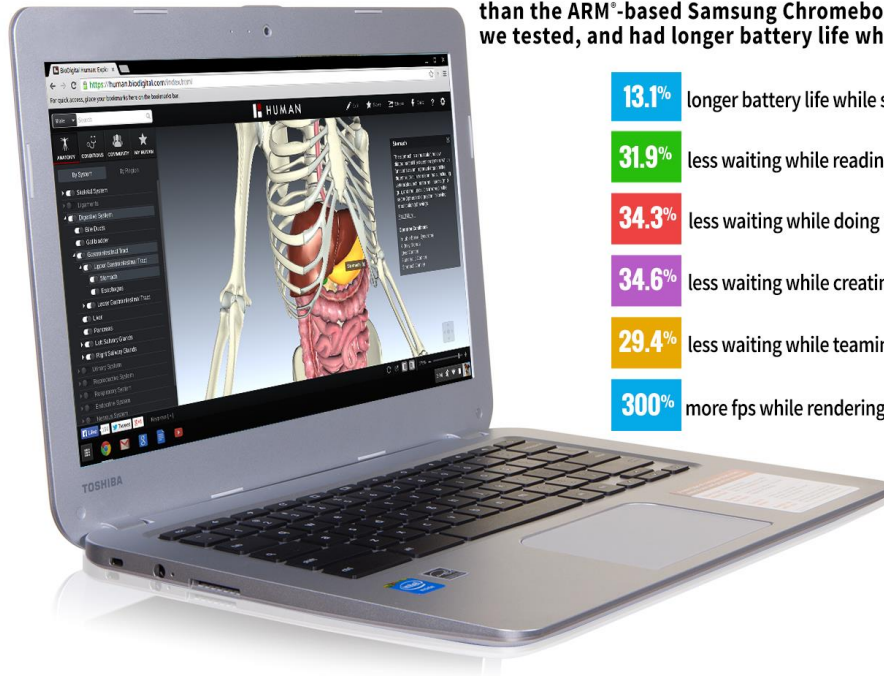


## Less waiting, *more learning*



The Intel® processor-powered Toshiba Chromebook was faster than the ARM®-based Samsung Chromebook 2 in every scenario we tested, and had longer battery life while browsing.

- 13.1% longer battery life while surfing the web
- 31.9% less waiting while reading and taking notes online
- 34.3% less waiting while doing math homework online
- 34.6% less waiting while creating an English presentation
- 29.4% less waiting while teaming up in science class
- 300% more fps while rendering an anatomy simulation

Students today need reliable technology to succeed. They need to grab their device, start assignments, and be able to switch between tasks and apps quickly. These kinds of devices also benefit teachers, as they have to wait less on students in the classroom. Students can easily become distracted while they want on their devices.

With all the choices of Chromebook™ devices, however, it's difficult to choose one that will provide a reliable and experience for students with less hassle. Here in the Principled Technologies labs, we put two Chromebook devices through scenarios that included common tasks such as reading an e-book or watching a video. In addition, we looked at how long the devices could run unplugged and at how many frames per second they could deliver when rendering an anatomy solution.

Which Chromebook is the better choice? We found that only the Intel® processor-powered Toshiba Chromebook aced the test. It lasted over 13 percent longer unplugged than the ARM® processor-based Samsung® Chromebook 2 and delivered up to 34 percent less waiting in four student scenarios and four times as many frames per second (fps) while rendering an anatomy simulation. With the Intel processor-powered Toshiba Chromebook, students can spend less time waiting and more time learning.

## LESS WAITING AND MORE LEARNING WITH THE RIGHT CHROMEBOOK

With more Chromebook models available, it has become more difficult for schools to choose the model that can offer students a better experience. We looked at two available Chromebooks, one with an Intel processor and one with the latest ARM processor from Samsung, and put them through a series of tasks that real students would perform regularly while learning. We looked at how long each Chromebook could keep going unplugged while browsing the Internet. We also measured how many frames per second each Chromebook could deliver while rendering an anatomy simulation. For more on how we tested, see [Appendix B](#). For detailed results, see [Appendix C](#).

We chose two systems that were as comparable as possible, and these systems share the same display size and the same amount of storage. In addition to the processor, they differ in battery size, as the Intel processor-powered Toshiba Chromebook has a 52Wh rather than a 35Wh battery. The ARM processor-based Samsung Chromebook 2 also has a higher resolution display and more memory than the Intel processor-powered Toshiba Chromebook has. For more information on the two systems, see [Appendix A](#).

## BATTERY LIFE WHILE BROWSING

Battery life is important—finding an outlet or power strip to plug into can create an avoidable distraction. We found that the Intel processor-powered Toshiba Chromebook lasted 13.1 percent longer than the ARM processor-based Samsung Chromebook 2 while lightly browsing the Internet—an additional 1 hours and 19 minutes without a charge (see Figure 1).

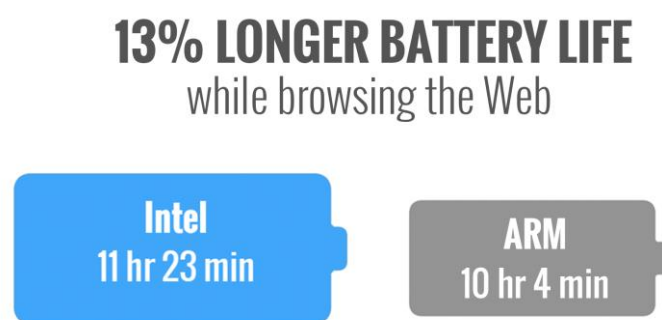


Figure 1: The amount of the time the two Chromebooks lasted unplugged while browsing the Internet.

## READING A TEXTBOOK AND TAKING NOTES ONLINE

Mateo opens his Chromebook and powers it on to do some homework. He opens Chrome™ and goes to his Kno™ online textbook, and then opens a new document

in Google Docs to take notes. He reads and takes notes for a while, and then comes upon something he doesn't know, so he searches Wikipedia for it. Then he goes back to reading his textbook and taking notes. He opens the BioDigital Human™ app to work with a 3D model. When he reaches a stopping point, he plays a Khan Academy video his teacher shared with the class. Toward the end of the video, Mateo remembers something a friend told him about earlier in the day, so he opens the New York Times app to read about it.

## Reading a textbook and taking notes online

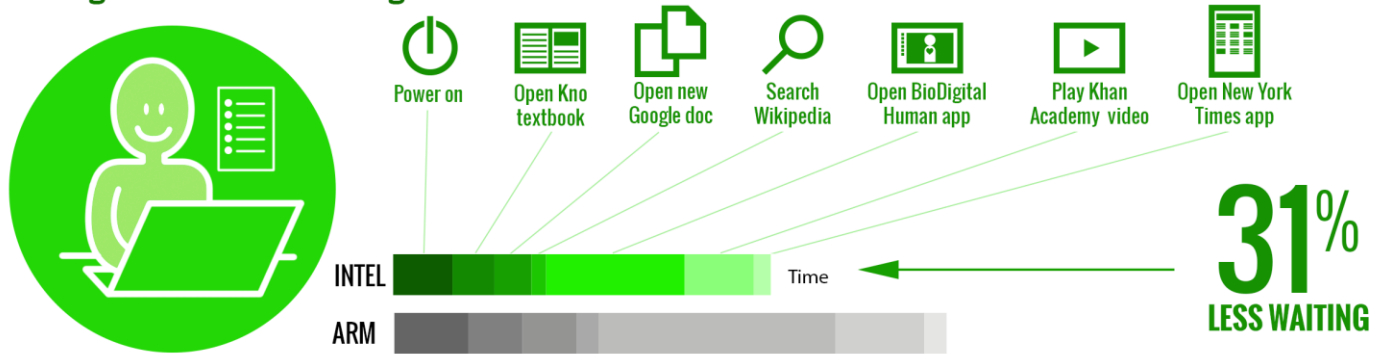


Figure 2: The amount of time spent waiting when using the two Chromebooks in seven tasks related to reading a textbook and taking notes online.

Mateo would have to wait 70.0 percent longer for the BioDigital Human app to open when using the ARM processor-based Samsung Chromebook 2.

As Figure 2 shows, the Intel processor-powered Toshiba Chromebook required 31.9 percent less waiting than the ARM processor-based Samsung Chromebook 2. This means that if Mateo were using the ARM processor-based Chromebook, he would spend almost 50 percent longer waiting on his Chromebook. Instead of waiting longer for his system to turn on, he could be up and running and on his way to reading his biology textbook. Mateo wouldn't want to wait 70.0 percent longer for the BioDigital Human app to open when using the ARM processor-based Samsung Chromebook 2.

## DOING MATH HOMEWORK ONLINE

Madison gets home from school and turns on her Chromebook to do her math homework. She opens the GeoGebra app and then opens her math notes that she has saved in a Google Docs document. She also opens the Design Something app to work with a 3D model. To prepare for her test the next day, she opens the CK-12 Parallel and Perpendicular Lines assessment. Then, Madison takes a break to watch a TED-Ed video her friend sent her.

## Doing math homework online

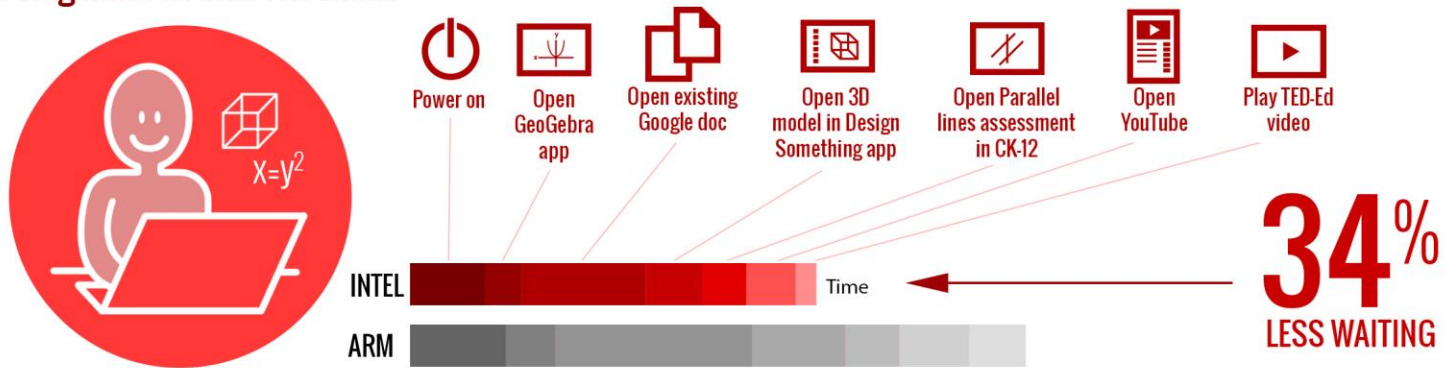


Figure 3: The amount of time spent waiting when using the two Chromebooks in seven tasks related to doing math homework online.

Madison would get frustrated waiting 56.9 percent longer to open her Google Docs document when using the ARM processor-based Samsung Chromebook 2.

As Figure 3 shows, the Intel processor-powered Toshiba Chromebook required 34.3 percent less waiting than the ARM processor-based Samsung Chromebook 2. Instead of getting frustrated waiting 56.9 percent longer for the Google Docs document to open on her ARM processor-based Samsung Chromebook 2, Madison could be learning about parallel and perpendicular lines on her Intel processor-powered Toshiba Chromebook. Madison’s teacher wouldn’t want her to wait 64.0 percent longer just to open a 3D model on the ARM processor-based Samsung Chromebook 2.

## CREATING AN ENGLISH PRESENTATION

Ethan has an English project to present on the use of metaphor in Romeo and Juliet. He turns on his Chromebook and searches for the TED-Ed video on Shakespearean Dating Tips. While watching the video, he opens Google Keep™ and takes some notes. He also goes to Wikipedia to search for some information on Shakespeare’s life and work. He then opens a new presentation in Google Slides and starts making slides. To talk about the metaphor of stars as eyes, he opens the Planetarium app and looks at some constellations. He also opens Google Maps™ and searches for Verona to look at the city in Street View™. When finished, Ethan rehearses to make sure he’s ready to present, going to Google Drive and opening his presentation to practice.

## Creating an English presentation

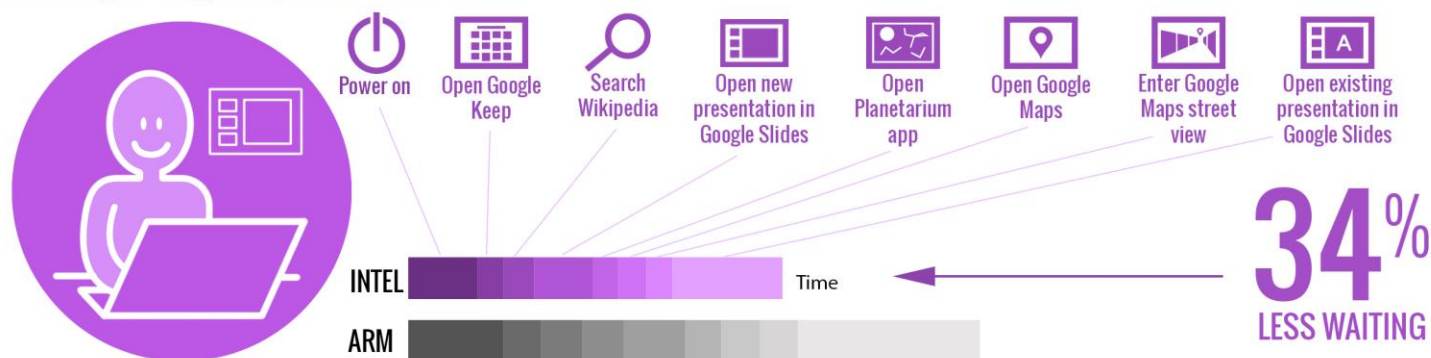


Figure 4: The amount of time spent waiting when using the two Chromebooks in eight tasks related to creating an English presentation.

Ethan would have to wait 67.0 percent longer when opening his presentation on the ARM processor-based Samsung Chromebook 2.

As Figure 4 shows, the Intel processor-powered Toshiba Chromebook required 34.6 percent less waiting than the ARM processor-based Samsung Chromebook 2. If Ethan were using the Intel processor-powered Toshiba Chromebook, he wouldn't have to wait 67.0 percent longer each time he opens his Google Slides presentation, both at home when he's practicing or in class when he's presenting. Each app he would use to create his presentation—Google Keep, Planetarium, Google Maps—would take less time to open on the Intel processor-powered Toshiba Chromebook.

## TEAMING UP IN SCIENCE CLASS

Jada is working on a project in her third-period science class. She opens her spreadsheet in Google Sheets to prepare for their group lab later in the period. She also opens a new document in Google Docs to take notes that she can share with her group. She opens the PhET Build an Atom simulation and opens the Useful Periodic Table app to help her with the simulation. Eventually, the whole class gets stuck on a tough problem, and her teacher suggests that they all watch a Crash Course video on the nucleus. Jada searches for the video, and then plays it on the TV via Chromecast™.

## Teaming up in science class

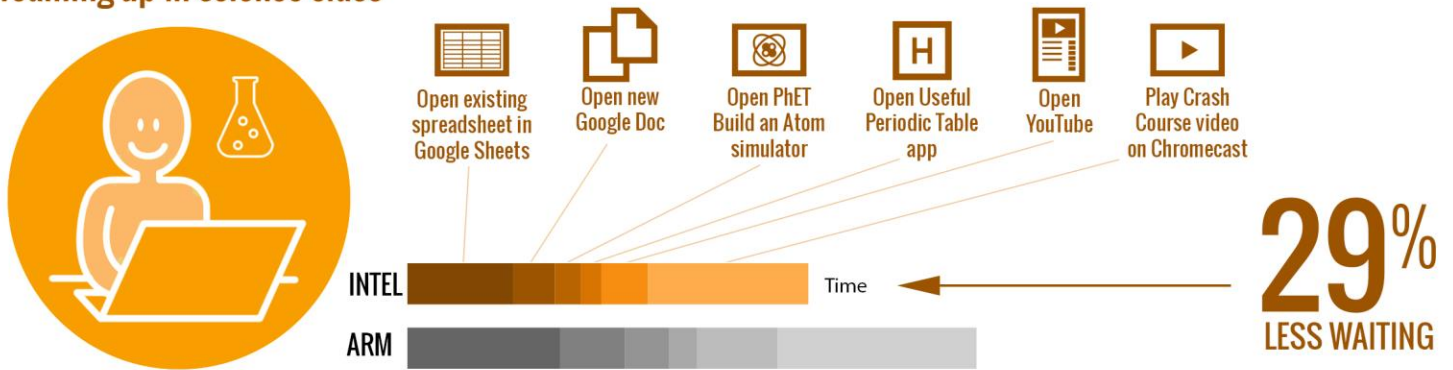


Figure 5: The amount of time spent waiting when using the two Chromebooks in six tasks related to teaming up in science class.

Jada’s teacher would have to wait 72.5 percent longer when opening YouTube before playing the video for her class on the ARM processor-based Samsung Chromebook 2.

As Figure 5 shows, the Intel processor-powered Toshiba Chromebook required 29.4 percent less time than the ARM processor-based Samsung Chromebook 2. This means that if Jada were using the Intel processor-powered Toshiba Chromebook, she could be figuring out the structure of an atom instead of waiting for her spreadsheet to open. With the ARM processor-based Samsung Chromebook 2, she would be spending valuable class time waiting instead of learning. Jada’s teacher would have to wait 72.5 percent longer when opening YouTube before playing the video for the class on the ARM processor-based Samsung Chromebook 2.

## RENDERING AN ANATOMY SIMULATION

With four times as many frames per second, the Intel processor-powered Toshiba Chromebook can provide students with smoother, faster graphics in apps.

Immersive 2D and 3D graphics in education apps only enhance learning if they render quickly and smoothly. Some education apps like BioDigital Human are now using WebGL™,<sup>1</sup> a new Web standard for 2D and 3D, because WebGL doesn’t require teachers and students to install a browser plugin. We looked at the BioDigital Human app and found that the Intel processor-powered Toshiba Chromebook delivered four times as many frames per second than the ARM processor-based Samsung Chromebook 2 while rendering the digestive system—36 frames per second versus 9 frames per second (see Figure 6).

<sup>1</sup> WebGL and the WebGL logo are trademarks of the Khronos Group Inc.

# 300% MORE FRAMES PER SECOND

while rendering an anatomy simulation



Figure 6: The number of frames per second the two Chromebooks delivered while rendering an anatomy simulation.

## THE BOTTOM LINE

Which Chromebook model is the better for students? Longer wait times to open apps or documents can frustrate and distract students from their tasks on hand. For teachers, when students are less engaged with material it can take longer to get to learning in the classroom or more time to complete assignments at home. We put two Chromebook models to the test, and found the Intel processor-powered Toshiba Chromebook required students to wait significantly less than the ARM processor-based Samsung Chromebook 2 while delivering four times as many frames per second. We also found that the battery of the Toshiba Chromebook lasted significantly longer without a charge while lightly browsing the Internet. This report card has good news: With the Intel processor-powered Toshiba Chromebook, students can learn more by waiting less on their devices and worrying less about battery life.

## APPENDIX A: DETAILED SYSTEM CONFIGURATION

Figure 7 presents detailed information on the two Chromebooks we tested.

System	Intel processor-powered Toshiba Chromebook	ARM processor-based Samsung Chromebook 2
Vendor and model	Toshiba® CB35-A3120 Chromebook	Samsung® XE503C32-K01US Chromebook
Processor	Intel Celeron® Processor 2955U (Haswell microarchitecture)	Samsung Exynos 5 Octa 5800
Processor frequency (GHz)	1.4	1.3 Quad + 2.0 Quad
Processor cores	2	4 + 4
Memory	2GB DDR3L SDRAM	4GB DDR3L SDRAM
Storage	16GB SSD	16GB SSD
Battery type	4-cell Li-Polymer	2 cell Li-Polymer
Battery capacity	52 Wh	35 Wh
Display	13.3" (1,366 x 768)	13.3" (1,920 x 1,080)
Wireless	802.11 a/b/g/n	802.11ac (802.11 a/b/g/n compatible)
Bluetooth	4.0	4.0
USB ports	2 x USB 3.0	1 x USB 3.0 1 x USB 2.0
System weight	3.3 lbs.	3.2 lbs.
OS	Chrome OS version 35.0.1916.155	Chrome OS version 35.0.1916.155
Firmware	Google_Leon.4389.61.43	Google_Peach_Pit.4482.94.0

Figure 7: Detailed configuration information for the two Chromebooks.

## APPENDIX B: DETAILED TEST METHODOLOGY

### Battery life while browsing

#### Setting up the test

1. Make sure the display will not automatically turn off during the test.
  - a. Install the Keep Awake extension.
  - b. To switch to the sun icon, click the icon in the top-right corner of the Chrome browser.
2. Open Google Chrome from the shelf, and bookmark the msn.com Web site.
3. Set the displays to as close as possible to 70 nits.
4. Plug the Chromebook chargers into a power strip.
5. Make sure the batteries are all 100 percent charged.
6. Place both Chromebooks next to the clock.

#### Running the test

1. Start the video camera.
2. Open Google Chrome from the shelf, and go to the bookmarked Web site.
3. Turn the power strip off, and note the time.
4. After both Chromebooks have fully discharged, review the video to determine when each Chromebook powered off.
5. Fully charge the Chromebooks.
6. Repeat steps 1 through 5 two more times.

### Reading a textbook and taking notes online

1. Simultaneously start the timer and power on the system.
2. When the login window appears, stop the timer, and record the result.
3. Enter the password, and press Enter.
4. Open Google Chrome from the shelf.
5. Type `kno.com`, and press Enter.
6. Select Course Manager.
7. Simultaneously start the timer and select the Campbell Biology textbook under My Stuff.
8. When the textbook is fully displayed, stop the timer, and record the result.
9. Simultaneously start the timer and open Google Docs from the shelf to open a new document.
10. When the document is fully displayed, stop the timer, and record the result.
11. Press Ctrl+T to open a new Chrome tab.
12. Type `Wikipedia.org` and press Enter.
13. Type `muscles`, and simultaneously start the timer and press Enter.
14. When the Wikipedia page is fully displayed, stop the timer, and record the result.
15. Open the Chrome tab for the Kno textbook.
16. Open the Chrome tab for the document.
17. Simultaneously start the timer and open the BioDigital Human app from the apps list.
18. When the BioDigital Human app is fully displayed, stop the timer, and record the result.
19. Simultaneously start the timer and open YouTube from the apps list.
20. Click Watch Later.

21. Play the Khan Academy video.
22. When the video begins playing, stop the timer, and record the result.
23. Simultaneously start the timer and open the New York Times app from the apps list.
24. When the New York Times app is fully displayed, stop the timer, and record the result.
25. Repeat steps 1 through 24 two more times.

### Doing math homework online

1. Simultaneously start the timer and power on the system.
2. When the login window appears, stop the timer, and record the result.
3. Enter the password, and press Enter.
4. Simultaneously start the timer and open the GeoGebra app from the apps list.
5. When the GeoGebra app is fully displayed, stop the timer, and record the result.
6. Simultaneously start the timer and open Google Drive from the apps list.
7. Open the existing document.
8. When the document is fully displayed, stop the timer, and record the result.
9. Open the Chrome tab for the GeoGebra app.
10. Open the Design Something app from the apps list.
11. Simultaneously start the timer and open the pen holder model under Recent Models.
12. When the model is fully displayed, stop the timer, and record the result.
13. Press Ctrl+T to open a new Chrome tab.
14. Type `ck12.org/geometry` and press Enter.
15. Open the Parallel and Perpendicular Lines concept, and click Assessments.
16. Simultaneously start the timer and select Parallel and Perpendicular Lines Practice.
17. When the assessment fully loads, stop the timer, and record the result.
18. Simultaneously start the timer and open YouTube from the apps list.
19. When YouTube is fully displayed, stop the timer, and record the result.
20. Click Watch Later.
21. Simultaneously start the timer and play the TED-Ed video.
22. When the video begins playing, stop the timer, and record the result.
23. Repeat steps 1 through 22 two more times.

### Creating an English presentation

1. Simultaneously start the timer and power on the system.
2. When the login window appears, stop the timer, and record the result.
3. Enter the password, and press Enter.
4. Open YouTube from the apps list.
5. Type `TED-Ed Shakespearean dating tips`, and press Enter.
6. Click the link for the TED-Ed video.
7. Simultaneously start the timer and open Google Keep from the apps list.
8. When Google Keep is fully displayed, stop the timer, and record the result.
9. Open the Chrome tab for the TED-Ed video.
10. Press Ctrl+T to open a new Chrome tab.

11. Type `Wikipedia.org` and press Enter.
12. Type `Shakespeare`, and simultaneously start the timer and press Enter.
13. When the Wikipedia page is fully displayed, stop the timer, and record the result.
14. Simultaneously start the timer and open Google Slides from the shelf to open a new presentation.
15. When the Presentation choose a theme screen is fully displayed, stop the timer, and record the result.
16. Select the Simple Light theme.
17. Simultaneously start the timer and open the Planetarium app from the apps list.
18. When the Planetarium app is fully displayed, stop the timer, and record the result.
19. Open the Chrome tab for the presentation.
20. Simultaneously start the timer and open Google Maps from the apps list.
21. When Google Maps is fully displayed, stop the timer, and record the result.
22. Type `Verona, Italy` and press Enter.
23. Drag the yellow pegman to the center of the city.
24. Simultaneously start the timer and release the pegman to enter Street View.
25. When Street View is fully displayed, stop the timer, and record the result.
26. Open the Chrome tab for the presentation.
27. Close the Chrome tab.
28. Simultaneously start the timer and open Google Drive from the apps list.
29. Open the existing presentation.
30. When the presentation is fully displayed, stop the timer, and record the result.
31. Repeat steps 1 through 30 two more times.

### Teaming up in science class

1. Open the lid to resume from sleep.
2. Simultaneously start the timer and open Google Drive.
3. Open the existing spreadsheet.
4. When the spreadsheet is fully displayed, stop the timer, and record the result.
5. Simultaneously start the timer and open Google Docs from the shelf to open a new document.
6. When the document is fully displayed, stop the timer, and record the result.
7. Press `Ctrl+T` to open a new Chrome tab.
8. Type `phet.colorado.edu/en/simulations/category/html`, and press Enter.
9. Simultaneously start the timer and open the Build an Atom simulation.
10. When the simulation is fully displayed, stop the timer, and record the result.
11. Simultaneously start the timer and open the Useful Periodic Table app from the apps list.
12. When the Useful Periodic Table app is fully displayed, stop the timer, and record the result.
13. Open the Chrome tab for the simulation.
14. Simultaneously start the timer and open YouTube from the apps list.
15. When YouTube is fully displayed, stop the timer, and record the result.
16. Type `Crash Course nucleus`, and press Enter.
17. Simultaneously start the timer and click the link for the Crash Course chemistry video.
18. Play the video on the TV via Chromecast.
19. When the video begins playing on the TV, stop the timer, and record the result.

20. Repeat steps 1 through 19 two more times.

## Rendering an anatomy simulation

### Setting up the test

1. Enable the chrome frames per second flag.
  - a. Open Google Chrome from the shelf.
  - b. Type `chrome://flags`, and press Enter.
  - c. Select the Enable link below the FPS counter.
2. Close the Chrome window.

### Running the test

1. Reload the page.
2. Show the Digestive System.
3. To zoom in on the stomach and surrounding organs, double-click the stomach.
4. Once the app has fully rendered the image of the digestive system and the counter has stopped, note the number of frames per second reported by the frames per second counter, and record the result.
5. Repeat steps 1 through 4 two more times.

## APPENDIX C: DETAILED RESULTS

Figure 8 presents the detailed results, with battery life while browsing reported in hours and the time to complete tasks in the scenarios recorded in seconds. We performed all tasks three times and used the median scores.

	Intel processor-powered Toshiba Chromebook	ARM processor-based Samsung Chromebook 2
<b>Battery life while browsing</b>		
<b>Battery life while lightly browsing the Internet (higher is better)</b>		
Run 1	11:41:00.00	10:22:00.00
Run 2	11:23:00.00	09:55:00.00
Run 3	11:23:00.00	10:04:00.00
<b>Median</b>	<b>11:23:00.00</b>	<b>10:04:00.00</b>
<b>Reading a textbook and taking notes online</b>		
<b>Time to turn on system (lower is better)</b>		
Run 1	00:06.30	00:07.80
Run 2	00:06.50	00:07.90
Run 3	00:06.30	00:07.70
<b>Median</b>	<b>00:06.30</b>	<b>00:07.80</b>
<b>Time to open Kno textbook (lower is better)</b>		
Run 1	00:04.50	00:05.40
Run 2	00:04.50	00:05.80
Run 3	00:04.40	00:05.80
<b>Median</b>	<b>00:04.50</b>	<b>00:05.80</b>
<b>Time to open new document in Google Docs (lower is better)</b>		
Run 1	00:03.80	00:06.00
Run 2	00:03.90	00:05.90
Run 3	00:03.90	00:05.80
<b>Median</b>	<b>00:03.90</b>	<b>00:05.90</b>
<b>Time to search Wikipedia (lower is better)</b>		
Run 1	00:01.60	00:02.30
Run 2	00:01.50	00:02.00
Run 3	00:01.40	00:02.20
<b>Median</b>	<b>00:01.50</b>	<b>00:02.20</b>
<b>Time to open BioDigital Human app (lower is better)</b>		
Run 1	00:14.80	00:25.50
Run 2	00:15.00	00:25.70
Run 3	00:15.00	00:25.40
<b>Median</b>	<b>00:15.00</b>	<b>00:25.50</b>
<b>Time to play Khan Academy video (lower is better)</b>		
Run 1	00:07.50	00:09.70
Run 2	00:07.20	00:09.70
Run 3	00:07.30	00:09.70
<b>Median</b>	<b>00:07.30</b>	<b>00:09.70</b>
<b>Time to open New York Times app (lower is better)</b>		
Run 1	00:01.70	00:02.30
Run 2	00:01.80	00:02.30
Run 3	00:01.80	00:02.30
<b>Median</b>	<b>00:01.80</b>	<b>00:02.30</b>
<b>Total time waiting</b>	<b>00:40.30</b>	<b>00:59.20</b>

	Intel processor-powered Toshiba Chromebook	ARM processor-based Samsung Chromebook 2
<b>Doing math homework online</b>		
<b>Time to turn on system (lower is better)</b>		
Run 1	00:06.30	00:08.20
Run 2	00:06.40	00:08.00
Run 3	00:06.40	00:08.20
<b>Median</b>	<b>00:06.40</b>	<b>00:08.20</b>
<b>Time to open GeoGebra app (lower is better)</b>		
Run 1	00:03.30	00:04.50
Run 2	00:03.30	00:04.50
Run 3	00:03.40	00:04.50
<b>Median</b>	<b>00:03.30</b>	<b>00:04.50</b>
<b>Time to open existing document in Google Docs (lower is better)</b>		
Run 1	00:10.80	00:17.20
Run 2	00:10.90	00:17.00
Run 3	00:11.10	00:17.10
<b>Median</b>	<b>00:10.90</b>	<b>00:17.10</b>
<b>Time to open 3D model in Design Something app (lower is better)</b>		
Run 1	00:05.00	00:07.80
Run 2	00:05.00	00:08.30
Run 3	00:05.00	00:08.20
<b>Median</b>	<b>00:05.00</b>	<b>00:08.20</b>
<b>Time to open CK-12 Parallel and Perpendicular Lines assessment (lower is better)</b>		
Run 1	00:03.70	00:04.70
Run 2	00:03.80	00:04.70
Run 3	00:03.80	00:04.70
<b>Median</b>	<b>00:03.80</b>	<b>00:04.70</b>
<b>Time to open YouTube (lower is better)</b>		
Run 1	00:04.20	00:06.40
Run 2	00:04.20	00:06.30
Run 3	00:04.20	00:06.30
<b>Median</b>	<b>00:04.20</b>	<b>00:06.30</b>
<b>Time to play TED-Ed video (lower is better)</b>		
Run 1	00:01.80	00:04.90
Run 2	00:01.90	00:04.90
Run 3	00:01.80	00:05.00
<b>Median</b>	<b>00:01.80</b>	<b>00:04.90</b>
<b>Total time waiting</b>	<b>00:35.40</b>	<b>00:53.90</b>
<b>Creating an English presentation</b>		
<b>Time to turn on system (lower is better)</b>		
Run 1	00:06.30	00:08.40
Run 2	00:06.30	00:08.50
Run 3	00:06.20	00:08.50
<b>Median</b>	<b>00:06.30</b>	<b>00:08.50</b>
<b>Time to open Google Keep (lower is better)</b>		
Run 1	00:02.20	00:03.40
Run 2	00:02.20	00:03.40
Run 3	00:02.20	00:03.60

	Intel processor-powered Toshiba Chromebook	ARM processor-based Samsung Chromebook 2
<b>Median</b>	<b>00:02.20</b>	<b>00:03.40</b>
<b>Time to search Wikipedia (lower is better)</b>		
Run 1	00:02.70	00:03.70
Run 2	00:02.60	00:03.50
Run 3	00:02.70	00:03.80
<b>Median</b>	<b>00:02.70</b>	<b>00:03.70</b>
<b>Time to open new presentation in Google Slides (lower is better)</b>		
Run 1	00:05.30	00:09.00
Run 2	00:05.40	00:09.20
Run 3	00:05.40	00:08.80
<b>Median</b>	<b>00:05.40</b>	<b>00:09.00</b>
<b>Time to open Planetarium app (lower is better)</b>		
Run 1	00:02.30	00:03.30
Run 2	00:02.10	00:03.40
Run 3	00:02.20	00:03.30
<b>Median</b>	<b>00:02.20</b>	<b>00:03.30</b>
<b>Time to open Google Maps (lower is better)</b>		
Run 1	00:02.30	00:03.50
Run 2	00:02.40	00:03.30
Run 3	00:02.40	00:03.30
<b>Median</b>	<b>00:02.40</b>	<b>00:03.30</b>
<b>Time to enter Google Maps Street View (lower is better)</b>		
Run 1	00:02.40	00:03.40
Run 2	00:02.30	00:03.40
Run 3	00:02.30	00:03.40
<b>Median</b>	<b>00:02.30</b>	<b>00:03.40</b>
<b>Time to open existing presentation in Google Slides (lower is better)</b>		
Run 1	00:09.60	00:16.20
Run 2	00:09.70	00:16.10
Run 3	00:09.70	00:16.30
<b>Median</b>	<b>00:09.70</b>	<b>00:16.20</b>
<b>Total time waiting</b>	<b>00:33.20</b>	<b>00:50.80</b>
<b>Teaming up in science class</b>		
<b>Time to open existing spreadsheet in Google Sheets (lower is better)</b>		
Run 1	00:09.50	00:13.40
Run 2	00:09.40	00:13.50
Run 3	00:09.40	00:13.60
<b>Median</b>	<b>00:09.40</b>	<b>00:13.50</b>
<b>Time to open new document in Google Docs (lower is better)</b>		
Run 1	00:03.60	00:05.50
Run 2	00:03.60	00:05.60
Run 3	00:03.50	00:05.80
<b>Median</b>	<b>00:03.60</b>	<b>00:05.60</b>
<b>Time to open PhET Build an Atom simulation (lower is better)</b>		
Run 1	00:02.30	00:03.90
Run 2	00:02.30	00:03.90
Run 3	00:02.30	00:03.90

	Intel processor-powered Toshiba Chromebook	ARM processor-based Samsung Chromebook 2
<b>Median</b>	<b>00:02.30</b>	<b>00:03.90</b>
<b>Time to open Useful Periodic Table app (lower is better)</b>		
Run 1	00:01.90	00:02.60
Run 2	00:01.80	00:02.60
Run 3	00:02.00	00:02.60
<b>Median</b>	<b>00:01.90</b>	<b>00:02.60</b>
<b>Time to open YouTube (lower is better)</b>		
Run 1	00:04.00	00:06.80
Run 2	00:04.00	00:06.90
Run 3	00:04.00	00:06.90
<b>Median</b>	<b>00:04.00</b>	<b>00:06.90</b>
<b>Time to play Crash Course video on Chromecast (lower is better)</b>		
Run 1	00:14.10	00:17.50
Run 2	00:14.10	00:17.50
Run 3	00:14.00	00:17.60
<b>Median</b>	<b>00:14.10</b>	<b>00:17.50</b>
<b>Total time waiting</b>	<b>00:35.30</b>	<b>00:50.00</b>
<b>Rendering an anatomy simulation</b>		
<b>Frames per second while rendering an anatomy simulation (higher is better)</b>		
Run 1	37	9
Run 2	36	9
Run 3	36	9
<b>Median</b>	<b>36</b>	<b>9</b>

Figure 8: Detailed results.

## ABOUT PRINCIPLED TECHNOLOGIES



Principled Technologies, Inc.  
1007 Slater Road, Suite 300  
Durham, NC, 27703  
[www.principledtechnologies.com](http://www.principledtechnologies.com)

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