



## Refresh your Chromebooks™ to give students more time for learning

### New Chromebooks powered by Intel can save time in the classroom

Using technology in the classroom can make learning come alive. But if your school bought its Chromebooks three years ago, your tech might be lagging behind the newer, faster options on the market. Investing in new Chromebooks with Intel® processors could improve the everyday classroom experience for teachers and students alike.

To quantify those improvements, Principled Technologies compared a new Intel®-powered Chromebook\* against a representative three-year-old Chromebook. We found that the new Chromebook could cut wait times by up to 49 percent compared to the older system, helping students work with fewer interruptions. The new Chromebook powered by Intel also had a much longer battery life, which could let your students work anytime and anywhere for more hours before needing to plug in.

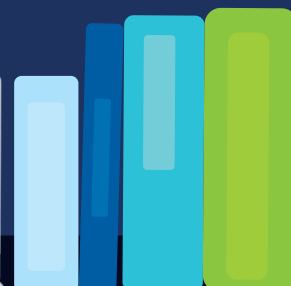
With these advantages, your students can get more time to learn, and teachers can move through lesson plans with fewer interruptions.



up to  
**49%**  
less  
waiting



**85%**  
longer  
battery life



## Creating classroom scenarios for testing

Here at Principled Technologies, we ran four classroom scenarios on both the older Chromebook and the new Chromebook powered by Intel. Our goal was to approximate the kinds of things that students do in their classes every day. We included G Suite for Education apps, such as Google Sheets™ and Google Docs™; media creation apps, such as WeVideo and Autodesk® Pixlr® Editor; and educational apps for multiple subjects, such as PhET® Build an Atom and Planetarium. We also ran a comprehensive battery life test.

Though our scenarios are representative of real classroom work, they capture just a small part of a school day. Students could repeat some of the tasks many times during a class. In this way, the small time savings we saw with an Intel-powered Chromebook can add up quickly. If a student saves five seconds on a task that she does eight or ten times per class, she might gain over a minute of extra time for learning on that task alone.

For system configuration, see [Appendix A](#). For test methodologies, see [Appendix B](#). For complete results, see [Appendix C](#).

No matter how careful your students are, they're still kids, and they're bound to drop, scratch, or spill liquid on their Chromebooks from time to time. Over several years, that wear and tear can add up. With a new Chromebook fresh out of the box, you're guaranteed a reset on any damage. There's no chance that the device won't function because a student has dropped it one too many times.



### Time-saving tasks in Geometry

- Turn on the Chromebook
- Open existing doc in Google Docs
- Search for an image in Google™ Search
- Open PDF
- Open Onshape® CAD app
- Create new workspace in Onshape

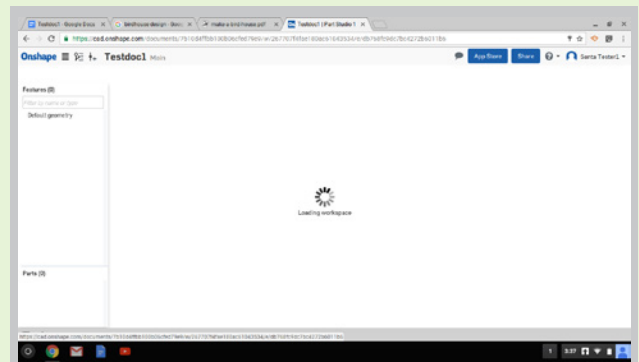
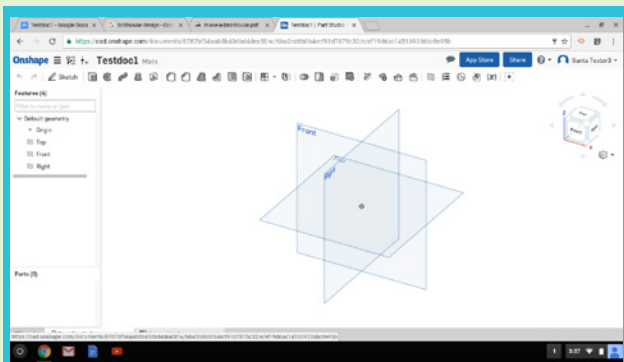
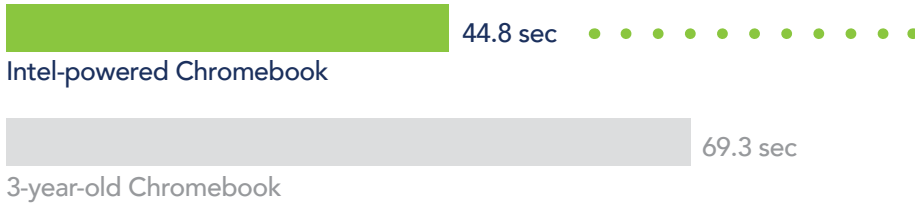
## Spend less time waiting to build geometry knowledge



The subject of today's math class is 3D shapes, with each student designing a house made of geometric shapes and calculating its surface area. After turning on their Chromebooks, students open up their planning documents, search for architecture ideas, and open the geometry help guide. Then, they open their CAD apps and create new workspaces to start building.

Compared to a student using the new Intel-powered Chromebook, students using the older Chromebook would have to deal with longer wait times at every step. On some tasks, they'd have to wait more than seven seconds longer to accomplish the same thing.

When students' Chromebooks work quickly, they can provide a better user experience while minimizing the chance of students getting distracted during long wait times. By upgrading to the new Intel-powered Chromebook, you could gain back precious seconds of instructional time.



To take these screenshots, we opened Onshape on both Chromebooks at the same time. When it had fully loaded on the Intel-powered Chromebook (left), it was still loading on the 3-year-old Chromebook (right).

## Create a video without long loading times



In today's English class, students are working in groups to create a video interpretation of a short story they studied. They turn

on their Chromebooks and open a new document along with the e-textbook containing the story. Then, they search Wikipedia for background information on the story's setting before opening WeVideo and creating a new video project. They find an opening image on Flickr and open it in Pixlr Editor to add titles.

If this class were equipped with the new Intel-powered Chromebooks, they'd encounter much shorter delays than a class still using their older Chromebooks. Doing exactly the same tasks, the students with the older versions would spend 22 seconds waiting that they could be using to focus on their work. That might not seem like a lot, but those lost seconds can add up and cost serious classroom time.

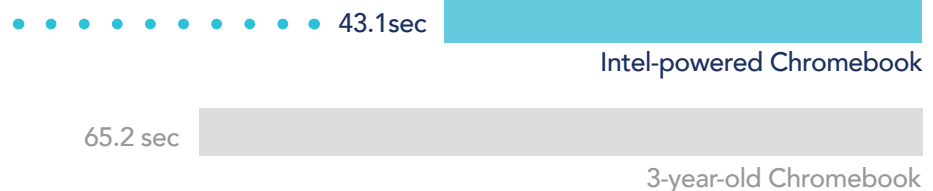
### Time-saving tasks in English

- Turn on the Chromebook
- Open new doc in Google Docs
- Open CourseSmart eTextbooks bookshelf
- Search Wikipedia®
- Open WeVideo app
- Create new video project in WeVideo
- Search for image on Flickr®
- Open Autodesk Pixlr Editor app**
- Load image into Pixlr Editor



**49%**  
less waiting  
to open Pixlr Editor

**33%**  
less waiting  
overall



### Time-saving tasks in US. History

- Turn on the Chromebook
- Open Google Keep™
- Open new presentation in Google Slides**
- Open Planetarium app
- Open Google Maps™
- Enter Google Maps Street View

## Design a presentation with less wait time



U.S. History students are learning about the historical method in today's class.

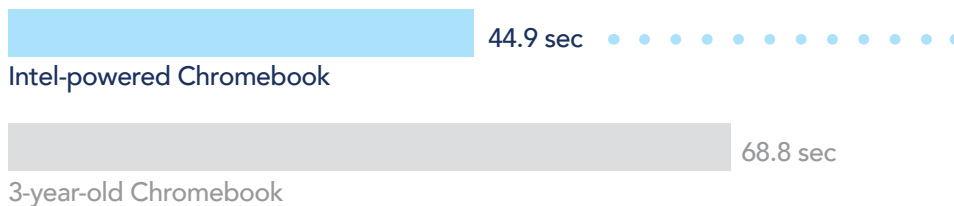
The teacher has devised a project in which they'll act as historians, creating a presentation about a recent event in their community. One student is focusing on the 50th anniversary celebration of the science museum near her home.

She turns on her Chromebook and opens up her notes about the celebration before opening a slide deck to start organizing her thoughts. At the event, she was able to look at the night sky through a real telescope, so she pulls up the Planetarium app to take a screenshot of the way the stars looked that night. She also pulls up Google Maps Street View so she can take a screenshot of the museum itself.

This student is using a new Chromebook, which turns on 4 seconds faster and opens a new presentation almost 10 seconds faster than the older system. With her new Intel-powered Chromebook, this student can make concrete progress on her presentation while a student with the older Chromebook would be still waiting. Students aren't learning when they're staring at load screens, and the more seconds they spend waiting, the fewer they have for their classwork.



**41%**  
**less waiting**  
to open a new presentation



**34%**  
**less waiting**  
**overall**

## Wait less time while investigating the elements



Students in today's Chemistry class have a study period to research and report on an element in the periodic table. They open up their spreadsheets of research and new documents for notes before diving into the PhET Build an Atom simulation. They also reference the Periodic Table app and watch a video their teacher recommended.

Yet again, students completing these tasks with the older Chromebook would have to spend more time waiting than students with the new Intel-powered Chromebook. Both the spreadsheet and the document would take seven seconds longer to open, which can feel like a long time when you just want to get started. With the Intel-powered Chromebook, you can minimize the amount of time students spend waiting, offering them a better experience and creating an engaging learning environment.

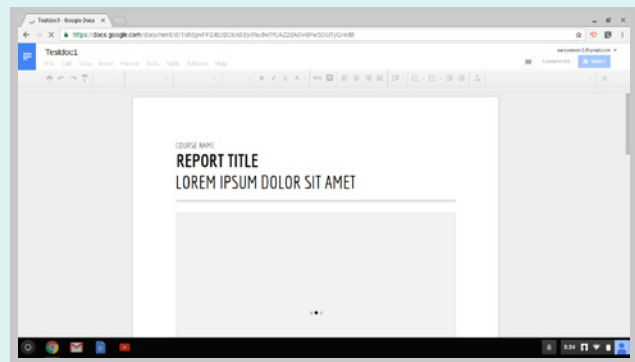
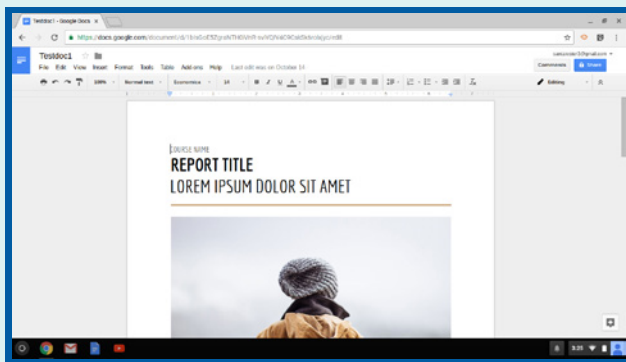
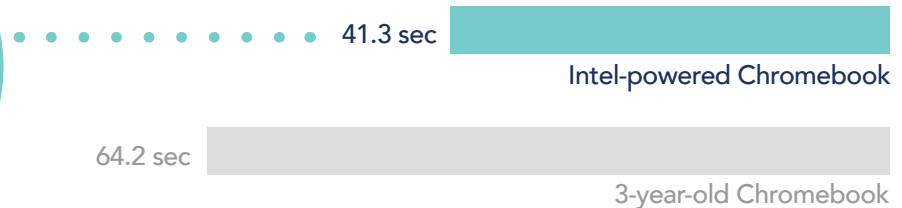
### Time-saving tasks in Chemistry

- Open existing spreadsheet in Google Sheets
- Open new doc in Google Docs**
- Start PhET Build an Atom simulation
- Open ChemReference: Periodic Table app
- Open YouTube™



**40%**  
less waiting  
to open a new document

**35%**  
less waiting  
overall



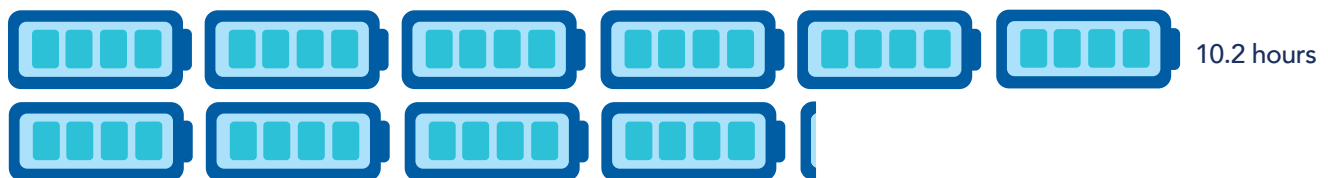
To take these screenshots, we opened Google Docs on both Chromebooks at the same time. When it had fully loaded on the Intel-powered Chromebook (left), it was still loading on the 3-year-old Chromebook (right).

## Get more opportunities for productivity with a longer battery life

Nothing interrupts a student's work like a laptop dying. It's one thing to have to wait for an app to load; it's another to have to stop learning entirely to get up in the middle of class, find an outlet, plug in, and sit back down. Depending on the classroom, the student may have to move seats to charge his or her Chromebook or leave a cord strung across the room, creating a tripping hazard. Schools can help students and teachers avoid these problems by choosing Chromebooks with long battery lives.

The older Chromebook we tested had a battery life of under six hours, but the average length of an American school day is just over six and a half hours.<sup>1</sup> If students with these older Chromebooks start with a full charge and use their laptops in every class, they may not make it through the school day without needing to plug in.

In contrast, the new Intel-powered Chromebook lasted over 10 hours in our testing. That means that if students charge their devices overnight, they'll easily last the entire school day, so they never have to worry about plugging in. Not only that, but they'll likely have several more hours of battery life available after school. Since they're not tethered to an outlet, they can work on homework while waiting for a rehearsal to start, watching a sibling's soccer game, or riding in the car on the way to a piano lesson.



Intel-powered Chromebook



3-year-old Chromebook



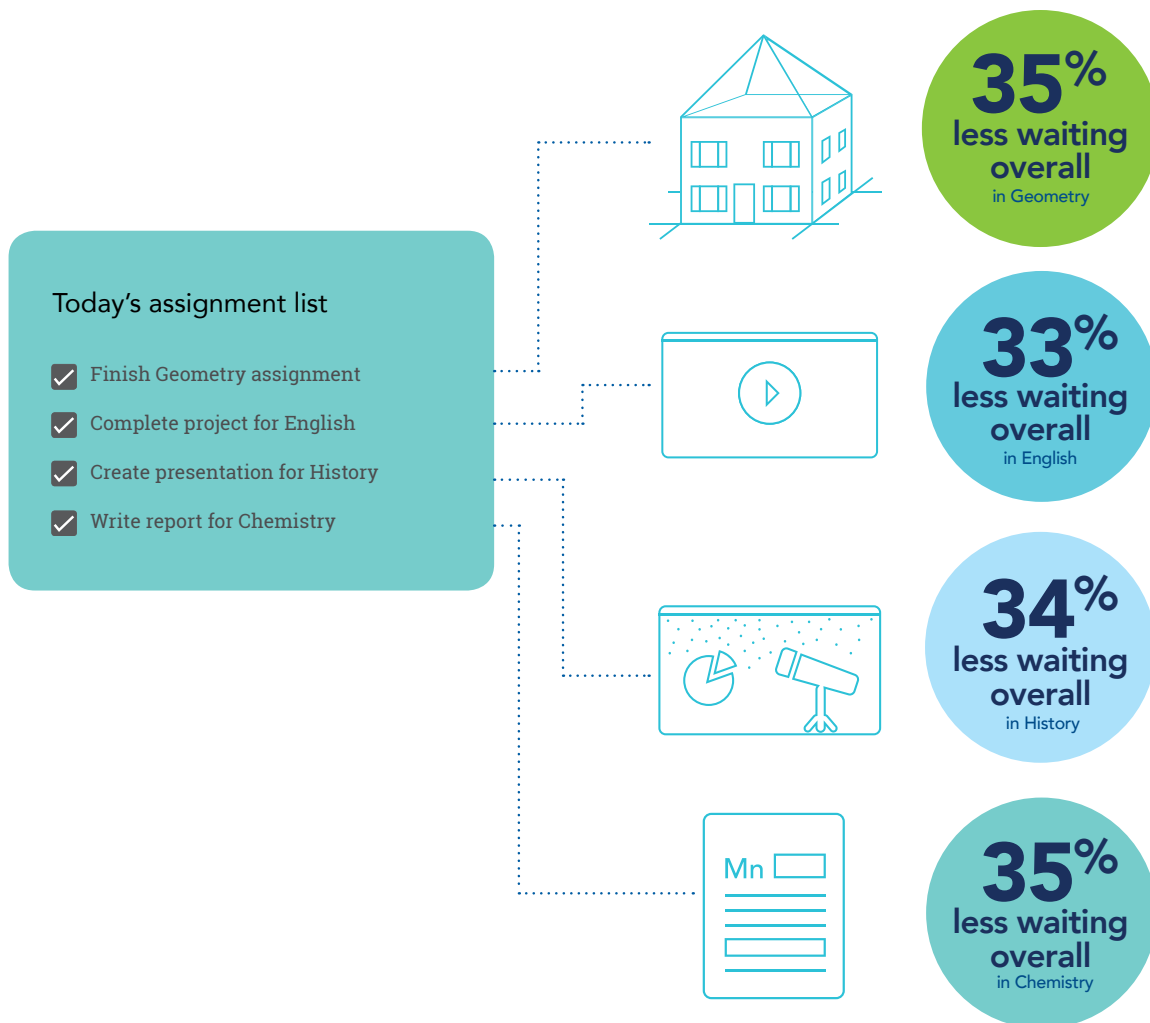
Every year, schools have new technologies available to them: new kinds of devices, innovative new applications, and new capabilities and features on familiar devices or apps. In September 2016, Google introduced support for Android apps on Chromebooks.<sup>2</sup> Because Android apps are optimized for touch, this new capability is especially useful for Chromebooks with touchscreens, such as the Intel-powered Chromebook we tested. With this Chromebook, teachers can build lessons that incorporate popular Android apps for education, such as Khan Academy and Duolingo. Students can download these apps easily through the Google Play store. As of this paper's publication, only two Chromebooks on the market supported this capability, and the older Chromebook we tested wasn't one of them.<sup>3</sup>

## Conclusion

Your students' Chromebooks are a teaching tool, and the best teaching tools are the ones that help create a more engaging, productive classroom. If students completed each of our testing scenarios once every school day—and they'd likely run through several of the tasks more often than once per day—students with the old Chromebooks would have spent 4.6 more hours waiting than students with the new Chromebooks at the end of the school year. That's over two-thirds of an entire school day...wasted. With only 180 days in the average school year and an enormous amount of content to teach, you can't afford to lose two-thirds of a day to old technology.

Students with the new Intel-powered Chromebook are also likely to have several more hours of battery life available at the end of the school day. While kids with older Chromebooks might have to find an outlet to keep working after school, students with new Intel-powered Chromebooks could start on their homework any time and anywhere.

To reclaim time for learning, consider upgrading your three-year-old Chromebooks to new Intel-powered Chromebooks.



1 [https://nces.ed.gov/surveys/sass/tables/sass0708\\_035\\_s1s.asp](https://nces.ed.gov/surveys/sass/tables/sass0708_035_s1s.asp)

2 [https://googlechromereleases.blogspot.com/2016/09/stable-channel-update-for-chrome-os\\_21.html](https://googlechromereleases.blogspot.com/2016/09/stable-channel-update-for-chrome-os_21.html)

3 <https://sites.google.com/a/chromium.org/dev/chromium-os/chrome-os-systems-supporting-android-apps>



On October 14, 2016, we finalized the hardware and software configurations we tested. Updates for current and recently released hardware and software appear often, so unavoidably these configurations may not represent the latest versions available when this report appears. For older systems, we chose configurations representative of typical purchases of those systems. We concluded hands-on testing on November 2, 2016.

## Appendix A: System configuration information

System	New Intel-powered Chromebook	3-year-old Chromebook
Vendor and model	Acer® Chromebook R 11	Samsung® Chromebook
Processor	Intel Celeron® Processor N3160	Samsung Exynos 5 Dual
Processor frequency (GHz)	1.6	1.7
Processor cores	4	2
Memory	2GB DDR3L SDRAM	2GB DDR3L SDRAM
Storage	16GB SSD	16GB SSD
Battery type	3-cell Li-Ion	2 cell Li-Polymer
Battery capacity	32 Wh	30 Wh
Display	11.6" (1,366 × 768)	11.6" (1,366 × 768)
Wireless	802.11ac	802.11n
Bluetooth	Bluetooth 4.0 compatible	Bluetooth 3.0 compatible
USB ports	2 × USB 3.0 1 × USB 2.0	2 × USB 3.0 1 × USB 2.0
System weight	2.7 lbs.	2.42 lbs.
OS	Chrome OS version 53.0.2785.154	Chrome OS version 53.0.2785.154
Firmware	Google_Cyan.7287.57.82	Google_Snow.2695.117.0

## Appendix B: How we tested

In our testing, we performed a variety of real-world tasks, including searching for terms, opening PDFs, opening videos, and more. We used specific search terms and opened specific files, which we recount in the methodologies in this section. We treat these actions as representative of the generic action “search for a term,” “open a PDF,” and so on.

In order to construct unique, real-world scenarios for our hypothetical students Abigail and Salma, we have altered some of the specific hypothetical search terms and files in the stories we tell in this report. We have not altered the actions themselves in any way; our hypothetical students are performing the same tasks we performed in our testing.

### Collaborating in geometry

1. Simultaneously start the timer and open the lid to 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 Google Docs from the app shelf.
5. Open the existing document.
6. When the document is fully displayed, stop the timer, and record the result.
7. Open Google Search from the apps list.
8. Type `birdhouse design`.
9. Simultaneously start the timer and click Images.
10. When all images are displayed, stop the timer, and record the result.
11. Press Ctrl+T to open a new Chrome tab.
12. Type `birdhouse construction basics virginia` and press Enter.
13. Simultaneously start the timer and open the Make a Birdhouse PDF link from [www.dgif.virginia.gov](http://www.dgif.virginia.gov)
14. When the PDF is fully displayed, stop the timer, and record the result.
15. Simultaneously start the timer and open the Onshape app from the apps list.
16. When the dashboard is fully displayed, stop the timer, and record the result.
17. Select Create to create a new workspace.
18. Enter a document name.
19. Simultaneously start the timer and select OK to create the workspace.
20. When the workspace is fully displayed, stop the timer, and record the result.
21. Repeat steps 1 through 20 two more times.

### Making a video in English

1. Simultaneously start the timer and open the lid to 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 Google Docs from the shelf.
5. Select the Blank document template to create a new document.
6. When the document is fully displayed, stop the timer, and record the result.
7. Simultaneously start the timer and open the CourseSmart eTextbooks app from the apps list.
8. Select Launch Bookshelf.
9. When the Bookshelf is fully displayed, stop the timer, and record the result.
10. Press Ctrl+T to open a new Chrome tab.
11. Type `wikipedia.org` and press Enter.
12. Type `Boston Tea Party`, and simultaneously start the timer and press Enter.
13. When the Wikipedia page is fully displayed, stop the timer, and record the result.
14. Open the Chrome tab for the Google Docs document.
15. Simultaneously start the timer and open the WeVideo app from the apps list.
16. When the dashboard is fully displayed, stop the timer, and record the result.
17. Simultaneously start the timer and select Create New to create a new project.
18. When the video editor is fully displayed, stop the timer, and record the result.
19. Press Ctrl+T to open a new Chrome tab.
20. Type `flickr.com` and press Enter.
21. In the search bar, type `Boston Tea Party Museum`

22. Simultaneously start the timer and press Enter.
23. When all the images have fully loaded, stop the timer, and record the result.
24. Scroll down and find Boston Tea Party Museum by al tittle.
25. Select the image.
26. Select the download arrow, and select Original to download the image.
27. Open the Pixlr Editor app from the apps list.
28. Select Open Image From Computer.
29. Select the image.
30. Simultaneously start the timer and select Open.
31. When the image is fully displayed, stop the timer, and record the result.
32. Repeat steps 1 through 31 two more times.

## Designing a presentation in history

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. Select the Google Keep Chrome extension to create a note.
8. For the Title, type Test.
9. Simultaneously start the timer and open Google Keep from the apps list.
10. When Google Keep is fully displayed, stop the timer, and record the result.
11. Simultaneously start the timer and open Google Slides from the apps list.
12. Select the blank presentation template to open a new presentation.
13. When the presentation loads is fully displayed, stop the timer, and record the result.
14. Simultaneously start the timer and open the Planetarium app from the apps list.
15. When the Planetarium app is fully displayed, stop the timer, and record the result.
16. Open the Chrome tab for the presentation.
17. Simultaneously start the timer and open Google Maps from the apps list.
18. When Google Maps is fully displayed, stop the timer, and record the result.
19. Type `Verona, Italy`, and press Enter.
20. Simultaneously start the timer and select the first photo to enter Street View.
21. When Street View is fully displayed, stop the timer, and record the result.
22. Repeat steps 1 through 21 two more times.

## Working on a report in chemistry

1. Open the lid to resume from sleep.
2. Simultaneously start the timer and open Google Sheets.
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.
6. Select the Blank document template to create a new document.
7. When the document is fully displayed, stop the timer, and record the result.
8. Press `Ctrl+T` to open a new Chrome tab.
9. Type `phet.colorado.edu/en/simulations/category/html`, and press Enter.
10. Open the Build an Atom simulation.
11. Simultaneously start the timer and select the play button to start the simulation.
12. When the simulation is fully displayed, stop the timer, and record the result.
13. Simultaneously start the timer and open the ChemReference: Periodic Table app from the apps list.

14. When the ChemReference: Periodic Table app is fully displayed, stop the timer, and record the result.
15. Open the Chrome tab for the simulation.
16. Simultaneously start the timer and open YouTube from the shelf.
17. When YouTube is fully displayed, stop the timer, and record the result.
18. Repeat steps 1 through 17 two more times.

## Measuring battery life

1. Use the brightness meter to set each screen as close as possible to 160 nits.
2. Open Google Chrome from the shelf, and open the following tabs:
  - a. Gmail Inbox
  - b. Google Docs, with "Resume" template loaded
  - c. Google Sheets, with "Monthly Budget" template loaded
  - d. Google Slides, with "Pitch" template loaded
3. Leave the Chromebooks open on the Google Docs tab.
4. Start the video recording.
5. Simultaneously start the timer, and disconnect the Chromebooks from their power sources.
6. After both Chromebooks have been fully discharged, review the video to determine when each Chromebook powered off.
7. Fully charge the Chromebooks.
8. Repeat steps 1 through 7 two more times.

## Appendix C: Complete results for scenario testing

Task	New Intel-powered Chromebook	3-year-old Chromebook	Percentage improvement with new Chromebook
<b>Collaborating in a classroom</b>			
Turn on system	9.56	13.72	30%
Open existing document in Google Docs	13.56	21.25	36%
Search for image in Google Search	1.50	2.78	46%
Open PDF document	4.29	5.58	23%
Open Onshape CAD app	5.90	8.89	33%
Create new workspace in Onshape app	9.98	17.10	41%
<b>Total time waiting</b>	<b>44.79</b>	<b>69.32</b>	<b>35%</b>
<b>Making a video</b>			
Turn on system	9.56	13.72	30%
Open new document in Google Docs	10.84	18.06	40%
Open CourseSmart eTextbooks bookshelf	7.68	12.12	36%
Search Wikipedia	1.50	2.74	45%
Open WeVideo app	3.53	6.44	45%
Create new video project in WeVideo app	5.22	6.53	20%
Search for image on Flickr	2.28	2.98	23%
Open Pixlr Editor	3.28	6.54	49%
Load image into Pixlr Editor	2.44	2.65	7%
<b>Total time waiting</b>	<b>43.05</b>	<b>65.24</b>	<b>34%</b>
<b>Creating a presentation</b>			
Turn on system	9.56	13.72	30%
Open Google Keep	8.36	11.69	28%
Open new presentation in Google Slides	13.69	23.56	41%
Open Planetarium app	3.22	4.88	34%
Open Google Maps	6.67	10.10	34%
Enter Google Maps Street View	3.44	4.80	28%
<b>Total time waiting</b>	<b>44.94</b>	<b>68.75</b>	<b>34%</b>

Task	New Intel-powered Chromebook	3-year-old Chromebook	Percentage improvement with new Chromebook
<b>Teaming up in science class</b>			
Open existing spreadsheet in Google Sheets	15.92	23.53	32%
Open new document in Google Docs	10.72	17.97	40%
Start PhET Build an Atom simulation	3.53	5.64	37%
Open ChemReference: Periodic Table app	4.28	5.88	27%
Open YouTube	6.87	11.16	38%
<b>Total time waiting</b>	<b>41.32</b>	<b>64.18</b>	<b>35%</b>

Table 1: For columns 1 and 2, lower numbers are better, and times are measured in seconds. For column 3, higher numbers are better.

This project was commissioned by Intel Corp.



**Facts matter.®**

Principled Technologies is a registered trademark of Principled Technologies, Inc. All other product names are the trademarks of their respective owners.

**DISCLAIMER OF WARRANTIES; LIMITATION OF LIABILITY:**

Principled Technologies, Inc. has made reasonable efforts to ensure the accuracy and validity of its testing, however, Principled Technologies, Inc. specifically disclaims any warranty, expressed or implied, relating to the test results and analysis, their accuracy, completeness or quality, including any implied warranty of fitness for any particular purpose. All persons or entities relying on the results of any testing do so at their own risk, and agree that Principled Technologies, Inc., its employees and its subcontractors shall have no liability whatsoever from any claim of loss or damage on account of any alleged error or defect in any testing procedure or result.

In no event shall Principled Technologies, Inc. be liable for indirect, special, incidental, or consequential damages in connection with its testing, even if advised of the possibility of such damages. In no event shall Principled Technologies, Inc.'s liability, including for direct damages, exceed the amounts paid in connection with Principled Technologies, Inc.'s testing. Customer's sole and exclusive remedies are as set forth herein.