Proposal for the design and development of a digital learning resource

Loïc Requin
University Limerick #18136613
EL6072 Assignment 1

Proposal for the design and development of a digital learning resource

Title of e-learning course

3D Printer calibration series: Maximum safe printing speed.

Summary

In this course, participants learn about calibrating their Fused Filament Fabrication 3D printer to print as fast as possible can while ensuring a consistent quality.

The course is a freely accessible online learning resource published on www.mekamake.com

Prerequisites

- General understanding of what a 3D printer is.
- Experience of using a slicer software.
- Understand the format of a Mathematical equation.
- A 3D printer or Slicer software is not required to follow the course.

Learning outcomes

- Define the Volumetric Extrusion Rate (VER)
- Explain how the feed-rate and the VER affect the quality of printed parts.
- Calibrate the maximum feed-rate using G-Code commands.
- Use the calibration spreadsheet to define the maximum reliable speed of your 3D printer.

Writing style

The data gathered during the task analysis helps define the characteristics of the audience.

A 2013 online survey (Moilanen; Vadén, 2013) based on 344 3D printer users helps determine the profile of potential learners (Gutierrez, 2017; Lee & Owens, 2004). 3D printer users typically are:

- Self driven learners with 67% also holding 3rd level degrees.
- Community driven participants with more than half identifying with the maker movement.
- Ranging between 13 and 74 years old with the majority around 35.
- Based in Europe and North America (87%), thus suggesting English language proficiency and access to up-to-date Information Technology.

The first point points indicate the majority of the audience is literate and able to comprehend the required technical concepts. The audience will expect a precise language rich with details and justifications.

A certain level of detail is expected and the technical jargon and concepts should be clearly defined and explained.

The second point tells us the audience is computer literate, able to navigate forums and social media platforms.

The median age of the audience (35) provides cues about the way the learners interacts with digital media and distribute their attention online.

The audience is familiar with the codes of online written communication and expects a concise, informal and direct tone.

The 4th point and the broad age range indicates the audience may include many non-native English speakers with varying levels of English literacy.

The vocabulary should remain simple with explanations for technical terms. The written style should exclude idioms or regional specific expressions. The pronunciation in audio recording needs to be clear and articulate.

The audience is primarily composed of hobbyists and enthusiasts. The tone should be positive, fun and re-enforce the passion and drive of the learners for the topic.

The course is about a very practical topic, so an active voice is important though the Voiceover comment and the written content.

Proposal for the design and development of a digital learning resource

Interactive features

The course employee different ways to compensate for the absence of a live instructor and give a human presence:

- The splash screen includes a picture of the lecturer.
- The video introduction with simulated eye contact and visible hands sets a good first impression.
- All the subsequent screens include a voiceover comment to lecture and guide the learner.

Navigation

The side bar hides automatically to free screen estate. The freed space can be use to fit more information or up scale text and infographics.

The minimised UI show san overview of the progression using a white highlight, the resources button, the glossary button and the main interaction button.

Moving the cursor over the side bar for a second reveals the expanded UI.

The expanded UI displays the titles of each section.

The navigation buttons are placed consistently and logically.

For Instance readers of roman scripts expect the end of the page in the bottom right corner. Placing the main interaction function in this corner facilitates the UI acceptance. (Johnson p.4)

To avoid ambiguity, the main interaction button changes its function depending on the activity or task. (Johnson p.8)

On the first screen, the main navigation button reads “Start” and “Next” on the subsequent screens. During a review activity or a quiz, the button can reads “Submit” or “Retry” depending if the answer is to be submitted or was incorrect.

Interaction and activities

The topic at hand usually requires to own a 3D printer and other software components.

Various features help create an immersive experience and facilitate the transfer of knowledge without requiring learners to have any equipment at their disposal:

- A simplified representation of the key components with infographics.
- Animations
- A G-Code terminal simulator

The review quizzes use drag and drop features to associate concepts and verify knowledge.

Clickable hotspots reveal pictures to relate the infographics to real examples.

Infographics use animations with sounds to provide a reference.

The resources section includes links to references including a digital worksheet learners can use offline to apply the techniques learned during the course:

- Glossary of key terms and concepts (Lannon & Gurak 2017 p.437)
- Links to references like G-Code reference, calibration spreadsheet

Accessibility

To ensure accessibility, the video should include an audio descriptions and the images should include a metadata description usable by screen readers like VoiceOver, Jaws or Orca.
The colour palette allows colour blind participant to distinguish elements. The visuals are tested through a colour blindness simulator (coblis).

Proposal for the design and development of a digital learning resource

Interface design

Text

The sans-serif font Avenir, maintains a good level of readability on low resolution displays.

The many grease levels of Avenir allow to finely tune the emphasis of the text. (Lannon & Gurak 2017 p.323)

To achieve a high level of readability the small text dark colour contrasts with the bright background. A slightly grey background and dark greys for bold or large text keeps the contrast within comfortable levels.

Colour

The palette uses distinct contrasted colour to increase the association with specific components like the filament or the heated elements. (Johnson p.61).

A vibrant yellow accent captures the attention of the learner for the interactive or key elements.

The use of green and red is limited and made more accessible by associating a different brightness to each. Instead of relying solely on the colour to indicate a positive (green) or negative (red) test answer, the highlight includes a checkmark or a cross symbol.

The navigation UI uses neutral greys to avoid distractions and relies on different shades and show to create a sense of depth. The UI hovers over the content and blends with the chrome of the web browser.

Infographics

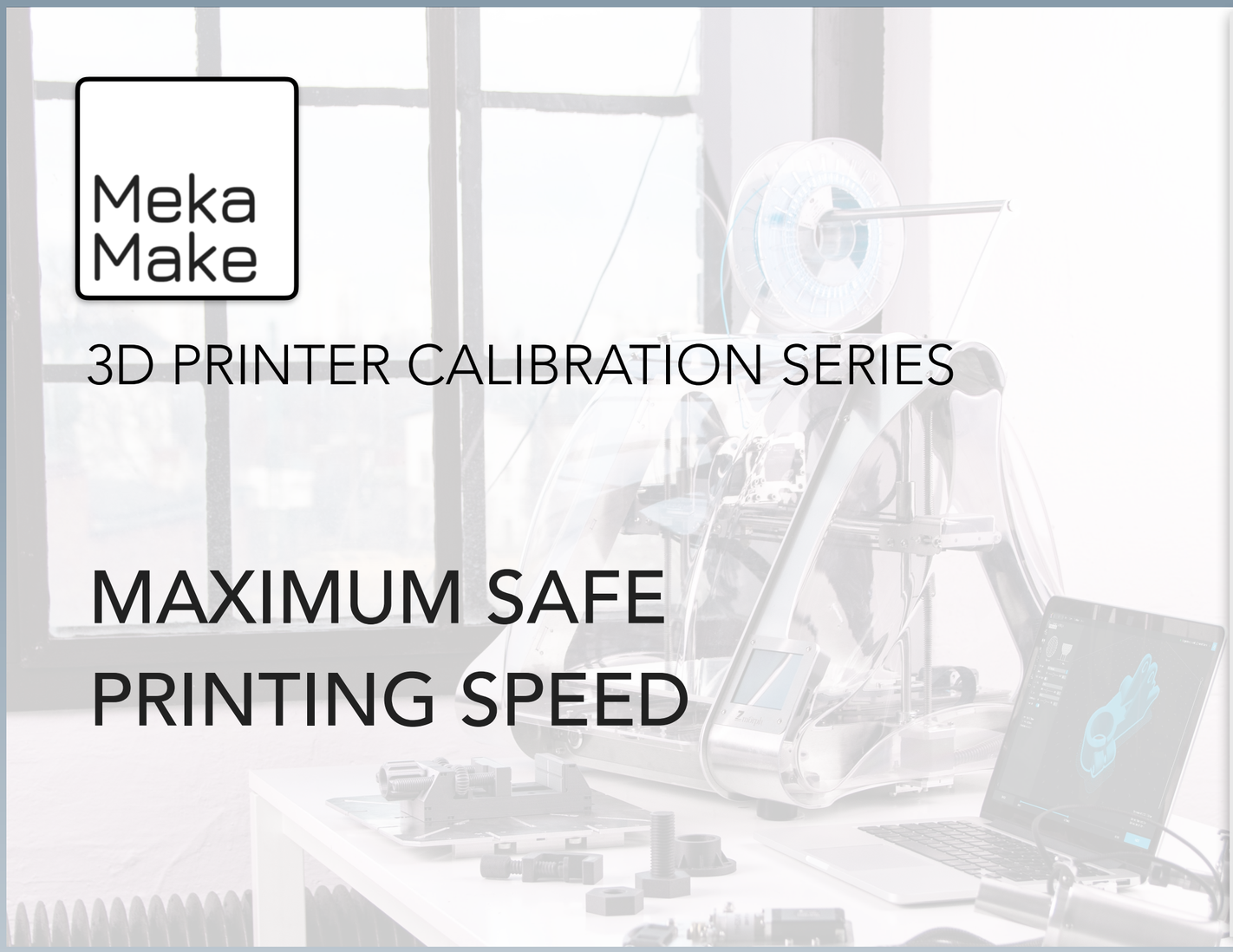
The same flat simple style is used for the the infographics and animation.

Shadows are reserved for the navigation UI.

References:

Johnson, J. (2010). ‘Our colour vision is limited’, Designing with the Mind in Mind, Morgan Kaufman, 61.
Johnson, J. (2010). ‘We perceive what we expect’, Designing with the Mind in Mind, Morgan Kaufman, 4.
Lannon, J.M. & Gurak, L.J. (2017), ‘Creating a Design that Works for Your Readers', Technical Communication, Harlow: Pearson, 323
Lannon, J.M. & Gurak, L.J. (2017), ‘Placing definitions in a document', Technical Communication, Harlow: Pearson, 437.

Storyboard



Printing well and fast. Is it possible?

In this course I'll teach you how to calibrate the maximum volumetric extrusion rate of your 3D printer to print as fast as possible without compromising on quality.

6 chapters
Learn at your own pace
Total duration: 45m

Start

Graphic / Animation Info:

The text, infographics and video contents are placed in the whole frame.
The side bar contains the voice of the Instructor, the navigation and resources.
The side bar is now visible and will hide to free space for contents and activities.
The side-bar is translucent.

Navigation:

By placing the Start button on the bottom right corner, learners get familiar with using the side bar to navigate and interact with the course.

Review comments:

Content Description:

The side includes the Why and terminal objective: print reliably and as fast as possible.
The duration and time requirements are also indicated to allow learners to establish if they can commit to the course.

Voiceover Script:

No-audio

Next

Graphic / Animation Info:

Video in the main area. The navigation bar is visible for now and will collapse to free content space.

Navigation:

Section is highlighted in navigation bar.
Click the next section to

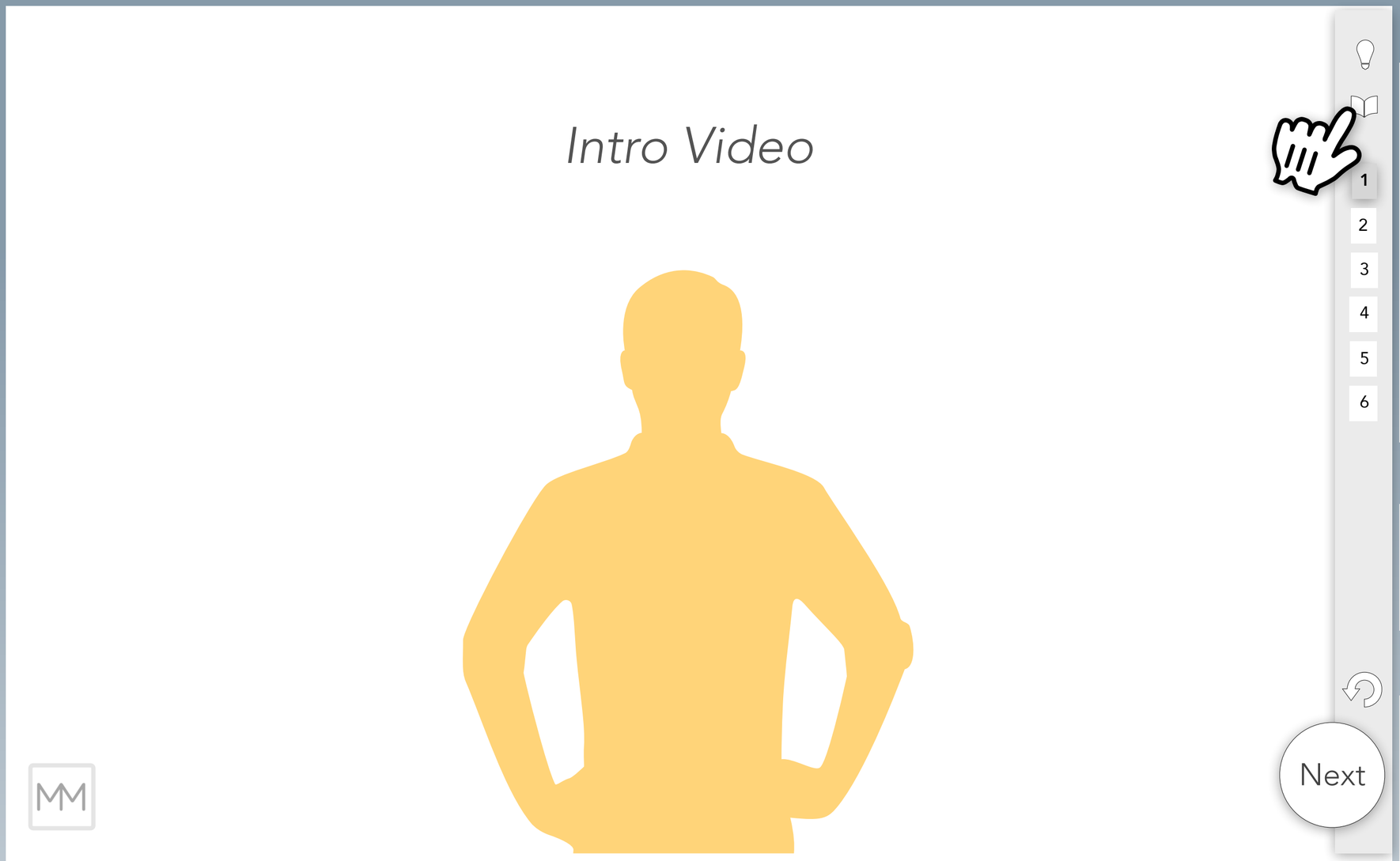
Review comments:

Content Description:

Video of Instructor. American framing, hands and face visible. Neutral background.
It is important to visually connect with the instructor even if this is a recorded video.
The Instructor highlights the Why, the terminal objective and explains how to use the navigation UI.

Voiceover Script:

Hello and welcome to the second course of the MekaMake 3D printer calibration series.
Have you ever had good results with one kind of filament and the same model failing to print with another kind of plastic or increasing the speed?
Why can't we print fast, well and reliably? Each 3D printer is composed of many components: slicer, controller, extruder, motion system, heating or cooling. Depending of their quality and characteristics, each component can affect the printing performance when it reaches its physical limits. The key in obtaining reliable and predictable prints is to determining the mechanical limits of your printer and configure your slicer accordingly for each type of material. This way you push your printer to its limits without compromising on quality.
Before you continue, let's take a look at the course navigation. The side bar contains the playback controls, the glossary and links to references. It will hide automatically. Just move the cursor to the edge of the screen to bring it back. To take a break click on the MekaMake logo. The course will resume where you left it so you can learn at your own pace.
When you are ready, click on the Next button to continue.



Graphic / Animation Info:

Video in the main area. The navigation bar is visible for now and will collapse to free content space.

Navigation:

Side bar
(cursor is part of the storyboard UI)

Review comments:

Content Description:

Video of Instructor. American framing, hands and face visible. Neutral background.
It is important to visually connect with the instructor even if this is a recorded video.
The Instructor highlights the Why, the terminal objective and explains how to use the navigation UI.

Voiceover Script:

Hello and welcome to the second course of the MekaMake 3D printer calibration series.
Have you ever had good results with one kind of filament and the same model failing to print with another kind of plastic or increasing the speed?
Why can't we print fast, well and reliably? Each 3D printer is composed of many components: slicer, controller, extruder, motion system, heating or cooling. Depending of their quality and characteristics, each component can affect the printing performance when it reaches its physical limits. The key in obtaining reliable and predictable prints is to determining the mechanical limits of your printer and configure your slicer accordingly for each type of material. This way you push your printer to its limits without compromising on quality.
Before you continue, let's take a look at the course navigation. The side bar contains the playback controls, the glossary and links to references. It will hide automatically. Just move the cursor to the edge of the screen to bring it back. To take a break click on the MekaMake logo. The course will resume where you left it so you can learn at your own pace.
When you are ready, click on the Next button to continue.

Graphic / Animation Info:

Navigation:

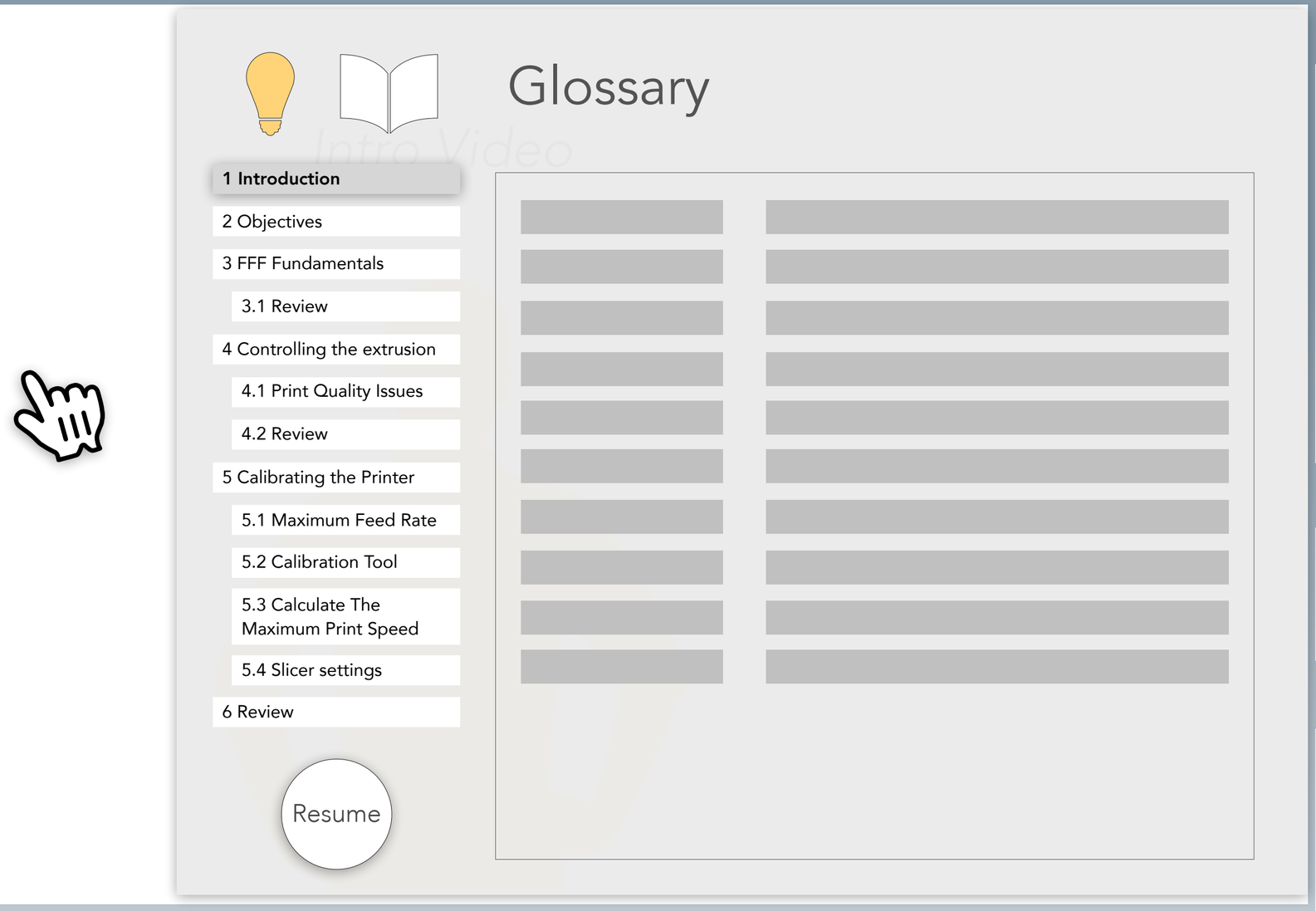
Side bar
(cursor is part of the storyboard UI)

Review comments:

Content Description:

UI of the expanded sidebar with resources selected.

Voiceover Script:



Graphic / Animation Info:

Navigation:

Click Resume or outside of the expanded sidebar to collapse the side bar and return to the slide.
(cursor is part of the storyboard UI)

Review comments:

Content Description:

UI of the expanded sidebar with glossary selected.

Voiceover Script:

After completing this course, you will be able to do the following:

- Define a FFF 3D printer's Volumetric Extrusion Rate (VER).
- Explain how the feed rate and the VER affect the quality of printed parts.
- Calibrate the maximum feed rate using G-Code commands.
- Use the calibration spreadsheet to define the maximum reliable speed of your 3D printer.

1
2
3
4
5
6

Next

Graphic / Animation Info:

Navigation:

Side bar

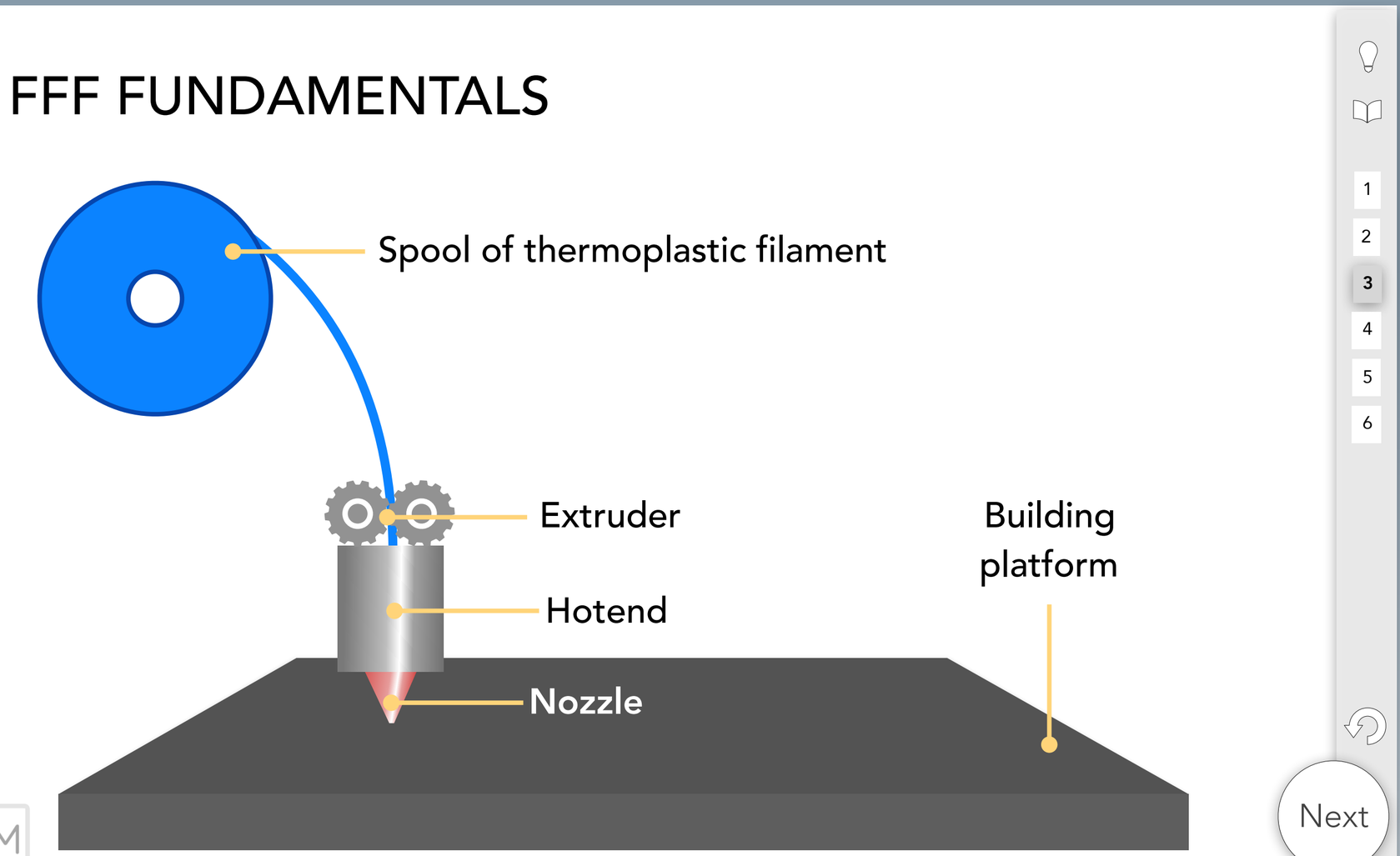
Review comments:

Content Description:

Presentation of the learning outcomes.

Voiceover Script:

The overall goal of this course is to accurately calibrate the Maximum Safe Printing Speed of your printer. To get there you are going to learn about some important parameters and practice using a simulator. There is no need for you to have a printer with you to complete this course. I encourage you to return to the last section and use the tools included in the course to repeat the steps on your machine when it is appropriate for you.
The course is broken down into 7 modules that you can complete at your own rate.
After completing each module of the course you should be able to <reads objectives>.
Click Next when you are ready to continue.



1
2
3
4
5
6

Next

Graphic / Animation Info:

Animation: Description appears as the components are named by the Voiceover.

Navigation:

Sidebar

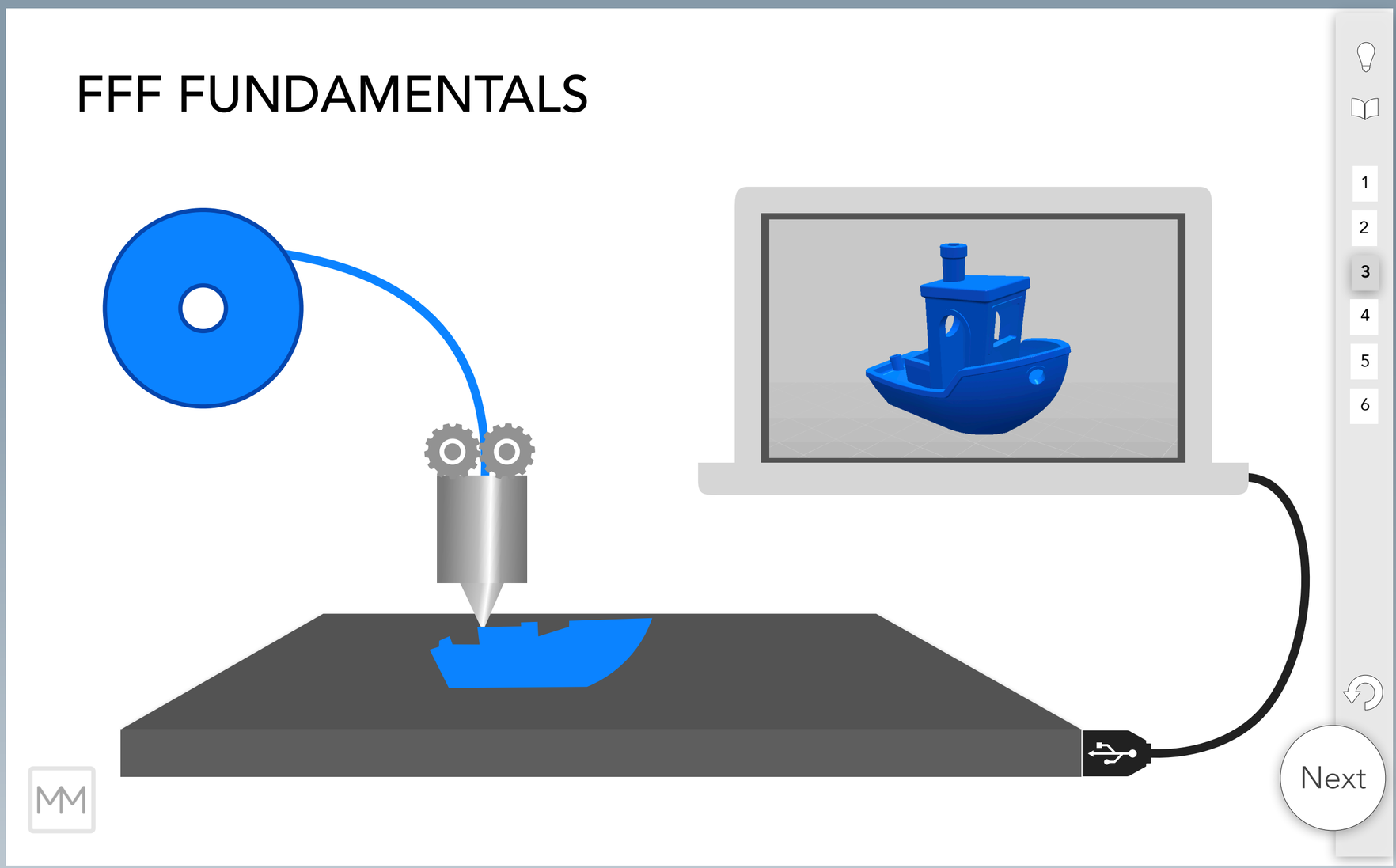
Review comments:

Content Description:

Learning Objective: Define the Volumetric Extrusion Rate (VER)
Bloom level: Remember
Concept: Review of fundamental FFF concepts: how fused filament fabricator work.

Voiceover Script:

Before diving into the details, let's review some fundamental notions about Fused Filament Fabrication.
This is a simplified representation of a 3D printer without the control and motion systems.
For the purpose of this course you will focus on the following components:
The filament which is stored in a spool.
The extruder is composed of multiple subcomponents including the gears that drive the filament and a nozzle.
The building platform.



Graphic / Animation Info:

Animation:
Cable connects computer.
Boat model is printed on the bed

Navigation:

Sidebar

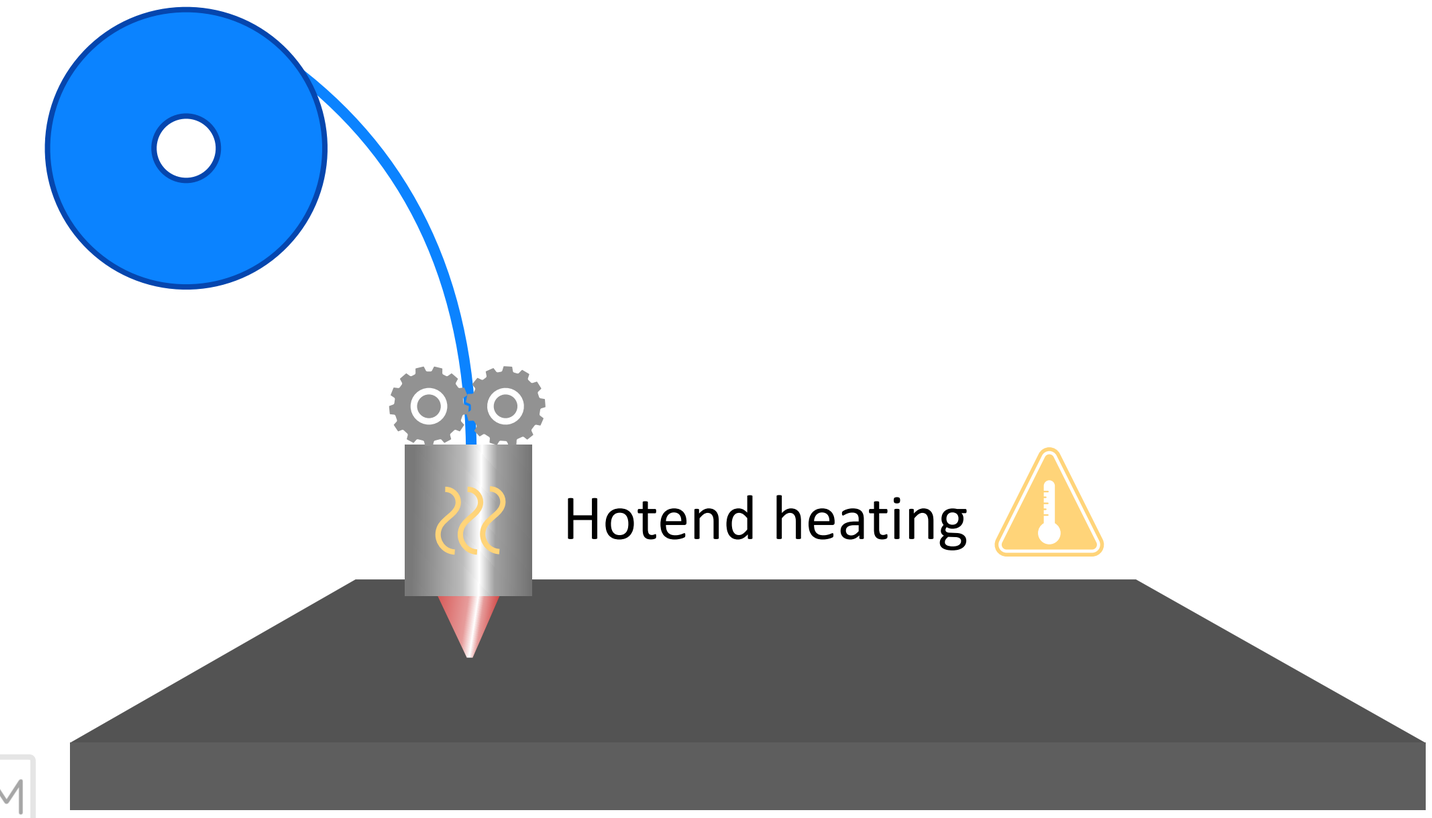
Review comments:

Content Description:

Learning Objective: Define the Volumetric Extrusion Rate (VER)
Bloom level: Remember
Concept: Review of fundamental FFF concepts: how fused filament fabricator work.

Voiceover Script:

A fused filament fabrication 3D printer performs the G-Code instructions sent by the slicer software.
The G-Code controls the different electro mechanical components of the 3D printer .
Click Next to continue.



1
2
3
4
5
6

Next

Graphic / Animation Info:

Animation:
Nozzle becomes reddish

Navigation:

Side bar

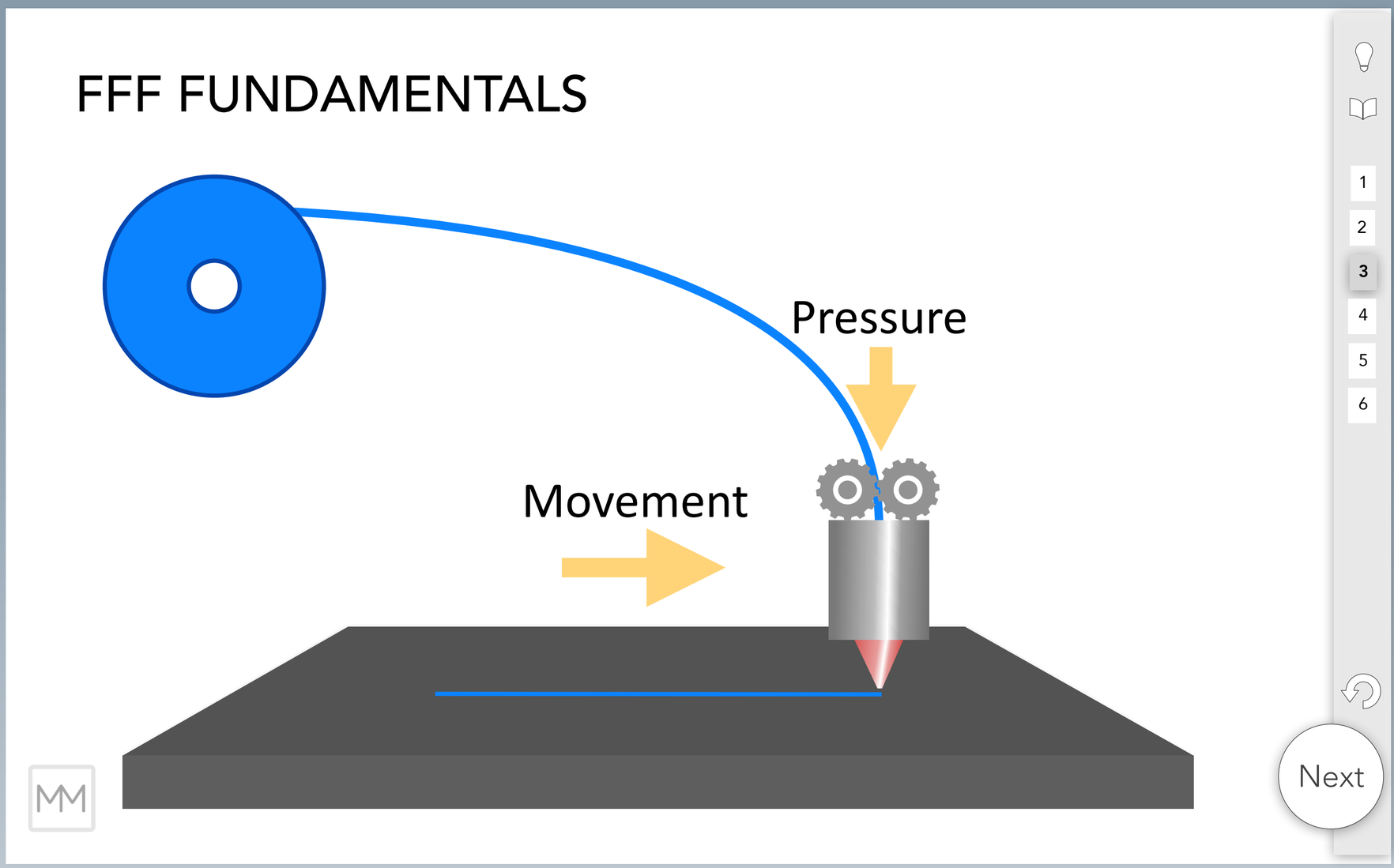
Review comments:

Content Description:

Learning Objective: Define the Volumetric Extrusion Rate (VER)
Bloom level: Remember
Concept: Review of fundamental FFF concepts: how fused filament fabricator work.

Voiceover Script:

As its name indicates, Fused Filament Fabrication requires to melt the solid filament into molten plastic so it can be extruded.
The hotend is component holding together a heating element and the nozzle. When starting a print, the M104 G-Code command is tells the printer to heat up the nozzle.
The hotted can reach temperatures above 200°C. Never touch the hotted when heating. Do not leave children unattended with a functioning 3D printer.
Click Next to continue.



Graphic / Animation Info:

Animation:
Extruder moves to the right, drawing an extrusion path on the platform.
Arrows appear blinking

Navigation:

Side bar

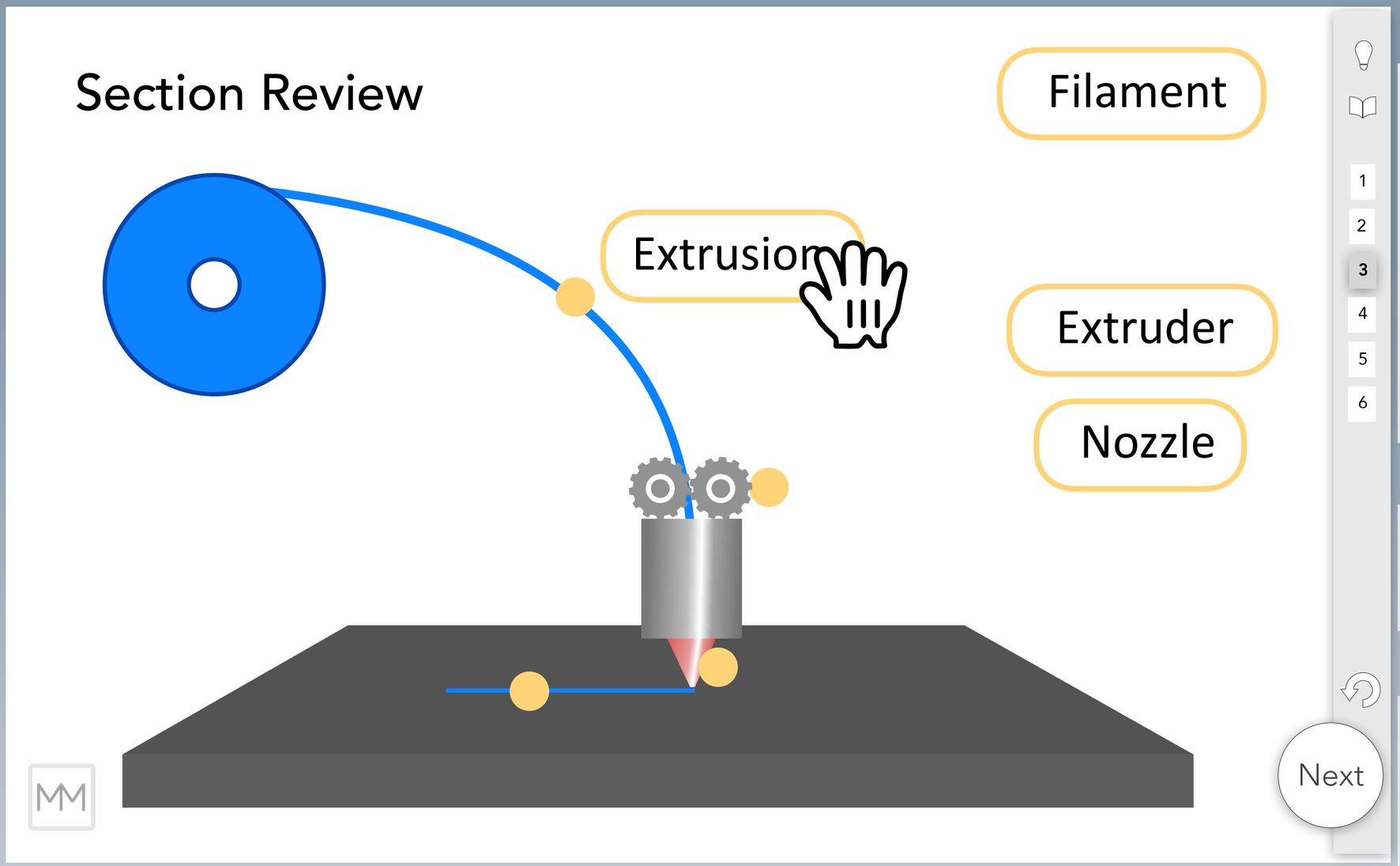
Review comments:

Content Description:

Learning Objective: Define the Volumetric Extrusion Rate (VER)
Bloom level: Remember
Concept: Review of fundamental FFF concepts: how fused filament fabricator work.

Voiceover Script:

The most common move performed by the 3D printer is the extrusion move, or G1 in G-Code. The following actions are performed at the same time:
The extruder's gears push the plastic filament through the nozzle.
The motion system moves the nozzle over the building platform usually called "bed".
This is a very simplified summary of how a FFF 3D printer works. Here we drew a single line. 3D models are composed of thousands of small lines.
Click next to continue.



Graphic / Animation Info:

Drag and drop the labels to the yellow spots.
(hand is part of the storyboard UI)

Navigation:

Side bar
(cursor is part of the storyboard UI)

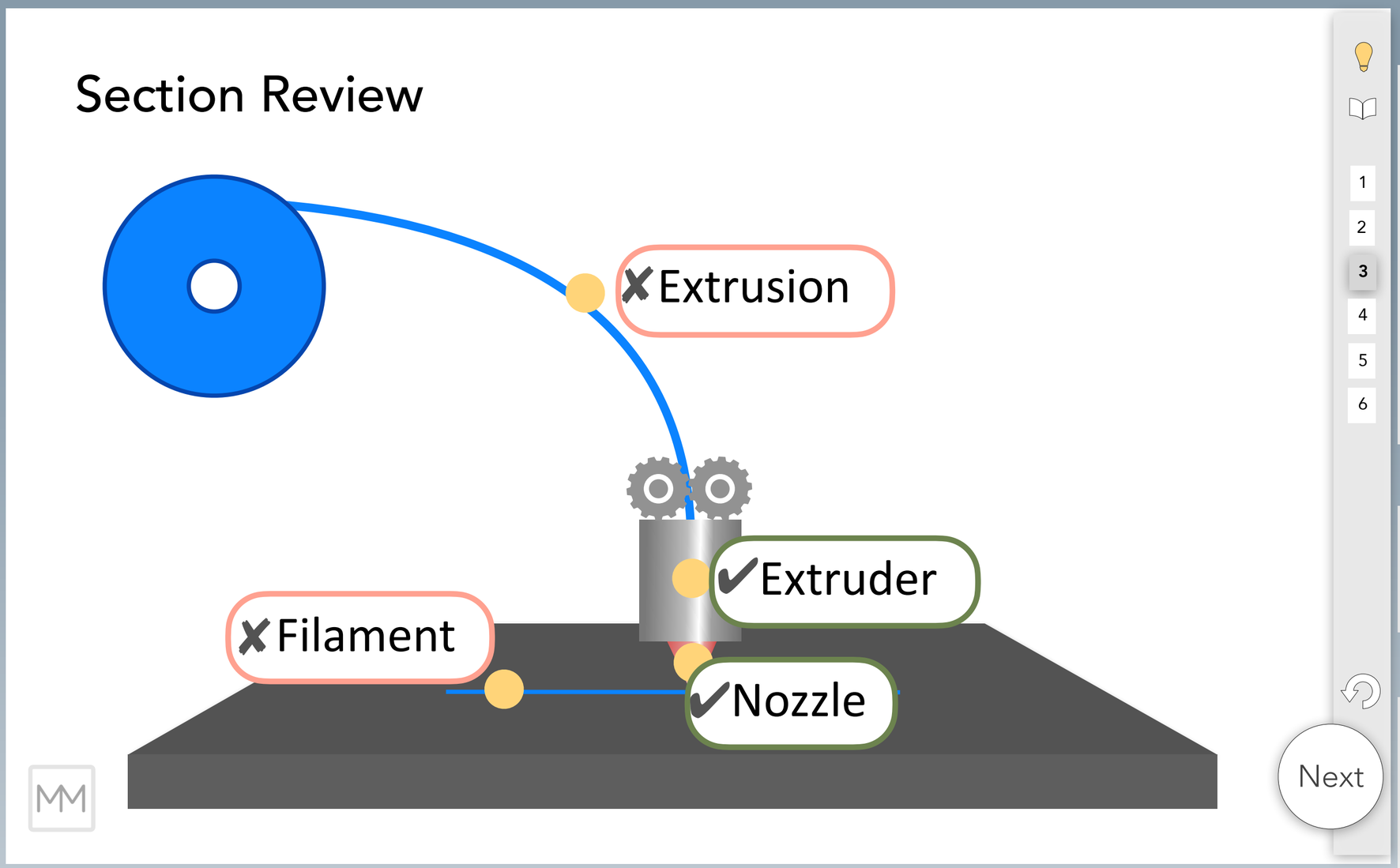
Review comments:

Content Description:

Quiz slide

Voiceover Script:

Let's see if you were following.
Place each label on the matching printer component.
Click Submit to verify your answers.



Graphic / Animation Info:

After clicking on submit, the bubble outline turns green with a check mark if answer is correct.
The bubble outline turns red with a cross if the answer is incorrect.
The correct answer is displayed next to the bubble

Navigation:

Side bar

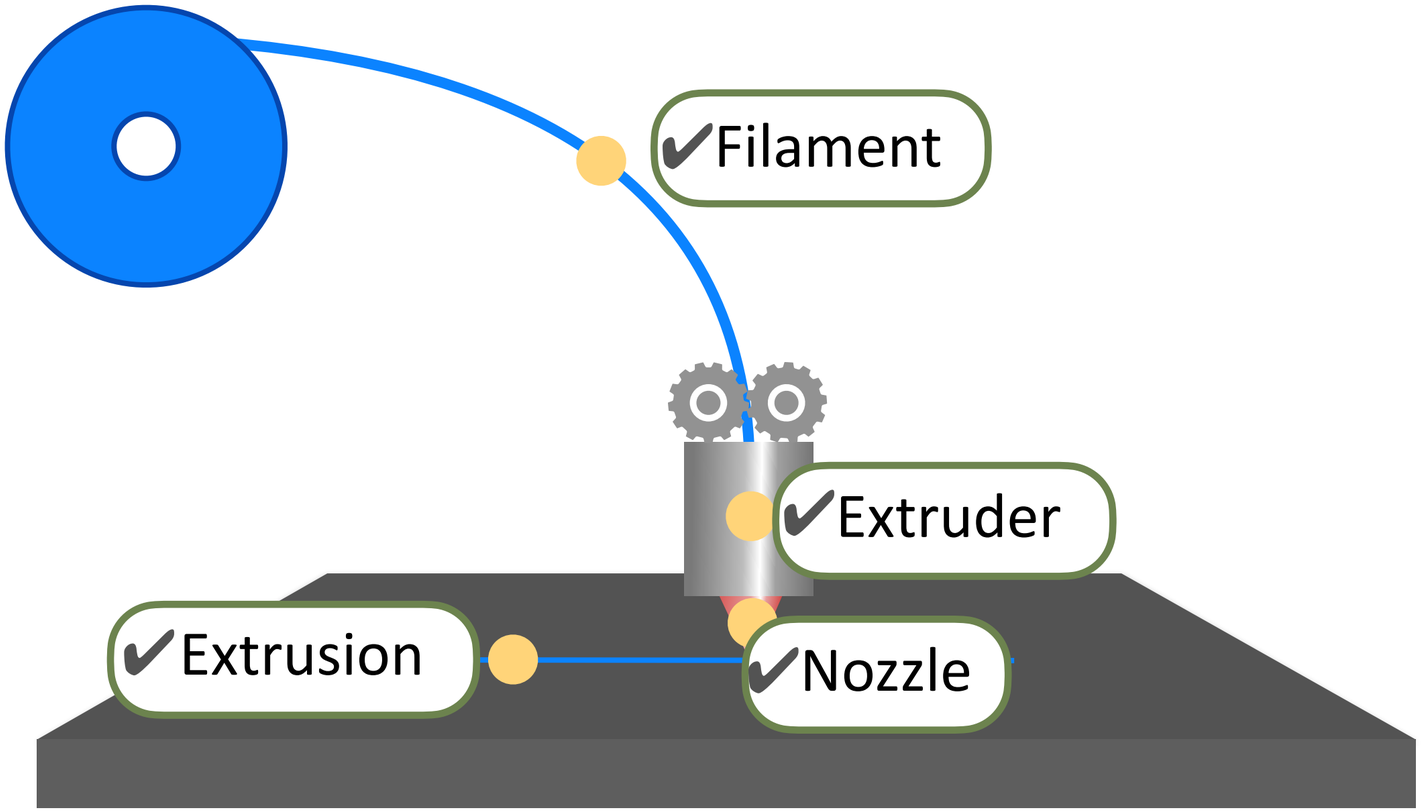
Review comments:

Content Description:

Quiz slide

Voiceover Script:

It seems you did not got all right.
Look at the definitions in the glossary and retry.



Graphic / Animation Info:

Drag and drop the labels to the yellow spots.
The bubble outline turns green with a check mark if answer is correct.
The bubble outline turns red with a cross if the answer is incorrect.
The correct answer is displayed next to the bubble

Navigation:

Side bar

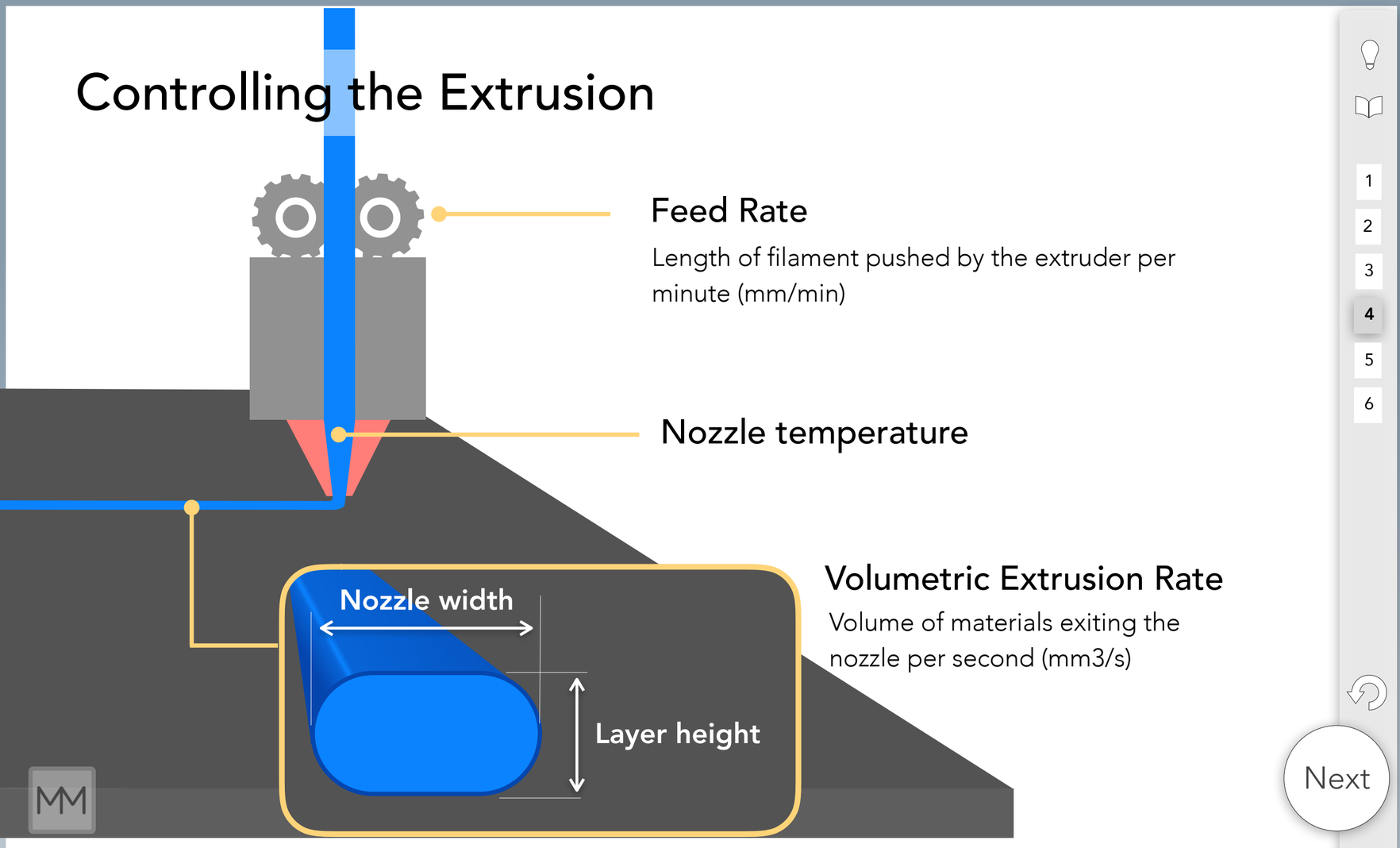
Review comments:

Content Description:

Quiz slide

Voiceover Script:

Well done! Now that you have the fundamental components right, let's look at the biggest challenge of printing with plastic.
Click Next when you are ready.



1
2
3
4
5
6

Next

Graphic / Animation Info:

Transition: Zoom in the extruder nozzle
Animation: The gears spin, the filament fills the nozzle, the nozzle heats up, the filament is extruded.
Each description appears with the voiceover comments.

Navigation:

Side bar

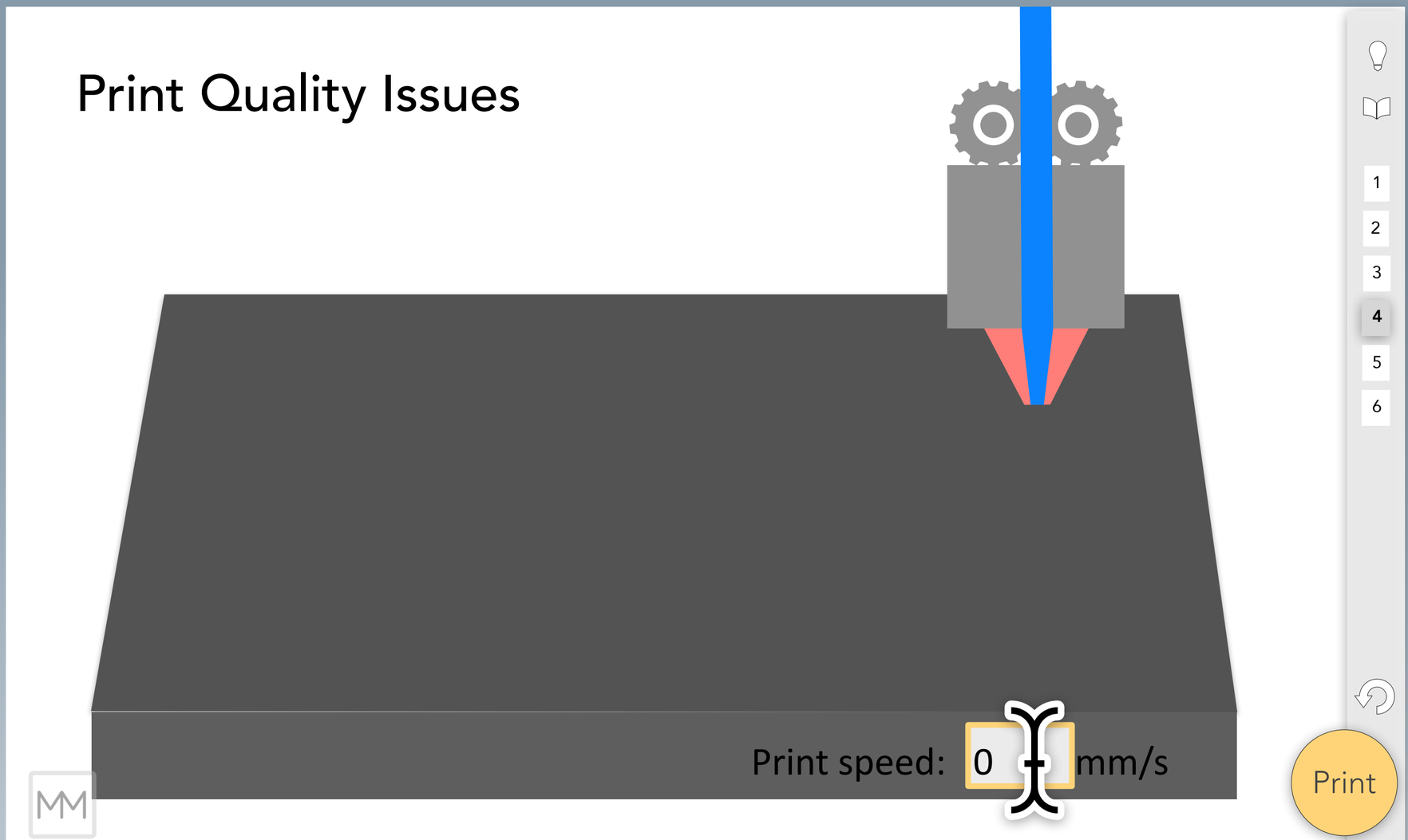
Review comments:

Content Description:

Learning Objective: Define the Volumetric Extrusion Rate (VER)
Bloom level: Understand
Concept: The performance of the printer is limited by different components. Knowing this limit is the key to avoid print issues.

Voiceover Script:

To ensure that the object is printed correctly, the slicer must tell the printer to extrude the right amount of plastic at any give time and with great precision.
First the slicer controls the speed at which the filament is pushed into the nozzle or feed rate.
Provided with the feed rate and filament diameter, the Slicer can determine the exact volume of filament that goes into the nozzle: the Volumetric Extrusion Rate.
The nozzle temperature determines the viscosity of the plastic extrusion and depends on the plastic properties. Each spool comes with a recommended set temperature. The temperature should remain constant through the printing process.
With a constant heat, nozzle diameter and layer height, the remaining variable to control the extrusion is the Feed Rate.



Graphic / Animation Info:

Animation: Learner types 40 in the text box
Click print of press return
extruder moves to the left drawing a straight line.

Navigation:

Side bar
(cursor is part of the storyboard UI)

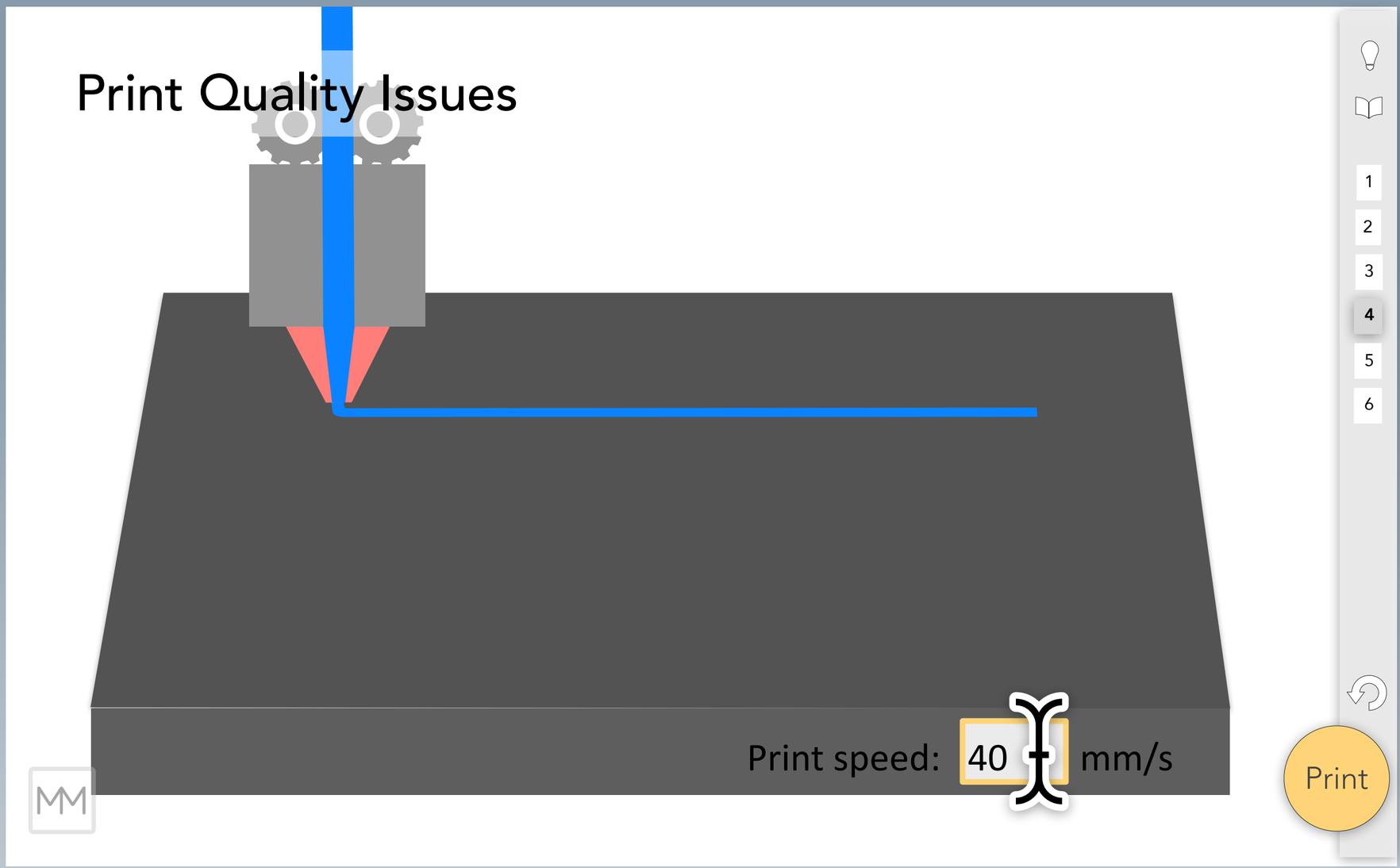
Review comments:

Content Description:

Learning Objective: Explain how the printing speed and the Volumetric Extrusion Rate affect the print quality.
Bloom level: Understand
Concept: Relate VER to printing quality issues.

Voiceover Script:

Printing an object with a FFF printer is a long process. To reduce the print time, the first thing one will do is to increase the print speed parameter in the slicer.
If you are in my course you probably experienced inconsistent print results after the print speed.
In this activity, we will look at how the feed rate can affect the print quality.
Enter 40 as a print speed value into the printer and press print.



1
2
3
4
5
6

Print

Graphic / Animation Info:

Animation: Learner types 80, extruder moves down then to the right and draws an irregular line.

Navigation:

Side bar
(cursor is part of the storyboard UI)

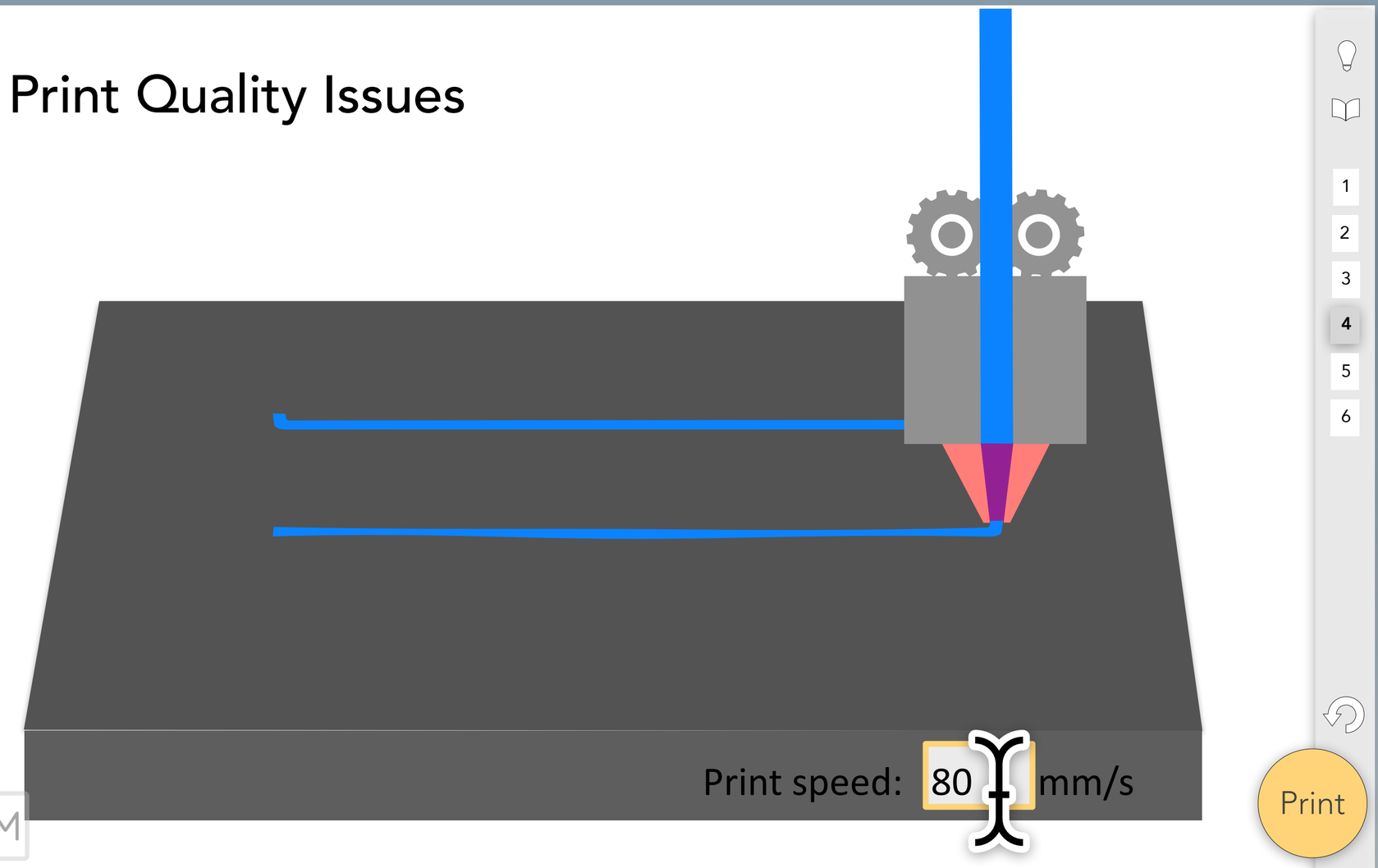
Review comments:

Content Description:

Learning Objective: Explain how the printing speed and the Volumetric Extrusion Rate affect the print quality.
Bloom level: Understand
Concept: Relate VER to printing quality issues.

Voiceover Script:

What happened? The hotend was able to provide enough energy to melt the filament constantly.
As a result, the viscosity was constant and the pressure in the nozzle constant.
A constant pressure results in a regular and smooth extrusion.
Let’s increase the print speed to 80 and print.



Graphic / Animation Info:

Animation: Learner types 80, extruder moves down then to the right and draws an irregular line.
The The colour of the nozzle chamber alternates blue/ purple.

Navigation:

Side bar
(cursor is part of the storyboard UI)

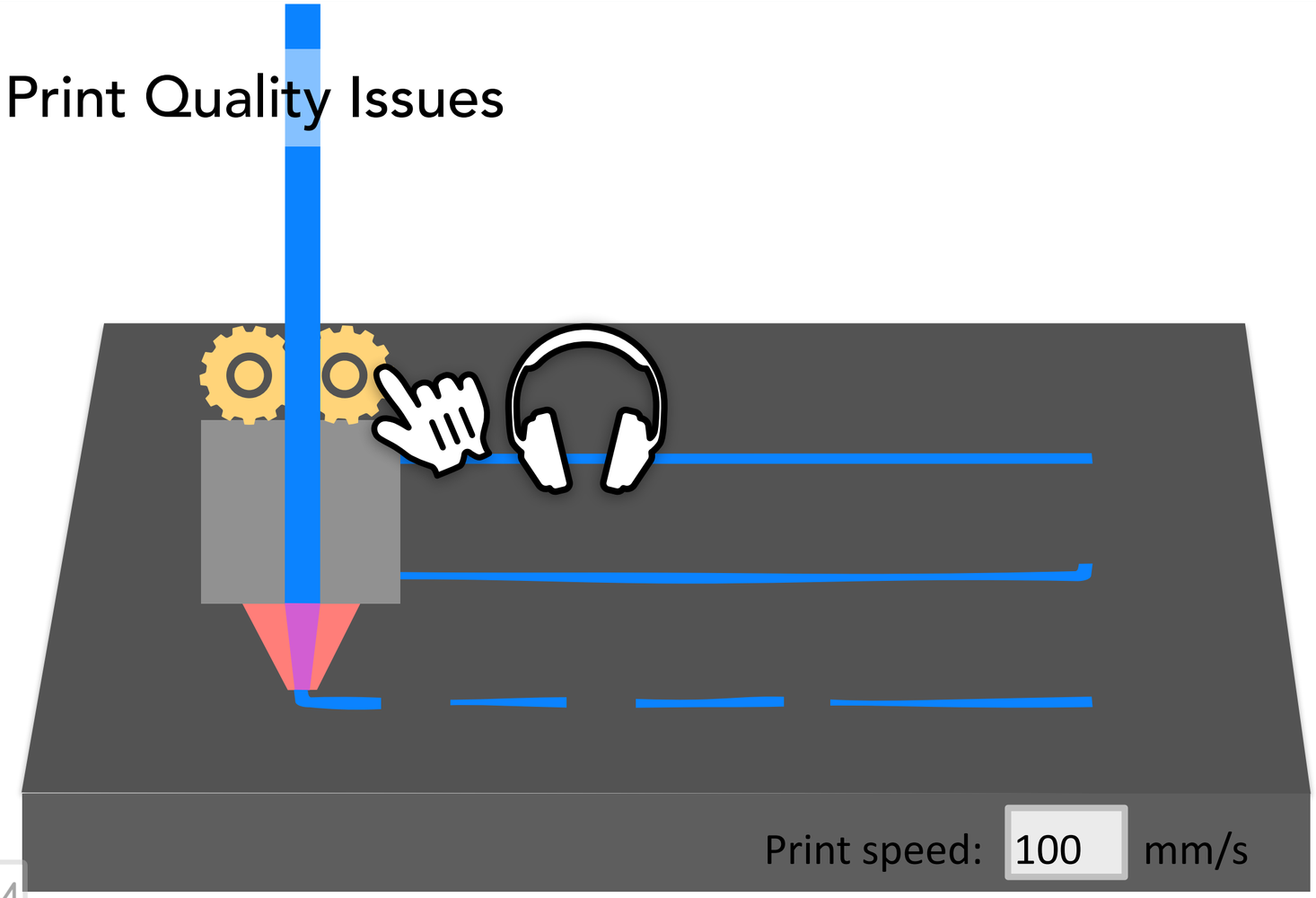
Review comments:

Content Description:

Learning Objective: Explain how the printing speed and the Volumetric Extrusion Rate affect the print quality.
Bloom level: Understand
Concept: Relate VER to printing quality issues.

Voiceover Script:

The extrusion is irregular. What happened? As the movement speed increased, the slicer increased the feed rate proportionally.
However the hotend components could not maintain a constant temperature in the nozzle. The viscosity fluctuates and with it the pressure drops, resulting in the variation of the extrusion width. This issue might not be noticeable on small moves or on complex objects where the extruder cannot reach the maximum speed.
Let's see what happens if you push the printer to 100 mm/s. Before pressing Print, make sure to increase the audio volume of your device.



1
2
3
4
5
6

Next

Graphic / Animation Info:

Animation: Learner types 100, extruder moves down then to the left and draws an irregular line with gaps. The colour of the nozzle chamber alternates purple/ pink

Navigation:

Side bar
(cursor is part of the storyboard UI)
Click on the gear to replay the sound.

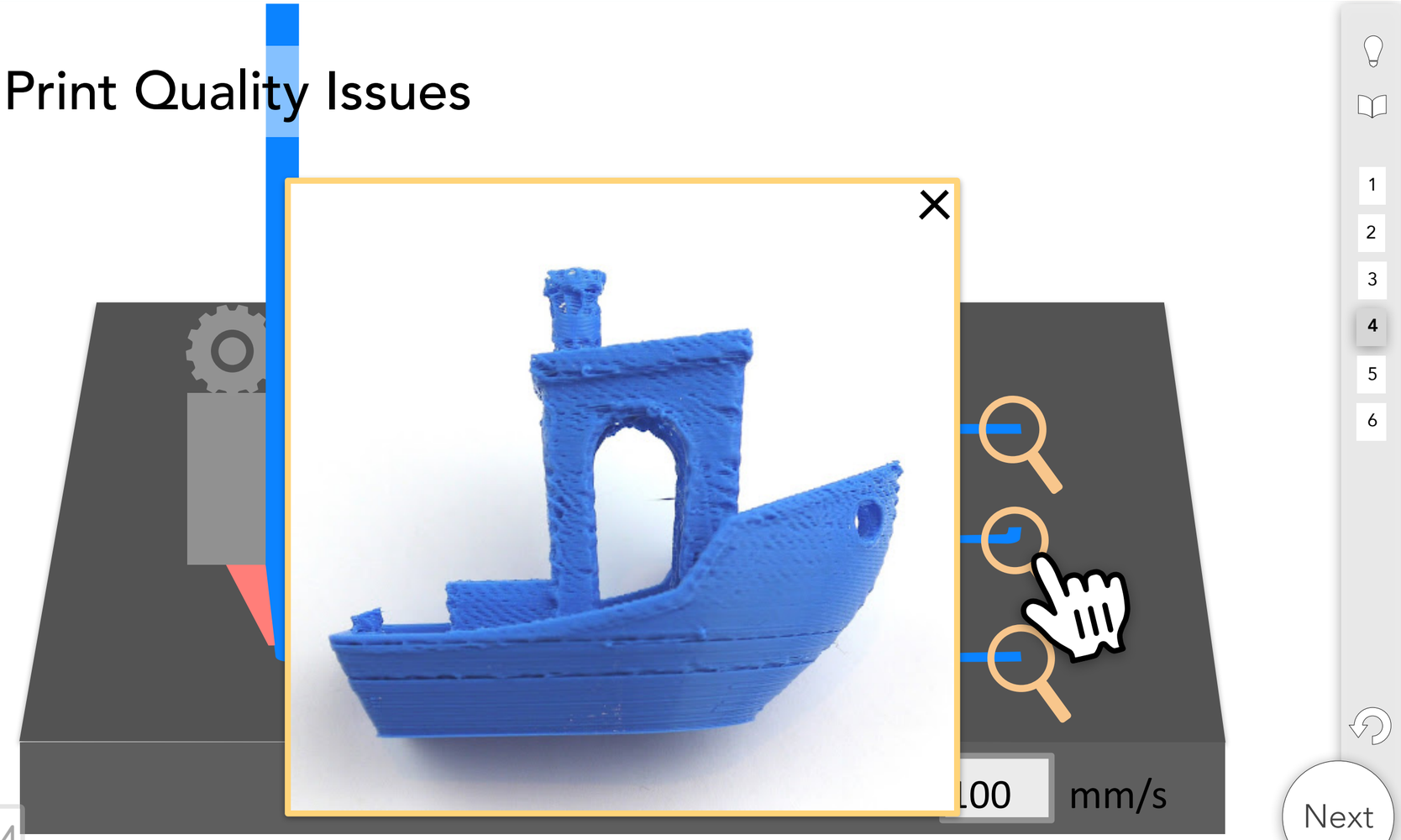
Review comments:

Content Description:

Learning Objective: Explain how the printing speed and the Volumetric Extrusion Rate affect the print quality.
Bloom level: Understand
Concept: Relate VER to printing quality issues.

Voiceover Script:

This time the extrusion shows gaps. With too much filament being pushed fed, the temperature in the nozzle drops bellow the filament's melting point. The extrusion stops. Did you notice the noise? When the filament is not moving, the extruder gears skip, making grinding or clicking sounds.
Click on the extruder gears to play the sound again.



Graphic / Animation Info:

Animation: A picture viewer opens for each magnifying glass button.

Navigation:

Side bar
(cursor is part of the storyboard UI)

Review comments:

Content Description:

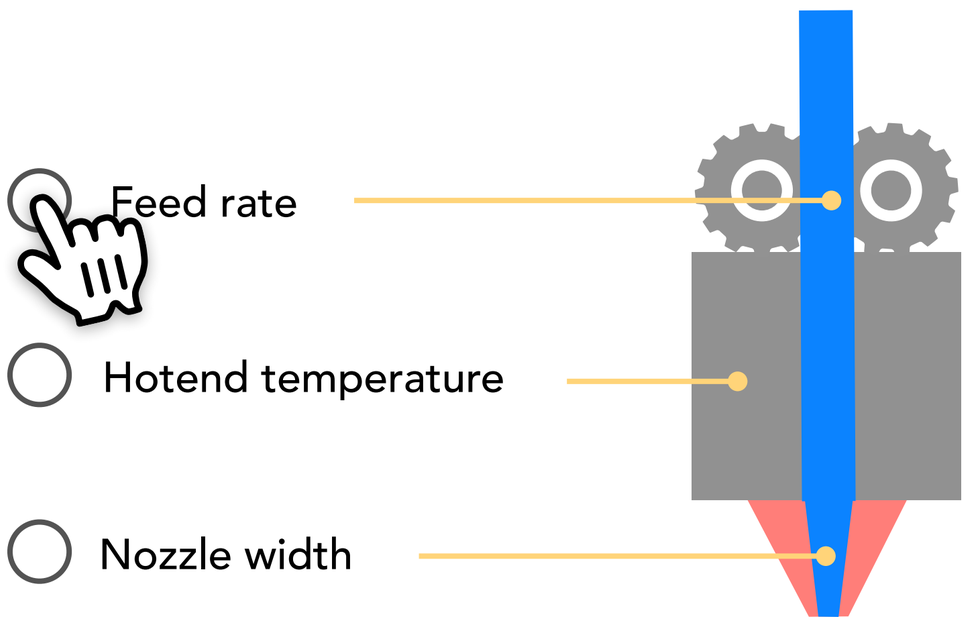
Learning Objective: Explain how the printing speed and the Volumetric Extrusion Rate affect the print quality.
Bloom level: Understand
Concept: Relate VER to printing quality issues.

Voiceover Script:

Take a moment to look at some examples.
Click on the magnifying lenses to reveal pictures of benchies for each scenario.
These printing quality issues are caused by unexpected pressure variations in the nozzle. The pressure variations usually indicate that a component of the extruder has reached its physical limits or the printer is not properly calibrated.

Section review

Which parameter proportional to the printing speed can cause irregular extrusions?



Submit

1
2
3
4
5
6

Graphic / Animation Info:

Graphic / Animation Info:
Radio buttons

Navigation:

(Arrow is part of the storyboard UI)
Sidebar

Review comments:

Content Description:

Quiz slide

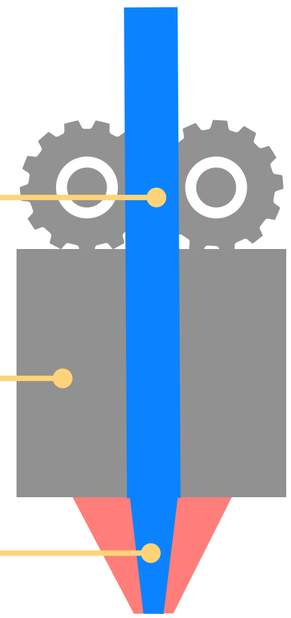
Voiceover Script:

Time for a quiz

Section review

Which parameter proportional to the printing speed can cause irregular extrusions?

- ✔ Feed rate
- Hotend temperature
- Nozzle width



1
2
3
4
5
6

Next

Graphic / Animation Info:

Graphic / Animation Info:
Check mark appears next to the correct answer.

Navigation:

Sidebar

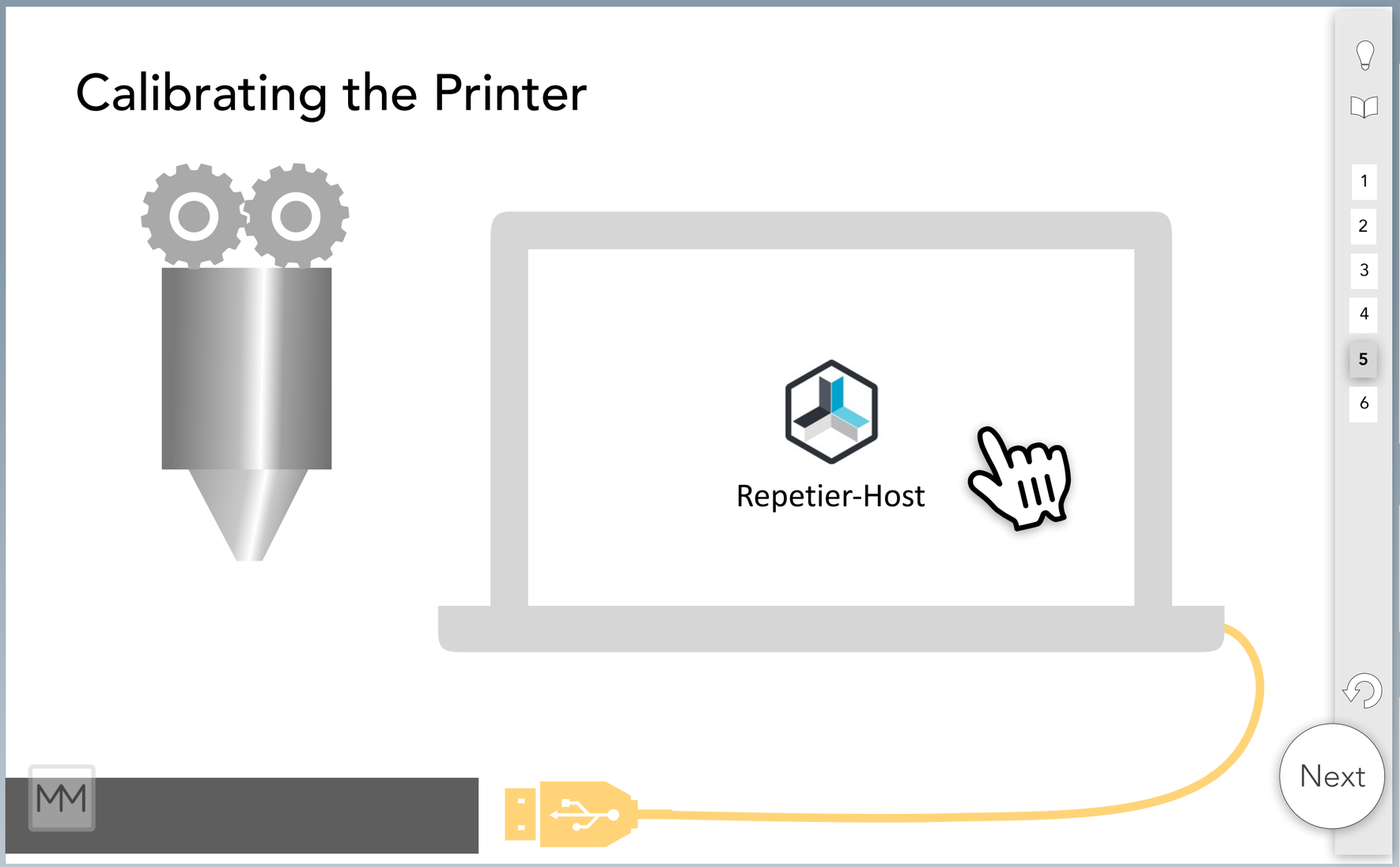
Review comments:

Content Description:

Quiz slide

Voiceover Script:

Script



Graphic / Animation Info:

Animation: Click the yellow USB connector to connect the cable to the print
Yellow arrow movesClick the Repetier-Host app icon
Filament loading in extruder, nozzle becomes red to indicated it is heated.

Navigation:

(Arrow is part of the storyboard UI)
Sidebar

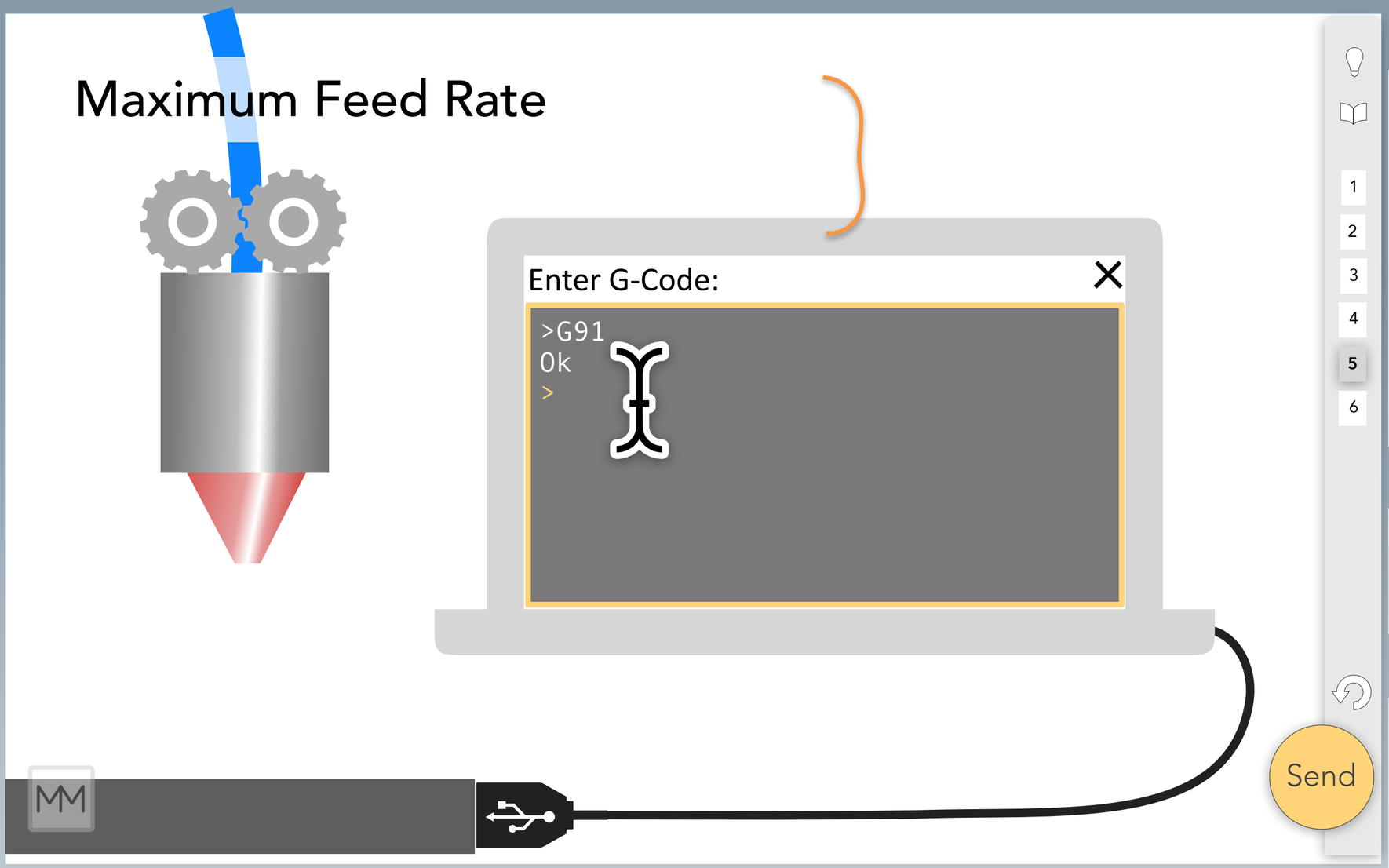
Review comments:

Content Description:

Learning Objective: Practice calibrating the maximum feed rate in the simulator.
Bloom level: Remember
Concept: Use G-Code to control extrusion manually.

Voiceover Script:

To determine the Maximum Feed Rate, you will extrude a bit of filament and verify if its thickness is constant.
You will then increase the feed rate and repeat until the filament aspect becomes uneven, curls or the extruder skips.
To do this, you will use a computer to send G-Code commands to the printer over a USB cable.
First, connect the printer. Click on the cable.
Second, open the Slicer software that includes a terminal entry. Click on the Repetier-Host icon.
For this example I used Repetier-Host. You can also use Prompterface or Octoprint. Follow the documentation provided with your printer to setup the connection.
Third, load the filament and pre-heat the printer according the the manufacturer recommendations. Click on the extruder.



Graphic / Animation Info:

Animation: Blinking cursor on computer screen.
After first command, returns ok

Navigation:

Side bar
(cursor is part of the storyboard UI)

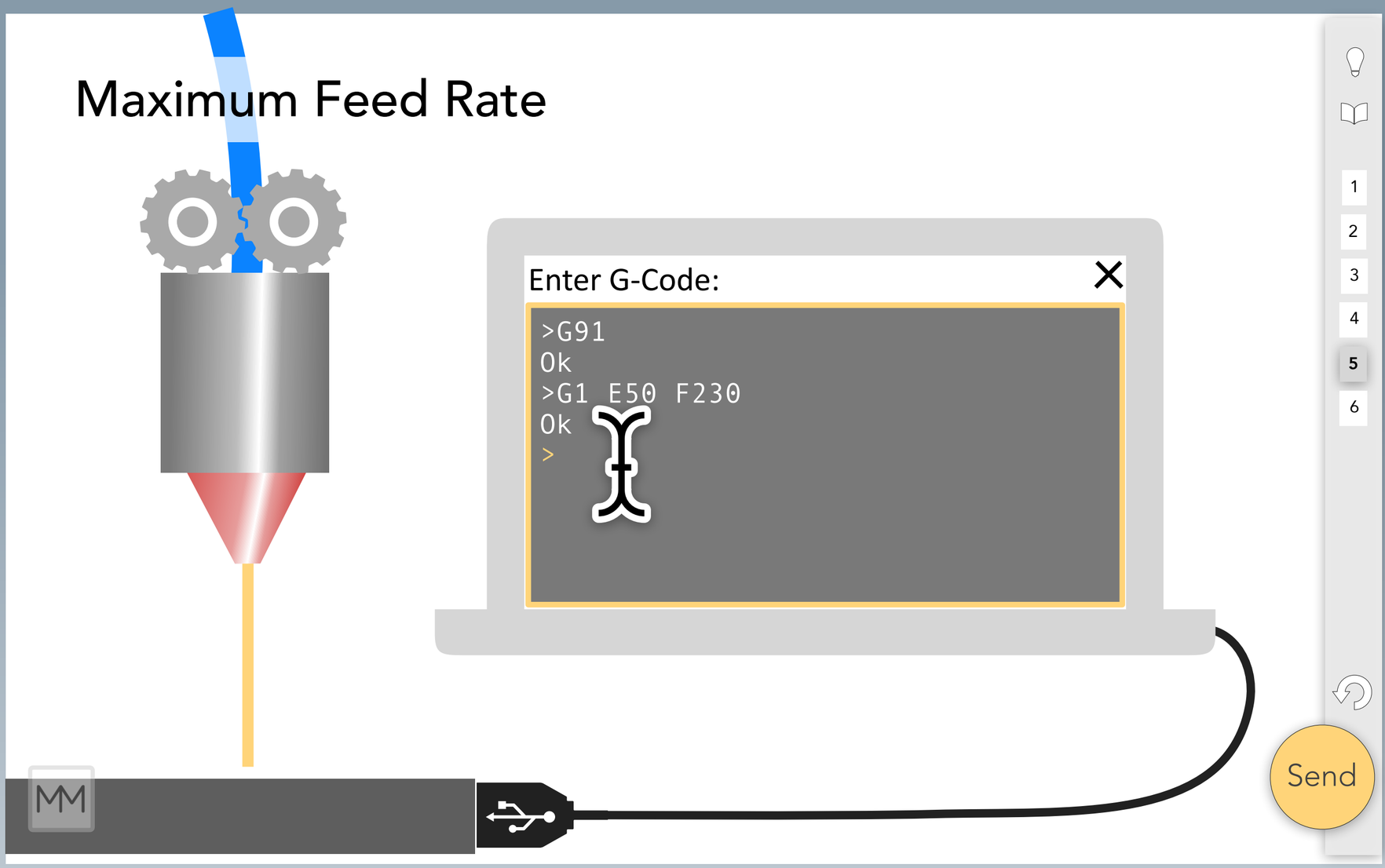
Review comments:

Content Description:

Learning Objective: Practice calibrating the maximum feed rate in the simulator.
Bloom level: Apply
Concept: Recognise signs of excessive feed rate.

Voiceover Script:

Now you are ready to send G-Code commands directly to the printer.
G-Code is the language that tells the firmware of a 3D printer to perform actions.
For Instance: move 60mm to the right while extruding 50mm of filament at 120 mm per minute would be G1 X60 E50 F120.
G-Code commands are case sensitive. Make sure to enter commands in uppercase. You will find the Code reference linked in the sidebar.
First tell the printer to enable relative positioning. Type G91 in the computer screen and click send. The printer should reply “Ok”.



Graphic / Animation Info:

Animation: Blinking cursor on computer screen.
Entry box where learner enters the commands.
Command is entered correctly: the gears on the extruder spin and a straight filament line appears.
The extrusion turn yellow. Disappears on click

Navigation:

Side bar
(cursor is part of the storyboard UI)

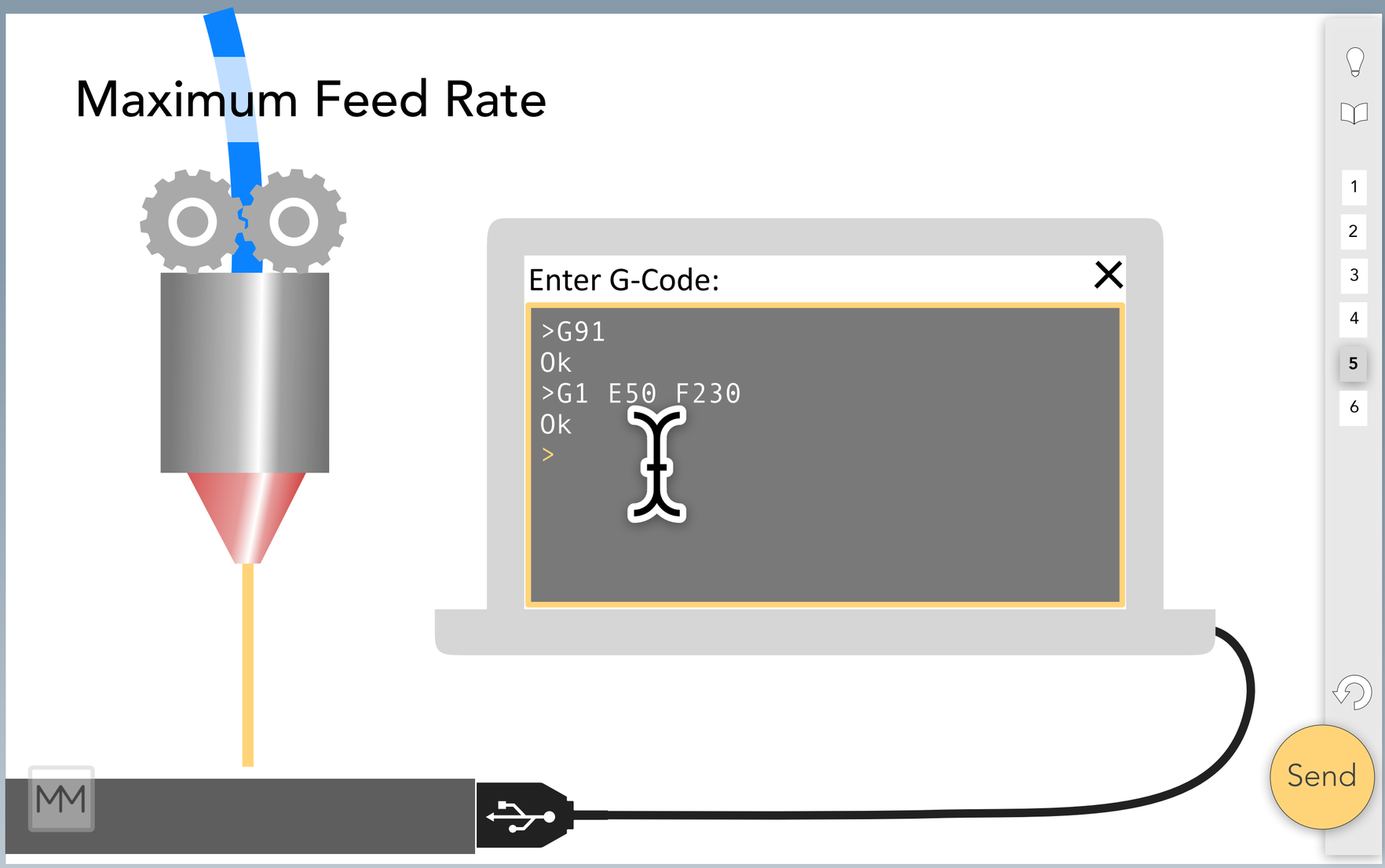
Review comments:

Content Description:

Learning Objective: Practice calibrating the maximum feed rate in the simulator.
Bloom level: Apply
Concept: Recognise signs of excessive feed rate.

Voiceover Script:

Next, tell the printer to extrude 50mm of filament at 230mm/min. Type G1 E50 F230 after the prompt and click send.
Look at the filament. Is it straight and even? Click on the filament to clear the nozzle and Next to continue.



Graphic / Animation Info:

Animation: Blinking cursor on computer screen.
Entry box where learner enters the commands.
2nd move command is entered correctly: the gears on the extruder spin and a straight filament line appears faster.
The extrusion turn yellow. Disappears on click

Navigation:

Side bar
(cursor is part of the storyboard UI)

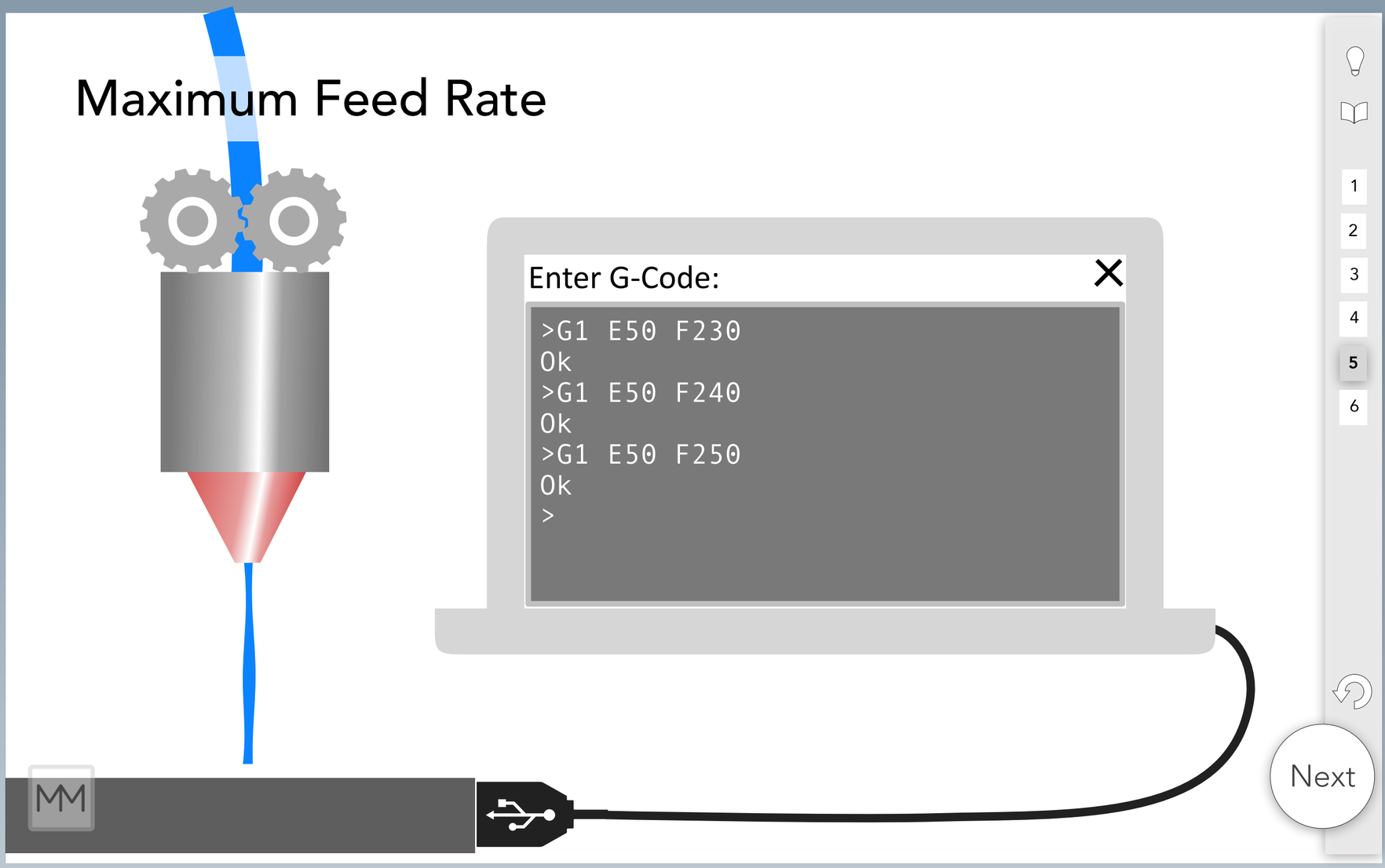
Review comments:

Content Description:

Learning Objective: Practice calibrating the maximum feed rate in the simulator.
Bloom level: Apply
Concept: Recognise signs of excessive feed rate.

Voiceover Script:

Now increase the feed rare to 240mm/min. Type G1 E50 F240 and click send.
Is the filament still straight and smooth? So far so good. Click the filament to remove it and print Next to continue.



Graphic / Animation Info:

Animation: Blinking cursor on computer screen.
Entry box where learner enters the commands.
3rd command is entered correctly: the gears skip, grinding noise, the green line thickness is uneven.

Navigation:

Side bar

Review comments:

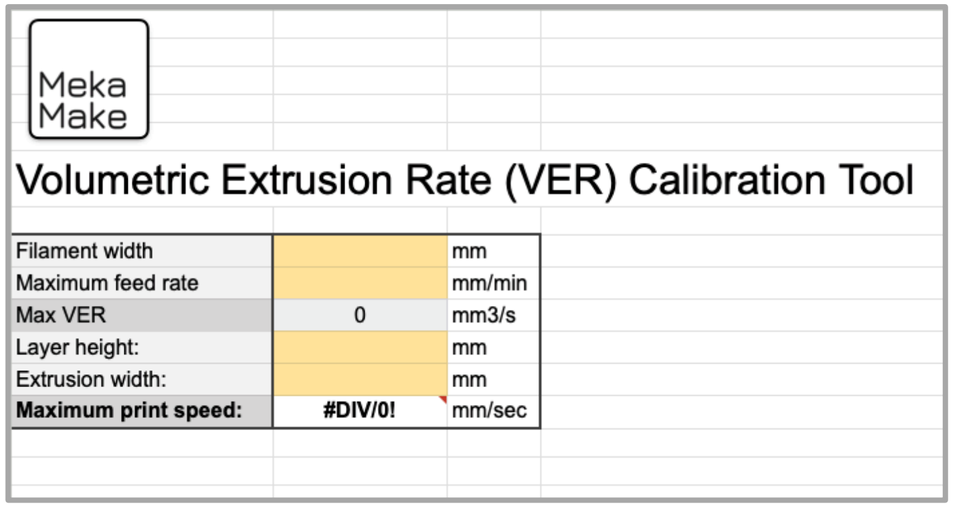
Content Description:

Learning Objective: Practice calibrating the maximum feed rate in the simulator.
Bloom level: Apply
Concept: Use a systematic approach to calibrate feed rate.

Voiceover Script:

Increase the feed rate to 250mm/min. Type G1 E50 F250 and press return.
The extrusion is uneven. Did you notice the grinding noise? This means the nozzle could not melt the filament fast enough.
Now you know the maximum feed rate the printer can reliably achieve is between 240 and 250mm/s
The next step would be to reduce the feed rate value by a small increments and extrude 10 times to ensure the results are consistent.
You have determined the Maximum Feed Rate of the printer. Click next to continue.

VER Calibration Tool



https://tinyurl.com/VERTool

Next

Content Description:

Overview of the Calibration Spreadsheet tool

Voiceover Script:

This is the feed rate calibration done, now let's do the math to determine the maximum print speed.
This spreadsheet will calculate the optimal print speed for you. All you need is to fill the cells with he appropriate values.
You have determined the maximum feed rate your printer can achieve. The rest of the required information like the layer height, the filament diameter and the nozzle diameter is in your slicer or printer manual.
Access the calibration tool from another window of the web browser and return to this page.
Ready? Click next to continue.

Graphic / Animation Info:

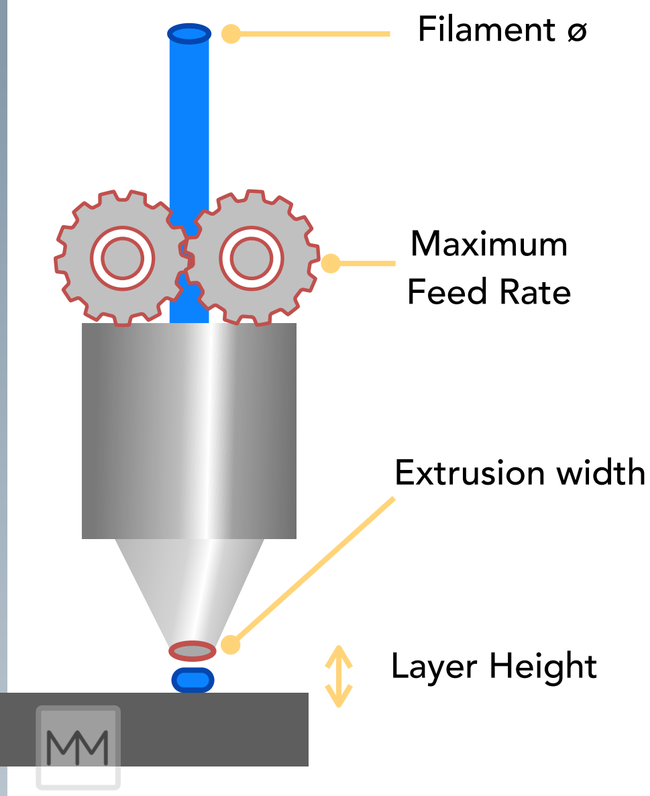
Graphic / Animation Info:

Navigation:

Side bar
(cursor is part of the storyboard UI)

Review comments:

Calculate The Maximum Print Speed



$$\text{Max VER}_{mm3/s} = \frac{\text{Filament area} \times \text{Max Feed Rate}}{\text{Time}}$$

$$\text{Max Print Speed}_{mm/s} = \frac{\text{Max VER}}{\text{Nozzle width} \times \text{Layer Height}}$$

1
2
3
4
5
6

Next

Graphic / Animation Info:

Animation: reveal the values as they are introduced by the narrator.
Learner enters the value to verify correct value.

Navigation:

Side bar

Review comments:

Content Description:

Learning Objectives: Use the VER calculator to define the maximum reliable speed of your 3D printer.
Bloom level: remember
Concept: Calculate the maximum print speed to configure the Slicer software.

Voiceover Script:

Here is are the maths behind the magic. Let's relate the printers components characteristics to the formula.
The maximum print speed is the max VER divided by the area of the extrusion.
The area of the extrusion is estimated by multiplying the nozzle width with the desired layer hight set in the slicer.

Calculate The Maximum Print Speed

Filament ø
1.75mm

Maximum Feed Rate
240mm/min

Extrusion width
0.4mm

Layer Height
0.2mm

Use the VER calibration tool to calculate the Max Print Speed for these slicer settings.

Max Print Speed = ?? *mm/s*

1
2
3
4
5
6

Submit

Graphic / Animation Info:

Animation: reveal the values as they are introduced by the narrator.
Learner enters the value to verify correct value.

Navigation:

Side bar
(cursor is part of the storyboard UI)

Review comments:

Content Description:

Learning Objectives: Use the VER calculator to define the maximum reliable speed of your 3D printer.
Bloom level: Apply
Concept: Calculate the maximum print speed to configure the Slicer software.
Correct answer is 120mm/s

Voiceover Script:

Here is an activity for you: practice using the spreadsheet.
On the left are the slicer settings values you need.
To check if you used the sheet correctly, enter the obtained max print speed value into the this page and click submit.

Update the Slicer Profile

Filament ø
1.75mm

Extrusion width
0.4mm

Layer Height
0.2mm

Print Speed
120 mm/s

1
2
3
4
5
6
Next

Graphic / Animation Info:

Animation: reveal the values as they are introduced by the narrator.
Learner enters the value to verify correct value.

Navigation:

Side bar

Review comments:

Content Description:

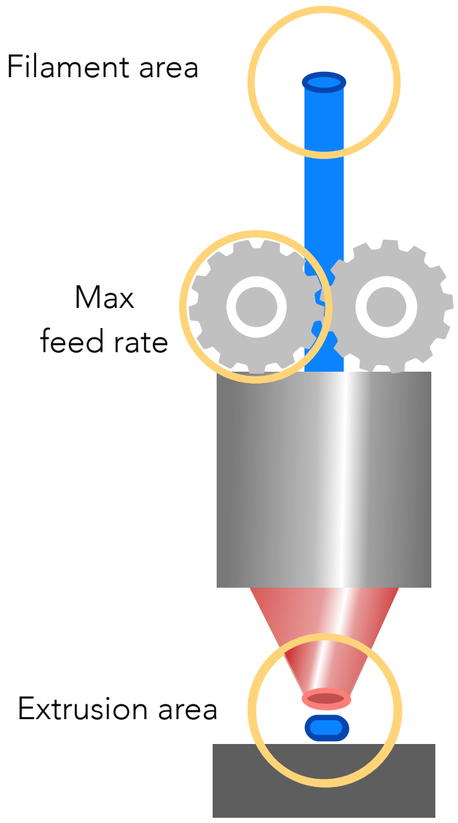
Learning Objectives: Use the VER calculator to define the maximum reliable speed of your 3D printer.
Bloom level: remember
Concept: Calculate the maximum print speed to configure the Slicer software.

Voiceover Script:

Well done!
You are now ready to calibrate the maximum feed rate of your printer and calculate your maximum print speed.
Check your slicer's documentation to locate the profiles and printer configuration details.
The resources page contains links to documentation pages of these well know slicers.

Section Review

Maximum Print Speed =



Submit

Graphic / Animation Info:

Drag and drop the labels to the yellow spots.
The bubble outline turns green with a check mark if answer is correct.
The bubble outline turns red with a cross if the answer is incorrect.
The correct answer is displayed next to the bubble

Navigation:

Side bar
(cursor is part of the storyboard UI)

Review comments:

Content Description:

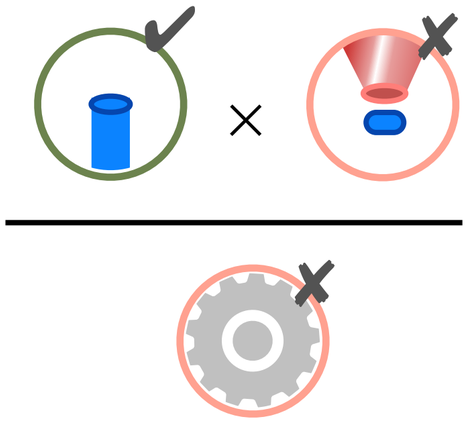
Quiz slide

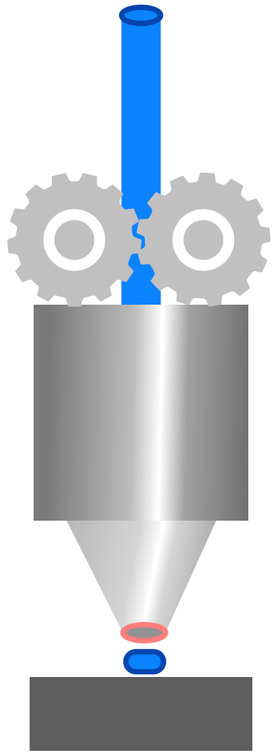
Voiceover Script:

Let's review what you have learned about the Volumetric Extrusion Rate and its hardware components.
Drag the relevant printer components on the appropriate location to complete the maximum print speed equation.
Click Submit to verify your answers.
To summarise, the Maximum Print Speed is the Maximum Volumetric Extrusion Rate adjusted by the desired extrusion area.

Section Review

Maximum Print Speed =





1
2
3
4
5
6

Retry

Graphic / Animation Info:

Drag and drop the labels to the yellow spots.
The bubble outline turns green with a check mark if answer is correct.
The bubble outline turns red with a cross if the answer is incorrect.
The correct answer is displayed next to the bubble

Navigation:

Side bar

Review comments:

Content Description:

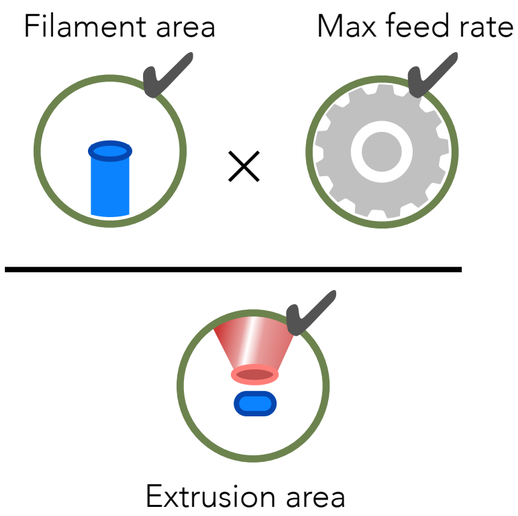
Quiz slide

Voiceover Script:

The answer is not quite right.
Take a moment to review the previous slide or look the definitions in the glossary.

Section Review

Maximum Print Speed = (Filament area × Max feed rate) / Extrusion area



Next

Graphic / Animation Info:

Drag and drop the labels to the yellow spots.
The bubble outline turns green with a check mark if answer is correct.
The bubble outline turns red with a cross if the answer is incorrect.
The correct answer is displayed next to the bubble

Navigation:

Path

Review comments:

Content Description:

Quiz slide

Voiceover Script:

Correct!
To summarise, the Maximum Print Speed is the Maximum Volumetric Extrusion Rate adjusted by the desired extrusion area.

Meka Make

Today you learned to do the following:

- Define a FFF 3D printer's Volumetric Extrusion Rate (VER).
- Explain how the feed rate and the VER affect the quality of printed parts.
- Calibrate the maximum feed rate using G-Code commands.
- Use the calibration spreadsheet to define the maximum reliable speed of your 3D printer.

1 2 3 4 5 6

Survey

Content Description:

Presentation of the learning outcomes.

Voiceover Script:

Congratulations!
After entering this value in the slicer, your printer cannot cross the red line.
Defining your maximum print speed should allow you to get repeatable print quality.
VER is not the the only parameter but you should now be able to calibrate other settings more effectively.
Check the other courses in the 3D Printer calibration series.
If you have enjoyed this course or would like to send feedback, please take the 1 minute survey.
Thanks for taking a MekaMake 3D print course.

Graphic / Animation Info:

Navigation:

Review comments: