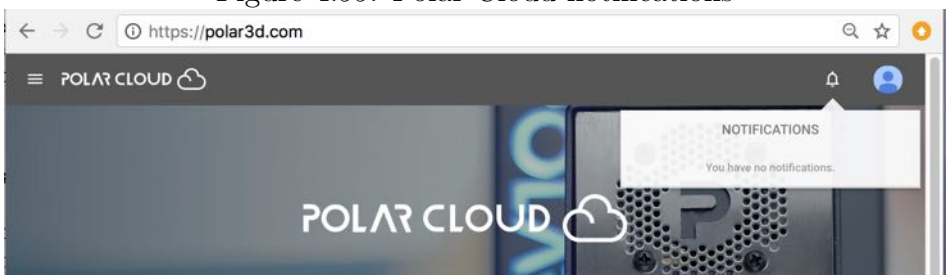
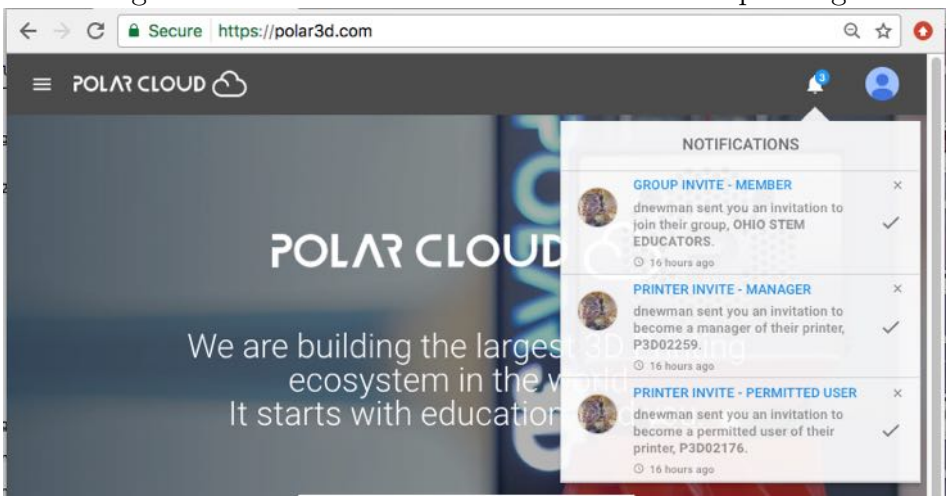
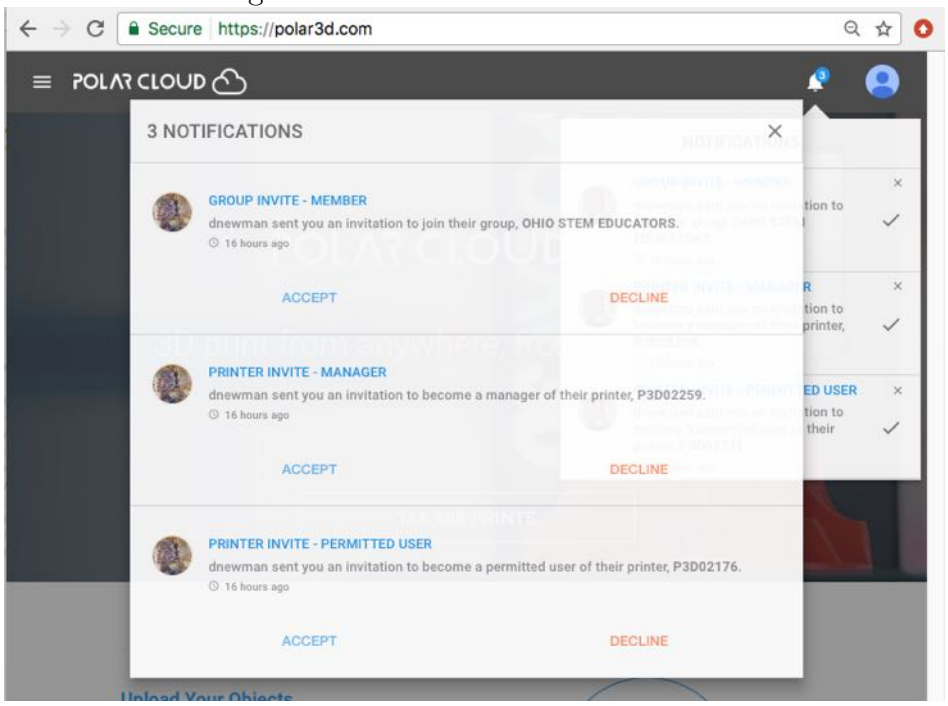


Figure 4.100: Polar Cloud notifications: three pending



When you invite a fellow Polar Cloud member to become a member of one of your groups, or invite a fellow Polar Cloud member to become a user or manager of a printer that you own or manage, that Polar Cloud member will receive an invitation notification.

Figure 4.101: Polar Cloud invitations



4.7.1 Responding to an invitation notification

Clicking on the bell icon, towards the upper right of a Polar Cloud screen, will display the list of notifications awaiting your attention; see Figure 4.101.

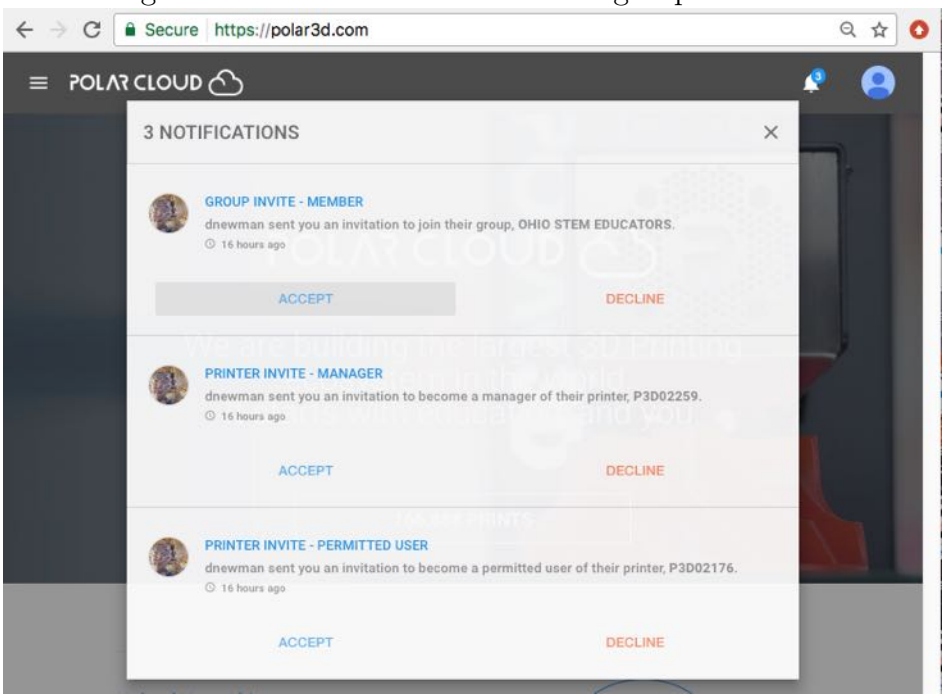
Figure 4.101 shows a range of the possible types of invitations: an invitation to join a group, an invitation to become a manager of a printer, and an invitation to become a user of a printer.

Note that the issuer of an invitation is not explicitly informed of your action on the invitation (in particular, no response notification back to the invitation issuer is generated when you "`DECLINE`" an invitation), though if you do "`ACCEPT`" an invitation, the issuer will thenceforth see, when looking at a group or

printer, that you are a member of the group or have access to the printer.

When you "ACCEPT" an invitation to join a group, see Figure 4.102, a confirmation that you joined will appear and you will have the opportunity to go see the group; see Figure 4.103.

Figure 4.102: Polar Cloud ACCEPT a group invitation



Clicking on the "CONFIRM" button in Figure 4.103 will take you to the group's SUMMARY display page, as shown in Figure 4.104.

Figure 4.103: Polar Cloud confirmation of joining a group

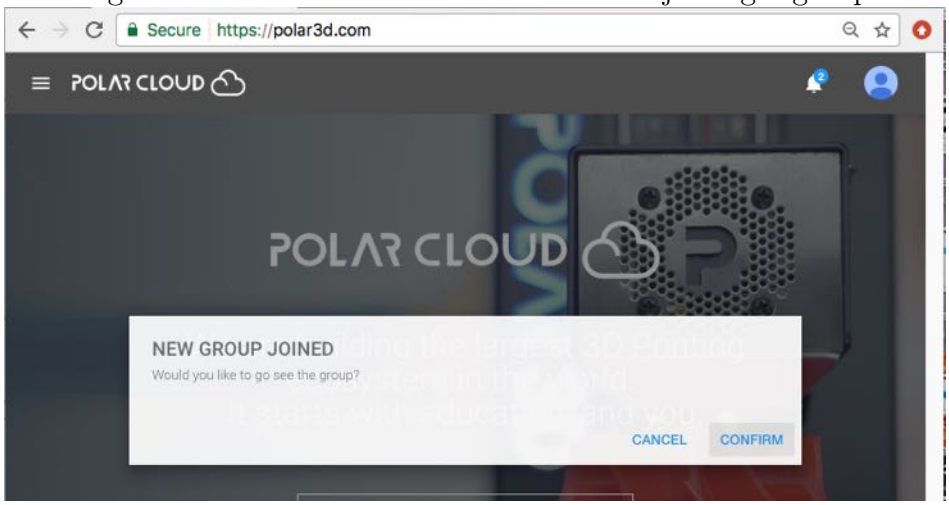
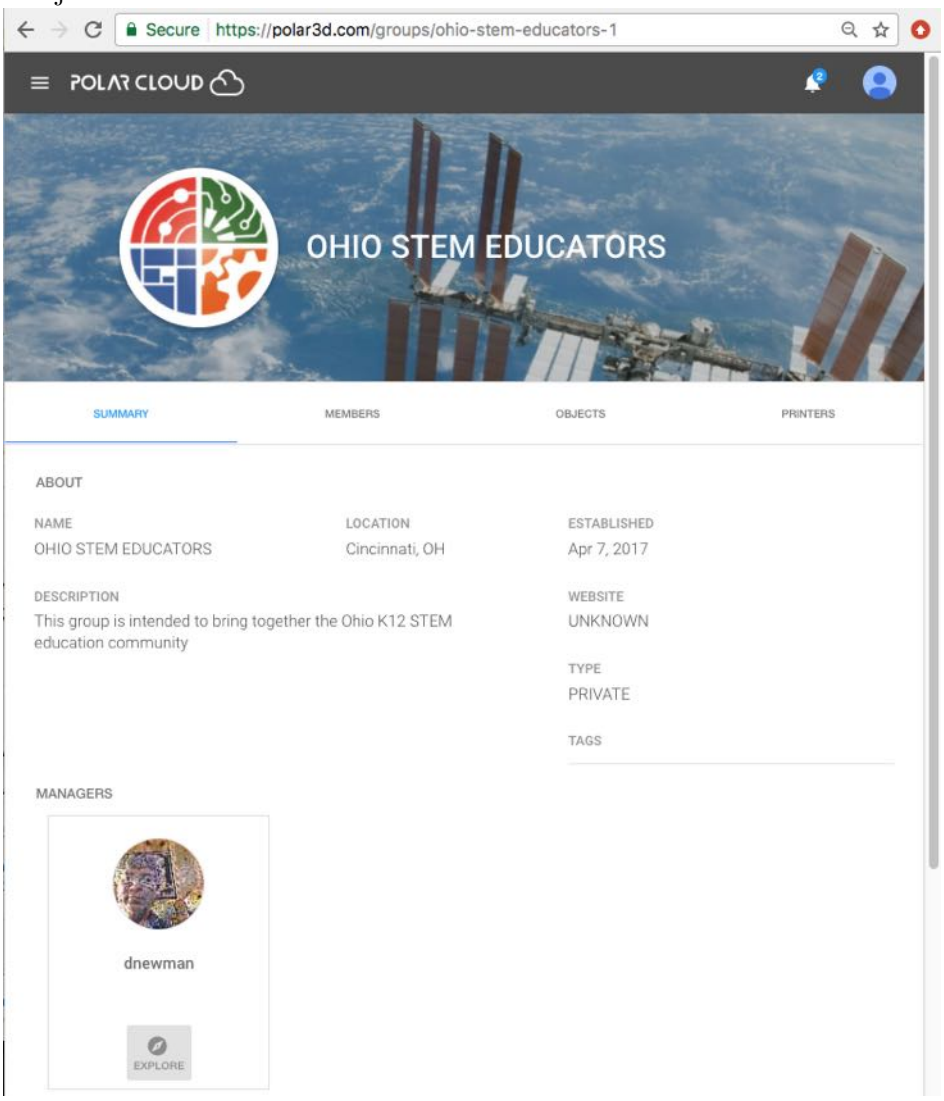


Figure 4.104: Polar Cloud `SUMMARY` display of group upon accepting invitation to join



When you "ACCEPT" a printer access invitation, whether that invitation is to become a manager (see Figure 4.105) or a user, a confirmation that you may now access the printer will appear and you will have an opportunity to go directly to that printer's dashboard; see Figure 4.106.

Figure 4.105: Polar Cloud: invitation to manage a printer

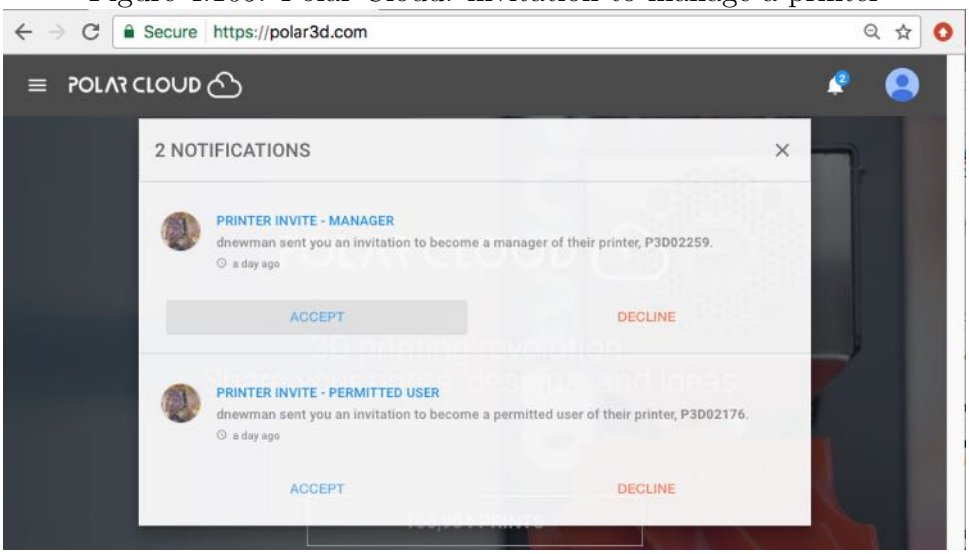


Figure 4.106: Polar Cloud confirmation of printer access

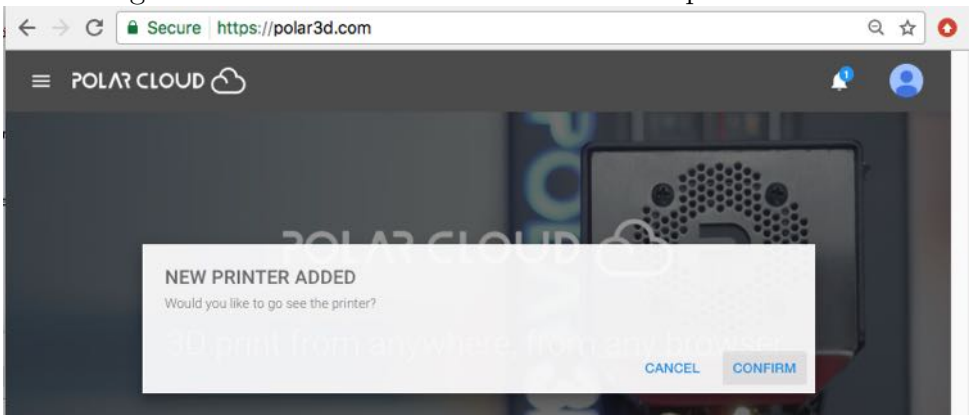
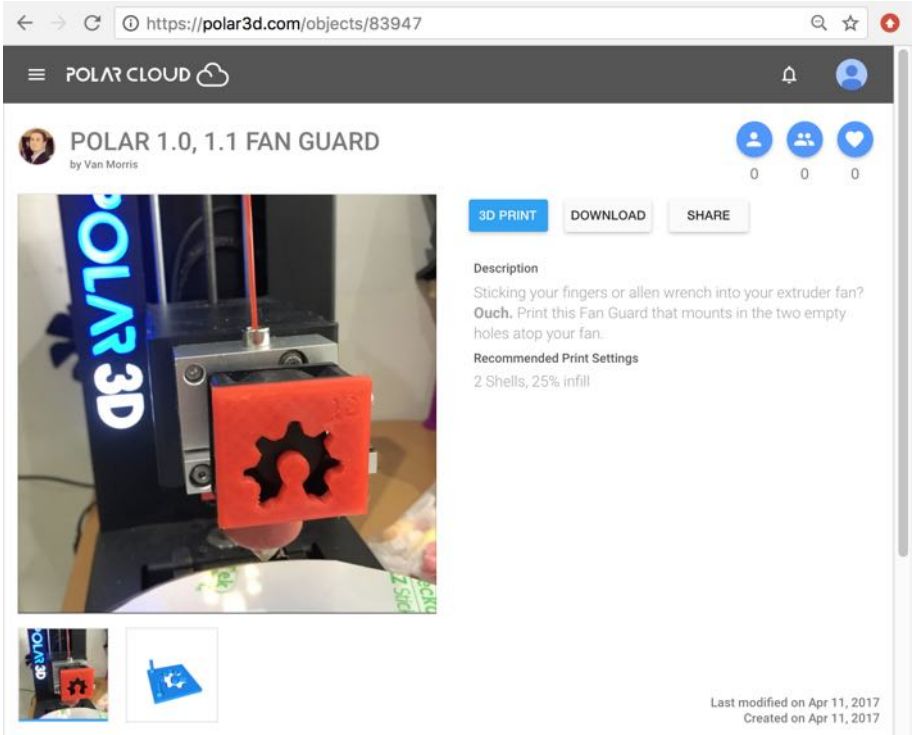


Figure 4.107: Polar Cloud object detail, by Van Morris

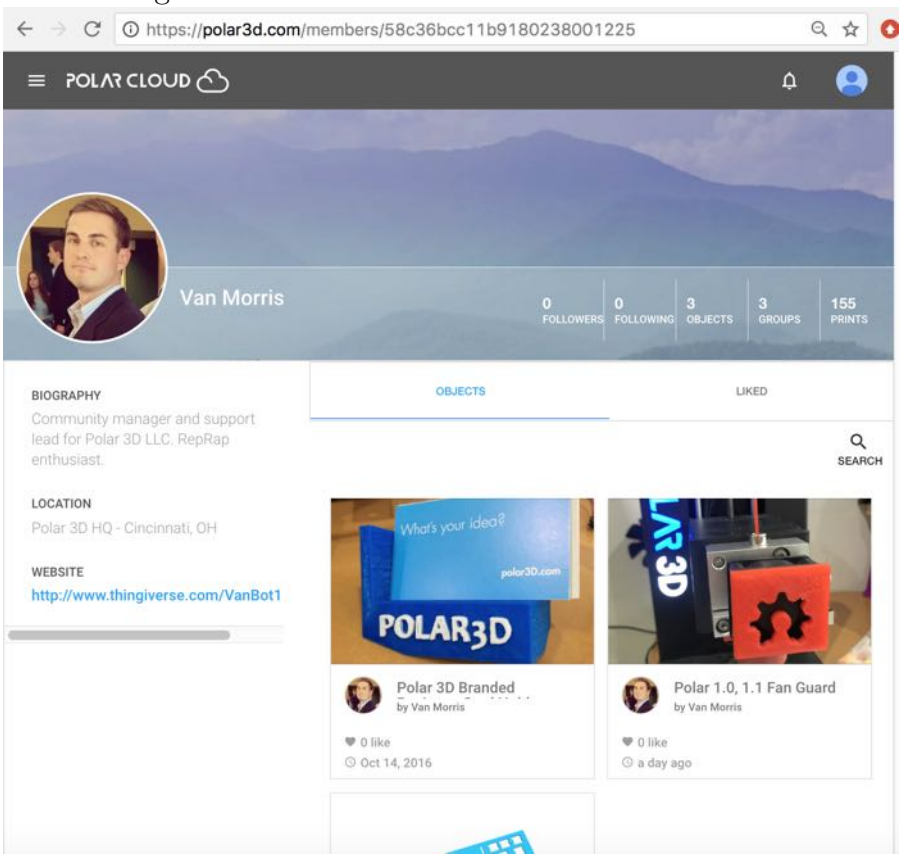


4.8 Viewing other Polar Cloud members

Clicking on the icon of a Polar Cloud member, whether that icon appears on an object detail page (*e.g.*, see the upper left of Figure 4.107), group member list, printer member list, or in the activity list for your account (so a user of a printer of yours), will take you to a Polar Cloud member page for that member, such as shown in Figure 4.108.

Note that student Polar Cloud members are typically members of "`PRIVATE`" or "`MODERATED`" class groups. Therefore, unless a student has posted (that is, shared) a "`PUBLIC OBJECT`", students typically are *not* visible to general Polar Cloud mem-

Figure 4.108: Polar Cloud member Van Morris



bers; students are typically visible only to other members of their own class groups and their class groups' managers (typically their own teacher(s)).

4.9 Collaborating through the Polar Cloud

You may share objects you have created or printed through the Polar Cloud, either with all Polar Cloud members, or with members in particular groups, or only with specific other Polar Cloud members. To share an object simply click the "SHARE" button (under "OBJECTS", "MY PRIVATE OBJECTS" or "MY SHARED OBJECTS", the object itself), and then choose with whom to share the object; see Section 4.2.2 or Section 4.10. An alternative, more group-centric, way to share objects with a group is also discussed in Section 4.4.5.

Note that your descriptions of objects and any printing recommendations or tips you wish to provide, and possibly photos of your printed object, see Section 4.2.4, may be particularly useful to other members when you share objects.

You may also search for and find and use objects that others have shared within the Polar Cloud; see Section 4.2.2. (Note how it is useful when other members provide detailed descriptions and helpful printing tips for their objects!)

You may allow others to access your printer(s) – share your printer(s) – through the Polar Cloud. To make your printer accessible to particular, specified Polar Cloud members, see Section 4.5.5; to allow access to your printer to all members in specified groups, see Section 4.4.6.

If others have made their printer(s) accessible to you, you can use others' printers. Accessible printers will show up in the list of printers displayed by selecting "PRINTERS" from the Polar Cloud left-hand top menu; see Figure 4.55 (or Figure 4.110).

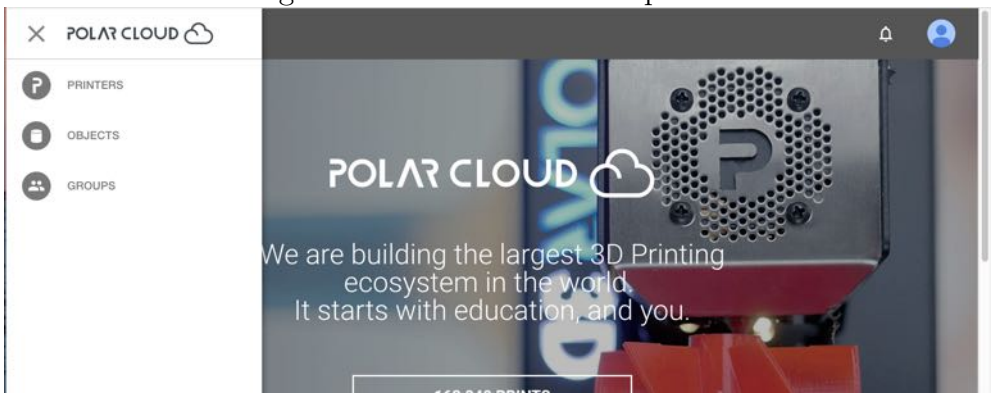
You may create groups of Polar Cloud members with a shared characteristic (*e.g.*, students in a class) or shared interests. A group is a particularly convenient way to share objects and share (access to) printers. See Section 4.4.

You may "LIKE" the objects of other members, and they may "LIKE" your objects; see Section 4.2.6. "LIKE"s are tallied and displayed along with the object (both in the icon displays of lists of objects, and on the object's screen).

4.10 Navigating through the Polar Cloud user interface

Go to http://polar3d.com and you will see the login screen, as shown in Figure 4.2. Once you have logged in, the main screen has an expandable menu icon at the upper left, with choices "PRINTERS", "OBJECTS", and "GROUPS"; see Figure 4.109.

Figure 4.109: Polar Cloud top menu



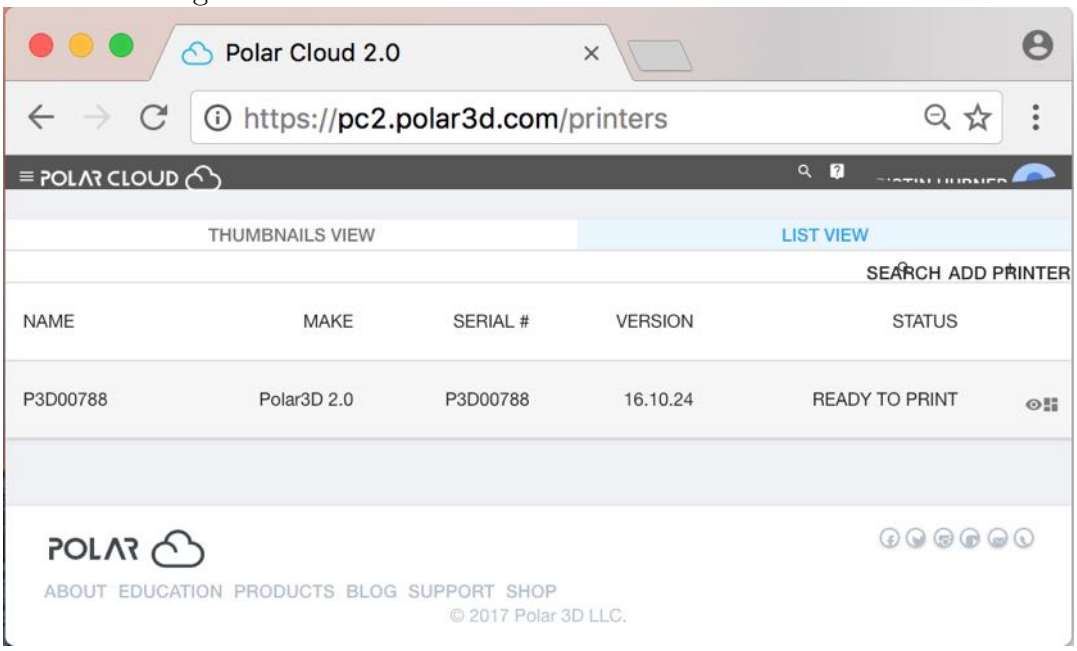
The main screen also has a drop down menu under the account name at the upper far right, with choices "`Settings`", your account email, and "`Sign Out`"; see Figure 4.1. And just to the left of the account drop down menu is a bell icon, for notifications.

You can return to the main screen from other Polar Cloud screens by clicking on the cloud icon towards the upper left.

4.10.1 Navigating the printers

Under "`PRINTERS`" will appear a list of printers (which can either be displayed via photos or via names – the icons for switching between views), a tab to "`ADD`" a printer, and a tab to "`SEARCH`" for a printer (relevant if you have many accessible printers). For an example of the thumbnail view, see Figure 4.55; for an example of the list view, see Figure 4.110.

Figure 4.110: Polar Cloud `PRINTERS` list view screen



Clicking on a specific printer from the "`THUMBNAIL VIEW`" (or clicking on the eye icon on that printer's line in the "`LIST VIEW`") will take you to the printer's dashboard screen, such as shown in Figure 4.111.

Clicking on the "`MANAGE`" tab from the printer dashboard (or on the squares icon on that printer's line in the "`LIST VIEW`") will take you to the printer management screen, such as shown in Figure 4.112. On the printer management screen are tabs "`QUEUE`" (display the current queue of jobs submitted to the printer), "`HISTORY`" (display the recent jobs printed on that printer), and "`MEMBERS`" (control which members may use the printer, and which members are considered managers of the printer).

(Note that "`DASHBOARD`" and "`MANAGE`" take you back and

Figure 4.111: Polar Cloud printer DASHBOARD screen

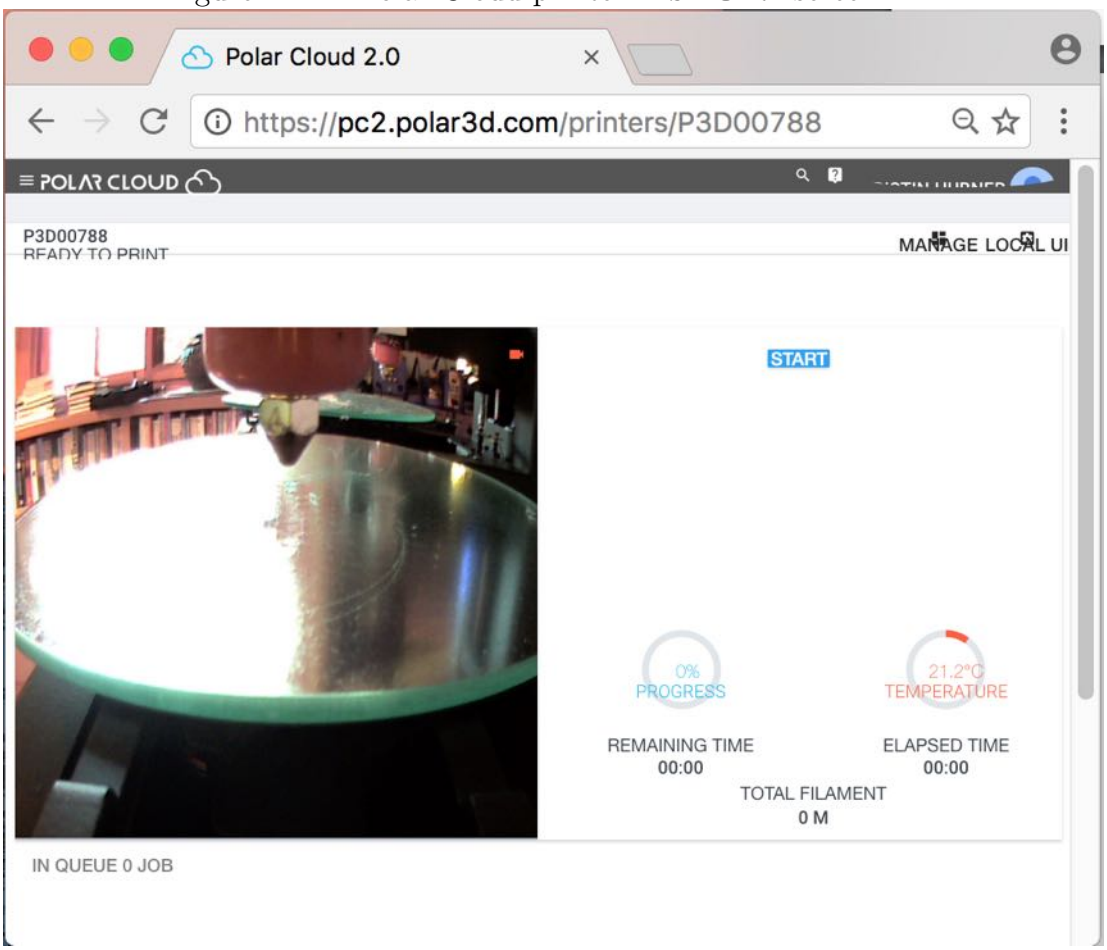
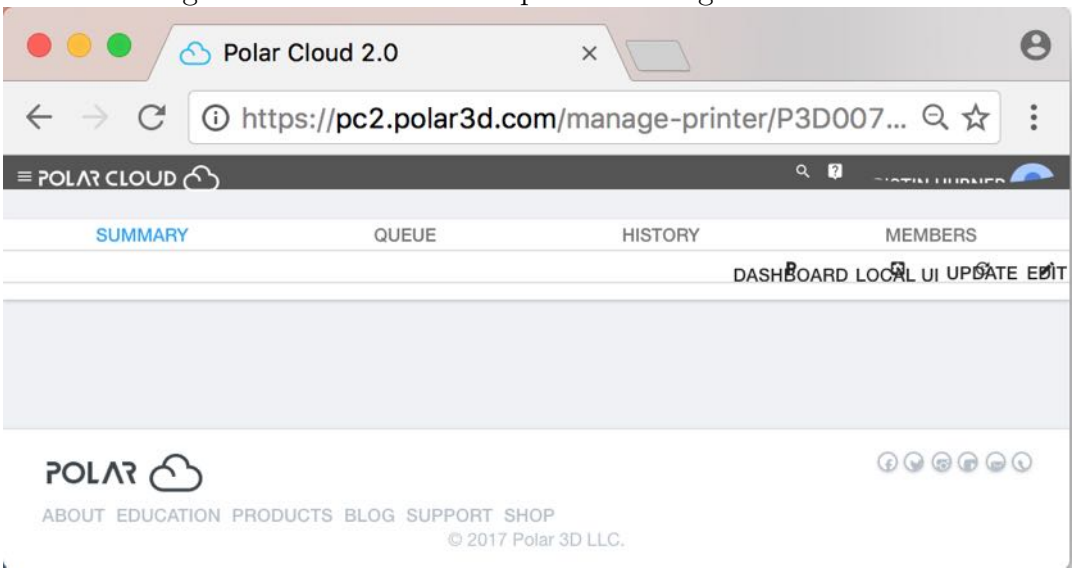


Figure 4.112: Polar Cloud printer management screen



forth between the printer dashboard screen and the printer management screen.) On either the dashboard or management screen, clicking the "`LOCAL UI`" tab will cause the Polar Cloud to attempt to connect back (over the Internet) to the printer's local interface (via its local IP address); see Section 4.5.9 and Chapter 5.

4.10.2 Navigating the objects

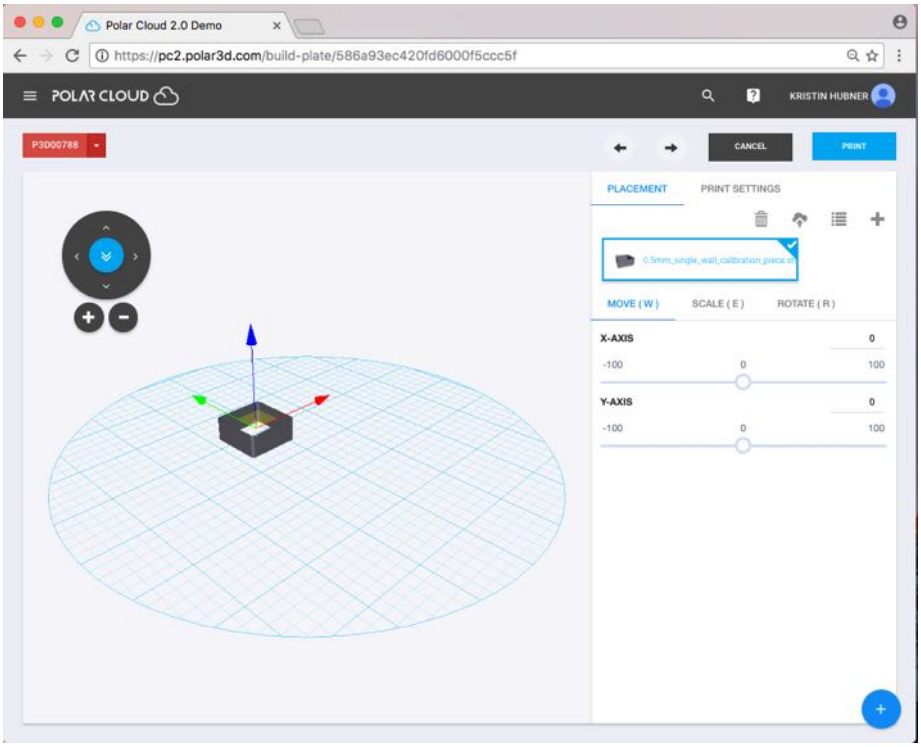
Expanding the Polar Cloud main screen's top left-hand menu and clicking "`OBJECTS`" (see Figure 4.8) will take you to the `OBJECTS` screen (Figure 4.9) with tabs for categories of objects: "`MY PRIVATE OBJECTS`", "`MY SHARED OBJECTS`", and "`PUBLIC OBJECTS`". Under each of these tabs, you may select (click on) any available object, or click a tab to "`UPLOAD`" or "`SEARCH`" for an object.

Clicking on the icon for an object itself will take you to a screen where (for one of your private objects) you may "3D PRINT", "DOWNLOAD", or "SHARE" your object, or "EDIT" the object's text description; see Figure 4.10. For shared objects, you have similar choices "3D PRINT", "DOWNLOAD", or "SHARE" (with "EDIT" the object text description not available for shared objects).

For any object, you may also "LIKE" the object by clicking on the heart icon (towards the upper right of the object screen).

Clicking on "3D PRINT" takes you to a screen where you may adjust "PLACEMENT" (position on the build plate) and "PRINT SETTINGS", or click the "PRINT" button when you are ready to print; see Figure 4.78.

Under "PLACEMENT", you may "MOVE", "SCALE", and "ROTATE" the object:



In the left hand side of the window, the object is schematically pictured on the build plate, with three colored axes (red for the x-axis, green for the y-axis, and blue for the z-axis), a "+" and "−" button, and a dial with four arrows around the outside and a central "restore" double arrow. The "+" and "−" buttons zoom in and zoom out, respectively, your view of the object, and the dial rotates your view of the object. The colored axes may be used to reposition the object on the build plate: position your cursor over an axis and drag the object along that axis.

In the right hand side of the window, you may select "`MOVE`", "`SCALE`", or "`ROTATE`".

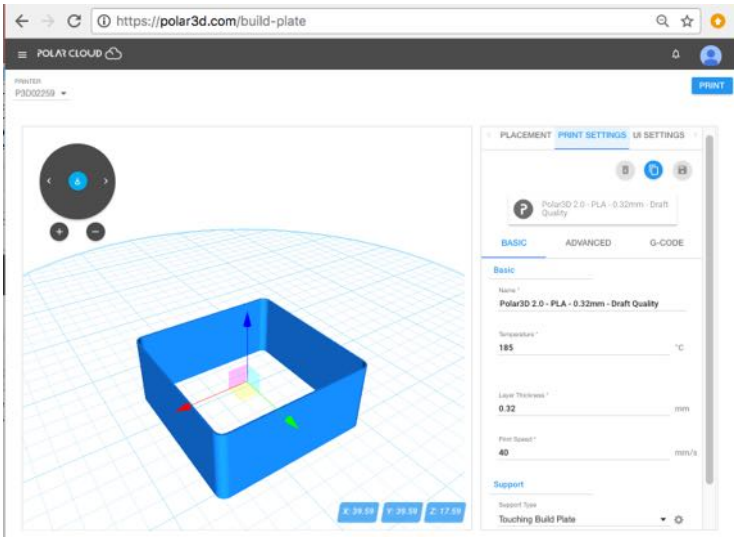
When "`MOVE`" is selected, as an alternative to dragging the object on the build plate, you may instead move the object on

the build plate via the "X-AXIS" and "Y-AXIS" sliders under "MOVE" in the right hand side of the window

When "SCALE" is selected, you may change the size of the object via any of the "X-AXIS", "Y-AXIS", or "Z-AXIS" sliders under "SCALE" in the right hand side of the window.

When "ROTATE" is selected, you may rotate the object via the "X-AXIS", "Y-AXIS", and "Z-AXIS" sliders under "ROTATE" in the right hand side of the window.

Under "PRINT SETTINGS":



1. You may adjust "BASIC" settings relating to: "Basic" settings such as extruder "Temperature" (a fundamental setting that must be aligned with the type of filament you are printing), "Layer Thickness", and "Print Speed"; or "Support" settings such as "Support Type" (where if your object is not actually touching the build plate, you may wish to add a type of support), or "Platform Adhesion Type" (which is where you may add a brim, raft, or skirt).

2. You may adjust "ADVANCED" settings relating to: "Fill" (infill) such as "Infill Speed, "Infill Overlap", and "Infill Amount"; "Filament" such as "Diameter" and "Flow"; "Retraction" such as "Amount Extruder Switch" (the amount to retract or raise the extruder when switching between extruders on a dual-extrusion 3D printer), "Speed" (the speed at which to perform the retraction – too quick a speed may "yank" up just-extruded filament whereas very slow retraction simply wastes time), "Amount" (the height by which to raise the extruder); "Quality" (which might be more alternately described as thickness of the exterior of the print object) such as "Initial Layer Thickness", "Extrusion Width", "Wall Thickness", "Bottom Layer Count", and "Top Layer Count"; "Speed (which goes into more detail than the basic "Speed" setting under "BASIC options) including among other things "Initial Layer Speed" (as printing the initial layer ; and "Cool" such as "Minimal Layer Time" and "Cooling Fan" (only relevant if your printer has a cooling fan).
3. You may adjust via the "G-CODE" tab the actual starting and ending Gcode that will be sent to the printer.

4.10.3 Navigating the groups

From the Polar Cloud's main screen left-hand menu, clicking "GROUPS" will take you to the GROUPS screen with its main tabs for "MY GROUPS" and "PUBLIC GROUPS", as shown in Figure 4.33. When "MY GROUPS" is active, tabs to "SEARCH" and "CREATE" a group are available; when "PUBLIC GROUPS" is active, only "SEARCH" is available.

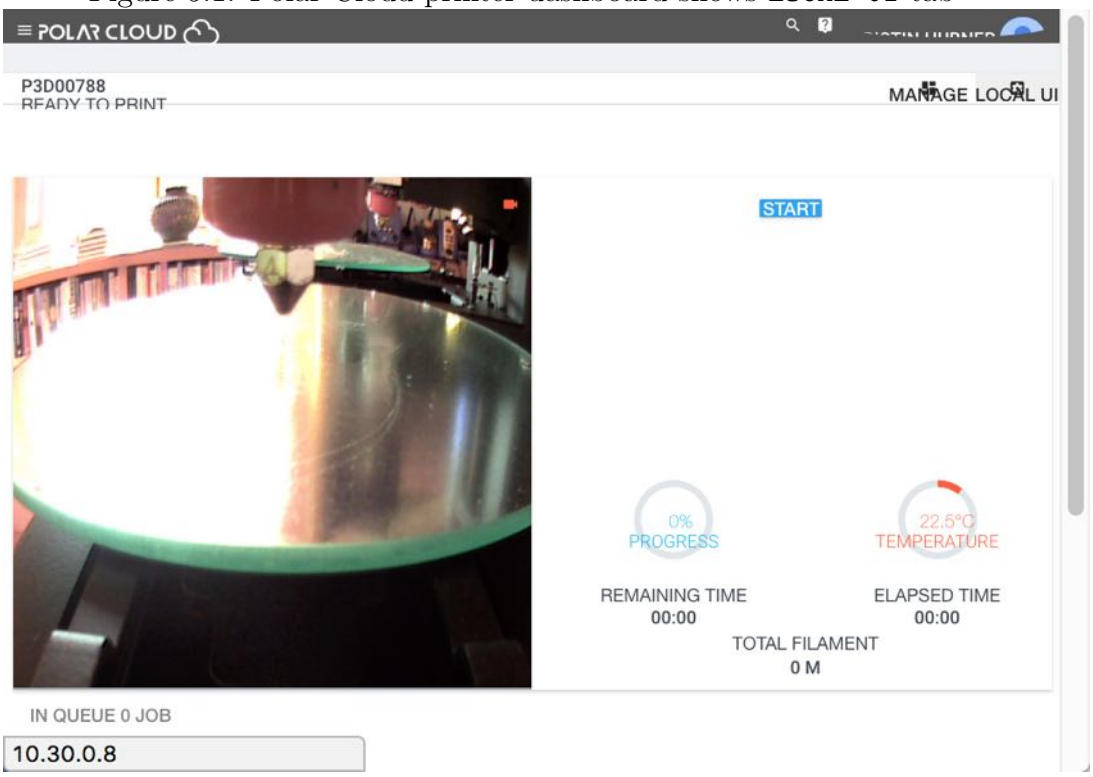
Chapter 5

The printer local web interface

If you are controlling your printer directly through its local WiFi (see Section C.1) rather than going through the Polar Cloud, then the printer's local web interface will be your main control interface. From a device on your local network (computer, tablet, or phone), simply open a browser window connecting to the printer's local IP address and you will be at the printer local web interface.

If you connect your printer to the Polar Cloud, then after performing its initial connection (see Chapter 1), you likely will seldom have a need or interest in connecting directly to the printer's local web interface. However, the printer's local web interface is still accessible. If you are on the same local network as the printer, you may simply open up a browser window and connect to its local IP address without going through the Polar Cloud. Or from within the Polar Cloud, navigate from the main menu to your list of printers, then click on the printer itself, and then click on the `LOCAL UI` tab (settings dial towards the upper

Figure 5.1: Polar Cloud printer dashboard shows `LOCAL UI` tab

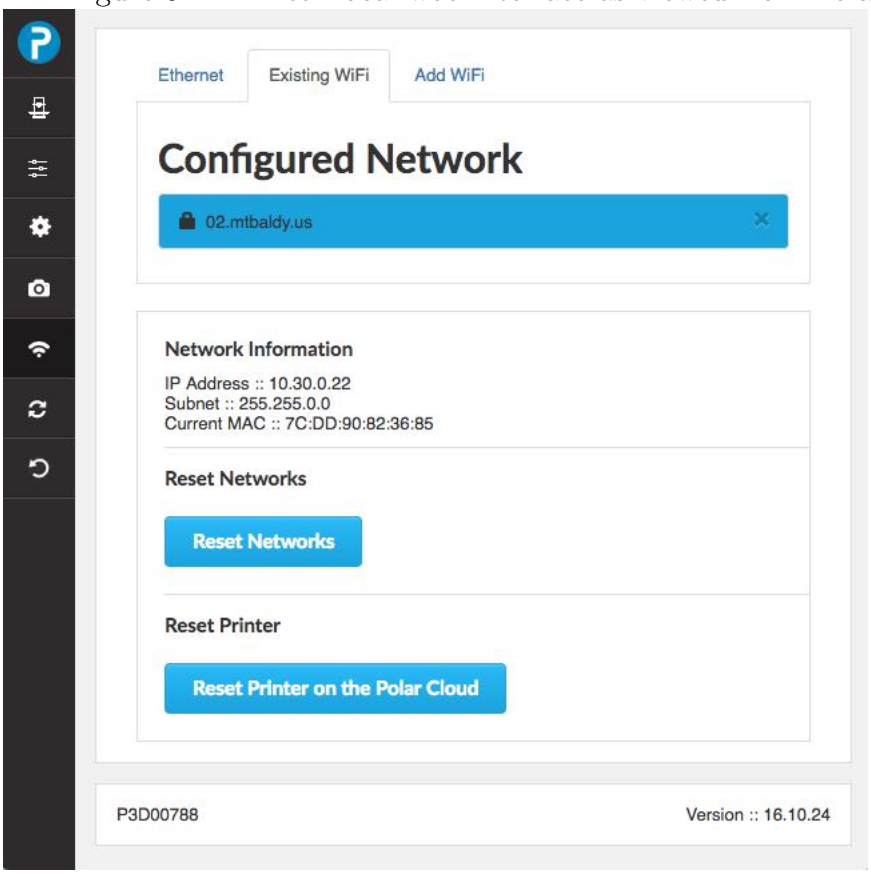


right), shown in Figure 5.1

The Polar Cloud will then attempt itself to connect to what it knows as the printer's local IP address. If your local network permits access to the printer's local IP address from the Internet (which some local networks may not), this will open a new window onto the printer local web interface, as shown in Figure 5.2.

(If your local network does not permit such access from the Internet, then you may still connect to the printer's local web interface more manually, by simply connecting directly to its local IP address, as previously mentioned.)

Figure 5.2: Printer local web interface as viewed from Polar Cloud



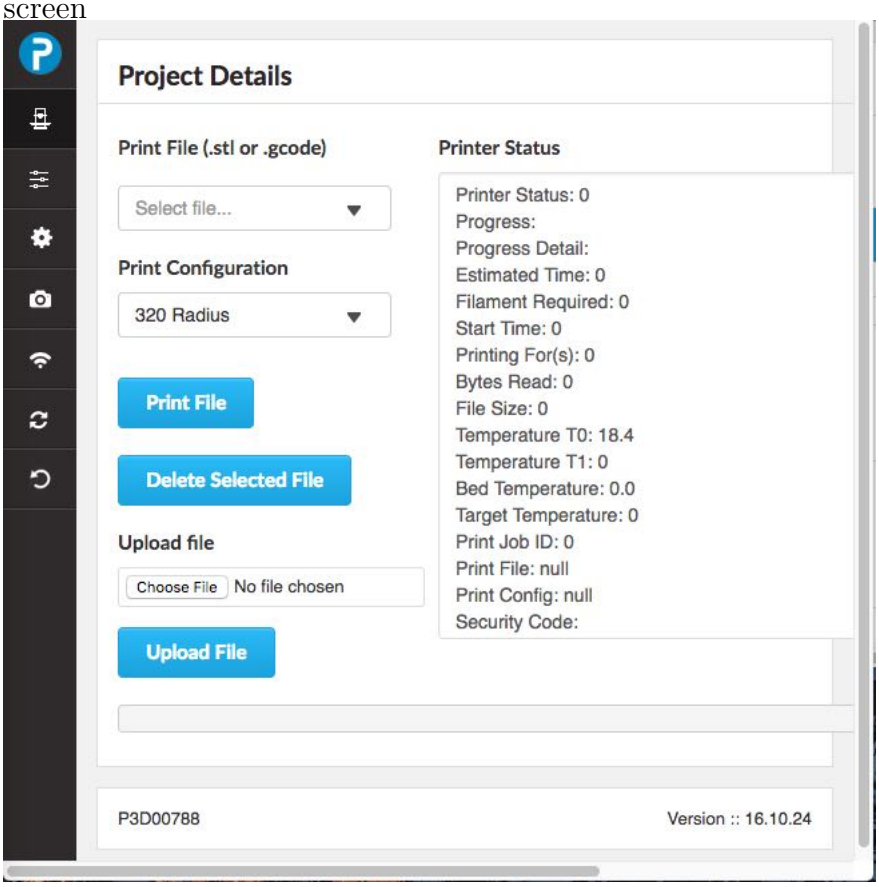
5.1 Navigating through the printer local web interface

Connecting to the printer's local IP address will put you at the network screen. This is the same screen you would see if you selected the networking icon on the left menu; see 6.

The tabs/icons at the left of the screen select additional screens:

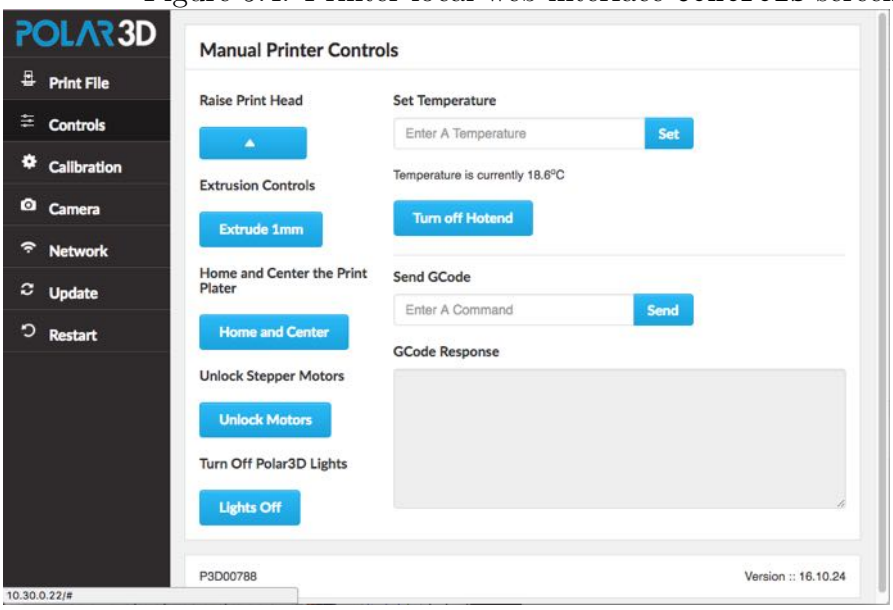
1. `POLAR3D` – the default (network) screen.
2. The printer icon ("`Print File`") selects the "`Project Details`" screen, where you may upload a file to print, or select an already available file to print (as the Polar3D printer's user interface ships with several test `.stl` files), and then initiate printing. This screen also displays, on the right hand side under "`Printer Status`", various status information regarding the printer.

Figure 5.3: Printer local web interface `Print File` (`Project Details`) screen



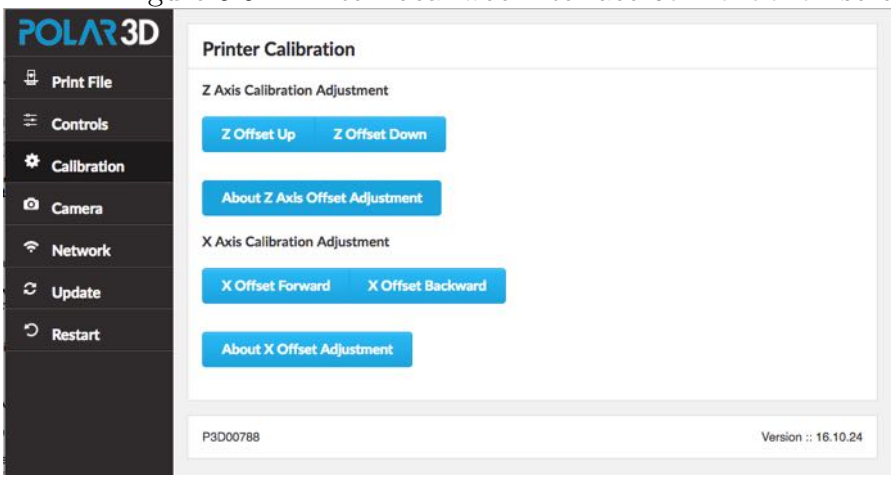
3. The lines-with-boxes icon (`Controls`). At this screen, you may manually direct the printer; *e.g.*, raise the print head, set the temperature, extrude a millimeter of filament, turn on/off the printer's LED lights, unlock the stepper motors (so that the print head and build plate shuttle may be moved manually), *etc.*

Figure 5.4: Printer local web interface `Controls` screen



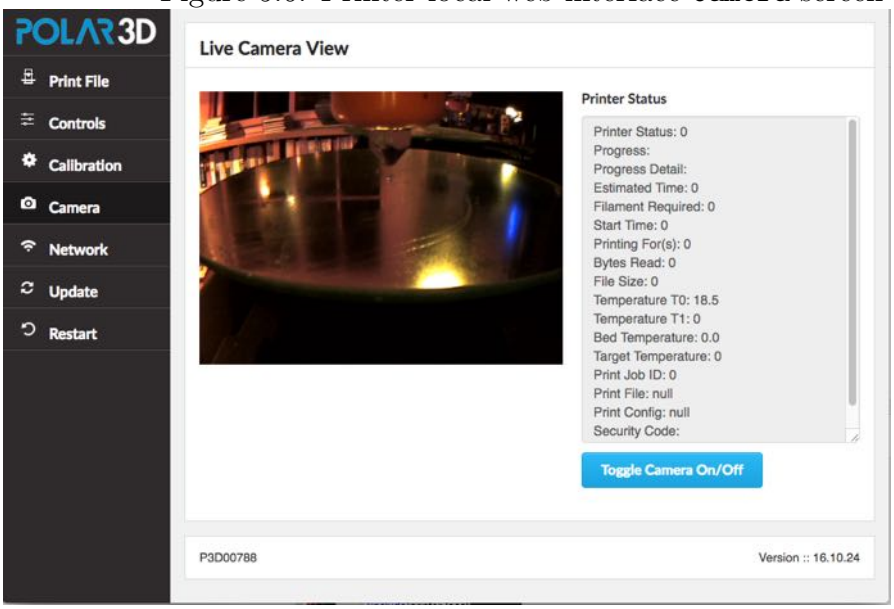
4. The dial/gear icon (`Calibration`) will take you to the "`Calibration`" screen, where you may perform Z axis (Z rod) and X axis (build plate shuttle) calibration.

Figure 5.5: Printer local web interface `Calibration` screen



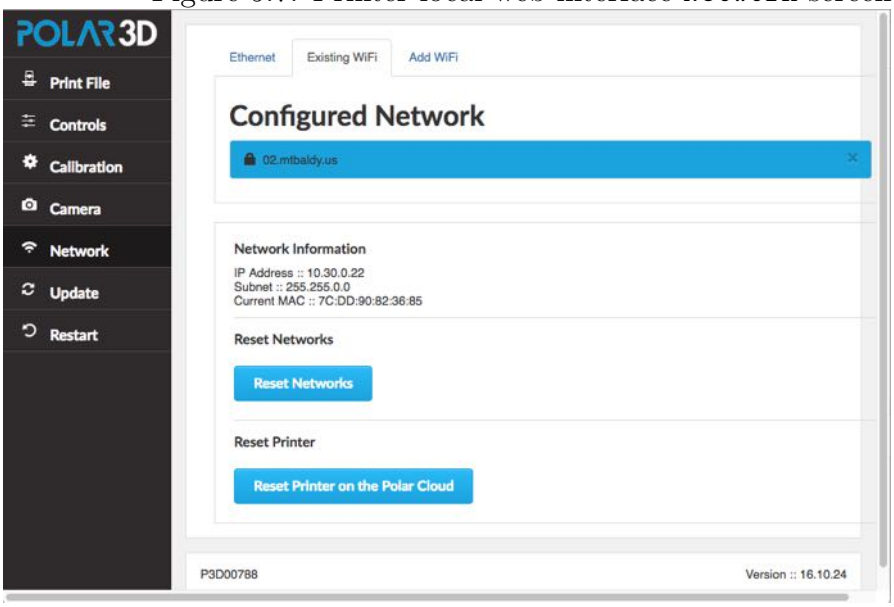
5. The camera icon (`Camera`) takes you to a screen showing live camera feed from the printer, and various printer status details.

Figure 5.6: Printer local web interface `Camera` screen



6. The network icon (`Network`) icon will take you to the "`Configured Network`" screen, where you may see what network the printer is on currently and the printer's own IP address on that network, and even switch to a different network.

Figure 5.7: Printer local web interface `Network` screen



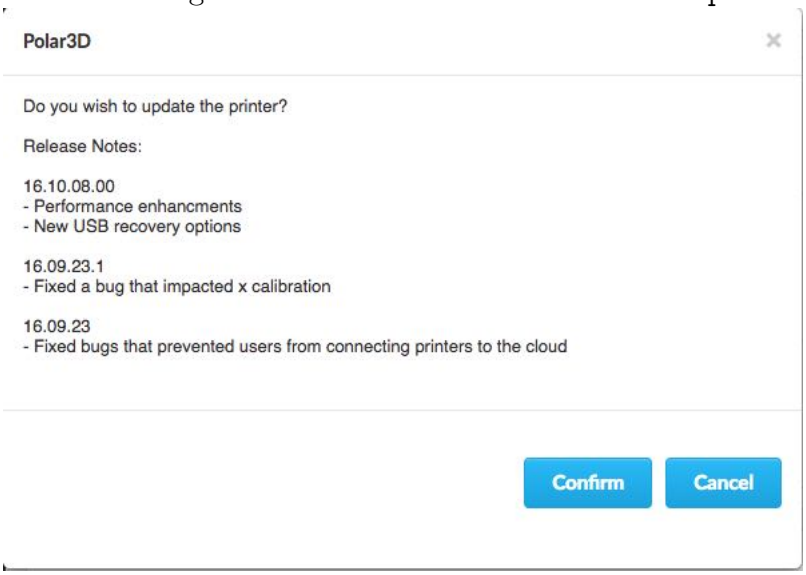
Note that the `Reset Networks` button will remove any configured network profiles, resetting the printer's network knowledge back to factory defaults. Thus you would *not* normally want to click this button *except* when permanently transferring the printer to an entirely new location (entirely different network milieu) or owner! (If you are merely temporarily moving your own printer to another network, it is more convenient to instead *add* the new WiFi network or plug in the Ethernet cable, and then use the "`Restart`" tab on the left pane to have the printer reconnect using the newly added network; see step 7 in Section 1.1. Then you can switch back to the original network later, by selecting that network and then again clicking "`Restart`", without having to entirely redo the network profile.)

Note that the "`Reset Printer on the Polar Cloud`" button on the "`Configured Network`" screen will obsolete any existing ownership of this printer in the Polar Cloud. That is, any Polar Cloud members who had formerly been the owner of or been allowed access to this printer will now no longer see the `P3D`*`serial-number`* printer, and instead will see a reference to `P3D`*`serial-number`*`-deleted-`*`date`*. (Such members may wish to move any queued jobs that had been on that printer to some other printer.) Thus you would *not* normally want to click this button except when transferring ownership of the printer to some other person (some other Polar Cloud member). After clicking this button, the printer will need to be re-registered to some Polar Cloud account in order to be used by any Polar Cloud members; see step 10 of Section 1.1.

Thus both the buttons `Reset Networks` and even more so `Reset Printer on the Polar Cloud` are primarily of interest when *transferring the printer to another owner*.

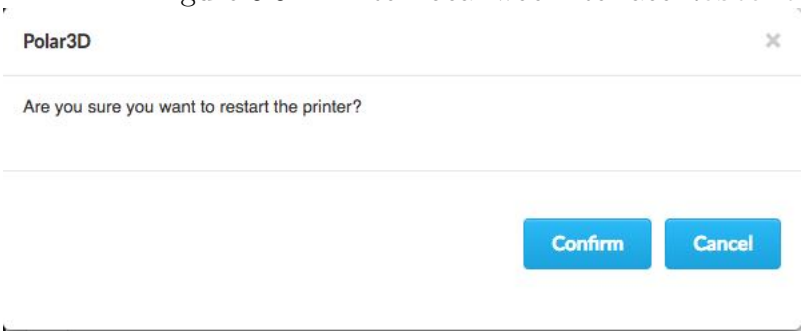
7. The update icon (`Update`) if clicked will show you a summary of any current update, and ask if you wish to apply that update:

Figure 5.8: Printer local web interface `Update` screen



8. The restart icon (`Restart`) will ask if you wish to restart the printer:

Figure 5.9: Printer local web interface `Restart` screen



Chapter 6

CAD software – create your own objects

There are many computer-aided design (CAD) software packages available; for 3D printing, you will just need a package that can save object files in `.stl` file format.

The Polar Cloud itself provides access to some convenient CAD software you can access and use – see Section 4.3. Alternatively, if you prefer you may use many popular CAD packages of your choice to generate `.stl` files.

For younger designers or beginners, we recommend Tinkercad. It is a browser-based design program so no software needs to be installed locally. This makes it a great solution for Chromebooks.

Sketchup is another good solution for designing 3D parts. Make sure to install the STL plugin so you can export your design for 3D printing.

Autodesk Fusion 360 is higher-level CAD software provided

on a cloud platform, available free to students and hobbyists, and available for Mac or PC.

Autodesk 123D Design, OnShape, and Morphi are good apps for iPad users. They have free versions (123D) or free for education versions (OnShape), or free with limitations (Morphi) and you can pay to unlock all the features. Morphi offers discount pricing for schools based on the number of seats purchased.

Blender is an open-source design package that can also be used for 3D animation, so time spent learning this tool means students can do more than just create models for printing.

OpenSCAD is open-source software for creating 3D CAD objects, with a focus on programming and engineering.

Sculptris is focussed on art, and in particular, virtual sculpting.

Note that AutoDesk offers several professional design software packages that are for free to students and teachers. Some have already been listed above, but to list a few more with comparisons:

1. Autodesk 123D Design is a good intermediate design tool.
2. Autodesk Fusion 360 is higher-level CAD software provided on a cloud platform.
3. Autodesk Maya is an animation package that can be used for 3D modeling.
4. Autodesk Inventor is a mechanical design and 3D CAD software package that offers professional-grade 3D mechanical design, documentation, and product simulation tools. This is good for advanced users who need exact tolerances

in designs that they are creating.

Chapter 7

STEAMtrax curriculum

STEAMtrax is an innovative new curriculum that integrates engineering and 3D printing technology with core academic knowledge in science, math, language arts, social studies, and art. In the true spirit of the Framework for 21st Century Learning skills, students are engaged in relevant learning scenarios that encourage the essential skills of problem solving, collaboration, communication, clear and critical thinking as well as developing core academic knowledge. Each lesson imbeds 3D design, printing and scanning technology as an integral part of the STEAMtrax Engineering Process.

STEAMtrax curriculum module features include:

1. Problem-based, thematic storylines make learning relevant and fun.
2. Hands-on, constructivist learning stations to clarity science concepts.
3. Integration of 3D design, printing, and scanning built into each module.

4. Engineering Project Design Process encourages critical thinking.
5. A variety of formative and summative assessments, including rubrics.
6. Flexible modules easily align to NGSS or state standards.
7. Available in digital or print form.
8. Hands-on science kits are available for each module.
9. Modules available for grades K-12.

To see a current list of available STEAMtrax modules, go to:

http://www.polar3d.com/curriculum

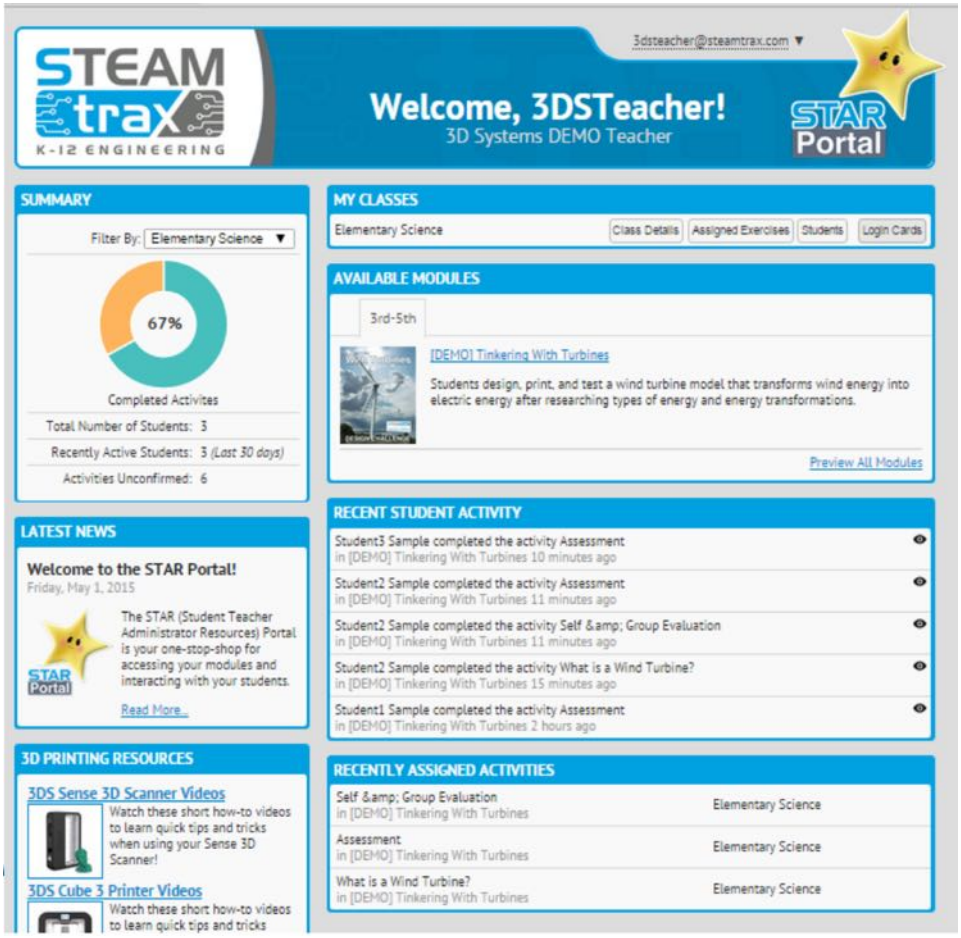
7.1 STEAMtrax Star Portal

STEAMtrax modules are available in print form, if desired. But more often, teachers and students will wish to access STEAMtrax modules through the STEAMtrax Star Portal, at:

http://build.steamtrax.com

In addition to including access to all the print materials, the STEAMtrax Star Portal also includes an interactive teacher dashboard for each teacher, and an interactive student dashboard for each student.

7.1.1 STEAMtrax Star Portal teacher dashboard



The teacher dashboard includes nine panels:

1. SUMMARY – A per-class (for cases where a teacher has more than one class using STEAMtrax) summary of the percent of activities (assignments) completed, the total number of students, the number of students recently active (last 30 days), and the number of activities which are unconfirmed (not yet checked by the teacher).
2. MY CLASSES – Access to class information including the

name of the class, the students in the class and the assignments for each student, the assigned exercises for the class and the total number of students who have been assigned/completed/confirmed for each such assignment, and the login data for each student. (The class and student data is customized for each teacher by STEAMtrax; see Section 7.2 for details on this process.)

3. LATEST NEWS – STEAMtrax news for teachers.
4. 3D PRINTING RESOURCES – How-to videos on printers, software, and scanners, as well as other helpful tips for teachers.
5. ENGINEERS TODAY – News on engineering. (Student dashboards also have this panel.)
6. 3D PRINTING ZONE – 3D printing news, resources, and interesting `.stl` files. (Student dashboards also have this panel.)
7. RECENT STUDENT ACTIVITY – A running list of recent student activity. The teacher can review a student activity/assignment submission by clicking a preview icon next to the submission item. Within the preview, the teacher can decide to "Confirm Assignment Completion" or "Reassign to Student". This is a way for the teacher to track which assignments he or she has reviewed, and to provide feedback to students by reassigning when the submission needs re-working.
8. RECENTLY ASSIGNED ACTIVITIES – A running list of the class assignments for this class.

9. AVAILABLE MODULES – Teacher-level access to modules. All purchased modules, organized by grade band, can be accessed from this panel.

7.1.2 STEAMtrax module teacher view

Every engineering module is organized with four sections. Within each section, material visible only to teachers is labelled in green on the dashboard, while material also visible to students is labelled in red on the dashboard.

1. Module Preparation – Pre-Lesson Instructions. Teacher-

visible materials under Module Preparation typically include:

(a) Welcome – Outlines for the teacher the four key sections of the module.

(b) Targeted concepts & skills – Outlines for the teacher how the module aligns to standards.

(c) Teacher background – Introduction for the teacher to background science and math concepts that will be taught in the module.

(d) Setup-Up and Management – Guidance to teachers on what should be printed out ahead of time, and how to set-up the learning stations.

(e) Materials Needed – A complete list for the teacher of all the hands-on materials needed to run the module. (Note that pre-packaged, hands-on, Engineering Kits of everything needed may optionally be purchased along with the STEAMtrax module.)

(f) Parent letter – A letter, customized for each module, for the teacher to send home with students. (The student module view also has access to this letter.)

(Note that in print delivery format, any setup and management instructions, list of materials needed, background concepts for the teacher, targeted concepts and skills outlining how the module aligns to standards, and the parent letter are all collected into a "Teacher Guide".)

2. Classroom Guide – A Facilitation Guide to orient the teacher and guide the teacher through the module, a Classroom

Guide to use in the classroom, and 3D printing file(s) and instructions as a starting point for use and reference.

(a) Facilitation Guide – A detailed resource including pacing, facilitation questions, objectives, and overall step-by-step guidance to run the module. It is recommended that the teacher print this out ahead of time to understand the module flow, and jot down any notes.

(b) Classroom Guide – A detailed resource for teachers to use in the classroom. Every module follows the Engineering Design Process, and the classroom guide resource is built to guide teachers and students through the process. The Class Guide EDP may include pop-up slides for the teacher to project on a screen or electronic white board to guide students through the process of the module.

(c) 3D Printing Files – Sample `.stl` file(s) and step-by-step CAD instructions for the teacher and students to use and reference. (The student module view also has access to this section.)

3. Student Activities – Activities for the students, and downloadable materials.

   (a) Activities may include readings, videos to watch, assignments to print 3D objects, *etc.*

   (b) Lesson downloads always includes at a minimum a Student Notebook, in which students are to record their observations and conclusions.

4. Student Assessments – Evaluation form, rubric, and an as-

sessment, as well as a (teacher-only visible) assessment key.

(a) Evaluation Rubric – Downloadable, and provided as an example rubric for students, as well as the teacher, to reference. (The student module view has access to this also.)

(b) Self & Group Evaluation – Students also have a copy of this form in their Student Notebooks. The teacher can choose whether to have students fill it out in their Student Notebooks, or whether (if the teacher clicks an "Assign to Students" button on this evaluation section) to have it also show up in the students' Star Portal as an assignment to be completed online.

(c) Assessment – The assessment is not visible to students *until* the teacher assigns it (by clicking an "Assign to Students" button); at that point, once assigned, it becomes visible to the students.

(d) Teacher Answer Key – Assessment answer key for teacher reference.

7.1.3 STEAMtrax Star Portal student dashboard

The student dashboard includes five main panels:

1. SUMMARY – Total assignments, Complete assignments, Confirmed assignments. (Confirmed assignments are those that the teacher has reviewed and checked off.)
2. ACTIVITY LOG – A record of what the student has been

assigned, when it was assigned, and (if completed) when it was completed.

3. ENGINEERS TODAY – Updates on engineering.
4. 3D PRINTING ZONE – 3D printing news, resources, and interesting `.stl` files.
5. AVAILABLE MODULES – Student-level access to modules.

In addition, for K-8 students a "Stacy STEAMtrax" character icon displays a blurb guiding the student to any new assignment or confirming to the student that all assignments have been completed.

7.1.4 STEAMtrax module student view

Just like teachers, students can access a module by clicking on the module link under the AVAILABLE MODULES panel in their student dashboard; (see Section **??**). And (again like teachers) the students see four main sections in each module in the student module view. However, students do not see also the teacher-only visible background and guidance material within the sections. Instead, in the student module view, what appears may typically be something like:

1. Module Preparation
   (a) Parent letter
2. Classroom Guide
   (a) 3D Printing Files

3. Student Activitities
   (a) Activities
   (b) Lesson downloads – Includes at a minimum a Student Notebook.
4. Student Assessments
   (a) Evaluation Rubric
   (b) Self & Group Evaluation
   (c) Assessment – Only becomes visible to students once the teacher assigns it.

7.2 STEAMtrax user import

STEAMtrax is accessed through its Star Portal at

http://build.steamtrax.com

So that STEAMtrax will be ready to use the first time a teacher logs in at that portal, STEAMtrax has a process for entering general information regarding the teacher and class that will be using STEAMtrax. The instructions for importing the teacher and general class data may be found at:

https://polar3d.freshdesk.com/support/solutions/articles/9000096273-user-import-instructions

Please contact Polar 3D if you have any questions or difficulties entering the class data.

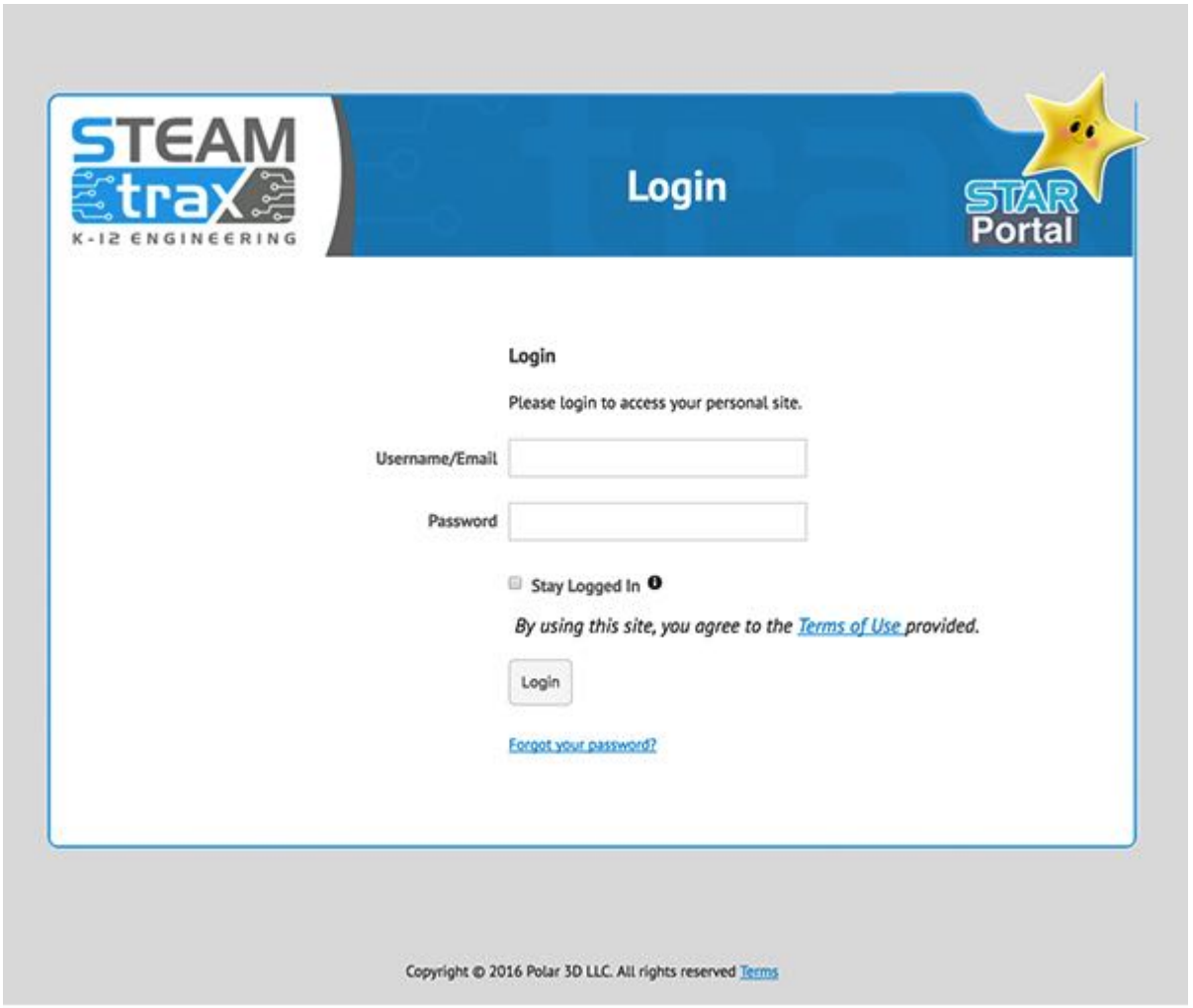
7.3 STEAMtrax user password management

The teacher and each student using STEAMtrax will each have their own password.

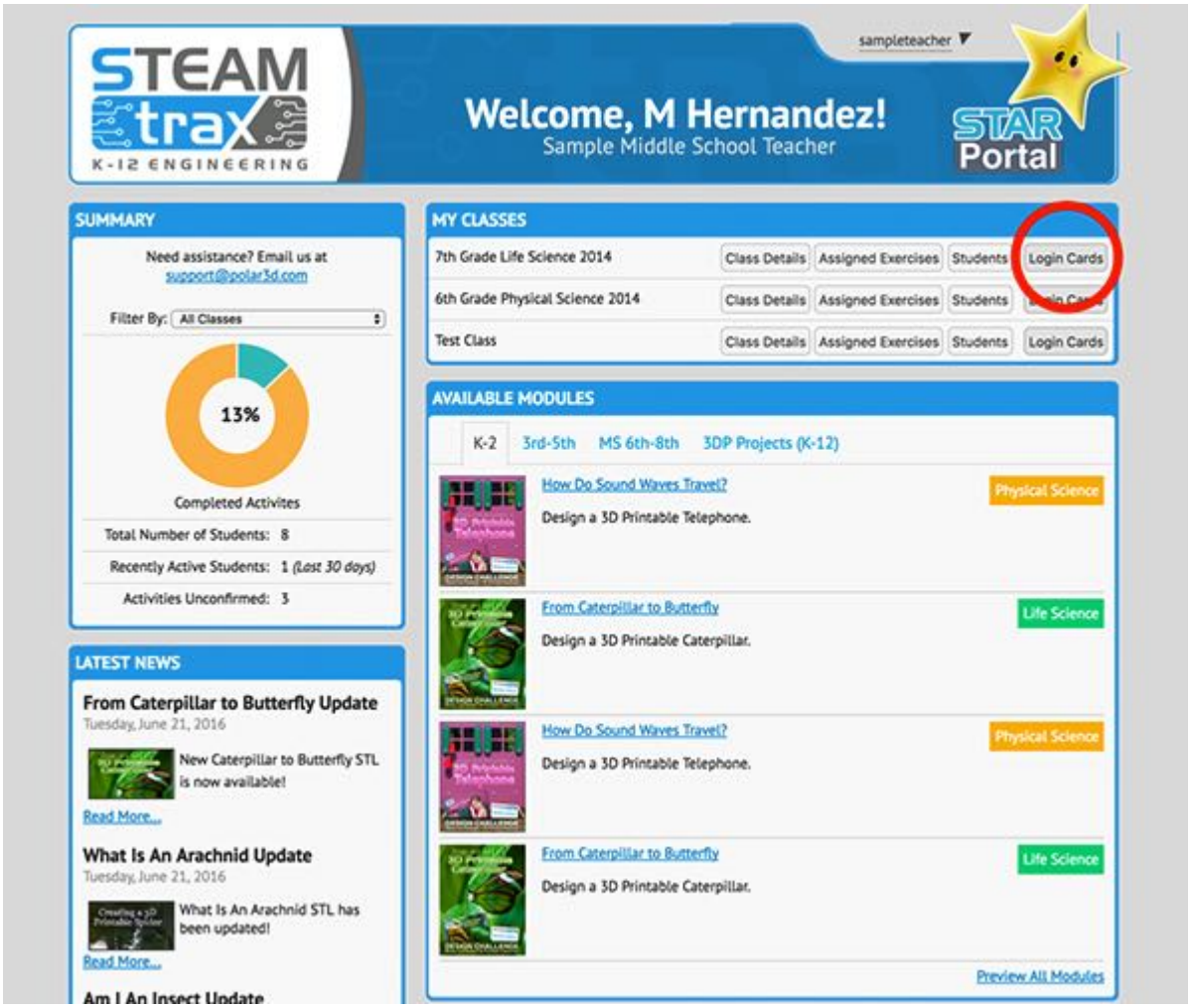
With a busy lesson plan and a short period, there's nothing worse than lost class time; retrieving lost student passwords can be a huge time waster! Because we know that keeping a class on topic and engaged is the bedrock of classroom management, the STEAMtrax Star Portal includes a simple mechanism to make it easy to retrieve lost student passwords and to prevent student passwords from being lost in the first place:

1. Log in to the teacher's STEAMtrax portal at

   http://build.steamtrax.com



2. Locate the student's class in the MY CLASSES panel.

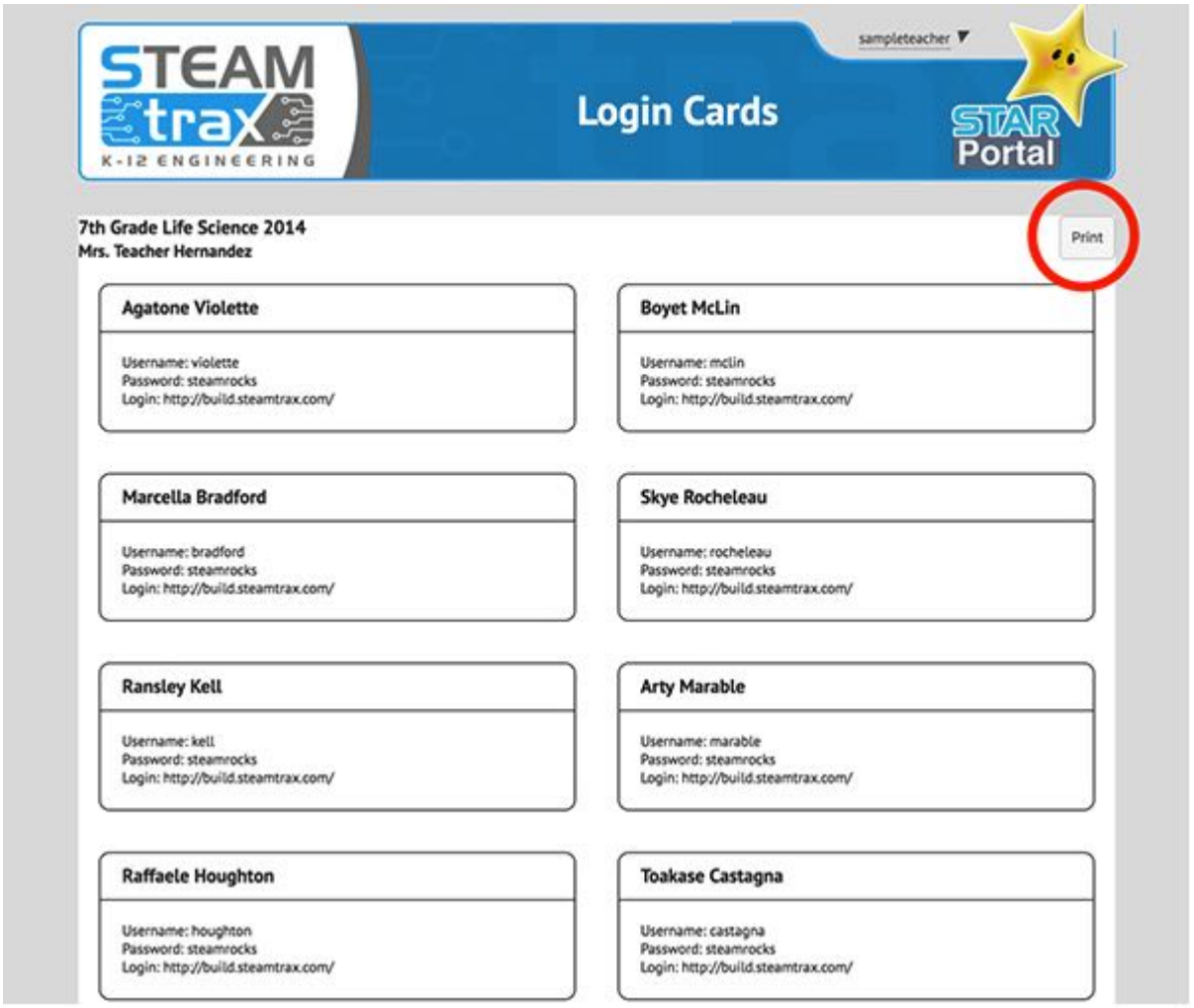


3. Click on the `Login Cards` button associated with that class.

The screen will then display a list of all students, including their user names and passwords. This list is updated every time a student changes his/her password, so you always have easy access to the most up-to-date login information for each and every one of your students.

4. Note the `Print` button in the upper righthand corner of the Login Cards screen. By printing this Login Cards page on a sheet of 8.5 X 11 Avery label paper, you can create

an adhesive label for each student that can be attached to the inside of a binder, folder or adhered to the back of the student's STEAMtrax Student Notebook. This allows the students to easily manage his/her own password by referring to this label.



For additional discussion, see:

Polar 3D support: My student forgot his/her password!

Chapter 8

Operational tips

1. Good adhesion of objects to the build plate improves build quality, and reduces the frustration of objects coming loose partway through a build.
2. Good positioning of object(s) on the build plate can improve speed and quality of prints.
3. Know the characteristics of your filament.
4. Perform periodic maintenance on the printer, as discussed in Chapter 10.

8.1 Positioning objects

Thoughtful positioning of your object on the build plate can improve print speed and quality:

1. For faster print completion, position objects towards the edge of the build plate.

2. Print multiple small objects at once; this can actually improve the quality of objects (as well as production speed).
3. Avoid straight-line extrusion runs through the center of the build plate.

8.1.1 Position objects towards the edge of the build plate

In consequence of the Polar3D printer's underlying polar coordinates architecture, note that objects may print faster if you position them towards the edge of the build plate, rather than at the center. Positioning an object towards the edge of the build plate won't effect the speed of extrusion; but when the printer needs to spin the build plate to achieve a non-extrusion move, the same angular spin results in a longer arc length (faster movement) towards the edge of the build plate.

8.1.2 Print multiple small objects at once

When printing a small object, especially a small and tall object, the printer may print so quickly that successive layers are deposited while lower layers are still hot and malleable, resulting in a "smooshed" or "melted" effect on the print: a less than optimal print outcome.

One approach is to slow down the print, for instance by inserting Gcode for a delay after each layer. Another approach is to point a small fan at the build plate, to speed up the cooling process, so that even small, quickly-printed layers get cool before the printer gets to the next layer. A third approach is to

consider printing multiple objects: the time the printer spends moving to another section of the build plate, and then printing a layer of another object, is likely to suffice to let the first object's layer cool.

See Section 4.6.1 and Section 4.6.1.1 for a discussion of adding an object or objects to the build plate.

8.1.3 Avoid straight-line extrusion runs through the center of the build plate

The Polar3D printer's underlying polar coordinates architecture means that in order to perform a "straight-line" extrusion through the very center of the build plate, the printer must pause extruding when it reaches the center of the build plate and perform a 180° spin, before resuming printing. This makes this a point where if your printer's calibration is less than perfect, it may be more apparent here (straight-line extrusion runs through the center point of the build plate) than anywhere else: with less than perfect callibration, you might see a jog in the output, a bit of a blob at the exact center, a slight bend in the line, etc.

So if the appearance of an exact, smooth, straight line is an important part of the object you are printing, try to position the object so that (visible) such straight lines of material don't have to go through the exact center of the build plate – or else be very careful with your callibration.

8.2 Adhesion and adhesion problems

Sometimes during a print an object will come loose from the build plate, usually resulting in the print being ruined.

The first layer of the print needs to stick to the build plate. Preparing the build plate properly, to be sticky so that that first layer adheres, can aid in avoiding this occurrence.

It is also important that the initial layer print at the correct height above the build plate: just a little "squished" so that it adheres, not too high so that it doesn't adhere, nor too low so that it is overly "squished" or dragged by the print nozzle.

If the printer has just been turned on and heated up, it is also important that the extruder is consistently emitted melted plastic during the entire first layer, rather than "burping" and failing to emit melted filament at spots in the first layer. This does not tend to be a problem with the Polar3D printer – but if you do encounter a problem consistently extruding melted filament when the printer first begins extruding, consider printing a few skirt loops to establish a smooth flow of filament, before printing the actual object.

And printing at the proper temperature for your filament is important for adhesion.

Some objects, however, will need extra assistance for adhesion. In those cases, printing a brim or raft may aid in keeping the object in place.

8.2.1 Making the build plate sticky

You should ensure that the build plate is a bit "sticky". What sort of stickiness works best depends a bit on what type of filament you are using. The filament that Polar 3D sells is PLA (PolyLactic Acid) filament, which sticks well to certain brands of hair spray, to the glue in many common glue sticks, or to ordinary blue painter's tape.

Hair spray is particularly quick and easy to apply. Aqua Net Extra Hold works well; or look for any other hair spray containing VA/crotonates/vinyl neodecanate copolymer. After applying a generous layer to a new or freshly cleaned build plate, you need only lightly "touch up" the hair spray for additional prints; for a video demonstration, see:

https://www.instagram.com/p/BJBaWwrjCwF/

As the hair spray will tend to build up over time, every so often, (every few weeks, depending on how heavily used the printer is), clean the build plate with hot water and paper towels, and then reapply a fresh generous layer of hair spray.

But if glue sticks are more convenient for your classroom, they work too, though they may result in an object sticking *too* well if a heavy layer is applied – try to apply a very thin, even coat to the build plate. Any PVA (Polyvinyl acetate) based glue stick, including Elmer's washable glue sticks/Purple Disappearing glue sticks, or Scotch glue sticks, should work.

A layer of blue painter's tape on the build surface is another way to achieve an adhesive surface, though applying it is liable to take a bit more time. (Also, sometimes an object will start

pulling the tape off, at which point the rest of the build will likely be warped.) Lay down a uniform layer of tape, with no gaps and no overlapping of the edges of the strips of tape. The painter's tape will need to be replaced when its surface becomes less adhesive, typically after about five to ten prints at the same location.

For ABS filament, the above build plate preparation approaches (hair spray, glue stick, or painter's tape) work; in addition, ABS will also stick to PEI sheets, PET sheets, or Kapton tape, or the build plate may be spread with "ABS juice" – a slurry made from ABS and acetone (which dissolves ABS).

8.2.2 First layer height calibration

For proper adhesion, as well as a smooth base layer, it is important that the initial layer of the object print at the correct height above the build plate: just a little "smooshed" so that it adheres. When the Z height of the first layer is well-calibrated, the lines of the first layer should be slightly touching. If there are gaps in the first layer between the lines of material, then the Z height is too high; if the lines of material are overlapping and aren't forming a smooth surface (or material is getting dragged or smeared by the print nozzle), then the Z height is too low.

To adjust the calibration, connect to your printer's local web interface (*e.g.*, connect to your printer's local IP address – see Chapter 5), select "`Calibration`", and click on "`Z offset down`". This action will lower the Z home by 0.05mm (about 1/2 the thickness of a sheet of paper). Continue to lower the gantry

until the tip of the extruder is just touching the build plate. When you are at the correct height, click the "`Just Right`" button.

Also, though unlikely: check that the build plate is maintaining a consistent height from the extruder nozzle over the build plate shuttle's range of motion (since if the height isn't consistent, that first layer may not be getting consistent "smooshing"). Check the Z height with the extruder at the middle of the build plate; then slide the build plate shuttle forward so that the extruder is at the edge of the build plate and confirm that the Z height hasn't changed. If the Z height *is* changing from middle to edge of build plate, then see Section 10.6 for a discussion of checking and correcting build plate shuttle alignment.

8.2.3 First layer print speed and thickness

"`PRINT SETTINGS`" (in the Polar Cloud, specified under "`Object`", the object in question, "`3D Print`") has a couple of settings that may affect the printing of the first layer and therefore its adhesion properties. See in particular the "`ADVANCED`" setting of "`Speed`", "`First Layer Speed`", and the "`ADVANCED`" setting of "`Quality`", "`Initial Layer Thickness`".

8.2.4 Temperature and adhesion

With PLA filament, if you print at too high of a temperature, the PLA will curl slightly when it cools along the edges, which might pull the edges up off the build plate over time. If you're using Polar 3D filament, we recommend 185°C. PLA filament

from other manufacturers may need to be printed at a slightly different temperature; check any information from the manufacturer of the filament.

Note that ABS filament is quite prone to curling as it cools, which is one reason why we don't recommend ABS filament for beginners; PLA filament is much more forgiving (if printing at the proper temperature).

8.2.5 Brims, rafts, and skirts

Sometimes, especially when printing an object with a small footprint on the build plate, an extra adhesion feature such as a brim may be helpful.

A brim is extra material, typically only one or two layers tall and several outlines wide, printed around the perimeter of the object touching the object, extending outward, to stabilize the object. A brim tends to be helpful with small or isolated parts of a model, *e.g.*, hooves of an animal, to aid with adhesion of the small area of the object to the build plate by extending the area.

A raft is a few extra layers of material, printed as a horizontal latticework, extending under the entire object. Besides helping with adhesion, it can also provide a strong foundation for the rest of the print. The number of layers in the raft controls the height (and to some degree the strength) of the raft; the raft offset controls how far beyond the main object the raft will extend; the raft separation determines the distance between the raft and the object itself – typical distances range from 0.14–0.2mm – where you want to aim for a close enough distance to

give adequate adhesion during the build, but not so close that it becomes very difficult to remove the raft from the object once the print has finished; the raft infill controls the density of the interior of the raft, where you want enough material to support the bottom of your main object but not so much that the raft is so solid that it bonds too tightly to the bottom of your main object.

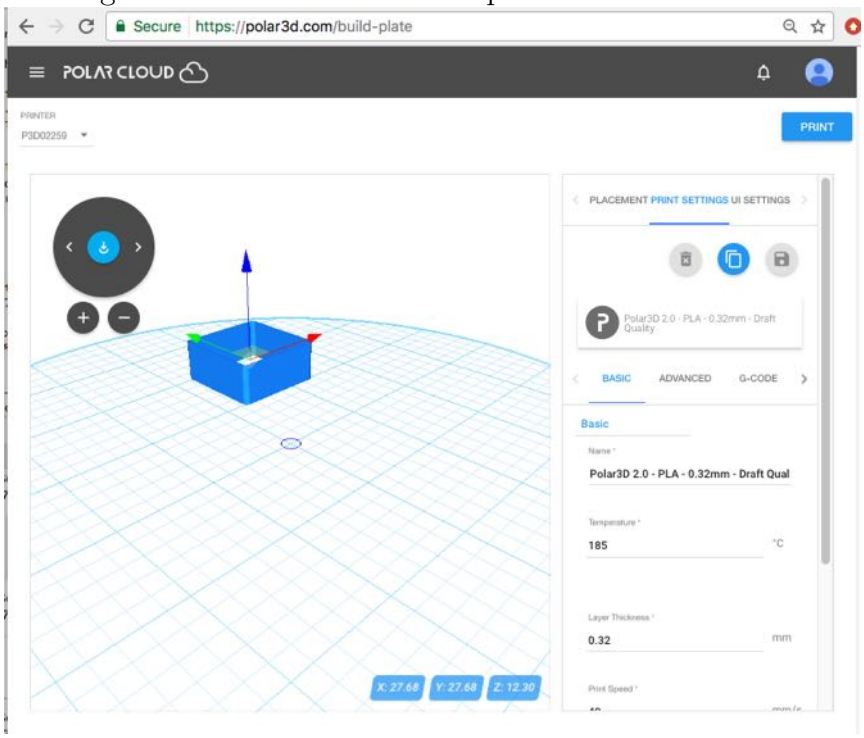
A skirt is an outline of extra material printed surrounding the perimeter of the object, but not touching it, typically offset 3 or 4 millimeters from the object; it is thus similar to a brim that has been moved farther from the object itself. However, unlike a brim, sometimes a skirt might be quite tall – even the height of the object itself – rather than, like a brim, being only a few layers high. This is because a skirt is sometimes used to shield the object from drafts; as such, they tend to be used more with filament such as ABS where uneven cooling can cause warping.

Including a brim around small or isolated parts of a model object may aid in adhesion and stability of that portion of the build. Including a raft under a model object may aid in adhesion of model objects that have small footprints on the build plate, as well as adding stability and a solid foundation for the rest of the build, especially if the overall object is relatively large compared to its small footprint on the build plate. Building a skirt along with an object may help establish smooth nozzle flow, or may be used to shield especially thermal-sensitive filament material from thermal drafts during the print.

Only brims tend to be of much interest when using PLA filament, such as that shipped with the Polar3D printer and sold

by Polar 3D. Rafts and skirts, in contrast, may be of interest with other filament materials, such as ABS.

Figure 8.1: Polar Cloud build plate `PRINT SETTINGS`



The Polar 3D Cloud 2.0 has a feature whereby you can ask to add a brim, raft, or skirt to your object. Once you have selected an object and clicked "`3D PRINT`" to get ready to print it, then go to "`PRINT SETTINGS`", (see Figure 8.1), and under "`BASIC`" settings scroll down to `Support`, (see Figure 8.2). Then under "`Platform Adhesion Type`" use the drop-down menu to select "`None(Skirt)`, "`Brim`", or "`Raft`", as desired; see Figure 8.3. Then click the gear icon to adjust the parameters (layers, outlines, raft infill, *etc.*) as desired; see Figure 8.4.

Figure 8.2: Polar Cloud build plate `Support`

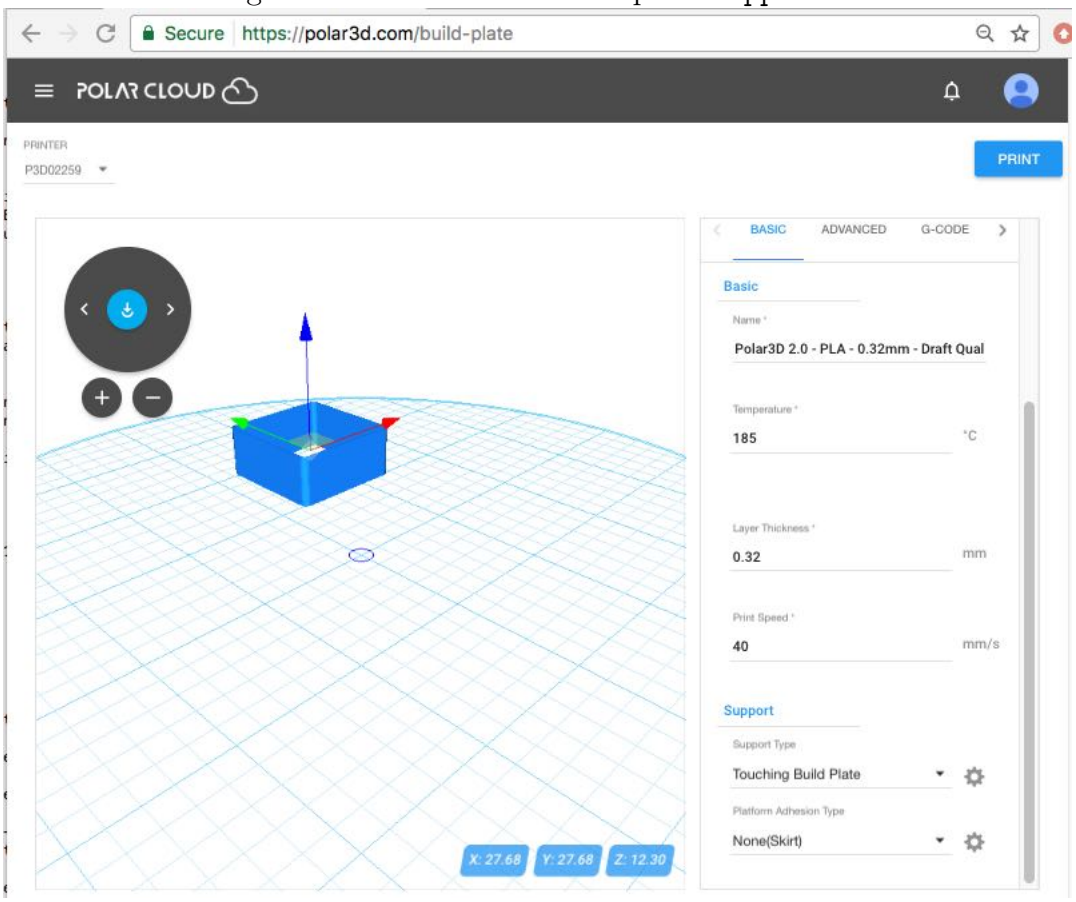


Figure 8.3: Polar Cloud build plate `Platform Adhesion Type`

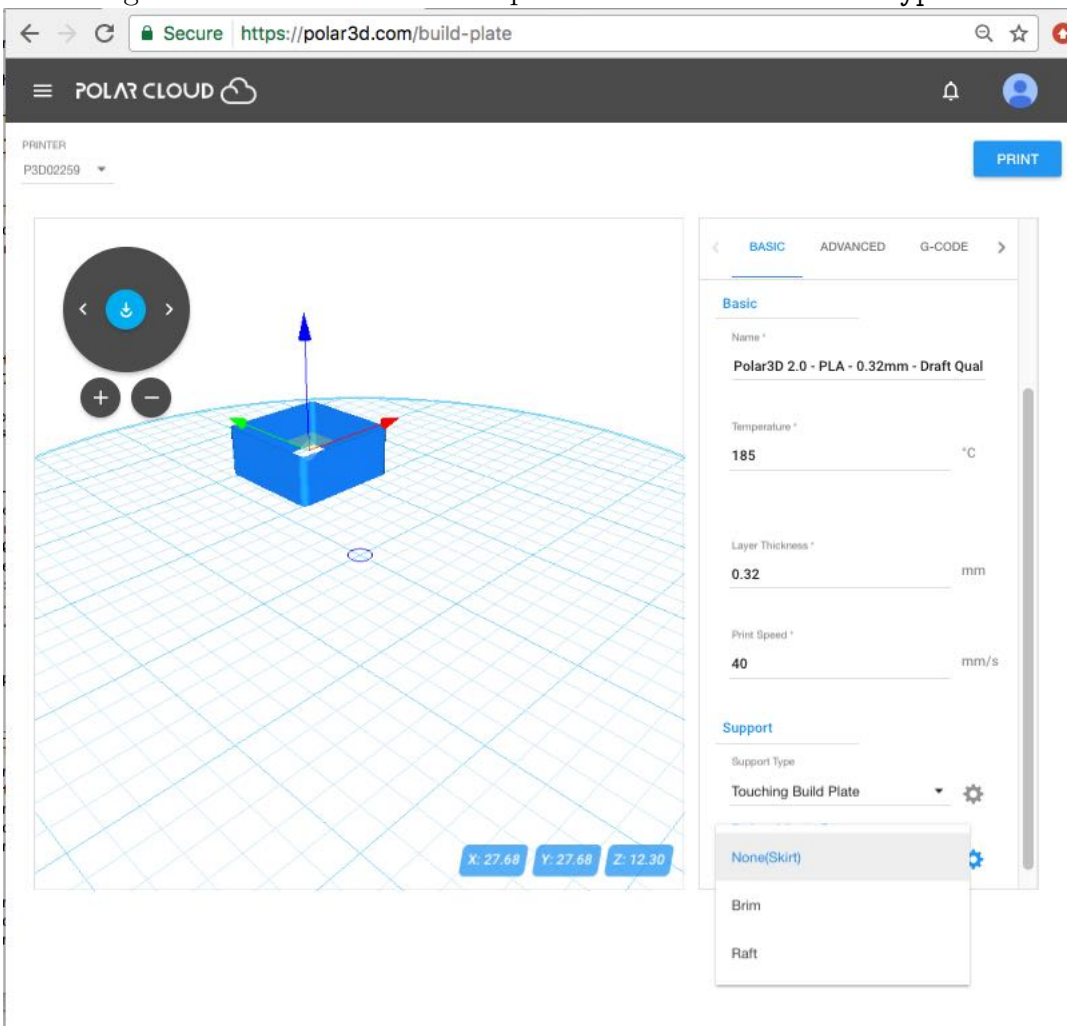
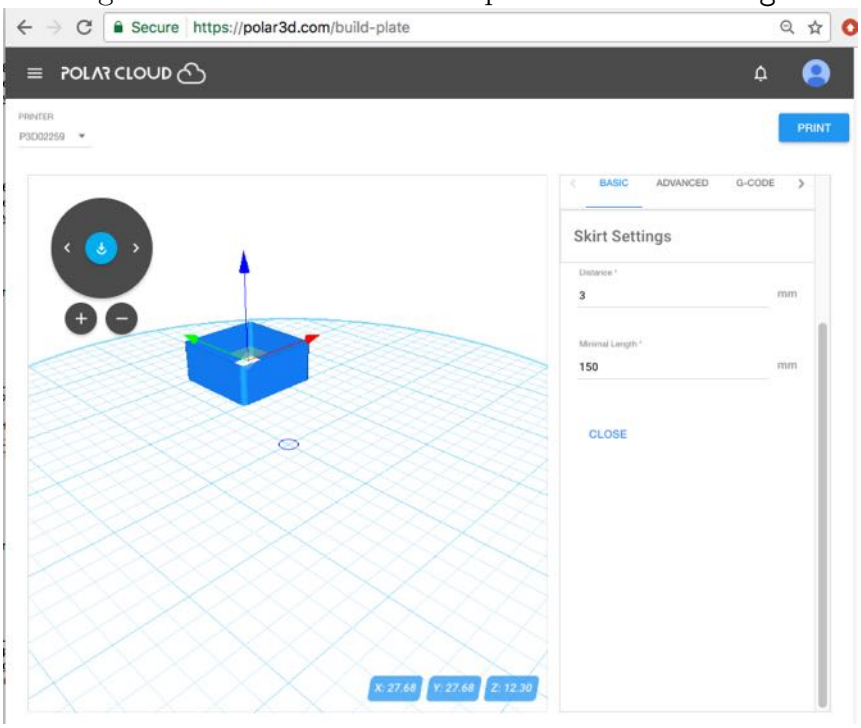


Figure 8.4: Polar Cloud build plate `Skirt Settings`



8.3 Removing objects from the build plate

Cooling a printed object, still on the build plate, briefly in the refrigerator or freezer may make it easier to remove from the build plate. Remove the build plate, with freshly printed object still attached, from the 3D printer and place it in the refrigerator or freezer: four or five minutes in the freezer may suffice.

A spatula may be useful to aid in removing objects from the build plate.

Note that while an object may be less "stuck" to the build plate while still slightly warm, delicate or fragile details may

benefit from thoroughly cooling before you attempt to remove an object.

For some objects, printing with a raft may better allow removal from the build plate without damage to the bottom of the object.

After removing an object, check whether it is time to clean the build plate and/or apply more hair spray (or other adhesion aid).

8.4 Filament

If you have a Polar3D printer and have filament from a previous 3D printer, you are in luck! Polar3D does not use proprietary filament. This means that as long as you have 1.75mm diameter filament, your Polar3D printer can print it.

Note that we strongly recommend use of PLA filament in the classroom as it: (1) is easier for beginners, and (2) does not require ventilation.

Our other suggestion is that when it comes to filament, cheaper is not always the best choice. An extra cheap roll of filament may not have the same print quality as the Polar 3D filament, or other standard brands of filament. For instance, you may find particles within the filament cause jams in the 3D printer, making it an annoyance to keep cleaning it out; (see Section 10.3). Or filament whose diameter does not remain consistent may result in lower quality prints.

Especially if you're using filament from a supplier other than

Polar 3D, *measure precisely* the diameter of your filament with a caliper. And know what temperature is best for your filament, and be sure to set the printer extruder temperature accordingly. See Polar Cloud `PRINT SETTINGS` to adjust for a different filament diameter (under "`ADVANCED`") or temperature (under "`BASIC`").

8.4.1 Types of filament

Note that while there any many different and interesting types of filament, different types of filament have different requirements for printing: know your filament's characteristics.

Just a sample...

For instance, glow-in-the-dark PLA filament is fun for students. But be aware that it is typically: (a) fairly abrasive on the extruder nozzle – be prepared to replace your extruder nozzle if you perform much glow-in-the-dark printing, (b) more expensive than regular PLA, and (c) green and blue glow effects are generally more satisfactory than other colors. Some users recommend that best glow effects result from objects that are fairly hollow but with thicker walls, so consider slicing objects using no (or very little) infill while adding a few more shells than usual.

Similarly, color-changing PLA filament – changing color in response to temperature or, for some brands, in response to UV light – can be fun for students. It also tends to be more expensive than regular PLA, but unlike the glow-in-the-dark PLA, does not tend to be especially abrasive.

Wood filament (PLA infused with wood dust/wood fibers) results in objects with the look and feel of wood. A number of different brands, incorporating different types of woods, are available. Note that it's moderately difficult to work with (as opposed to plain PLA which is relatively easy): it tends to be more finicky about print temperature (which typically needs to be a bit higher than that for Polar 3D PLA), is subject to some shrinking during printing, and may not adhere as easily as plain PLA.

Conductive PLA is PLA infused with conductive carbon. It allows printing low-voltage electronics. It tends to need to print at a slightly higher temperature than plain PLA, and while it is considered fairly easy to print, and is not reported to be particularly abrasive on the extruder nozzle, it is a little harder to get it to adhere (even to itself); also, it tends to be expensive compared to regular PLA.

Carbon Fiber PLA is PLA mixed with small, chopped carbon fibers. It results in strong objects, much stronger than regular PLA, but is *extremely* abrasive on the extruder nozzle; expect to have to replace your extruder nozzle after printing only 550g (half a regular spool) of carbon fiber PLA .

Metal PLA is PLA combined with fine metallic power, such as bronze powder, brass powder, copper powder, aluminum powder, or steel powder. Objects 3D printed using metal PLA filament will look and feel as if they were made of metal, can be polished like metal, and will be denser (heavier) than regular plastic objects, hefting more like metal. However, metal PLA is *quite* abrasive on the extruder nozzle, especially when the incorporated metal is a harder metal than the brass of the ex-

truder nozzle. Metal PLA filament is considered quite a difficult filament to get printing well, so be ready for a challenge!

ABS filament is second only to PLA filament in terms of popularity for general 3D printer use. However, it is not usually recommended for use in the classroom, due to the intense fumes it generates during printing which can be dangerous for those with breathing difficulties; when printing ABS, the 3D printer must be placed in a well-ventilated area, and you must avoid breathing in the fumes when it is in use. Also, ABS shrinks while cooling, so it is very prone to curling, and pulling up from the build plate. Due to ABS's thermal issues, it prints best on printers that incorporate both a heated build plate (to lessen the temperature differential between the bottom and top of the object while printing) and an enclosure around the print area (to lessen the effect of cooling drafts); neither feature is part of the Polar3D printer. However, by extra attention to issues of adhesion and thermal insulation, it is possible to print ABS on a Polar3D printer: use of Elmer's Xtreme glue stick on the build plate (to glue down the object even as it attempts to cool and shrink) and adding a tall skirt around the main object (to shield it from drafts) are techniques that can be used.

PET (PolyEthylene Terephthalate) filament and PETG (a blend of PET with Glycerol) filament are very versatile, reasonably easy to work with, newer filaments, with PETG being a version better adapted for 3D printing. However, PETG does tend to be more expensive than regular PLA.

There are many more types of filament, with new kinds continuing to come out. While some types produce fumes requiring ventilation (thus being less suitable for the classroom), or need

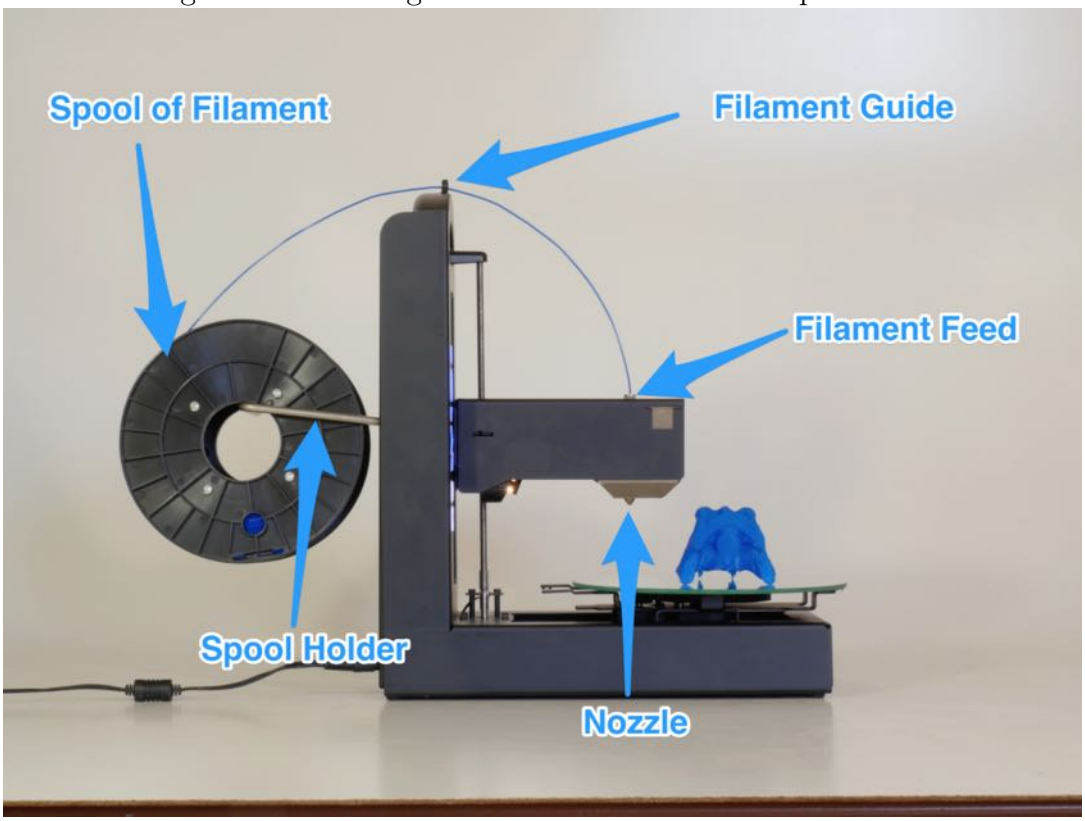
or benefit from a heated build plate (not a feature of the Polar3D printer), or are distinctly more challenging to use than regular PLA, and exotic types tend to be more expensive, still other types may be of interest to you.

For some further discussion of these and additional filament types, see:

Polar 3D youtube video: WWBD – The Different Types of Filaments

8.4.2 Loading and unloading (and changing) filament

Figure 8.5: Loading filament onto the Polar3D printer



The Polar 3D support site has detailed discussions of loading and unloading filament on Polar3D printers.

For Polar3D printers with serial numbers `P3D02150` and higher, see:

Polar 3D support document "Loading and Unloading Filament"

For Polar3D printers with serial numbers `P3D02000` - `P3D02150`, see:

Polar 3D support document "Loading and Unloading Filament"

For Polar3D printers with serial numbers `P3D00000` - `P3D02000`, see:

Polar 3D support document "Loading and Unloading Filament"

8.4.2.1 Loading filament

Refer to Figure B.1 and especially to Figure 8.5.

1. Take the spool of filament and hook it onto the spool holder.
2. Find the end of the string of filament.
3. If the end of the string of filament is blobby or thin (something to check if this spool has been previously used, so that the filament end got a bit melted previously) or kinked (*e.g.*, from being pinched in the spool holder), consider snipping the end off – perhaps snip an inch or two off – so that you have a "clean" end to feed into the printer.

4. Feed the filament through the filament guide (the hole at the top of the Polar3D printer). (Having the filament properly guided keeps the filament from flopping wildly from the spool to the print head.)

5. Stick the end of the filament into the feed hole at the top of the print head. The "feel" of this takes a bit of getting used to: when sticking the filament into the feed, you must push past some initial resistance: you must push the filament in far enough to engage with the filament drive gear inside the print head.

6. If you want to check whether the filament is all the way in, raise the temperature of the printer to 180°C,[1] and slowly hand feed the filament through. Seeing a string of molten plastic get extruded tells you you're ready to print!

8.4.2.2 Unloading filament

If the filament is still warm, you should be able to simply pull the filament straight up and out of the print head.

If the filament is stuck, raise the extruder temperature to 200°C.[2] Once the filament has softened, you should now be able to pull the filament straight up out of the print head.

[1] To set the temperature of the printer, you may use the Polar Cloud printer dashboard's temperature dial. Alternatively, you may use the "`Controls`" screen of the printer local web interface. If you are using a direct cable connection to the printer and Repetier-Host to control the printer, under Repetier-Host's "`Your Printer`", use the controls on the "`Manual Control`" screen to set the extruder temperature.

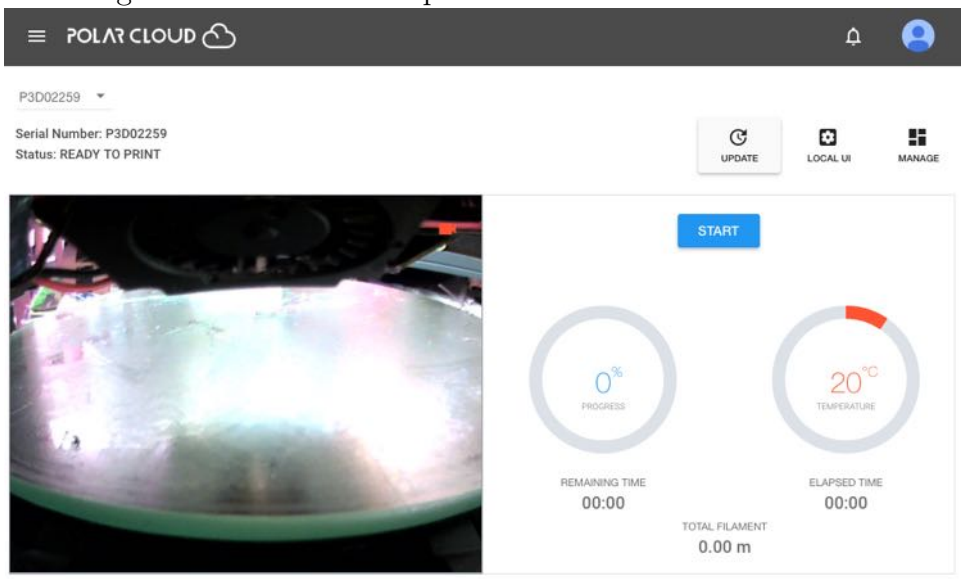
[2] Printer extruder temperature can be controlled at the Polar Cloud printer dashboard's temperature dial or at the printer local web interface's "`Controls`" screen. If using a direct cable connection with Repetier-Host to control the printer, under Repetier-Host's "`Your Printer`", use the controls on the "`Manual Control`" screen to set the extruder temperature.

Chapter 9

Updating the printer

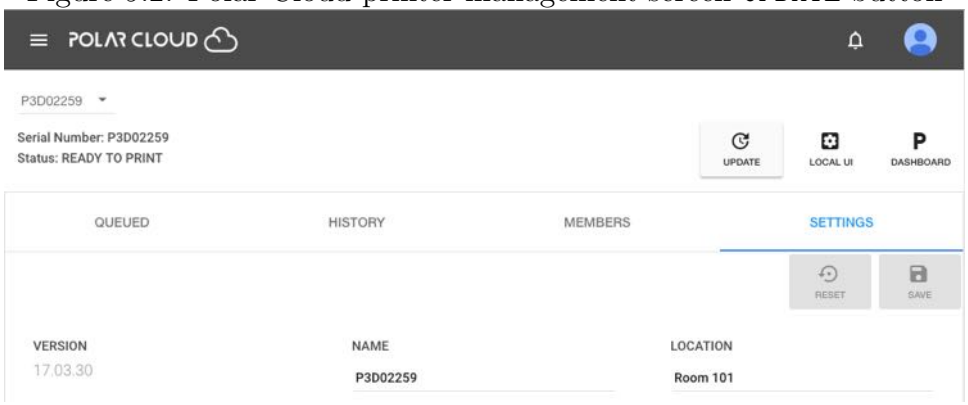
Occasionally, an update to the printer firmware will be available. When an update is available, you will see an update button visible in three locations:

Figure 9.1: Polar Cloud printer dashboard `UPDATE` button



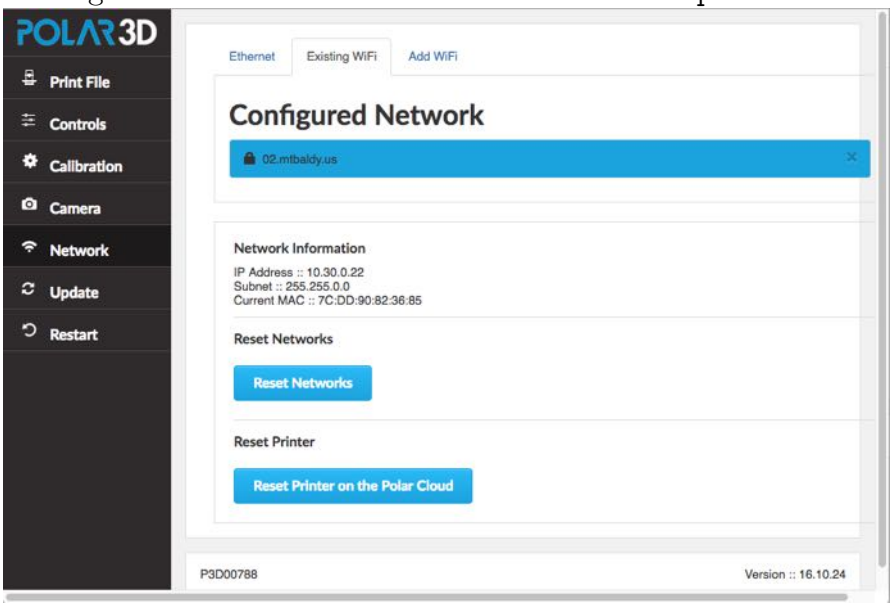
1. On the printer dashboard screen within the Polar Cloud; Figure 9.1.
2. On the printer manage screen within the Polar Cloud; Figure 9.2.

Figure 9.2: Polar Cloud printer management screen `UPDATE` button



3. On the printer's local web interface; Figure 9.3.

Figure 9.3: Printer local web interface shows `Update` tab



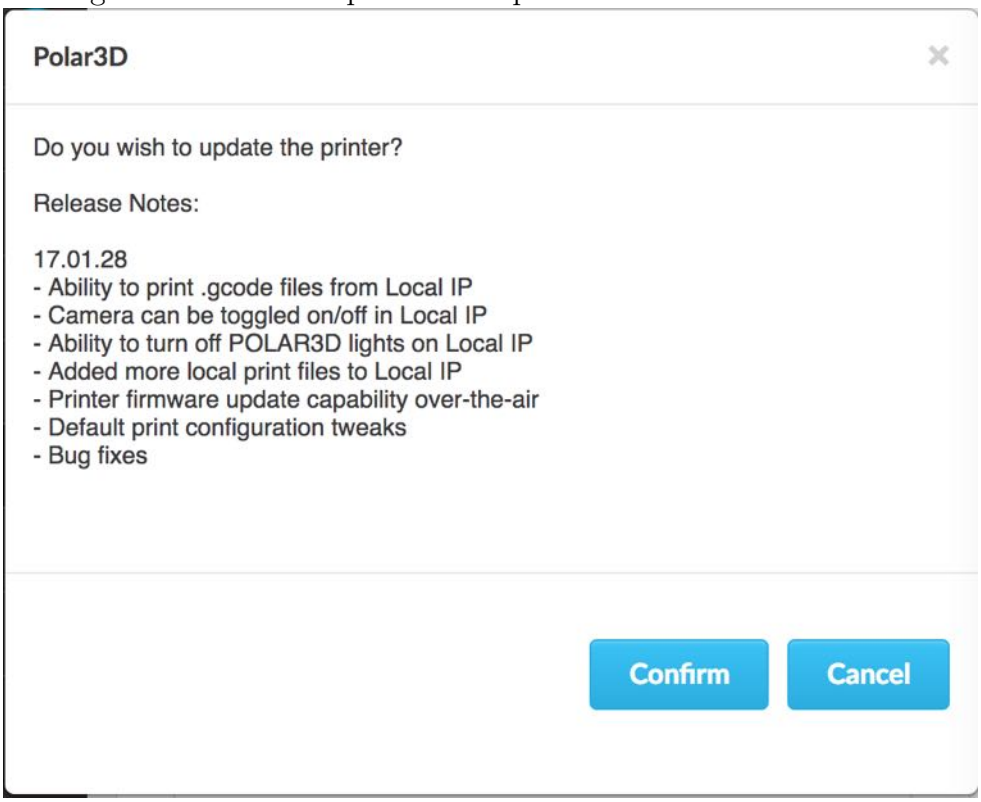
Clicking the `UPDATE` button or `Update` tab in any of these respective locations will cause the update to be performed.

Alternatively, you can force an update as follows. From a device (computer, tablet, phone) on your local network, open a browser window and go to the location:

`http://`*`localip`*`/update`

where *`localip`* is your printer's local IP address[1].

Figure 9.4: Printer update description and confirmation screen



[1] If you need a reminder of just what your printer's local IP address is, note that from within the Polar Cloud, selecting the `LOCAL UI` tab while viewing a printer dashboard screen will show you what the Polar Cloud believes to be the printer's IP address.

Whichever of the three approaches above you use to request an update, you will be presented with a screen describing the update which asks you to confirm that you truly wish to update the printer; an example is shown in Figure 9.4. Click "`Confirm`" to perform the update.

Note that when the printer is performing an update, the LED lights along the left-hand side of the printer will go through a color change: the LED lights towards the bottom (`3D`) will turn green, POLAR3D, and then the green color will gradually move up until all the lights are green, POLAR3D, indicating that the update is complete, before the lights return to their normal colors (blue over white, POLAR3D, for a printer connected to the Polar Cloud).

Chapter 10

Printer maintenance

The Polar3D printer's polar coordinates-based design means a simpler machine with fewer moving parts, so fewer maintenance issues. But as with any machine, there are a few parts that benefit from some occasional maintenance attention.

10.1 Cleaning your build plate

Something you will need to do fairly regularly is to clean your build plate.

Remove the build plate from the printer, and wash it with warm water. If bits of filament are still a bit stuck, rub it lightly with a fingernail or green scrubber (but do not scrub hard). Then dry the build plate thoroughly, both top and bottom, before replacing it on the printer.

For a video demonstration, see:

Polar 3D youtube video: WWBD – Cleaning your Build

Plate

10.2 Lubrication

There are five spots which can benefit from occasional lubrication: the bottom of the threaded Z rod, and around the bushings on each of the four steel rods (two rods for the build plate shuttle, and two rods for the gantry); see Figure B.1. We recommend Tri-Flow lubricant (often used on bicycle chains), which is a "dry" lubricant. Put a drop of the lubricant at the bottom of the threaded Z rod, and a drop both in front of and behind each bushing on each rod.

In addition, if you are hearing any squeaking from the printer, you may wish to apply a drop of lubricant at the top of the threaded Z rod, and on the drive pinion.

For a video demonstration see:

Polar 3D youtube video: WWBD – Care and Maintenance

10.3 Clean filament drive gear

Over time, small particles of filament may start clogging up the filament drive gear in the print head. A filament jam in the nozzle, or low quality (flaky) filament, or frequent changes of filament (pushing filament in or pulling it out) may accelerate this. So occasionally you should remove the block from over the filament drive gear, clear out any accumulated filament dust or particles, and reinstall the block.

For a video demonstration, see:

Polar 3D youtube video: WWBD – How to Unclog a Nozzle and Clear a Leaky Nozzle

10.4 Replace the nozzle on the extruder

Every so often, sooner if you print with abrasive filaments (see Section 8.4), or not for a long while if you stick with regular PLA filament, you may need to replace the extruder nozzle.

Polar 3D support solutions: How do I replace the nozzle on the extruder of my Polar 3D printer?

10.5 Replace a corrupted SD card

SD cards are fragile, and relatively easily corrupted by static discharges, or sudden power failures. So while it's rare, sometimes unfortunately an SD card will need replacing. Please contact Polar 3D support if you need a new SD card.

If you have had an SD card fail, and now have a new SD card from Polar 3D to install, for directions on replacing the SD card see:

Polar 3D support solutions: How to replace the SD card

or

Polar 3D support solutions: Replacing the SD card

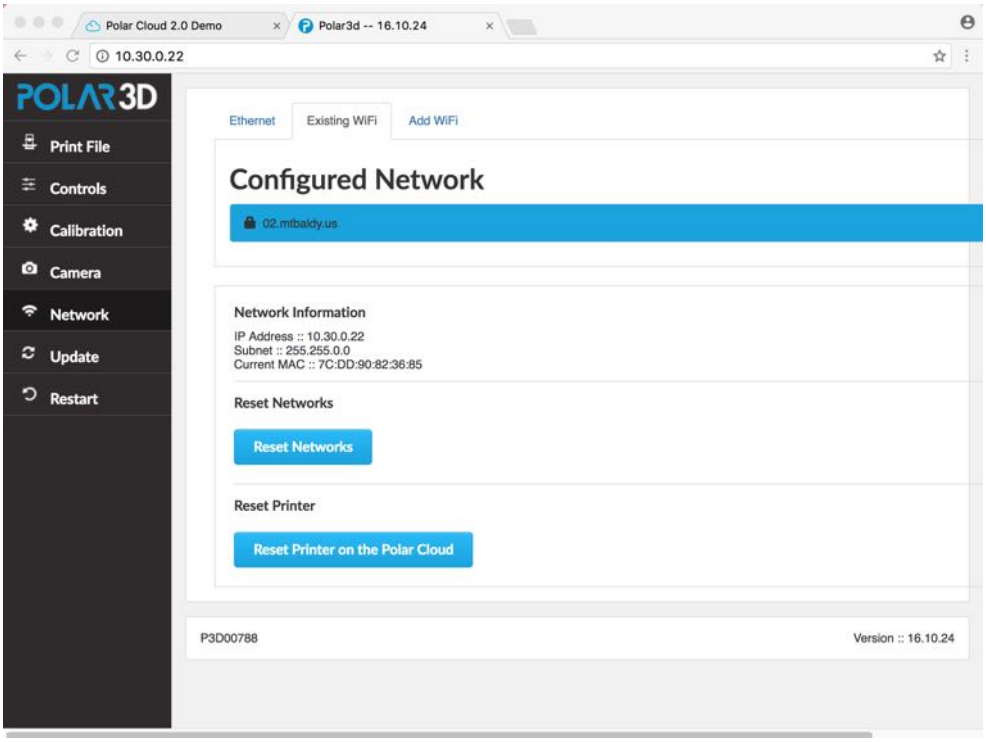
10.6 Printer calibration

One of the advantages of the Polar3D printer's underlying polar coordinates architecture, and minimal number of moving parts, is that the Polar3D printer doesn't tend to require frequent calibration. However, occasionally you may want to check and adjust its calibration.

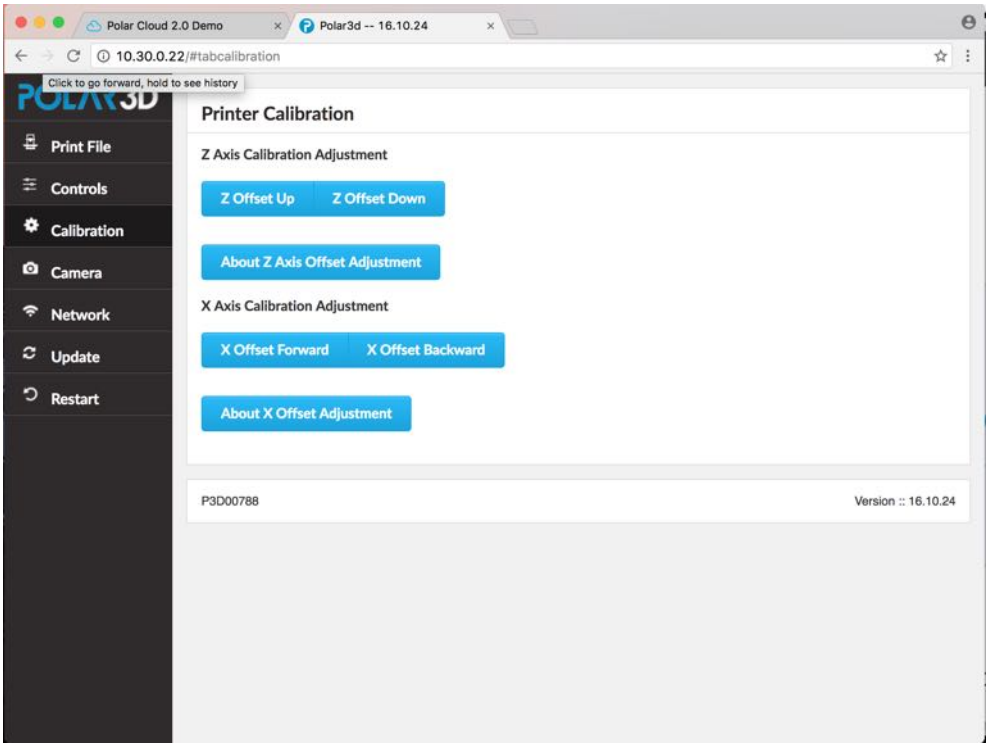
There are two general types of calibration: (1) the z height of the extruder, and (2) the consistent levelness of the build plate.

1. If the z height of the extruder is slightly high, the first print layer (first layer of material extruded) may only be lightly touching the build plate, instead of being "smooshed" so that it adheres to the build plate. If the z height is too low, filament either may not be able to come out at all, or may come out too "smooshed" and actually flattened.

   To calibrate the z height of the extruder, from within the Polar Cloud, click on the printer, and then click on the settings (dial icon); or when communicating directly with the printer, from your device (computer/tablet/phone), connect to the printer's local IP. At this point you should be seeing the printer's local interface:



Select "`Calibration`" from the stacked tabs on the left, and click "`Z offset down` or "`Z offset up`", as desired.



Each click will lower (or raise) the z home of the print head (and hence the extruder) by 0.05 millimeters (about 1/2 the thickness of a sheet of paper). Adjust the z height until the tip of the extruder is just touching the build plate. When you are at the correct height, select the "`Just Right`" button.

2. The build plate, when sliding forward or back, should remain at a consistent height relative to the extruder tip. Check the z height with the extruder at the middle of the build plate; then slide the build plate forward so that the extruder is at the edge of the build plate and confirm that the z height hasn't changed. If the z height *is* changing from middle to edge of build plate, then:

(a) The build plate shuttle arms in the back of the printer (near the Z rod) may be bent downwards. Push these arms up gently until the extruder nozzle stays at the same height across the entire radius of the build plate.

(b) The pads that the build plate mirror rests upon may be slightly off. This is normally checked at our factory when the printer is assembled, but something *might* have happened to throw off this alignment after leaving the factory, so it is worth checking to confirm that the mirror is still properly aligned.

Chapter 11

Troubleshooting

The Polar3D support website has a number of articles and videos discussing commonly encountered issues. You can also open a support ticket at that site.

11.1 Printer LED lights

In addition to the small, white lights around the camera underneath the print head which are the very first lights to turn on when the printer is plugged in, the Polar3D printer has LED lights running vertically on the left hand side, with "POLAR" showing in blue when the printer is turned on (plugged in), and with the color of "3D" being an indication of the state of the printer.

A summary of the meaning of the LED lights on these Polar3D printer is:

1. POLAR3D (BLUE over BLUE): The printer has finished turning on, but is *not* connected to a network, and has

stood up its own wireless network.

2. POLAR3D (BLUE over RED): The printer has been configured to connect to a network, but that network has not yet, or could not, be found. (The LED lights will only remain BLUE over RED for a short time: then the lights will either return to BLUE over BLUE if the network could not be found, or progress to BLUE over YELLOW if the network is found.)
3. POLAR3D (BLUE over YELLOW): The printer found a network to which it could connect, but the printer has not connected.
4. POLAR3D (BLUE over WHITE): The printer is connected through the local network and the Internet to the Polar Cloud.
5. POLAR3D (BLUE over GREEN): The printer has begun an update.[1]
6. POLAR3D (BLUE over GREEN): The printer is partway through an update.
7. POLAR3D (GREEN): The printer has just completed an update. (The LED lights will only remain solid GREEN for a short time; then the LED lights will return to their prior color(s), *e.g.*, BLUE over WHITE if the printer is connected to the Polar Cloud.)

See also the Polar3D support discussion: Polar3D Support: What do the different LED lights mean?

[1]The green color will move gradually upwards in the letters, until all the LED lights are green as the update completes, after which the LED lights will return to their normal color from before the update.

And the Polar3D video:

Youtube Polar3D channel: WWBD - LED Light Explained

11.2 Clogged or leaky nozzle

See:

Polar 3D youtube video: WWBD – How to Unclog a Nozzle and Clear a Leaky Nozzle

11.3 Flaws in printed objects

1. If an object appears warped due to coming partially or fully loose from the build plate during the print, take steps to improve adhesion; see Section 8.2 for some ideas.
2. If objects are printing with rough surfaces, or with layers that don't seem fully stuck together, so that the object can pull apart, the temperature of the extruder may have been too low; try increasing the temperature by 5°C and try again. In particular, if printing through the Polar Cloud, under "`PRINT SETTINGS`", "`BASIC`", adjust the "`Temperature`".
3. If individual layers, and especially the top layer, look bad, another possibility besides too low a temperature (mentioned above in item 2), is that the filament is not feeding smoothly and hence not extruding smoothly. Make sure that the spool of filament is feeding easily and smoothly,

(see Figure 2.1), and consider cleaning the filament drive gear, (see Section 11.2).

4. If strings of unintended extrusion are occurring between separate parts of your print, then either the temperature may be a bit too high – try decreasing the temperature by 5°C and try again – or else you may have a batch of filament that is simply rather runny even at lower temperatures – try increasing the retraction a few millimeters (3 or 4 millimeters). For adjusting the retraction if printing through the Polar Cloud, under "“PRINT SETTINGS”, “ADVANCED”, “Retraction”, adjust the “Amount” (and perhaps the “Speed” of the retraction).

5. If corners are messy or blurry or (unintentionally) rounded rather than sharp, or if there are ripple patterns (corner ringing) visible on vertical surfaces near direction changes (corners), the print speed may need to be slowed down. To slow down the entire print, if printing through the Polar Cloud, under “PRINT SETTINGS”, “BASIC”, adjust “Print Speed”.

6. If surfaces have blemishes where the interior print material shows through or penetrates (telegraphing), the exterior shell of material may be too thin: modify the print to have a thicker exterior (use more shells). In particular, if printing through the Polar Cloud, under “PRINT SETTINGS”, “ADVANCED”, “Quality”, adjust as relevant the “Wall Thickness”, “Bottom Layer Thickness”, and/or “Top Layer Count”.

7. If tall and narrow sections of the print look squished or melted, the print may be happening so fast, with one layer

on top of another, that the material is not cooling sufficiently between the layers. Slow down the print speed, or point a small fan at the printer, or print multiple objects (thereby forcing more movement and printing at each layer, hence forcing more time before returning to print another layer) to aid in cooling.

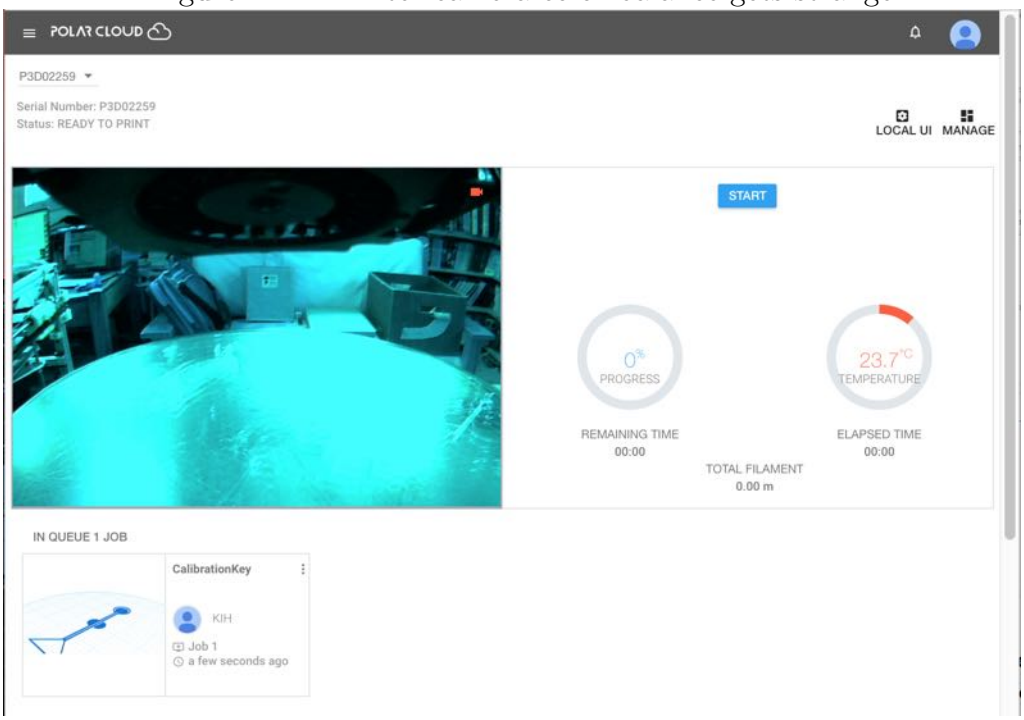
8. If you see a jog in the material output, or a slight bend in what should be a straight line, or a bit of a blob of material right where an intended straight line of output material crosses the exact center of the build plate, check the calibration of the printer and try to reposition your object so that any visually "important" straight lines are *not* positioned exactly across the center of the build plate; see Section 8.1.3.

9. if the object consistently appears to have skimpy lines of material being extruded (under-extrusion), or contrarily consistently appears to have excessive amounts of material being extruded (over-extrusion), this may indicate that the filament you are using has a diameter different from what the slicer expected. Measure your filament's diameter carefully, and then if appropriate adjust the slicer's expectation accordingly. In particular, when printing through the Polar Cloud, under an object's "`3D PRINT`" screen's "`PRINT SETTINGS`", "`ADVANCED`", "`Filament`", adjust the "`Diameter`".

11.4 Camera color balance

The camera in the Polar3D printer attempts to perform automatic color balancing. However, occasionally its color balancing algorithm may yield strange results, where the camera picture appears to have a strange overall tinge. (In particular, this may happen if the printer is left on in dark surroundings, such as overnight; when the lights get brighter, as in the morning, the color balancing may not readjust properly.) See for instance Figure 11.1, where the image has a blue cast.

Figure 11.1: Printer camera color balance gets strange



Power-cycling the printer (unplugging it and then plugging it back in) may reset the camera so that a correct color balance

is restored.

Appendix A

Polar3D printer specification sheet

Appendix B

Polar3D printer diagram

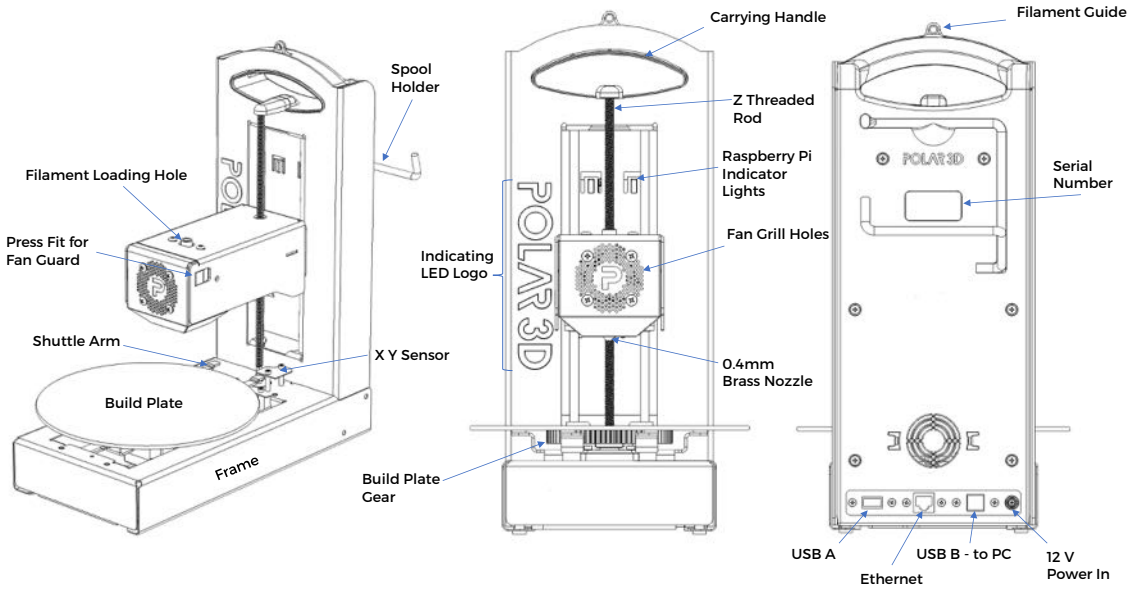


Figure B.1: Polar3D printer diagram

Appendix C

Connecting the printer directly to your device

The Polar3D printer supports direct, non-Internet-enabled, printing; in such modes, the features of the Polar Cloud are not available, but direct printing may be useful when Internet access is not available yet you need to print an object. (When Internet access is available, see instead Chapter 1 for a discussion of connecting the printer to the Polar Cloud.)

If this is a brand new Polar3D printer, which you are just unpacking from its shipping box, begin by performing steps 1 through 4 of Section 1.1; namely:

1. Spray the build plate generously with AquaNet hairspray; for a video demonstration, see:

   https:/www.instagram.com/p/BJBaWwrjCwF/

2. Twist the threaded Z rod clockwise to raise the print head enough (1" to 2") to install the build plate.

   After you have unpacked the build plate and prepared its

surface by applying a coat of hair spray (see above), and raised the print head to make room for installing the build plate, you are ready to install the build plate on the printer build plate shuttle.

The bottom center of the build plate has a gear affixed. Place the build plate so that the center of the gear seats over the bearing on the build plate shuttle, and the gear teeth engage with the geared axle of the printer build plate shuttle.

3. Insert the power cord into the adapter, and insert the adapter plug into your Polar3D printer. Do not force the adapter plug; it will *not* be flush with the printer.
4. Plug in to a power outlet; the Polar3D printer's LED lights should turn blue over blue: POLAR3D.

Then there are two ways to connect the printer directly to your device: wireless (WiFi) – see Section C.1, or via direct USB cable – see Section C.2.

C.1 Wireless direct connection and printing

For wireless (WiFi) direct connection and printing, you will use the printer's own hotspot and the printer's user interface to communicate directly with the printer from your device (computer, tablet, phone), and will be able to print object files stored on your device.

C.1.1 Wireless direct connection

For this type of connection, you will connect to the printer's hotspot directly. (Thus this process starts out rather similarly to configuring the printer to connect via WiFi to a local network, as discussed in Section 1.1, but instead of merely using the printer's own hotspot to configure the printer's connection to a local network, you will instead stay connected to the printer's hotspot and communicate directly with the printer, rather than using the Polar Cloud interface.)

1. Connect to the printer's hot spot.

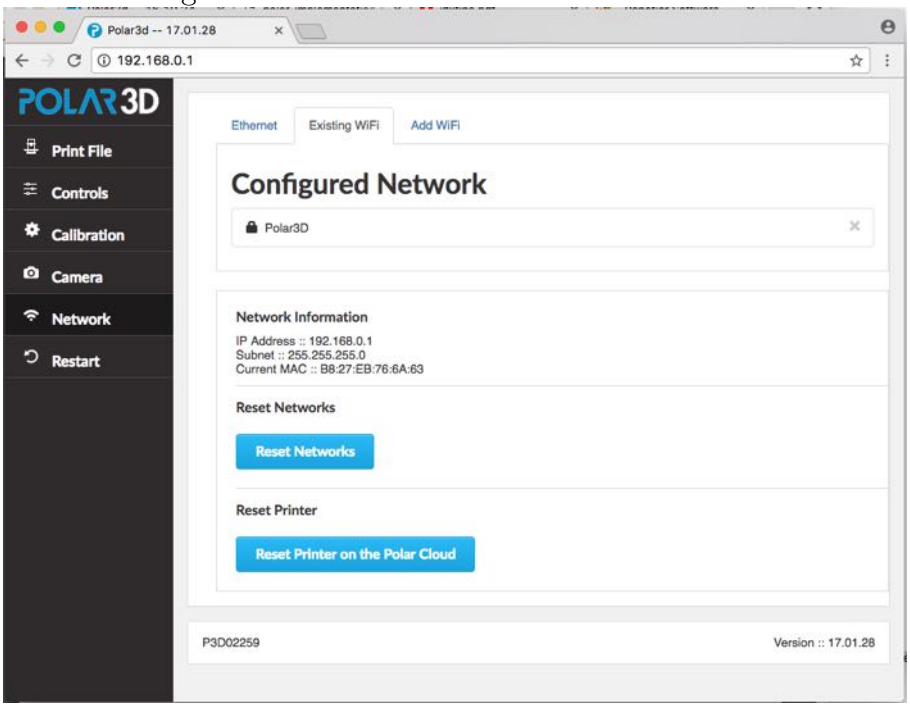
   The printer should already be plugged in and all its LED lights blue: POLAR3D. From your device (computer, tablet, or phone), select WiFi network. From the list of networks, select the P3D network named after your printer's serial number, as found on the back of the printer; for example, "`P3D00526-WIFI`". You will be prompted for a password, which will be the 8-character serial number consisting of `P3D` and five digits: in this example, "`P3D00526`".

   Note: Your device will not allow itself to be connected to two WiFi networks simultaneously. If your device is already connected to a WiFi network, you will need to (temporarily) disconnect from that network and then connect to the printer hotspot.

2. Connect to the printer.

   In your browser (Chrome, Internet Explorer, Safari, *etc.*) enter `192.168.0.1` into the navigation bar. (On the printer's hotspot, that is, on the private P3D network which is named

Figure C.1: Printer local web interface network status



after your printer's serial number and which the printer stood up itself, `192.168.0.1` will be the address of the printer.) You are now connected to the printer and should see the printer's local web interface, as shown in Figure C.1; (the printer local web interface is discussed in detail in Chapter 5).

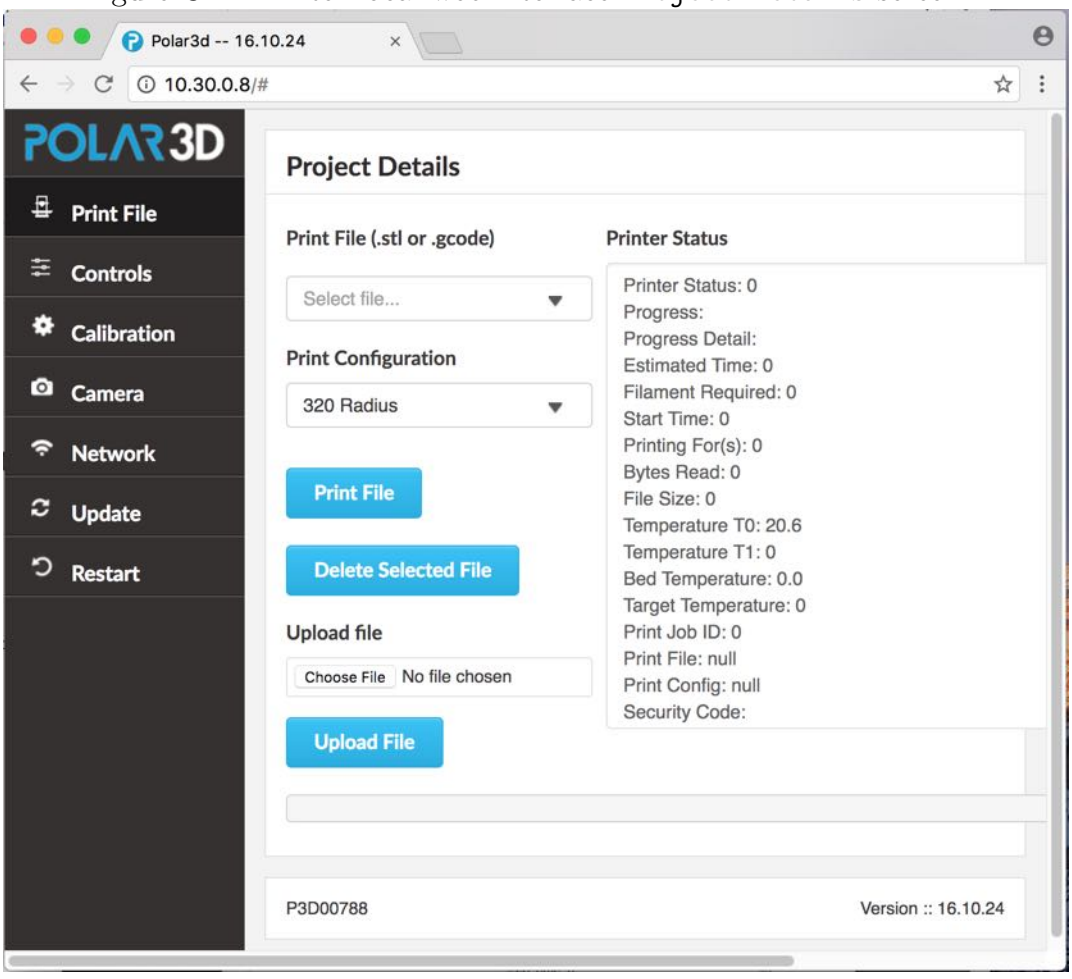
At this stage, in the printer local web interface, note that there is no blue highlighted network shown under `Configured Network`, meaning that the printer is *not* connected to any local WiFi, but rather is in HotSpot mode.

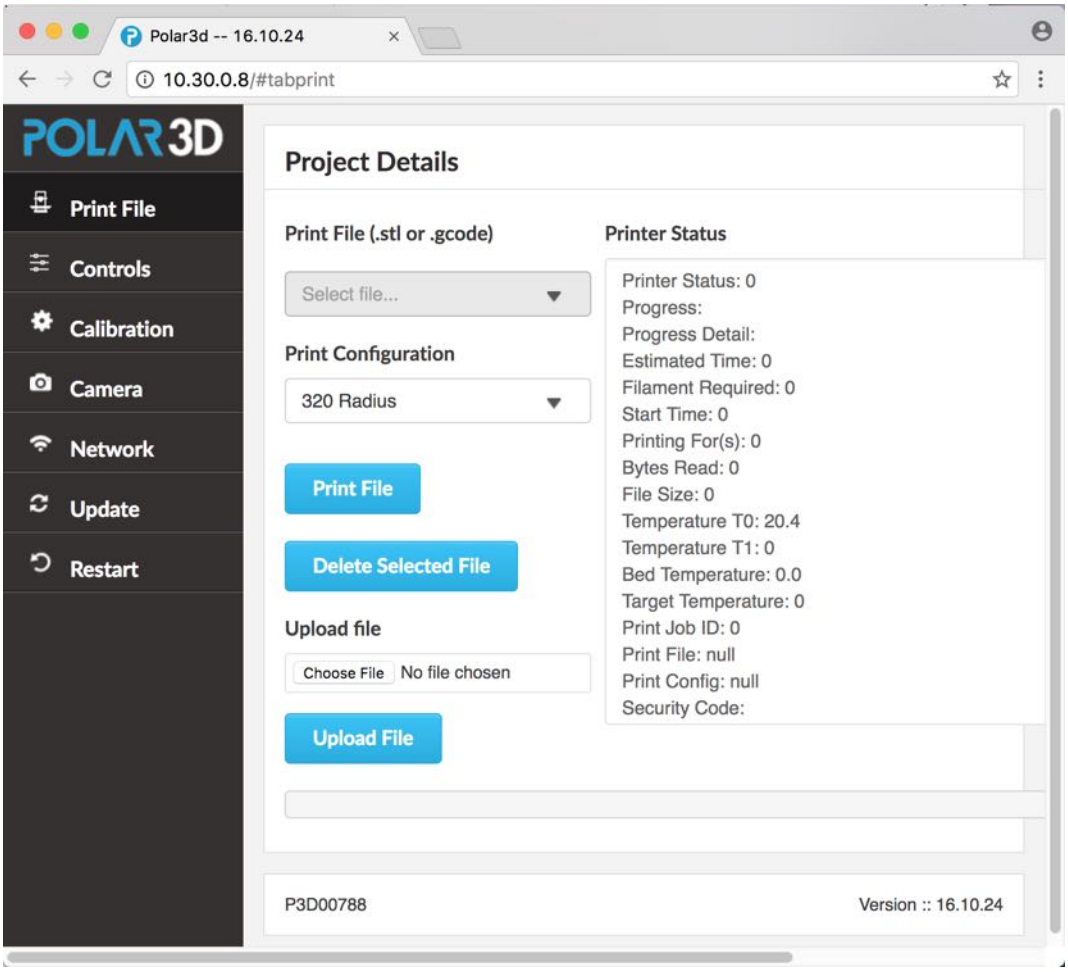
C.1.2 Wireless direct printing

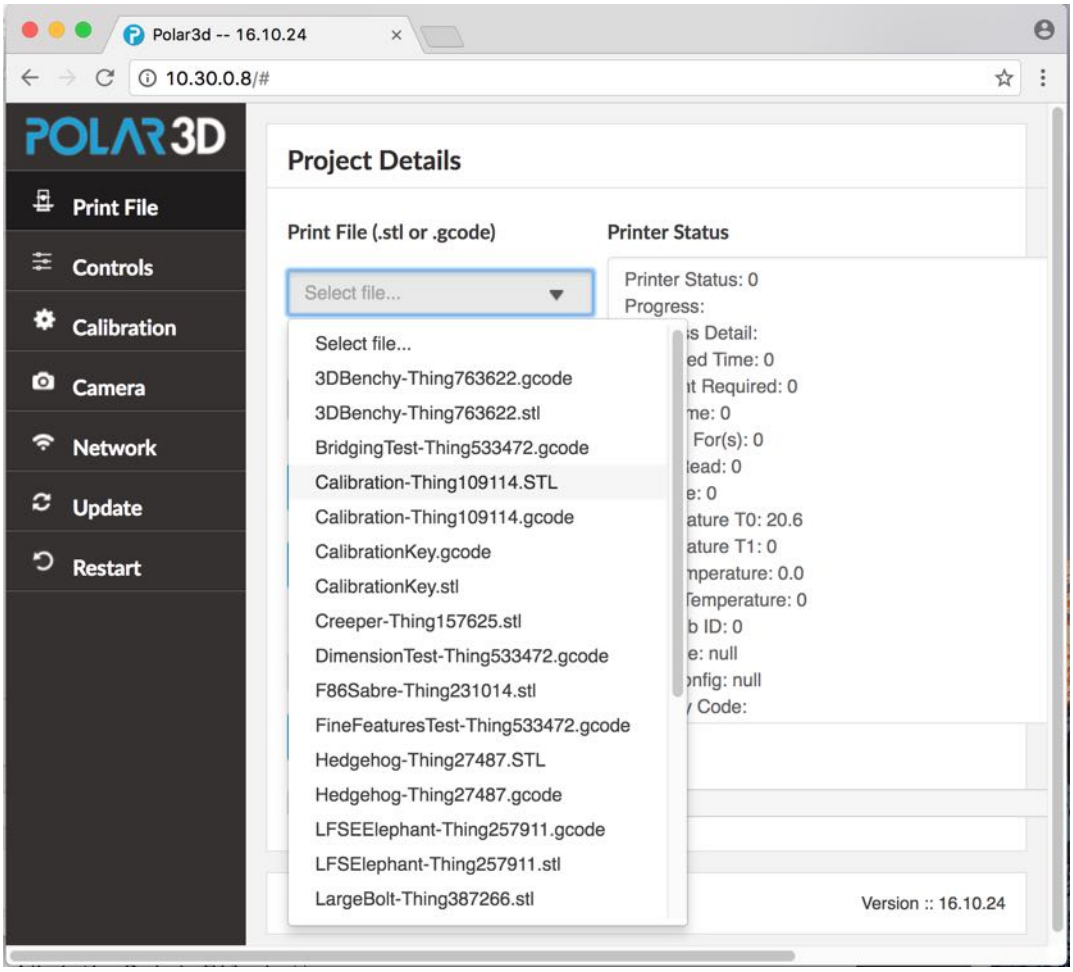
The steps below describe the full process for uploading and printing an arbitrary `.stl` file. (However, note that the Polar3D printer ships with several `.stl` files, suitable for an initial test of the printer, already onboard the printer user interface; for your very first print, you may wish to print one of them rather than uploading your own file.)

1. On the printer's user interface, click the `Print File` button (top choice in the column on the lefthand side of the window). This will take you to the `Project Details` screen, as shown in Figure C.2.
2. Upload a file to print. (If this is your very first print on this printer, you may prefer to skip this step, of finding and uploading an arbitrary `.stl` file, and instead go to step 3 to print one of the files shipped as test print files.)
   (a) Under `Upload File`, select `Choose File`.
   (b) Find the file, select the file, and click `Open`.
   (c) Click the `Upload File` button.
3. Select and print the file.
   (a) Click the `Select file...` drop down menu under `Print File (.stl or .gcode)`.

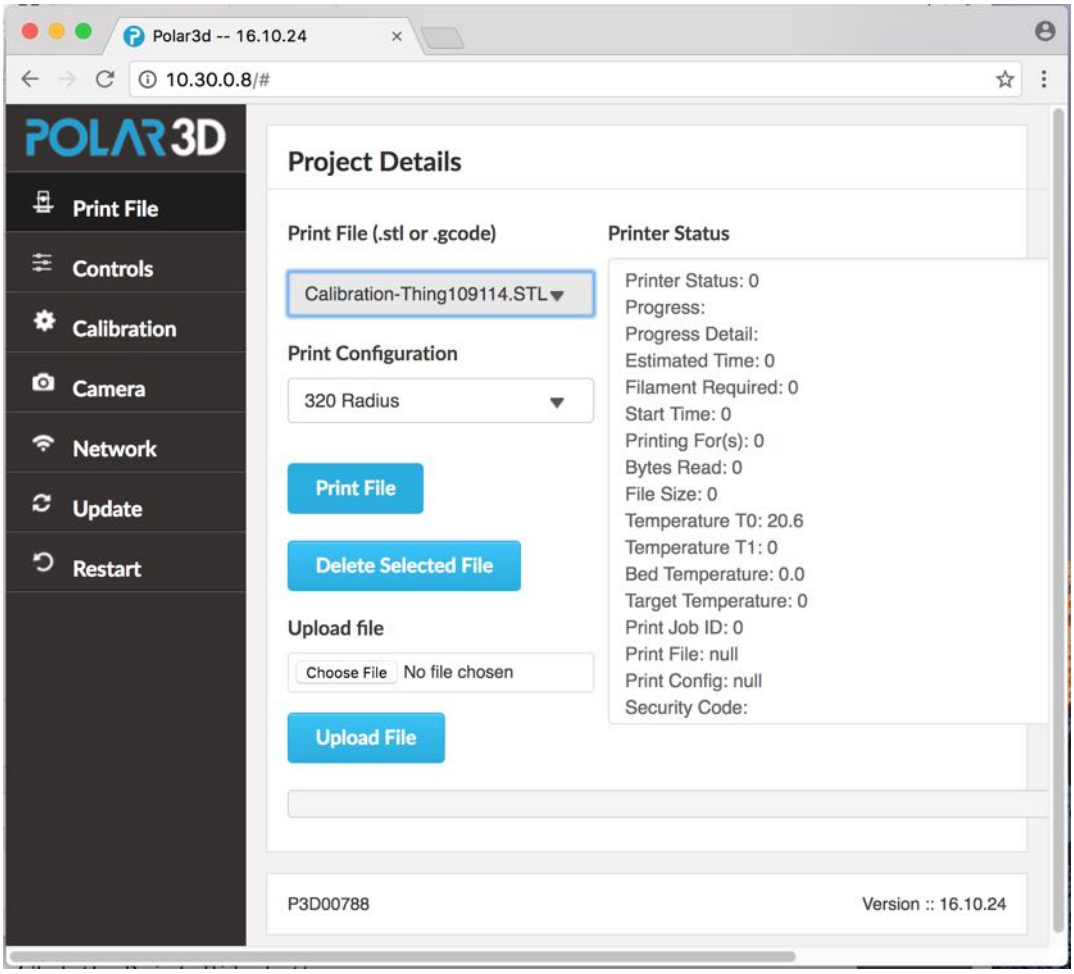
Figure C.2: Printer local web interface `Project Details` screen




Polar3d -- 16.10.24
10.30.0.8/#tabprint
POLAR3D
Print File
Controls
Calibration
Camera
Network
Update
Restart
Project Details
Print File (.stl or .gcode)
Select file...
Print Configuration
320 Radius
Print File
Delete Selected File
Upload file
Choose File
No file chosen
Upload File
Printer Status
Printer Status: 0
Progress:
Progress Detail:
Estimated Time: 0
Filament Required: 0
Start Time: 0
Printing For(s): 0
Bytes Read: 0
File Size: 0
Temperature T0: 20.4
Temperature T1: 0
Bed Temperature: 0.0
Target Temperature: 0
Print Job ID: 0
Print File: null
Print Config: null
Security Code:
P3D00788
Version :: 16.10.24



(b) Select the desired file. (Note that several sample `.stl` files ship with the Polar3D printer, accessible from the printer local interface, for your convenience in using them as a first print, or for calibration prints.)



4. Click the `Print File` button.

C.2 Cable direct connection and printing

With the cable direct method of connection and printing, since you won't be able to access either the Polar Cloud user interface, or the Polar3D printer's own onboard web user interface, you will need to run third-party printer control software on your device

(typically your computer) that can control the printer. In particular, Repetier-Host is free software which can be downloaded and installed on your computer for this purpose.

You will also need an appropriate cable to connect your printer with your computer, such as a type-A-male-to-type-B-male USB cable to connect to your printer.

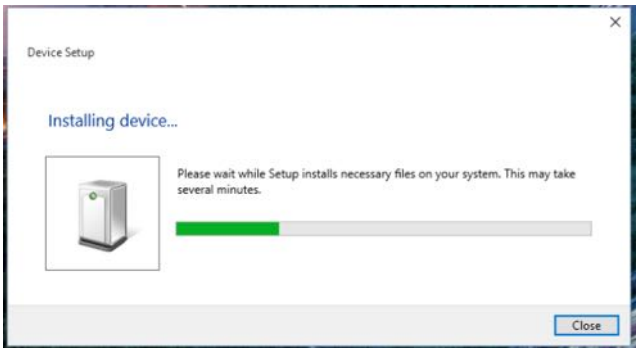
The proper type of USB cable looks like:

If you do not already have such a USB cable, you may purchase one from Amazon:

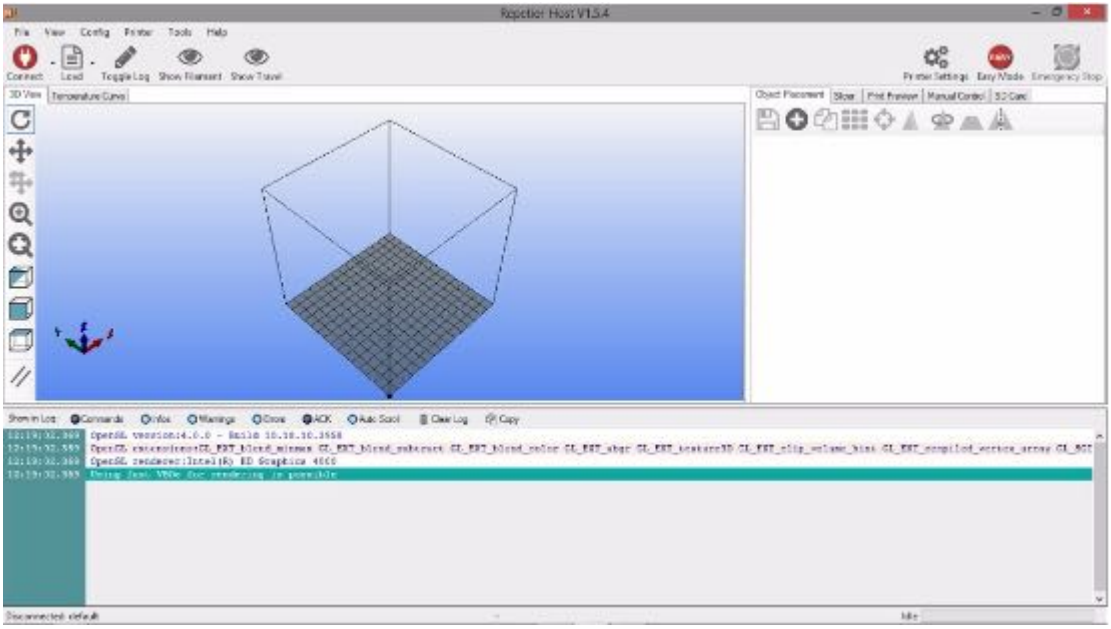
https://www.amazon.com/AmazonBasics-USB-2-0-Cable–Male/dp/B00NH11KIK

C.2.1 Cable direct connection

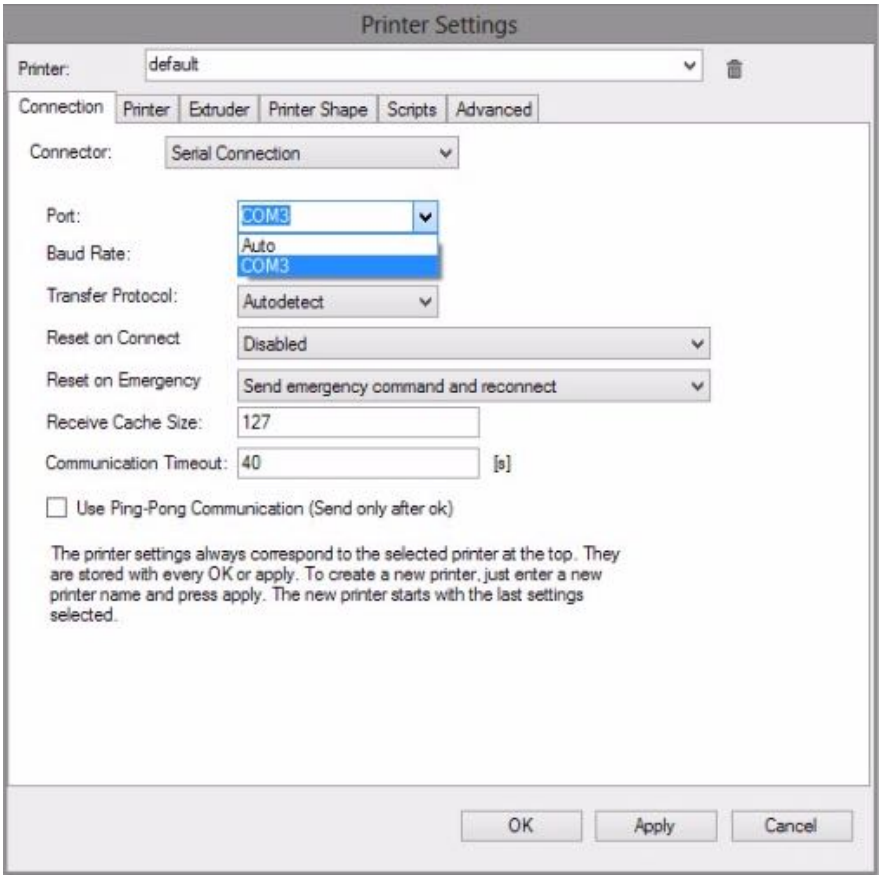
1. Obtain an appropriate cable, either a type-A-male-to-type-B-male USB cable of the type described above in Section C.2, or an Ethernet cable.
2. Plug the cable into the printer and into your computer. A window should pop up that says it is installing drivers. **Do not close that window!**



3. Now, download and install Repetier-Host.
4. Start up Repetier-Host. This is what you should see:



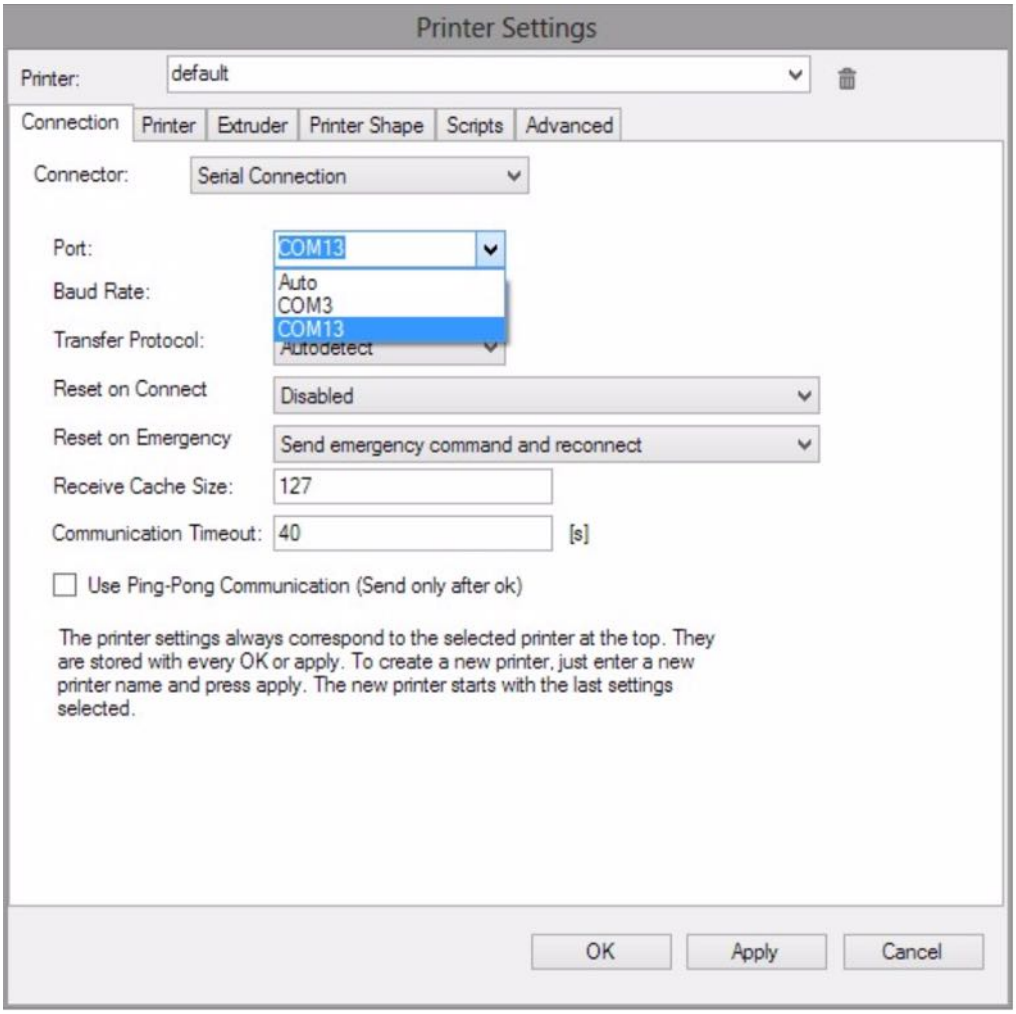
5. Once the drivers from step 2 have finished downloading, unplug your printer. Then click `Printer Settings` on the top right of the screen. You should now be looking at the following window:



First, set the `Baud Rate` to `115200`.

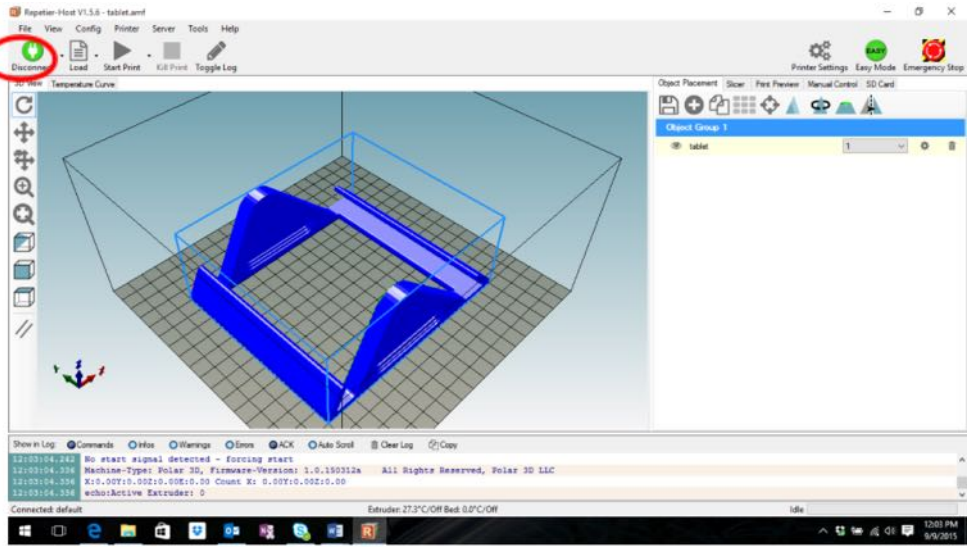
Next, click on the down arrow in the box labelled "`Port`" and make a note of the values shown in the dropdown menu. This will show you what ports you currently have on the device and will help you determine the port used by the Polar3D printer. Click "`Cancel`" to close the `Printer Settings` window.

6. Plug your printer back in. Open `Printer Settings` again. Select the new value in the drop down menu. In the example shown below, that new value is `COM13`, but the actual new value may vary.

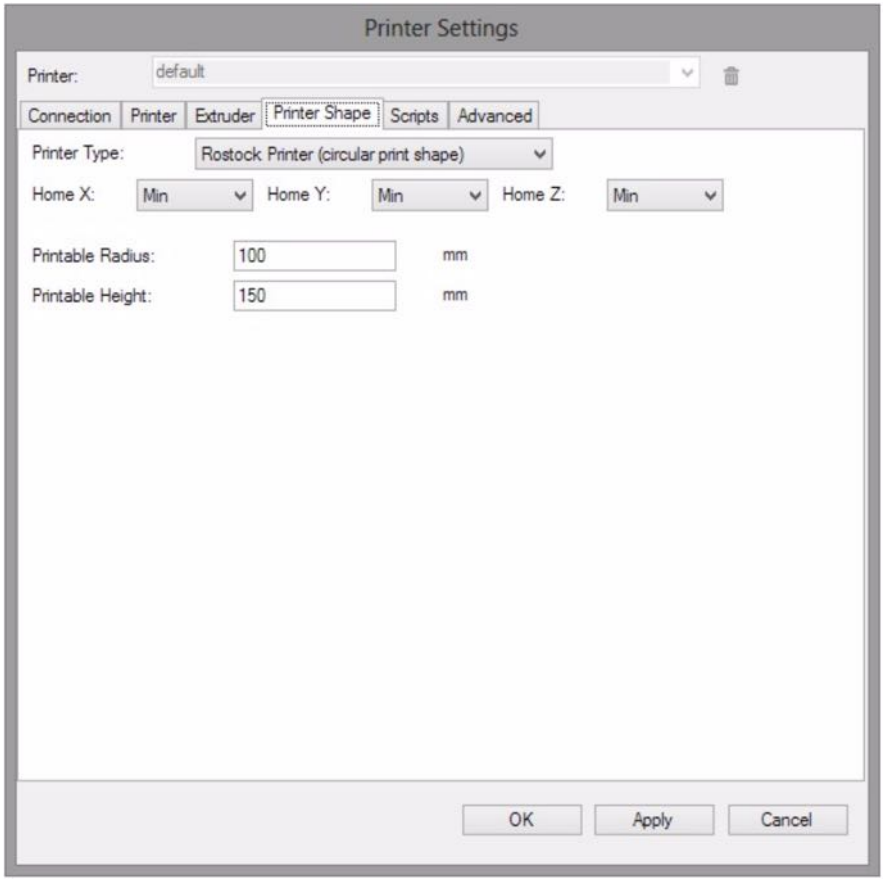


Click the "`Ok`" button to save the changes.

7. Click the red "`Connect` button (towards the top left of the Repetier-Host window). If it turns green, that means you are connected!

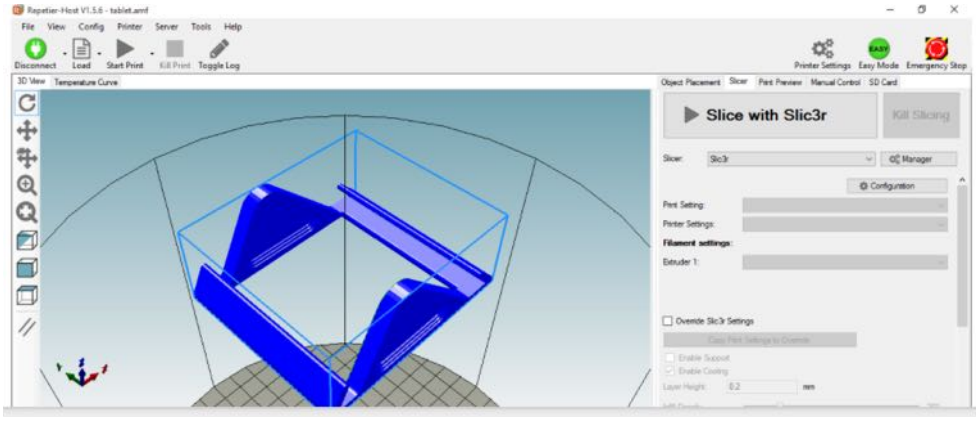


8. Now, configure Repetier-Host to work with your Polar3D printer. Under "`Printer Settings`", enter the values shown in the figure below:

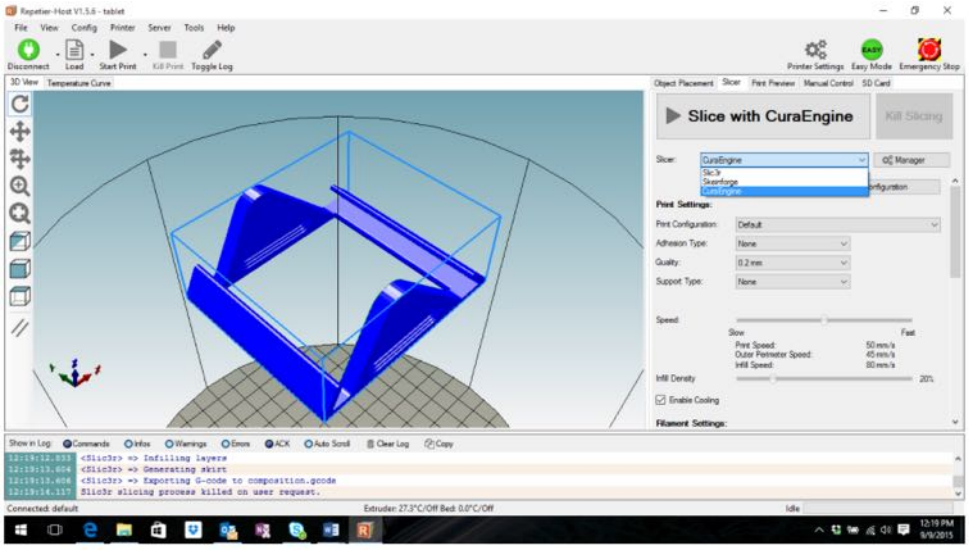


Click the "`Ok`" button to save these settings.

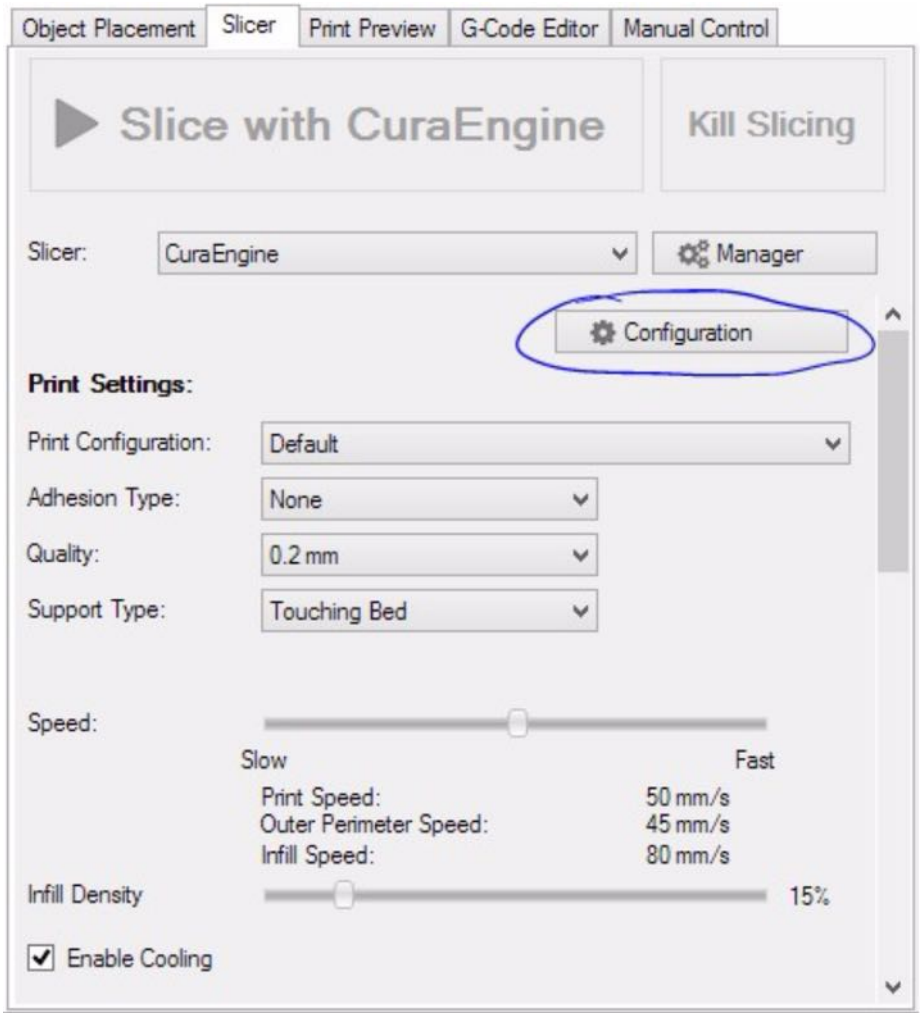
9. Now, configure the CuraEngine slicer settings. (CuraEngine is the slicer program that converts the 3D model – the `.stl` file – to Gcode that the printer can read.) Click on the tab that says "`Slicer`", towards the right of the window.



10. Make sure that the `Slicer` choice is set to `CuraEngine`:



Then click the"`Configuration`" button:



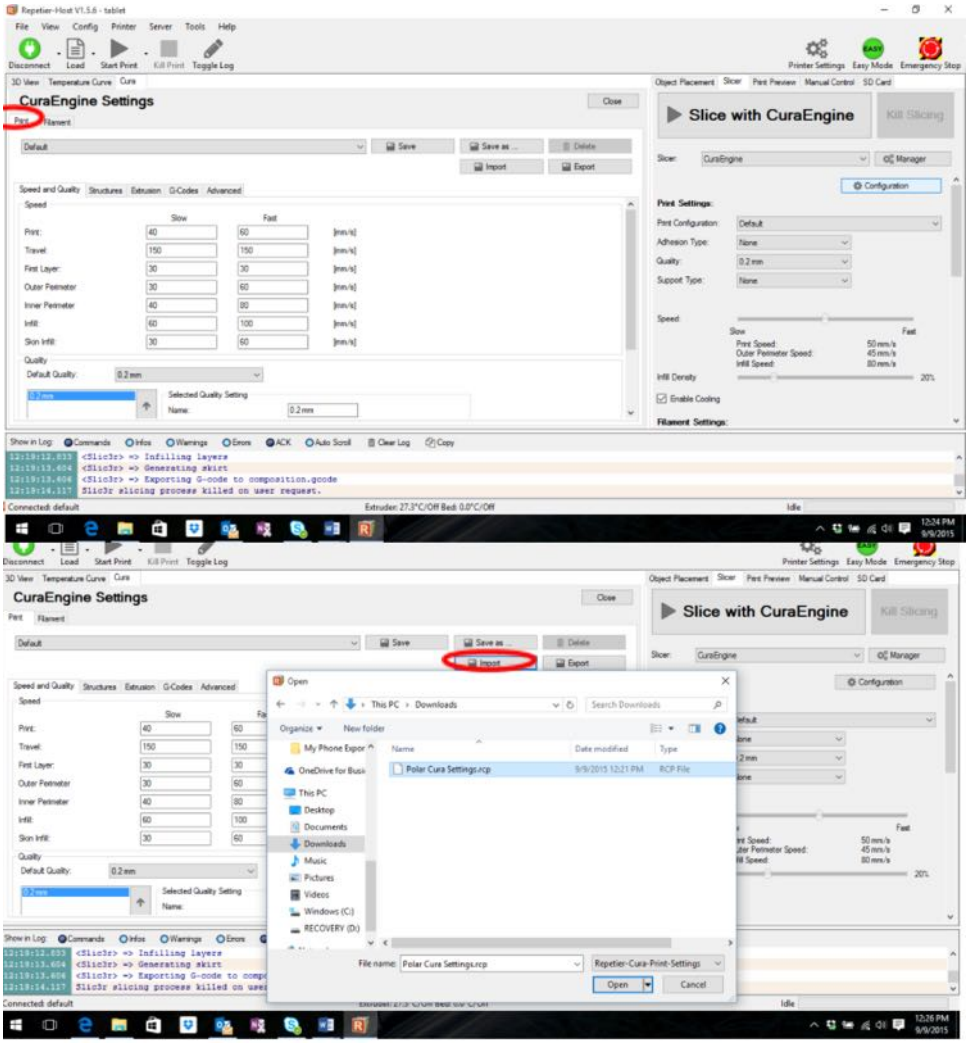
11. You will need to download two files from the Polar 3D support page. The files to download are named "`Polar Cura Settings.rcp`" and "`Polar PLA Settings.rcf`". They are available at the Polar 3D support website:

    Polar 3D support: Repetier-Host/USB printing

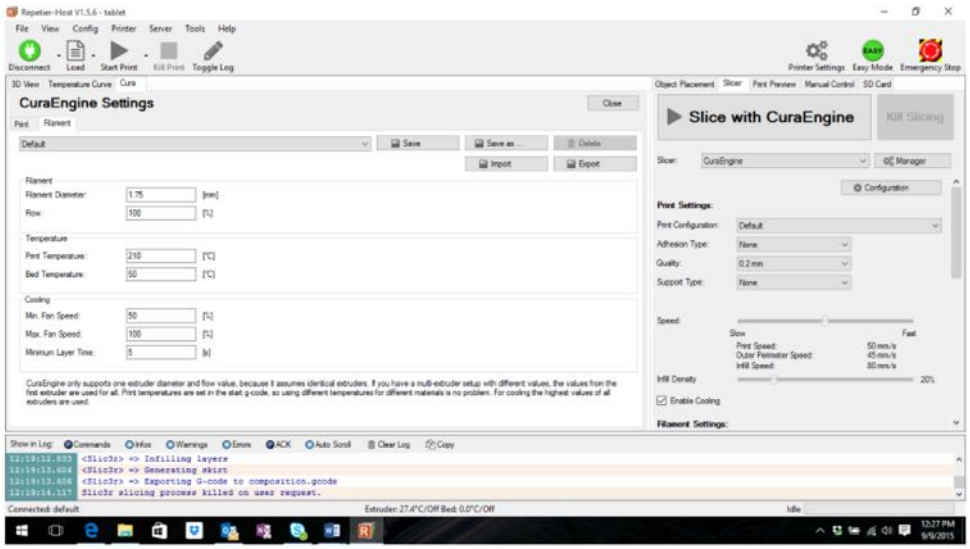
    Save the two files to your desktop.

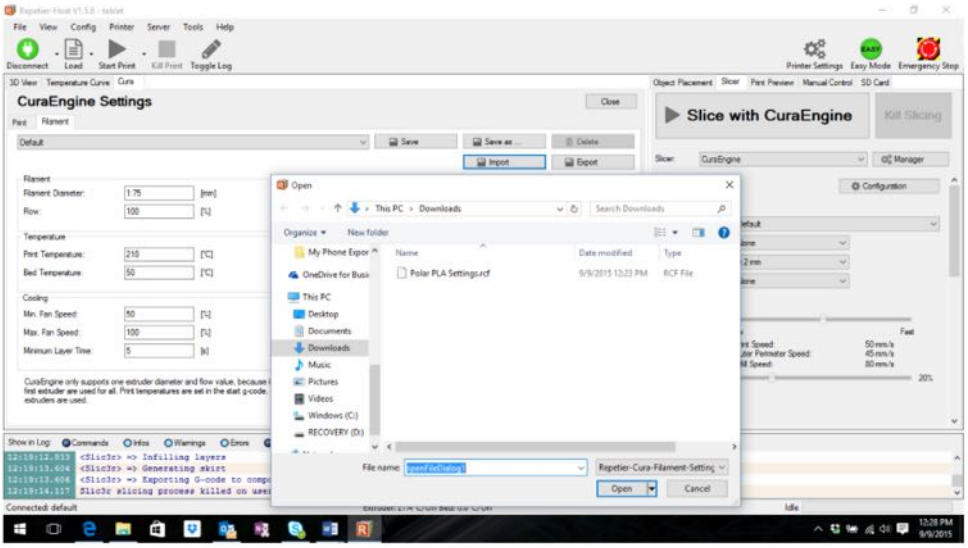
12. Still under the CuraEngine "`Configuration`" window from

step 10, navigate to the "`Print`" tab, click "`Import`", and then load "`Polar Cura Settings.rcp`":

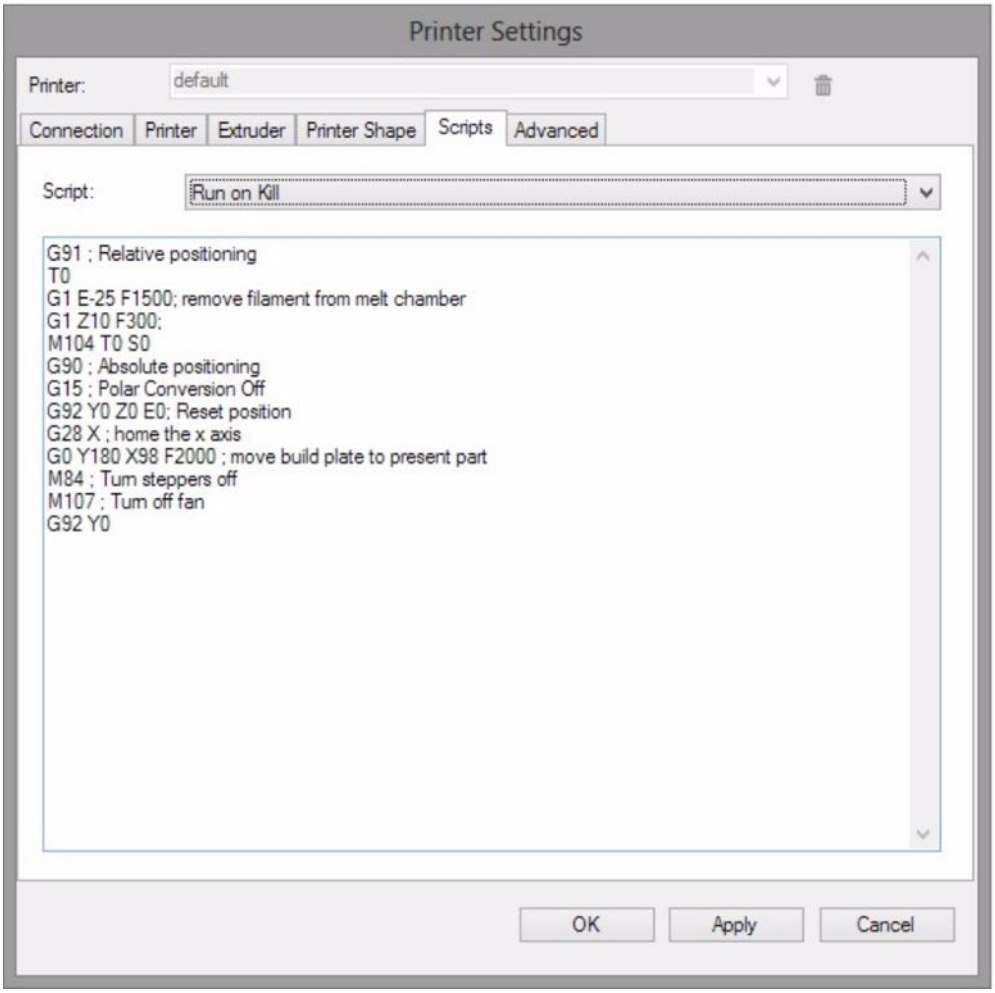


13. Next, navigate to the "`Filament`" tab, click "`Import`", and load '`Polar PLA Settings.rcf`":





14. Navigate back to "`Printer Settings`" (see for instance steps 4 and 5), click on "`Scripts`", then select "`Run on Kill`".



Copy the text as shown into the box – or you may copy the text from this link and paste it into the box. Click "OK" to save.

Everything is set up and configured properly, and now it's time to print! See Section C.2.2!

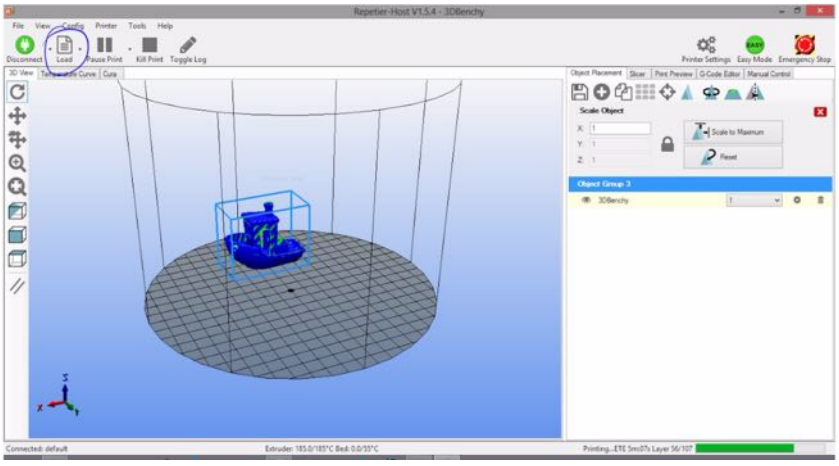
C.2.2 Cable direct printing

Once you have connected your printer via USB cable directly to your computer, and configured the printer controller software on your computer (*e.g.*, Repetier-Host), as described in Section C.2.1, you are ready to print an object!

1. Obtain an `.stl` file to print. (From your computer, you may want to look for an interesting file on the Polar Cloud, download it to your computer, and then you will be able to upload it from your computer to the printer.) But if this is your first print and you don't have something else you want to print, then for your convenience the Polar 3D support website has a sample `.stl` file along with the `.rcp` and `.rcf` files you already downloaded during the configuration in Section C.2.1. Go back to the Polar 3D support website and download the `3DBenchy.stl` file to your computer:

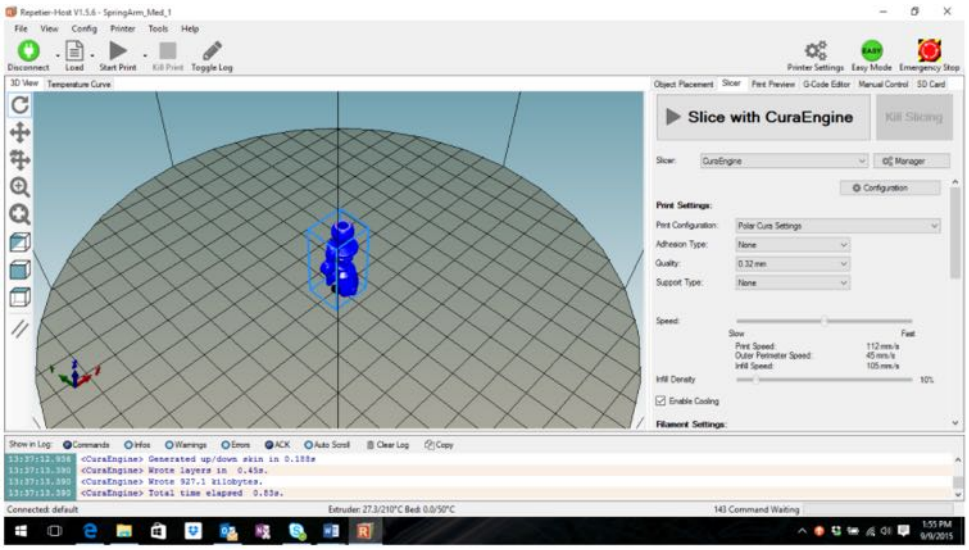
   Polar 3D support: Repetier-Host/USB printing

2. Use the Repetier-Host "`Load`" button (towards the upper left of the Repetier-Host main screen) to load an `.stl` file:



3. You may want to change the position of the object on the build plate. You will generally to position the object so that it is *not* at the center of the build plate, and instead is near the edge of the build plate – this will tend to increase the speed of the print. (See Section 8.1 for additional discussion of operational tips regarding positioning objects.) To move the object, right click on the object and drag it – for instance, towards the edgeof the build plate. You can also scale and rotate the object by utilizing the `Object Placement` tab on the right of the Repetier-Host screen.

4. Once you are satisfied with the placement of your object, click the "`Slicer`" tab, and then click "`Slice with CuraEngine`":



5. When the slicing completes, click "`Start Print`".

That's it!

Glossary

3D printer

The Polar3D printer melts plastic filament and deposits in layers or "slices" to additively build up a solid, three-dimensional object. More generally, there are a variety of forms of "3D printing"; see http://www.3dhubs.com/what-is-3d-printing for an overview.

Plastic filament 3D printers are relatively inexpensive, and accessible to students. Students may find it interesting to consider how the sorts of thinking and skills developed using a plastic filament 3D printer could transfer to alternate forms of 3D printing.

ABS

ABS (Acrylonitrile-Butadiene Styrene) is an oil-based plastic. If not quite as environmentally friendly as PLA, it is a bit tougher material, and besides its use as 3D printer filament, it is also used in making plastic objects for everyday use, including Lego bricks. 211, 213–215, 222, *See also* filament & PLA

brim

To promote adhesion of the object being printed, sometimes an extra ring of material may be printed encircling the object; this is referred to as a "brim".

build plate

For 3D printers in general, the build plate is the platform on which objects are printed. For the Polar3D printer, the build plate is a round mirror with a toothed gear on the underside, that meshes with a gear on the build plate shuttle. 1, 4, 208, 213, 218, 230, 233, 235, 239, 246, *See also* build plate shuttle

build plate shuttle

For the Polar3D printer, the build plate shuttle consists of the carriage underneath the build plate: the shuttle arms and pads, and the gear, on which the build plate rests. The build plate shuttle slides along two support rods (in the x axis of movement) and rotates (the θ polar coordinate) the build plate via its gear. See Figure B.1. 4, 5, 181, 182, 212, 231, 236, 247, *See also* build plate & polar coordinates

CAD

Computer Aided Design is the use of computer systems to aid in design. CAD output is often in the form of electronic files; for 3D printing, the industry de-facto standard is `.stl` files. 47, 49, 84, 196, *See also* `.stl` file

captive portal

A captive portal is a "landing" web page that a user must view, and at which a user typically must accept prescribed conditions for access, before access is permitted. Free WiFi hotspots at business centers, airports, coffee shops, *etc.*, typically permit access by means of a captive portal, where after a user accepts the conditions, the MAC address of the user's device is permitted access for some period of time. In the context of Polar3D printers, note that a Polar3D printer cannot navigate itself through a captive portal; so for a Polar3D printer to get on a local network, the local network must allow access to the Polar3D printer (perhaps involving local network configuration to recognize the printer's MAC address) *without* requiring the Polar3D printer to do an extra step of "viewing" or "agreeing to" some access agreement. This is the same sort of situation for any hardware device that needs to get on a local network. 8, 20, *see* MAC address

Cartesian coordinates

Cartesian coordinates are rectilinear coordinates, describing the position of a point in two-dimensional space via x and y coordinates, or in three-dimensional space via x, y, and z coordinates. Cartesian coordinates are named after the 17th century mathematician René Descartes who developed them; compare with polar coordinates. *See also* polar coordinates

corner ringing

This is a type of print defect characterized by a ripple pattern which quickly dampens and is seen on the vertical faces of prints, particularly after a direction change in the surface.

cylindrical coordinates

Cylindrical coordinates are one way of extending polar coordinates to three-dimensional space: cylindrical coordinates use the r and θ of polar coordinates, plus a z height. *See* polar coordinates

DHCP

DHCP (Dynamic Host Configuration Protocol) is a client/server protocol that automatically provides an IP host (such as your 3D printer) with its IP address and other related networking parameters such as the IP subnet mask and default gateway IP address. In the absence of a DHCP server on a local network, each network device (such as your 3D printer) will need to have a statically (*i.e.*, manually) assigned IP address.

extruder

The extruder, or extruder nozzle, of a 3D printer is the nozzle at the bottom of the print head, that is extruding the melted filament. 144, 145, 176, 220, 225, 232, 233, 235, *See* filament & print head

filament

In the 3D printing context, filament generally refers to the plastic filament that the printer melts and prints; PLA and ABS are two of the most common materials for 3D printer filament. 37, *See also* ABS & PLA

Gcode

Gcode, sometimes written as "G-code", is a numerical control programming language used to control the operation of machine tools such as 3D printers. While there is an international standard for Gcode, the 3D printing community loosely adheres to it. For example, different 3D printers accept different variations of Gcode. The specific Gcodes produced by different slicers and accepted by different printers are often not well specified. 139, 176, 207, 261, *See also* slicer

infill

Each model to be printed is comprised of an exterior and an interior. While the exterior is typically printed solid with no holes or gaps, the interior may range anywhere from completely empty to completely solid. The plastic printed in the interior is known as "infill" and its solidity is the "infill percentage". For example, 0% infill means the print is completely hollow and 100% infill means it is fully solid. Printing time is reduced and plastic is saved by printing with infill percentages significantly less than 100%. The amount of infill you should use depends upon the nature of the piece being printed and its intended usage.

MAC address

A MAC address (Media Access Control address) of a network device is a unique identifier assigned for network data layer communications purposes. MAC address are typically assigned by the manufacturer of a network device, encoding the manufacturer's registered identification number, and are stored in the device's read-only memory or other firmware. Among other uses, a device's MAC address is a way of identifying the device for network access purposes.

Mcode

Gcode can contain "miscellaneous" function codes known as "Mcodes" and which begin with the letter "M". *See* Gcode

MSDS sheet

Material Safety Data Sheets are a widely used system for cataloging information on chemicals, chemical compounds, and chemical mixtures – so for instance, the plastic of 3D printing filament. Note that 3D printing filament, especially PLA filament, is about as safe as plastic can get; but for those who need an MSDS document in their environment, Polar 3D has MSDS sheets available for the printing filament available from Polar 3D; see the Polar 3D support document Polar Filament MSDS Sheet. *See also* filament & PLA

NGSS

Next Generation Science Standards, released in 2013, were developed by a consortium of 26 states, the National Sci-

ence Teachers Association, the American Association for the Advancement of Science, the National Research Council, and the nonprofit organization Achieve. For details, see http://www.nextgenscience.org.

over-extrusion

When the extruder outputs a surplus of plastic, over-extrusion results. Over and under-extrusion are caused by a mismatch between the slicer's expectations and reality: the slicer expects that when a millimeter of raw filament is fed into the extruder, a specific volume V_e of plastic will then be extruded — output by the extruder. When the actual volume of plastic output, V_a, exceeds V_e, over-extrusion results; when V_a is less than V_e, under-extrusion results.

There are a number of causes of such a mismatch of plastic extruded, but it generally is the result of the input filament diameter not matching what the slicer expected, or the steps per mm for the extruder being incorrect. By carefully measuring your filament diameter, and then checking that that value is properly entered in the slicer – for a Polar3D printer, this means properly entered under the object's "`PRINT SETTINGS`", "`ADVANCED`", "`Filament`", "`Diameter`" – you can generally prevent over- and under-extrusion from occurring. (But note that poor quality filament whose diameter varies can cause intermittent over-extrusion and under-extrusion.) 241, *See also* filament, slicer & under-extrusion

PLA

PLA (PolyLactic Acid) is a biodegradable plastic, typically made from renewable raw materials such as cornstarch or sugarcane. Besides 3D printing filament, other common uses are for plastic cups and plastic water bottles. 1, 42, 210, 212, 214, 219, 220, 232, *See also* filament

polar coordinates

Polar coordinates describe two-dimensional location via radius, r, and angle, θ. Compare with Cartesian coordinates, which instead describe two-dimensional location via x and y coordinates. The Polar3D printer uses polar coordinates at the hardware level, which has several advantages; see the Polar 3D video "WWBD - Polar is Better".

Does this mean that you or your students need to use or understand polar coordinates? No! The Polar3D printer expects industry-standard `.stl` files, which describe location in the more familiar Cartesian x, y, and z coordinates; the Polar3D printer's firmware automatically converts from the Cartesian coordinates describing an object to the polar coordinates (technically, cylindrical coordinates) that the printer's hardware uses.

However, if you have students who are learning about polar coordinates in their math class – see Common Core standard http://www.corestandards.org/Math/Content/HSN/CN/B/4/ – you may wish to draw such students' attention to the underlying polar operation of the Polar3D printer, both to help motivate them as to why one might want to learn about polar coordinates, and to help them visualize the

relationship between polar coordinates and Cartesian coordinates.

Also, a couple of printer operational tips will be more intuitive if you are conscious that the printer is operating, at the hardware level, in polar coordinates. 207, 208, 230, 233, *see also* Cartesian coordinates

print head

The print head is the assembly including the heating element and the filament extruder. It moves up and down the Z rod. See Figure B.1. 1, 4, 29, 181, 225, 231, 235, 237, 246, 247, *See also* extruder & Z rod

raft

To promote better build plate adhesion or to accommodate an uneven build surface, most slicers can add to your print a thick series of layers which can later be removed once the print is finished. These layers — referred to as a raft — are printed slowly so as to promote better adhesion to the build plate as well as to level out the printing surface. 139, 175, 209, 213, 219, *See also* slicer

retraction

In the context of 3D printing, retraction typically refers to the amount by which the extruder nozzle is raised when performing non-extrusion moves between sections of the print. That is, during printing there are normally extrusion moves, during which filament is being extruded, and non-extrusion moves, during which the extruder nozzle is retracted (raised) and moved *without extruding melted fil-*

ament to some other portion of the build plate where extrusion will be resumed. Retracting (raising) the extruder nozzle for non-extrusion moves helps keep the extruder nozzle from dragging or smearing extruded material while it is being moved to its new position. 139, 176, 240, *See* extruder

SD card

An SD card is specific type of memory flash card and is used to convey print files to your printer without using a USB or network connection. SD cards come in a variety of sizes, ranging from a fraction of a gigabyte to upwards of 256 gigabytes or more. The term "SD" is an acronym for "Secure Digital".

shell

When a model is prepared for printing by a slicer, the slicer generates commands to print a solid exterior. The exterior is typically printed by following the model's perimeter. The perimeter may be printed multiple times per layer, each time inset from the prior pass. The final result can be thought of as a series of nested shells, one inside the other, from which arises the term "shell". With some slicers, you control the thickness of the solid exterior by specifying the number of shells to generate. 220, 240, *See also* slicer

skirt

A skirt is an extra outline of material surrounding, but not touching, the perimeter of a print object. A skirt is sometimes used to shield the main object from thermal drafts,

especially when printing using ABS filament, or to establish a smooth flow of filament. 139, 175, 209, 214, 222, *See also* ABS

slicer

The process of turning a 3D model into printing instructions — Gcode — is referred to as "slicing". That name derives from the fact that the process takes slices of the model and determines the necessary "tool paths" (extruder paths) to print that slice. The slice is a "layer" of the print. As the process is referred to as slicing, the software which implements the process is often called a "slicer". For a Polar3D printer, slicer settings are set in the Polar Cloud under "`PRINT SETTINGS`". (If using a direct connection to the Polar3D printer via a cable, and hence third-party software to control the printer, then the slicer is controlled by that other software; for instance, Repetier-Host uses the CuraEngine slicer.) 125, 139, 241, 261, *See also* extruder, Gcode & tool

slicing profile

Most slicers have a mechanism whereby you collect together a number of configuration settings used by that slicer when preparing a model for printing. Such a collection of settings is here referred to as a "slicing profile". A given slicer may use a different name (e.g., a "factory" in Simplify3D). *See* slicer

stepper motor

A stepper motor is a brushless DC (direct current) electric motor that divides a full rotation into a number of equal

steps. In a 3D printer, stepper motors are typically used to move the extruder and build plate. In particular, in a Polar3D printer, there are three stepper motors: one controls the movement of the print head up and down the Z rod (z axis), one controls the movement of the build plate shuttle (x axis), and one controls the rotation of the build plate (θ rotation). 181, *See also* build plate shuttle, polar coordinates, print head & Z rod

`.stl` file

STL originally stood for the STereo Lithography file format native to CAD software created by 3D Systems, describing the surface geometry of a three-dimensional object. It does not include features such as color or texture, nor does it specify a fixed size; it solely represents the shape. It has become the de-facto standard format used in 3D printing. 32, 36, 43, 47, 49, 52, 61, 63, 65, 66, 70, 80, 82, 84, 123, 125, 134, 136, 141, 180, 187, 193, 196, 199, 250, 253, 261, 267, *See also* CAD

telegraphing

A print defect caused by too thin of an exterior shell through which interior printing penetrates leaving visible surface blemishes. 240, *See also* shell

tool

In Gcode parlance, an extruder is a "tool" which is controlled by the printer. That is, a "tool" is another name for an extruder. If your printer has a single extruder, than that extruder may be referred to as "tool 0". If your printer

has two extruders, then the right extruder is "tool 0" and the left extruder is "tool 1". To further confuse matters, in Gcode motion commands for the right extruder may use the prefix "A" while the left extruder the prefix "B". *See also* extruder & Gcode

under-extrusion

When the extruder outputs a deficit of plastic, under-extrusion results. 241, *See also* over-extrusion

Z rod

On a Polar3D printer, the Z rod or Z threaded rod is the tall, threaded rod towards the back of the printer on which the print head (the printer extruder assembly) moves up and down; see Figure B.1. 4, 182, 231, 236, 246, *See also* extruder & print head

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This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Any Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
-Reorient or relocate the receiving antenna.
-Increase the separation between the equipment and receiver.
-Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
-Consult the dealer or an experienced radio/TV technician for help.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.