




## Spend less time *waiting*, more time *learning*

The Intel®-powered HP Chromebook™ 14 was faster than the ARM®-based model in every scenario we tested, and had longer battery life while browsing.



-  **63% longer battery life**  
while Web browsing
-  **49% less waiting to read**  
a textbook and take notes online
-  **50% less waiting to do math**  
homework online
-  **52% less waiting to create**  
an English presentation
-  **45% less waiting to team up**  
in science class
-  **89% more frames per second**  
while rendering an anatomy simulation

Students are busy. They want to pick up their devices, get going right away, and move from one thing to another quickly and easily. If the devices they use to do school work take too long to load an app or a video and force them to worry about battery life, it can be hard to keep them focused and engaged. Teachers value responsive devices with long battery life, too—the less time they spend waiting for students to open an app or document, the sooner they can start teaching. Instead of becoming distracted or frustrated, students are more likely to become and stay engaged.

How do schools choose the Chromebook™ model that is best for students and teachers? We put on our student hats, and used an Intel® processor-powered HP Chromebook 14 and an ARM processor-based model in common classroom tasks such as taking notes and watching videos. We looked at the frames per second both systems could deliver while rendering an anatomy simulation, and how long the two systems could keep running without a charge.

We found that the Intel processor-powered HP Chromebook 14 moved through our four student scenarios with up to 52 percent less waiting than the ARM processor-based model, rendered the anatomy simulation with 89 percent more frames per second, and lasted 63 percent longer without a charge while lightly browsing the Internet. With the Intel processor-powered HP Chromebook 14, students can spend less time waiting and more time learning.

## LESS WAITING AND MORE LEARNING WITH THE RIGHT CHROMEBOOK

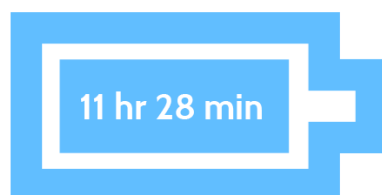
We chose two Chromebook models that were as comparable as possible, with the same display resolution and amount of memory and storage. In addition to the processor, they differ in display and battery size, as the Intel processor-powered HP Chromebook 14 has a 14" display and a 4-cell battery, instead of an 11.6" display and a 2-cell battery. For more on the test systems, see [Appendix A](#).

We put both the Intel processor-powered HP Chromebook 14 and the ARM processor-based model through a series of tasks that real students would perform regularly in the classroom. We also looked at how many frames per second each Chromebook could deliver while rendering an anatomy simulation and how long each Chromebook could keep going without a charge. For more on how we tested, see [Appendix B](#). For detailed results, see [Appendix C](#).

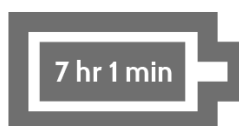
## BATTERY LIFE WHILE BROWSING

Battery life is vital—who has time to find an outlet and charge their device? We found that the Intel processor-powered HP Chromebook 14 lasted 63 percent longer than the ARM processor-based model while lightly browsing the Internet—an additional 4 hours and 27 minutes without a charge (see Figure 1).

### INTEL



### ARM



### 63% LONGER BATTERY LIFE

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

## READING A TEXTBOOK AND TAKING NOTES ONLINE

Dominic 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, Dominic 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

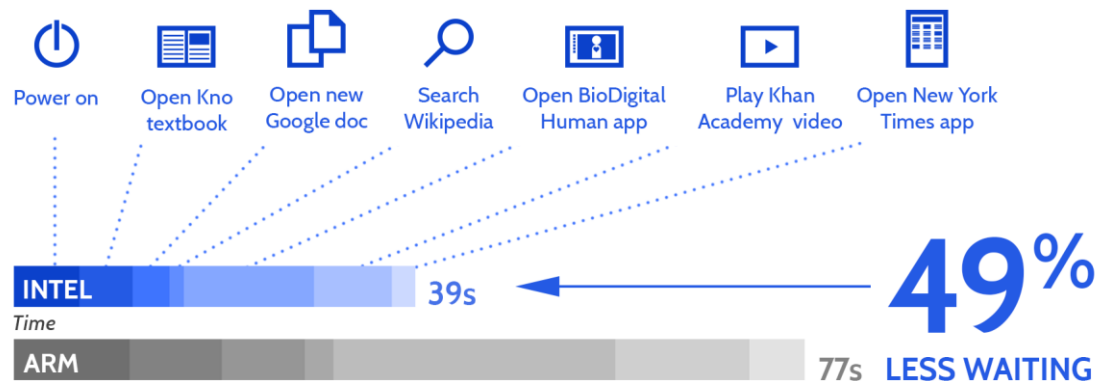


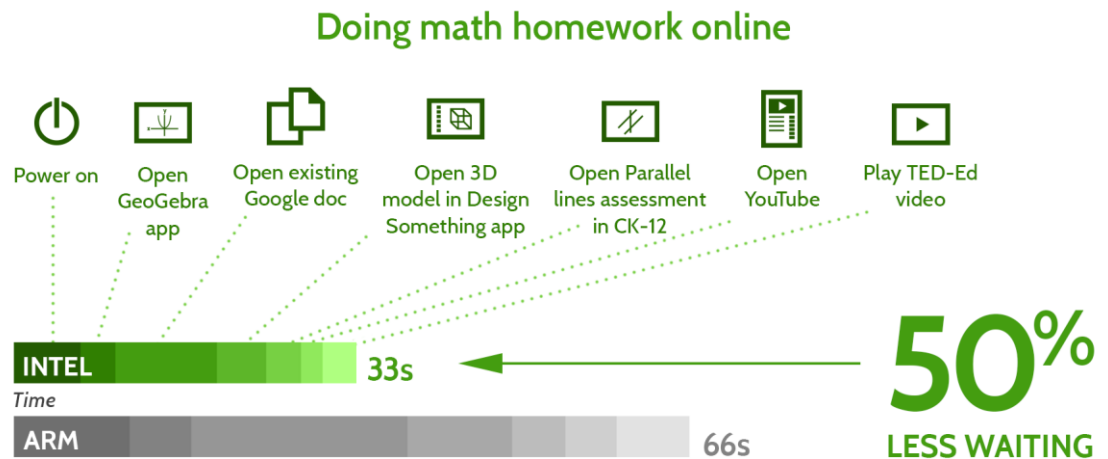
Figure 2: The amount of time spent waiting with the two Chromebooks in seven tasks when reading a textbook and taking notes online.

Dominic wouldn't want to wait almost 15 seconds longer for the BioDigital Human app to open on the ARM processor-based Chromebook.

As Figure 2 shows, the Intel processor-powered HP Chromebook 14 required 49 percent less waiting than the ARM processor-based Chromebook. This means that if Dominic were using the Intel processor-powered HP Chromebook 14, he would spend only about half as much time 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. Dominic wouldn't want to wait almost 15 extra seconds for the BioDigital Human app to open on the ARM processor-based model.

## DOING MATH HOMEWORK ONLINE

Emma 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, Emma takes a break to watch a TED-Ed video her friend sent her.



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

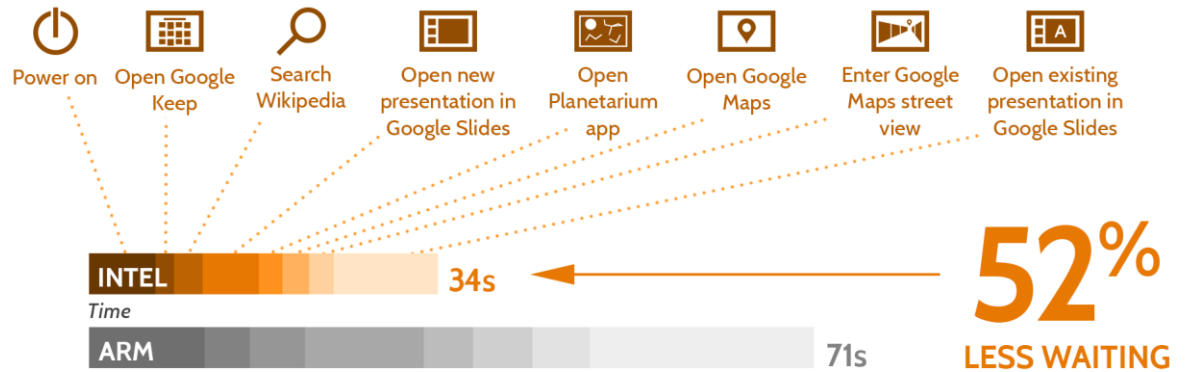
Emma would get frustrated waiting over 11 seconds longer to open her Google Docs document on the ARM processor-based Chromebook.

As Figure 3 shows, the Intel processor-powered HP Chromebook 14 required 50 percent less waiting than the ARM processor-based Chromebook. Instead of getting frustrated waiting 11 seconds longer for the Google Docs document to open on her ARM processor-based Chromebook, Emma could be learning about parallel and perpendicular lines on her Intel processor-powered HP Chromebook 14. Emma’s teacher needs her to stay focused, wouldn’t want her to wait over 5 extra seconds just to open a 3D model on the ARM processor-based Chromebook.

## CREATING AN ENGLISH PRESENTATION

Evan 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, Evan 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 with the two Chromebooks in eight tasks when creating an English presentation.**

Evan would save almost 12 seconds when opening his presentation on the Intel processor-powered HP Chromebook 14.

As Figure 4 shows, the Intel processor-powered HP Chromebook 14 required 52 percent less waiting than the ARM processor-based model. If Evan were using the Intel processor-powered HP Chromebook 14, he wouldn't have to wait almost 12 seconds 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 HP Chromebook 14.

## TEAMING UP IN SCIENCE CLASS

Sherida 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. Sherida searches for the video, and then plays it on the TV via Chromecast™.

## Teaming up in science class

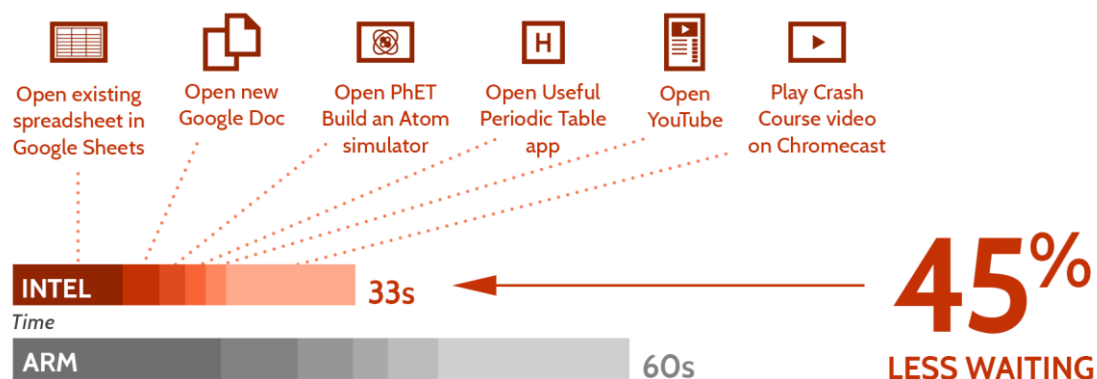


Figure 5: The amount of time spent waiting with the two Chromebooks in six tasks when teaming up in science class.

Sherida's teacher would lose 9 seconds waiting to discuss the Crash Course video when using the ARM processor-based Chromebook.

As Figure 5 shows, the Intel processor-powered HP Chromebook 14 required 45 percent less time than the ARM processor-based Chromebook. This means that if Sherida were using the Intel processor-powered HP Chromebook 14, she could be figuring out the structure of an atom instead of waiting for her spreadsheet to open. With the ARM processor-based Chromebook, she would be spending valuable class time waiting instead of learning. Sherida's teacher would lose 9 seconds waiting to discuss the Crash Course video with the class when using the ARM processor-based Chromebook.

## WEBGL<sup>1</sup> RENDERING IN AN ANATOMY SIMULATION

More frames per second means smoother, faster graphics in education apps for students on the Intel processor-powered HP Chromebook 14.

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™, 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 HP Chromebook 14 delivered 89 percent more frames per second than the ARM processor-based Chromebook while rendering the digestive system—51 frames per second versus 27 frames per second (see Figure 6). Almost twice as many frames per second means the Intel processor-powered HP Chromebook 14 can provide students with smoother, faster graphics in education apps, such as BioDigital Human.

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

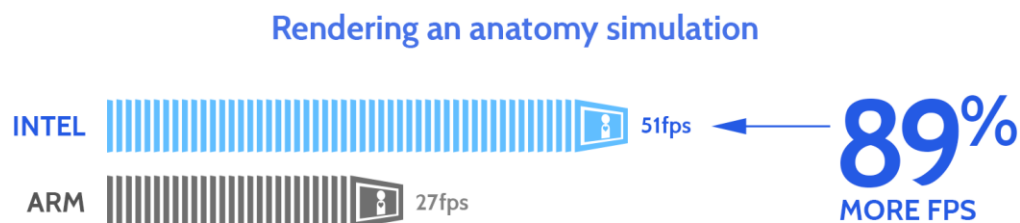


Figure 6: The number of frames per second the two Chromebooks delivered while rendering an anatomy simulation.

## THE BOTTOM LINE

Which model Chromebook is best for students and teachers? The longer students must wait for apps or documents to open, the more opportunities there are for distractions like chatting and doodling, and the longer it takes to get learning in the classroom or at home. We put two Chromebook models to the test, and found that the Intel processor-powered HP Chromebook 14 required significantly less waiting than the ARM processor-based model and delivered 89 percent more frames per second. The Intel processor-powered Chromebook also lasted significantly longer without a battery charge while lightly browsing the Internet. Based on our testing, the Intel processor-powered Chromebook is the better choice for schools: students can start learning faster, waste less time waiting, and spend more time learning.

## APPENDIX A: DETAILED SYSTEM CONFIGURATION

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

System	Intel processor-powered HP Chromebook 14	ARM processor-based Chromebook
Vendor and model	HP Chromebook 14	Samsung® Chromebook
Processor	Intel Celeron® Processor 2955U (Haswell microarchitecture)	Samsung Exynos 5 Dual
Processor frequency	1.4 GHz	1.7 GHz
Processor cores	2	2
Memory	2GB DDR3L SDRAM	2GB DDR3L SDRAM
Storage	16GB SSD	16GB SSD
Battery type	4-cell Li-Polymer	2 cell Li-Polymer
Battery capacity	51 Wh	30 Wh
Display	14" (1,366 × 768)	11.6" (1,366 × 768)
Wireless	802.11 a/b/g/n	802.11 a/b/g/n
Bluetooth	Bluetooth 4.0 compatible	Bluetooth 3.0 compatible
USB ports	2 × USB 3.0 1 × USB 2.0	1 × USB 3.0 1 × USB 2.0
System weight	4.07 lbs.	2.42 lbs.
OS	Chrome OS version 32.0.1700.103	Chrome OS version 32.0.1700.103
Firmware	Google_Falco.4389.78.0	Google_Snow.2695.117.0

**Figure 7: Detailed configuration information for the two Chromebooks.**



## APPENDIX B: DETAILED TEST METHODOLOGY

### 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. Click Explore, and sort by most popular models.
12. Simultaneously start the timer and open the LEGO® car (large model).

13. When the model is fully displayed, stop the timer, and record the result.
14. Press Ctrl+T to open a new Chrome tab.
15. Type `ck12.org/geometry` and press Enter.
16. Open the Parallel and Perpendicular Lines concept, and click Assessments.
17. Simultaneously start the timer and select Parallel and Perpendicular Lines Practice.
18. When the assessment fully loads, stop the timer, and record the result.
19. Simultaneously start the timer and open YouTube from the apps list.
20. When YouTube is fully displayed, stop the timer, and record the result.
21. Click Watch Later.
22. Simultaneously start the timer and play the TED-Ed video.
23. When the video begins playing, stop the timer, and record the result.
24. Repeat steps 1 through 23 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.

### WebGL rendering in an anatomy simulation

#### Setting up the test

1. Install the frames per second bookmarklet counter.
  - a. Open Google Chrome from the shelf.
  - b. Type `ricardocabello.com/blog/post/707`, and press Enter.
  - c. Drag and drop the Display Stats link to the bookmarks bar.
2. Close the Chrome window.
3. Open the BioDigital Human app from the app list.
4. Click Display Stats in the bookmarks bar.
5. In the omnibox, click the shield, and accept the warning to load unsafe script.

#### Running the test

1. Reload the page.
2. Show the list of conditions.
3. To enable the frames per second counter, click Display Stats in the bookmarks bar.
4. Select Pneumonia.

5. Once the app has fully rendered the image of the lungs, note the minimum number of frames per second in the range reported by the frames per second counter, and record the result.
6. Repeat steps 1 through 5 two more times.

## **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 to 70 nits as possible.
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.

## APPENDIX C: DETAILED RESULTS

Figure 8 presents the detailed results for the two Chromebooks. We performed all tasks three times. We have based the findings in the body of this report on the median scores for each task.

	Intel processor-powered HP Chromebook 14	ARM processor-based Chromebook
<b>Battery life while browsing</b>		
<b>Battery life while lightly browsing the Internet (higher is better)</b>		
Run 1	11:28:00.00	06:55:00.00
Run 2	11:37:00.00	07:03:00.00
Run 3	11:09:00.00	07:01:00.00
<b>Median</b>	<b>11:28:00.00</b>	<b>00:07:01.00</b>
<b>Reading a textbook and taking notes online</b>		
<b>Time to turn on system (lower is better)</b>		
Run 1	00:06.50	00:11.30
Run 2	00:06.40	00:11.10
Run 3	00:06.40	00:11.30
<b>Median</b>	<b>00:06.40</b>	<b>00:11.30</b>
<b>Time to open Kno textbook (lower is better)</b>		
Run 1	00:05.10	00:09.30
Run 2	00:05.20	00:09.00
Run 3	00:05.20	00:08.90
<b>Median</b>	<b>00:05.20</b>	<b>00:09.00</b>
<b>Time to open new document in Google Docs (lower is better)</b>		
Run 1	00:03.50	00:07.80
Run 2	00:03.70	00:08.30
Run 3	00:03.60	00:08.10
<b>Median</b>	<b>00:03.60</b>	<b>00:08.10</b>
<b>Time to search Wikipedia (lower is better)</b>		
Run 1	00:01.40	00:02.80
Run 2	00:01.40	00:02.90
Run 3	00:01.50	00:02.70
<b>Median</b>	<b>00:01.40</b>	<b>00:02.80</b>
<b>Time to open BioDigital Human app (lower is better)</b>		
Run 1	00:12.60	00:27.50
Run 2	00:12.70	00:27.10
Run 3	00:13.00	00:27.90
<b>Median</b>	<b>00:12.70</b>	<b>00:27.50</b>
<b>Time to play Khan Academy video (lower is better)</b>		
Run 1	00:07.60	00:13.10
Run 2	00:07.80	00:13.10
Run 3	00:07.30	00:13.00
<b>Median</b>	<b>00:07.60</b>	<b>00:13.10</b>
<b>Time to open New York Times app (lower is better)</b>		
Run 1	00:02.30	00:05.40
Run 2	00:02.30	00:05.40
Run 3	00:02.10	00:05.50
<b>Median</b>	<b>00:02.30</b>	<b>00:05.40</b>
<b>Total time waiting</b>	<b>00:39.20</b>	<b>01:17.20</b>

	Intel processor-powered HP Chromebook 14	ARM processor-based Chromebook
<b>Doing math homework online</b>		
<b>Time to turn on system (lower is better)</b>		
Run 1	00:06.60	00:11.30
Run 2	00:06.50	00:11.00
Run 3	00:06.40	00:11.60
<b>Median</b>	<b>00:06.50</b>	<b>00:11.30</b>
<b>Time to open GeoGebra app (lower is better)</b>		
Run 1	00:03.20	00:06.10
Run 2	00:03.40	00:06.00
Run 3	00:03.50	00:05.70
<b>Median</b>	<b>00:03.40</b>	<b>00:06.00</b>
<b>Time to open existing document in Google Docs (lower is better)</b>		
Run 1	00:10.00	00:21.30
Run 2	00:09.90	00:21.10
Run 3	00:09.80	00:20.90
<b>Median</b>	<b>00:09.90</b>	<b>00:21.10</b>
<b>Time to open 3D model in Design Something app (lower is better)</b>		
Run 1	00:04.80	00:10.20
Run 2	00:04.70	00:10.30
Run 3	00:04.90	00:10.10
<b>Median</b>	<b>00:04.80</b>	<b>00:10.20</b>
<b>Time to open CK-12 Parallel and Perpendicular Lines assessment (lower is better)</b>		
Run 1	00:03.40	00:05.20
Run 2	00:03.60	00:05.40
Run 3	00:03.30	00:05.00
<b>Median</b>	<b>00:03.40</b>	<b>00:05.20</b>
<b>Time to open YouTube (lower is better)</b>		
Run 1	00:01.90	00:05.00
Run 2	00:02.10	00:04.70
Run 3	00:02.10	00:05.00
<b>Median</b>	<b>00:02.10</b>	<b>00:05.00</b>
<b>Time play TED-Ed video (lower is better)</b>		
Run 1	00:03.50	00:07.10
Run 2	00:03.30	00:06.90
Run 3	00:03.10	00:07.10
<b>Median</b>	<b>00:03.30</b>	<b>00:07.10</b>
<b>Total time waiting</b>	<b>00:33.40</b>	<b>01:05.90</b>
<b>Creating an English presentation</b>		
<b>Time to turn on system (lower is better)</b>		
Run 1	00:06.50	00:11.20
Run 2	00:06.50	00:11.30
Run 3	00:06.50	00:11.30
<b>Median</b>	<b>00:06.50</b>	<b>00:11.30</b>
<b>Time to open Google Keep (lower is better)</b>		
Run 1	00:01.80	00:04.50
Run 2	00:01.90	00:04.40
Run 3	00:01.70	00:04.10

	Intel processor-powered HP Chromebook 14	ARM processor-based Chromebook
<b>Median</b>	<b>00:01.80</b>	<b>00:04.40</b>
<b>Time to search Wikipedia (lower is better)</b>		
Run 1	00:02.60	00:05.40
Run 2	00:02.80	00:05.60
Run 3	00:02.80	00:05.30
<b>Median</b>	<b>00:02.80</b>	<b>00:05.40</b>
<b>Time to open new presentation in Google Slides (lower is better)</b>		
Run 1	00:05.50	00:11.50
Run 2	00:05.30	00:11.90
Run 3	00:05.70	00:11.60
<b>Median</b>	<b>00:05.50</b>	<b>00:11.60</b>
<b>Time to open Planetarium app (lower is better)</b>		
Run 1	00:02.20	00:04.80
Run 2	00:02.30	00:04.80
Run 3	00:02.30	00:04.90
<b>Median</b>	<b>00:02.30</b>	<b>00:04.80</b>
<b>Time to open Google Maps (lower is better)</b>		
Run 1	00:02.60	00:05.70
Run 2	00:02.50	00:05.80
Run 3	00:02.70	00:06.00
<b>Median</b>	<b>00:02.60</b>	<b>00:05.80</b>
<b>Time to enter Google Maps Street View (lower is better)</b>		
Run 1	00:02.40	00:05.60
Run 2	00:02.40	00:05.40
Run 3	00:02.40	00:05.70
<b>Median</b>	<b>00:02.40</b>	<b>00:05.60</b>
<b>Time to open existing presentation in Google Slides (lower is better)</b>		
Run 1	00:10.20	00:21.90
Run 2	00:10.40	00:21.90
Run 3	00:10.20	00:22.30
<b>Median</b>	<b>00:10.20</b>	<b>00:21.90</b>
<b>Total time waiting</b>	<b>00:34.10</b>	<b>01:10.80</b>
<b>Teaming up in science class</b>		
<b>Time to open existing spreadsheet in Google Sheets (lower is better)</b>		
Run 1	00:10.70	00:20.40
Run 2	00:10.40	00:20.30
Run 3	00:10.80	00:19.90
<b>Median</b>	<b>00:10.70</b>	<b>00:20.30</b>
<b>Time to open new document in Google Docs (lower is better)</b>		
Run 1	00:03.50	00:07.30
Run 2	00:03.60	00:07.70
Run 3	00:03.60	00:07.50
<b>Median</b>	<b>00:03.60</b>	<b>00:07.50</b>
<b>Time to open PhET Build an Atom simulation (lower is better)</b>		
Run 1	00:02.30	00:05.80
Run 2	00:02.50	00:05.40
Run 3	00:02.50	00:05.30

	Intel processor-powered HP Chromebook 14	ARM processor-based Chromebook
<b>Median</b>	<b>00:02.50</b>	<b>00:05.40</b>
<b>Time to open Useful Periodic Table app (lower is better)</b>		
Run 1	00:01.90	00:03.40
Run 2	00:02.00	00:03.20
Run 3	00:02.00	00:03.40
<b>Median</b>	<b>00:02.00</b>	<b>00:03.40</b>
<b>Time to open YouTube (lower is better)</b>		
Run 1	00:02.10	00:05.10
Run 2	00:02.00	00:04.90
Run 3	00:02.00	00:04.80
<b>Median</b>	<b>00:02.00</b>	<b>00:04.90</b>
<b>Time to play Crash Course video on Chromecast (lower is better)</b>		
Run 1	00:12.60	00:18.90
Run 2	00:12.60	00:18.70
Run 3	00:13.00	00:18.40
<b>Median</b>	<b>00:12.60</b>	<b>00:18.70</b>
<b>Total time waiting</b>	<b>00:33.40</b>	<b>01:00.20</b>
<b>WebGL rendering</b>		
<b>Frames per second while rendering an anatomy simulation (higher is better)</b>		
Run 1	51	26
Run 2	51	28
Run 3	52	27
<b>Median</b>	<b>51</b>	<b>27</b>

Figure 8: Detailed results.



## ABOUT PRINCIPLED TECHNOLOGIES



Principled Technologies, Inc.  
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We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

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Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.

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