INTEL PROCESSOR-POWERED LENOVO THINKPAD 11E CHROMEBOOK FOR EDUCATION

10.1%
LESS WAITING
to read a textbook and take notes online

9.2%
LESS WAITING
to do math homework online

2.5%
LESS WAITING
to create an English presentation

11.9%
LESS WAITING
to team up in science class

35%
MORE FPS
while rendering an anatomy simulation

LESS WAITING, MORE LEARNING.

The Intel® processor-powered Lenovo® ThinkPad® 11e Chromebook™ was faster than the ARM®-based model in every scenario we tested, without sacrificing battery life.

As technology has become integral in the modern classroom, the choice of devices to purchase for students has become more important. Students should be able to grab their devices, start assignments, and switch between tasks and apps quickly. Teachers appreciate this too, as students can spend more class time learning instead of waiting. Slower devices can also frustrate students as they wait on their devices.

Here in the Principled Technologies labs, we looked at the Intel processor-powered Lenovo ThinkPad 11e Chromebook and the new ARM processor-based Samsung® Chromebook 2. We put these two devices through scenarios that included common tasks such as watching videos and taking notes. We looked at how many frames per second they could deliver when rendering an anatomy simulation and how long the devices could run unplugged.

Which Chromebook is the better choice? We found that the Intel processor-powered Lenovo ThinkPad 11e Chromebook delivered up to 11.9 percent less waiting in four student scenarios than the ARM processor-based Samsung Chromebook 2 and 35.0 percent more frames per second (fps) while rendering an anatomy simulation. The Intel processor-powered Lenovo ThinkPad 11e Chromebook delivered without sacrificing battery life, lasting more than 9 hours while Web browsing when unplugged. With the Intel processor-powered Lenovo ThinkPad 11e Chromebook, students can spend less time waiting and more time learning.

LESS WAITING AND MORE LEARNING WITH THE RIGHT CHROMEBOOK

Built to be rugged for the classroom, the Lenovo ThinkPad 11e Chromebook includes a rubber bumper, thicker bezel, stronger rear cover, hinges and brackets, reinforced ports, and a reduced gap between anchored keys.

Students and teachers' time is valuable, and choosing the right Chromebook for the classroom matters. To help with the decision, we looked at two Chromebooks, one with an Intel processor that Lenovo built with durability in mind and one with the latest ARM processor from Samsung, and put them through real world scenarios featuring tasks that students would perform while learning. We also measured how many frames per second each Chromebook could deliver while rendering an anatomy simulation and looked at how long each Chromebook could run unplugged while browsing the Internet. 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, display resolution, amount of storage, and amount of memory. For more information on the two systems, see Appendix A.

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.
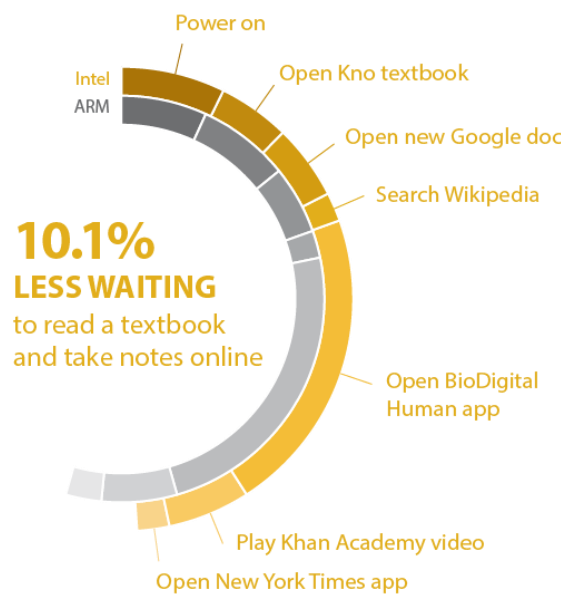
Figure 1: The amount of time spent waiting when using the two Chromebooks in seven tasks related to reading a textbook and to taking notes online.

Intel
ARM

Power on
Open Kno textbook
Open new Google doc
Search Wikipedia

10.1%
LESS WAITING
to read a textbook
and take notes online

Open BioDigital Human app

Play Khan Academy video
Open New York Times app

As Figure 1 shows, the Intel processor-powered Lenovo ThinkPad 11e Chromebook required 10 percent less waiting than the ARM processor-based Samsung Chromebook 2. Mateo wouldn't want to wait over 46 percent longer for the Kno online textbook to open when using the ARM processor-based Samsung Chromebook 2. Instead of waiting longer for the online textbook to open, he could be up and running and working on his assignment.

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.
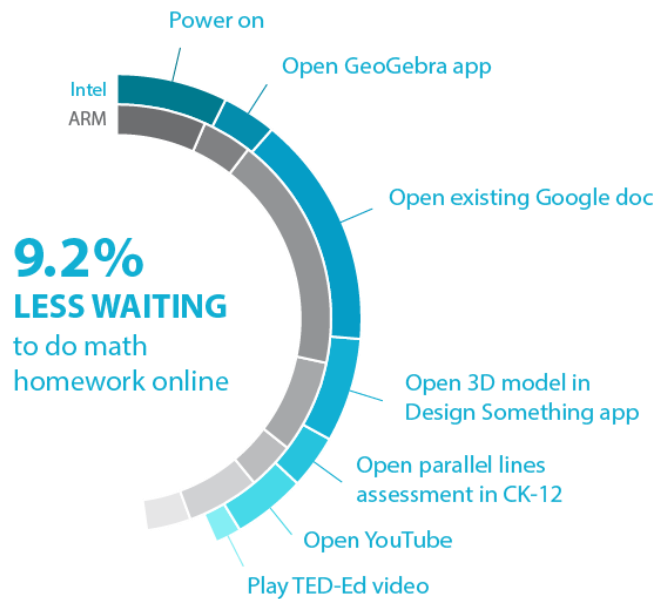
Figure 2: The amount of time spent waiting when using the two Chromebooks in seven tasks related to doing math homework online.

Power on
Open GeoGebra app
Intel
ARM
Open existing Google doc

9.2%
LESS WAITING
to do math
homework online

Open 3D model in Design Something app

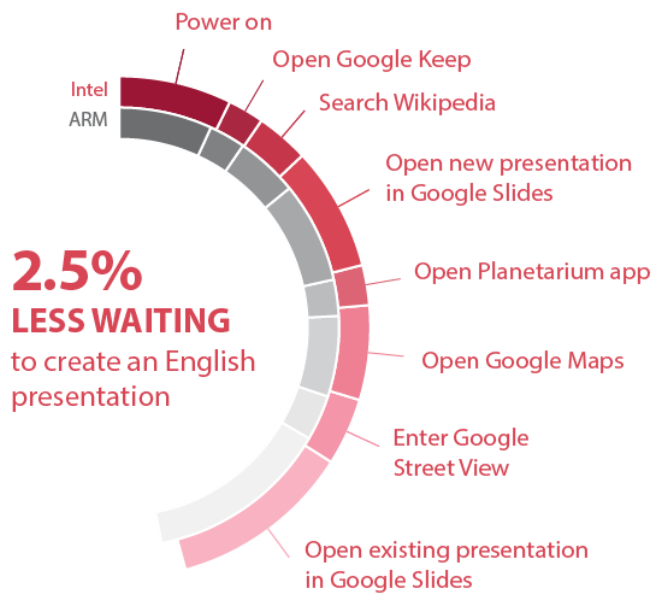Open parallel lines assessment in CK-12

Open YouTube

Play TED-Ed video

As Figure 2 shows, the Intel processor-powered Lenovo ThinkPad 11e Chromebook required 9 percent less waiting than the ARM processor-based Samsung Chromebook 2. Instead of getting frustrated waiting a few seconds 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 Lenovo ThinkPad 11e Chromebook. Madison would also have to wait twice as long to play the TED-Ed video 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.

Figure 3: The amount of time spent waiting when using the two Chromebooks in eight tasks related to creating an English presentation.

Power on
Open Google Keep
Search Wikipedia
Open new presentation in Google Slides
Open Planetarium app
Open Google Maps
Enter Google Street View
Open existing presentation in Google Slides

Intel
ARM

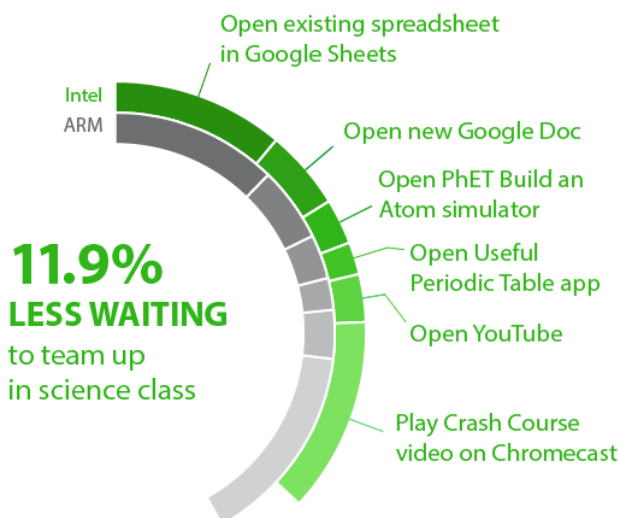**2.5%**
LESS WAITING
to create an English presentation

Ethan would have to wait 34 percent longer to search Wikipedia on the ARM processor-based Samsung Chromebook 2.

As Figure 3 shows, the Intel processor-powered Lenovo ThinkPad 11e Chromebook required more than 2 percent less waiting than the ARM processor-based Samsung Chromebook 2. If Ethan were using the Intel processor-powered Lenovo ThinkPad 11e Chromebook, he wouldn't have to wait a couple seconds longer each time he opens his Google Slides presentation, both at home when he's practicing or in class when he's presenting. Ethan would have to wait 34 percent longer just to search Wikipedia on the ARM processor-based Samsung Chromebook 2.

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™.

Figure 4: The amount of time spent waiting when using the two Chromebooks in six tasks related to teaming up in science class.

Intel
ARM

Open existing spreadsheet in Google Sheets

Open new Google Doc

Open PhET Build an Atom simulator

Open Useful Periodic Table app

Open YouTube

Play Crash Course video on Chromecast

11.9%
LESS WAITING
to team up
in science class

Google Docs, Google Sheets, Useful Periodic Table, and YouTube would all take less time to open if Jada were using the Intel processor-powered Lenovo ThinkPad 11e Chromebook.

As Figure 4 shows, the Intel processor-powered Lenovo ThinkPad 11e Chromebook required 11 percent less waiting than the ARM processor-based Samsung Chromebook 2. This means that if Jada were using the Intel processor-powered Lenovo ThinkPad 11e 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. Each app Jada would use in science class—Google Docs, Google Sheets, Useful Periodic Table, YouTube—would take less time to open on the Intel processor-powered Lenovo ThinkPad 11e Chromebook.

RENDERING AN ANATOMY SIMULATION

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™,[1] 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 Lenovo ThinkPad 11e Chromebook delivered 35 percent more frames per second than the ARM processor-based Samsung Chromebook 2 while rendering the digestive system (see Figure 5).
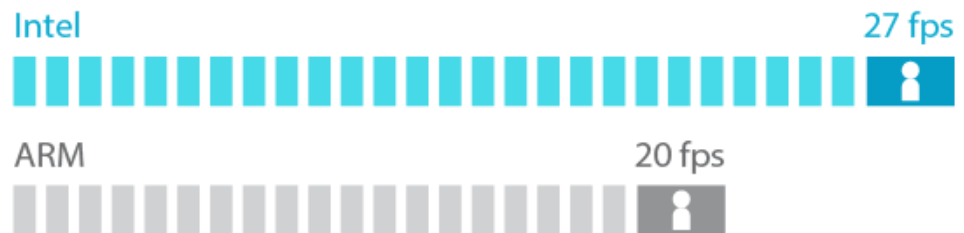

Figure 5: The amount of time spent waiting when using the two Chromebooks in six tasks related to teaming up in science class.

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 both systems lasted over 9 hours unplugged while browsing the Internet. This means the Intel processor-powered Lenovo ThinkPad 11e Chromebook can deliver less waiting in the classroom than the ARM processor-based Samsung Chromebook 2 without sacrificing battery life.

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[1] WebGL and the WebGL logo are trademarks of the Khronos Group Inc.

THE BOTTOM LINE

The longer students have to wait on devices to open apps or documents, the more likely they can become distracted or frustrated. These longer wait times can mean more time to complete assignments in the classroom or at home. For teachers, this can mean students that are less engaged in the classroom.

Which Chromebook model is the better choice for students? We put two Chromebook models to the test, and found the Intel processor-powered Lenovo ThinkPad 11e Chromebook delivered less waiting than the ARM processor-based Samsung Chromebook 2 and more frames per second while rendering an anatomy simulation. The Intel processor-powered Lenovo ThinkPad 11e Chromebook did so without sacrificing battery life, with both systems lasting more than 9 hours unplugged while browsing the Internet. This report card has good news: With the Intel processor-powered Lenovo ThinkPad 11e Chromebook, students can wait less and have more time for learning.

APPENDIX A: DETAILED SYSTEM CONFIGURATION

Figure 6 presents detailed information on the two Chromebooks we tested.

System	Intel processor-powered Lenovo ThinkPad 11e Chromebook	ARM processor-based Samsung Chromebook 2
Vendor and model	Lenovo 20DB-0007US Chromebook	Samsung® XE503C12-K01US Chromebook
Processor	Intel Celeron® Processor N2930 (Bay Trail-M)	Samsung Exynos 5 Octa 5420
Processor frequency (GHz)	1.83	1.3 Quad + 1.9 Quad
Processor cores	4	4 + 4
Memory	4GB DDR3L SDRAM	4GB DDR3L SDRAM
Storage	16GB SSD	16GB SSD
Battery type	4-cell Li-Polymer	2 cell Li-Polymer
Battery capacity	35 Wh	30 Wh
Display	11.6" (1,366 x 768)	11.6" (1,366 x 768)
Wireless	802.11ac (802.11 a/b/g/n compatible)	802.11ac (802.11 a/b/g/n compatible)
Bluetooth	4.0	4.0
USB ports	1 x USB 3.0 1 x USB 2.0	1 x USB 3.0 1 x USB 2.0
System weight	3.1 lbs.	2.7 lbs.
OS	Chrome OS version 35.0.1916.155	Chrome OS version 35.0.1916.155
Firmware	Google_Glimmer.5216.198.4	Google_Peach_Pit.4482.94.0

Figure 6: 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. 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. Simultaneously start the timer and open Street View by selecting the Street View button.
1. When Street View is fully displayed, stop the timer, and record the result.
24. Open the Chrome tab for the presentation.
25. Close the Chrome tab.
26. Simultaneously start the timer and open Google Drive from the apps list.
27. Open the existing presentation.
28. When the presentation is fully displayed, stop the timer, and record the result.

29. Repeat steps 1 through 28 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.

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.

APPENDIX C: DETAILED RESULTS

Figure 7 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 Lenovo ThinkPad 11e Chromebook	ARM processor-based Samsung Chromebook 2
Reading a textbook and taking notes online		
Time to turn on system (lower is better)		
Run 1	00:08.70	00:08.20
Run 2	00:08.70	00:08.20
Run 3	00:08.70	00:08.20
Median	**00:08.70**	**00:08.20**
Time to open Kno textbook (lower is better)		
Run 1	00:06.00	00:08.80
Run 2	00:06.10	00:08.80
Run 3	00:06.00	00:08.20
Median	**00:06.00**	**00:08.80**
Time to open new document in Google Docs (lower is better)		
Run 1	00:06.50	00:06.50
Run 2	00:06.30	00:06.60
Run 3	00:06.30	00:06.40
Median	**00:06.30**	**00:06.50**
Time to search Wikipedia (lower is better)		
Run 1	00:02.40	00:02.60
Run 2	00:02.40	00:02.60
Run 3	00:02.40	00:02.60
Median	**00:02.40**	**00:02.60**
Time to open BioDigital Human app (lower is better)		
Run 1	00:25.70	00:28.50
Run 2	00:25.60	00:28.60
Run 3	00:25.80	00:28.70
Median	**00:25.70**	**00:28.60**
Time to play Khan Academy video (lower is better)		
Run 1	00:07.00	00:07.30
Run 2	00:06.90	00:07.20
Run 3	00:06.90	00:07.20
Median	**00:06.90**	**00:07.20**
Time to open New York Times app (lower is better)		
Run 1	00:02.70	00:03.40
Run 2	00:02.80	00:03.30
Run 3	00:02.70	00:03.40
Median	**00:02.70**	**00:03.40**
Total time waiting	**00:58.70**	**01:05.30**

	Intel processor-powered Lenovo ThinkPad 11e Chromebook	ARM processor-based Samsung Chromebook 2
Doing math homework online		
Time to turn on system (lower is better)		
Run 1	00:08.80	00:08.10
Run 2	00:08.80	00:08.10
Run 3	00:08.80	00:08.30
Median	**00:08.80**	**00:08.10**
Time to open GeoGebra app (lower is better)		
Run 1	00:04.20	00:04.50
Run 2	00:04.30	00:04.60
Run 3	00:04.20	00:04.50
Median	**00:04.20**	**00:04.50**
Time to open existing document in Google Docs (lower is better)		
Run 1	00:18.70	00:21.60
Run 2	00:18.50	00:21.00
Run 3	00:18.70	00:21.40
Median	**00:18.60**	**00:21.40**
Time to open 3D model in Design Something app (lower is better)		
Run 1	00:08.10	00:08.40
Run 2	00:08.50	00:08.40
Run 3	00:08.30	00:08.40
Median	**00:08.30**	**00:08.40**
Time to open CK-12 Parallel and Perpendicular Lines assessment (lower is better)		
Run 1	00:04.10	00:04.30
Run 2	00:04.20	00:04.30
Run 3	00:04.20	00:04.35
Median	**00:04.20**	**00:04.30**
Time to open YouTube (lower is better)		
Run 1	00:05.90	00:06.60
Run 2	00:05.80	00:06.70
Run 3	00:05.90	00:06.60
Median	**00:05.90**	**00:06.60**
Time to play TED-Ed video (lower is better)		
Run 1	00:02.00	00:04.00
Run 2	00:02.00	00:03.90
Run 3	00:02.00	00:04.10
Median	**00:02.00**	**00:04.00**
Total time waiting	**00:52.00**	**00:57.30**
Creating an English presentation		
Time to turn on system (lower is better)		
Run 1	00:08.70	00:08.10
Run 2	00:08.70	00:08.20
Run 3	00:08.70	00:08.20
Median	**00:08.70**	**00:08.20**

	Intel processor-powered Lenovo ThinkPad 11e Chromebook	ARM processor-based Samsung Chromebook 2
Time to open Google Keep (lower is better)		
Run 1	00:02.80	00:03.20
Run 2	00:02.80	00:03.20
Run 3	00:02.80	00:03.20
Median	**00:02.80**	**00:03.20**
Time to search Wikipedia (lower is better)		
Run 1	00:04.00	00:05.60
Run 2	00:04.10	00:05.50
Run 3	00:04.10	00:05.50
Median	**00:04.10**	**00:05.50**
Time to open new presentation in Google Slides (lower is better)		
Run 1	00:09.60	00:09.00
Run 2	00:09.60	00:08.90
Run 3	00:09.60	00:08.90
Median	**00:09.60**	**00:08.90**
Time to open Planetarium app (lower is better)		
Run 1	00:03.10	00:03.20
Run 2	00:03.10	00:03.20
Run 3	00:03.10	00:03.20
Median	**00:03.10**	**00:03.20**
Time to open Google Maps (lower is better)		
Run 1	00:07.30	00:07.20
Run 2	00:07.50	00:07.10
Run 3	00:07.30	00:07.10
Median	**00:07.30**	**00:07.10**
Time to enter Google Maps Street View (lower is better)		
Run 1	00:05.00	00:04.10
Run 2	00:05.20	00:04.00
Run 3	00:05.20	00:04.00
Median	**00:05.20**	**00:04.00**
Time to open existing presentation in Google Slides (lower is better)		
Run 1	00:14.10	00:16.20
Run 2	00:14.10	00:16.00
Run 3	00:14.20	00:16.20
Median	**00:14.10**	**00:16.20**
Total time waiting	**00:54.90**	**00:56.30**
Teaming up in science class		
Time to open existing spreadsheet in Google Sheets (lower is better)		
Run 1	00:13.50	00:14.50
Run 2	00:13.30	00:14.70
Run 3	00:13.30	00:14.70
Median	**00:13.30**	**00:14.70**

	Intel processor-powered Lenovo ThinkPad 11e Chromebook	ARM processor-based Samsung Chromebook 2
Time to open new document in Google Docs (lower is better)		
Run 1	00:06.20	00:06.60
Run 2	00:06.20	00:06.60
Run 3	00:06.10	00:06.60
Median	**00:06.20**	**00:06.60**
Time to open PhET Build an Atom simulation (lower is better)		
Run 1	00:03.50	00:03.90
Run 2	00:03.50	00:03.90
Run 3	00:03.50	00:03.90
Median	**00:03.50**	**00:03.90**
Time to open Useful Periodic Table app (lower is better)		
Run 1	00:02.50	00:02.80
Run 2	00:02.50	00:02.80
Run 3	00:02.50	00:02.80
Median	**00:02.50**	**00:02.80**
Time to open YouTube (lower is better)		
Run 1	00:03.70	00:04.10
Run 2	00:03.60	00:04.30
Run 3	00:03.70	00:04.30
Median	**00:03.70**	**00:04.30**
Time to play Crash Course video on Chromecast (lower is better)		
Run 1	00:15.10	00:18.00
Run 2	00:15.20	00:18.00
Run 3	00:15.00	00:17.90
Median	**00:15.10**	**00:18.00**
Total time waiting	**00:44.30**	**00:50.30**
Rendering an anatomy simulation		
Frames per second while rendering an anatomy simulation (higher is better)		
Run 1	27	21
Run 2	27	20
Run 3	27	20
Median	**27**	**20**
Battery life while browsing		
Battery life while lightly browsing the Internet (higher is better)		
Run 1	08:59:00.00	09:12:00.00
Run 2	09:01:00.00	09:07:00.00
Run 3	09:02:00.00	09:05:00.00
Median	**09:01:00.00**	**09:07:00.00**

Figure 7: Detailed results.

ABOUT PRINCIPLED TECHNOLOGIES

![Principled Technologies® logo]

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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.

When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

We provide customized services that focus on our clients' individual requirements. Whether the technology involves hardware, software, Web sites, or services, we offer the experience, expertise, and tools to help our clients assess how it will fare against its competition, its performance, its market readiness, and its quality and reliability.

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.