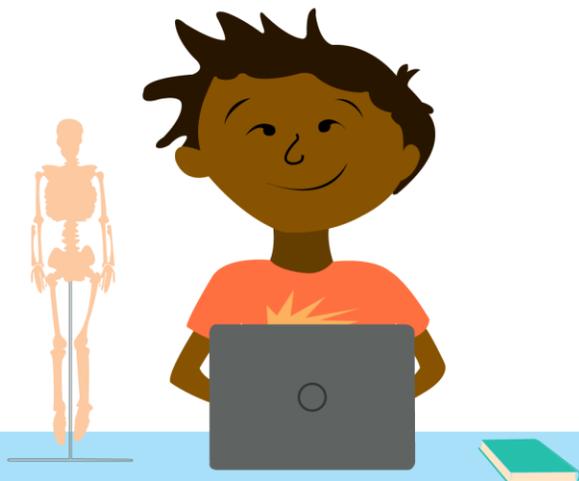


# Less time waiting = more time learning with the Dell™ Chromebook™ 11 powered by Intel®\*



42% less waiting

saving 43 seconds while creating a history project



40% less waiting

saving 43 seconds while learning in science class



Better visual experience

in BioDigital Human and Google Maps™

\*Dell Chromebook 11 with Intel Celeron® 2955U processor versus the Acer® Chromebook 13 with NVIDIA® Tegra® K1 processor

Chromebooks with faster processors can reduce the time it takes to do most tasks, which means one thing: your students can get more work done each class period. While slower devices can lead to distracted or frustrated students, better performing devices can help keep students engaged. With faster Chromebooks, students can save time on tasks they do over and over, which quickly adds up to a lot more time for learning.

In the Principled Technologies labs, we put two Chromebooks to the test in history project and anatomy class scenarios with commonly used apps including BioDigital Human, Edmodo®, Google Docs™, and WeVideo®.

The results were clear: the Dell Chromebook 11 with the Intel Celeron processor provided a significantly better experience for students than the NVIDIA Tegra K1 processor-based Acer Chromebook 13. In our two scenarios, students saved valuable classroom time with the Dell Chromebook 11—over 43 seconds while creating a history project and over 43 seconds while learning anatomy in science class. We also found that the Dell Chromebook 11 delivered a smoother and more responsive experience in BioDigital Human and Google Maps—69 percent and 37 percent more frames per second, respectively.

Minutes matter—the time saved with the Intel processor-powered Dell Chromebook 11 can quickly add up for students during a class period. The bottom line: in our tests, the Dell Chromebook 11 with the Intel Celeron processor provided a better learning experience when handling common classroom tasks.

## WHAT'S IN A CHROMEBOOK?

What's inside your Chromebook can make all the difference in how your device performs. The processor that drives these devices is key to getting the performance you want. To help you make the right choice for your school, we compared the Intel Celeron 2955U processor-based Dell Chromebook 11 against the NVIDIA Tegra K1 processor-based Acer Chromebook 13. For details about the systems we tested, see [Appendix A](#). If you want to learn more about our test process, take a look at [Appendix B](#).

### Less waiting while creating a history project with the Dell Chromebook 11



Jayden and his classmates are working on an US history video project. He opens a new WeVideo project and starts gathering facts about the Declaration of Independence in Google Docs. He makes title cards in WeVideo and starts writing a script to narrate the video. A quick Wikipedia® search tells Jayden that Independence Hall in Philadelphia is the birthplace of the American government, so he opens Google Maps™ and uses Street View™ to tour the site. He uses the PicMonkey™ Extension to take screenshots of the building to include in his video. Before saving the photos to his Google Drive, Jayden edits the images with the PicMonkey app. He picks his two favorite images in the Gallery app and uploads them to WeVideo, where he adds transitions to the images in the video timeline. Jayden publishes a rough draft to his Google Drive™ and previews his video presentation.

### Less waiting = more time for learning in history class

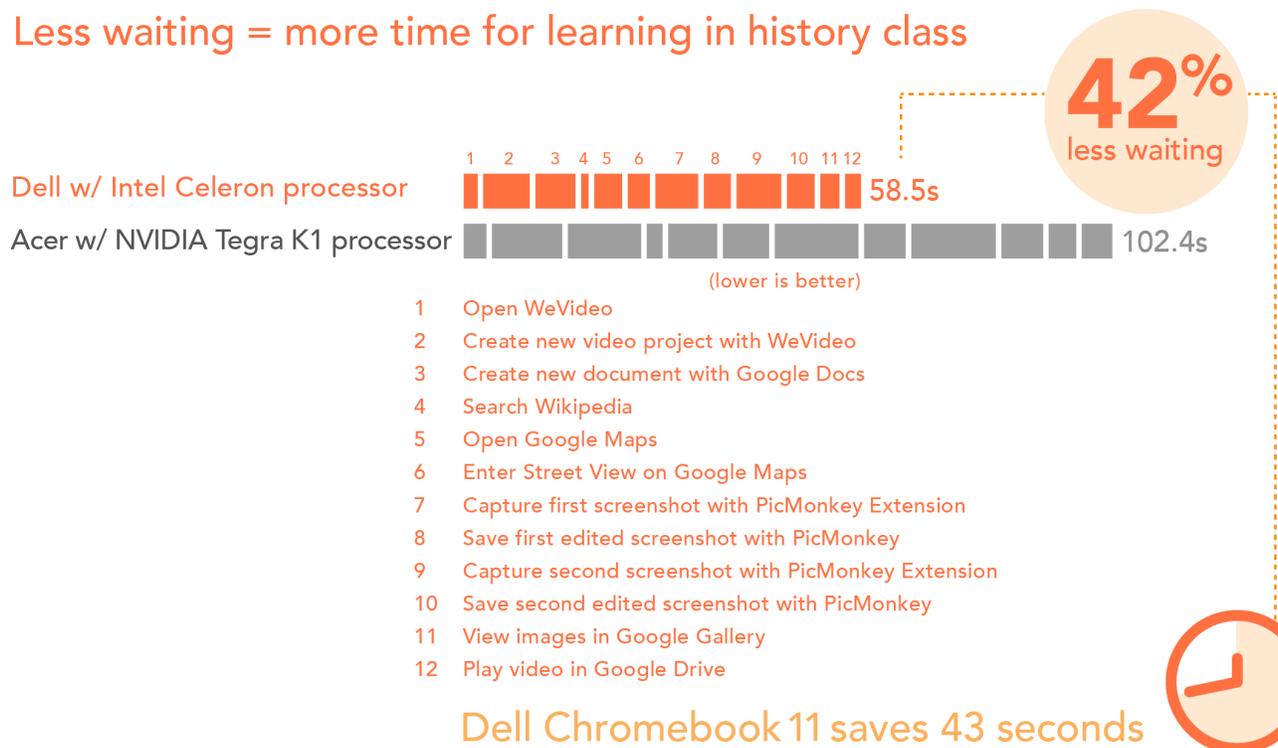


Figure 1: The Dell Chromebook 11 with an Intel Celeron processor outperformed the NVIDIA Tegra K1 processor-based Acer Chromebook 13 in our history project scenario.

Jayden would save 7 seconds each time he captures a screenshot with the Dell Chromebook 11.

As Figure 1 shows, Jayden and his classmates would spend 42 percent less time waiting while working on his history project with the Intel Celeron processor-powered Dell Chromebook 11. In our scenario, Jayden would save over 43 seconds with the Dell Chromebook 11—valuable time that would add up over the course of a classroom period. Jayden would save time during each step with the Intel Celeron processor-powered Dell Chromebook 11, including 7 seconds each time he captures a screenshot with the PicMonkey Extension. With the NVIDIA Tegra K1 processor-based Chromebook, he would have to wait 5 seconds longer every time he created a new document in Google Docs. When students have to do tasks like this over and over, those seconds add up to lots of wasted class time.

## More frames per second = better visual experience in Google Maps



**Figure 2: The Dell Chromebook 11 with the Intel Celeron processor delivered more frames per second than the NVIDIA Tegra K1 processor-based Acer Chromebook 13 when zooming in Google Maps.**

As Figure 2 shows, the Intel Celeron processor-powered Dell Chromebook 11 also rendered 37 percent more frames per second when zooming in Google Maps to give Jayden a smoother and more responsive experience than with the NVIDIA Tegra K1 processor-based Acer Chromebook 13. Even better for Jayden: the Dell Chromebook 11 was able to support the full version of Google maps (see Figure 3), which means he could access 3D maps for the Earth, Mars, and the Moon, if he wanted. With the NVIDIA Tegra K1 processor-based Chromebook, Jayden would be limited to Lite mode, where he would be stuck accessing only basic maps and satellite footage (see Figure 4).

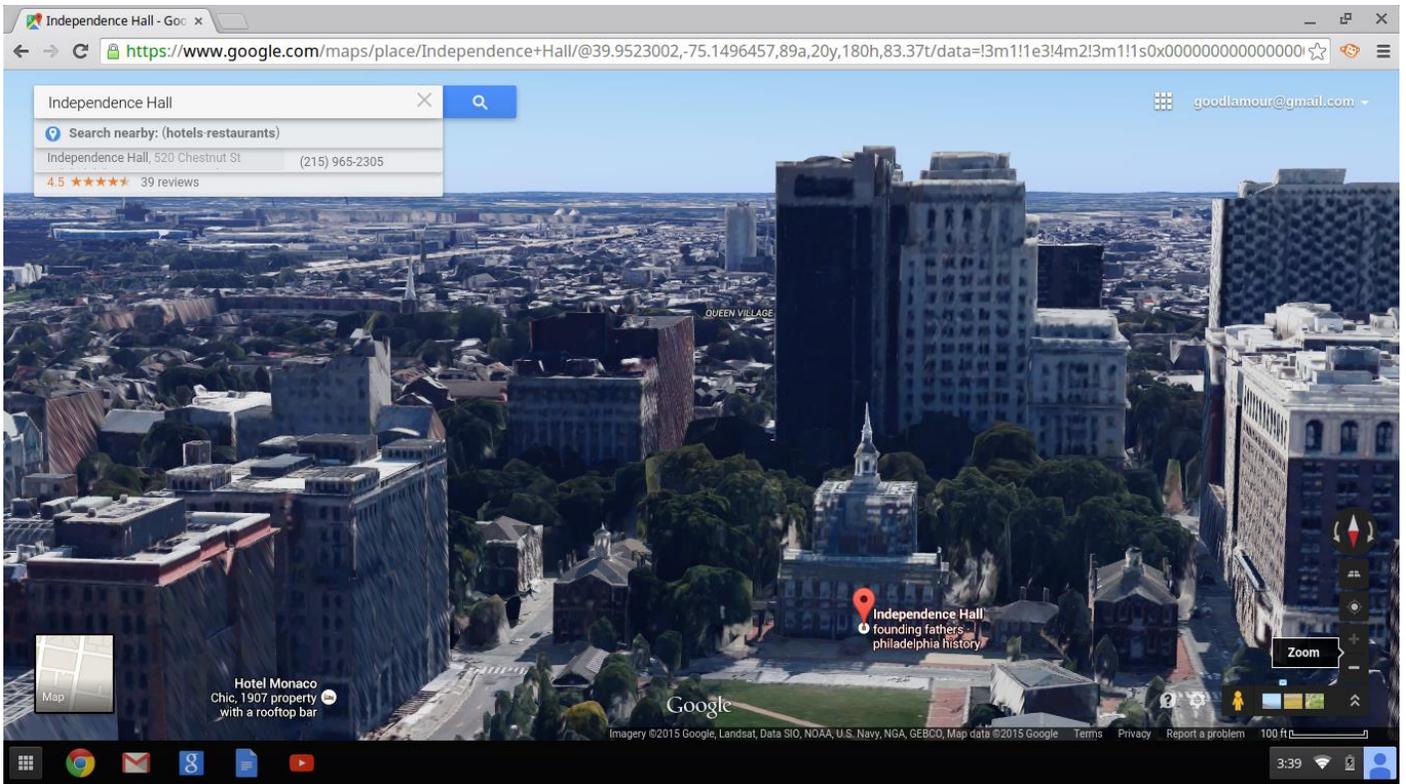


Figure 3: The Dell Chromebook 11 with Intel Celeron processor supported the full version of Google Maps, which includes 3D views.

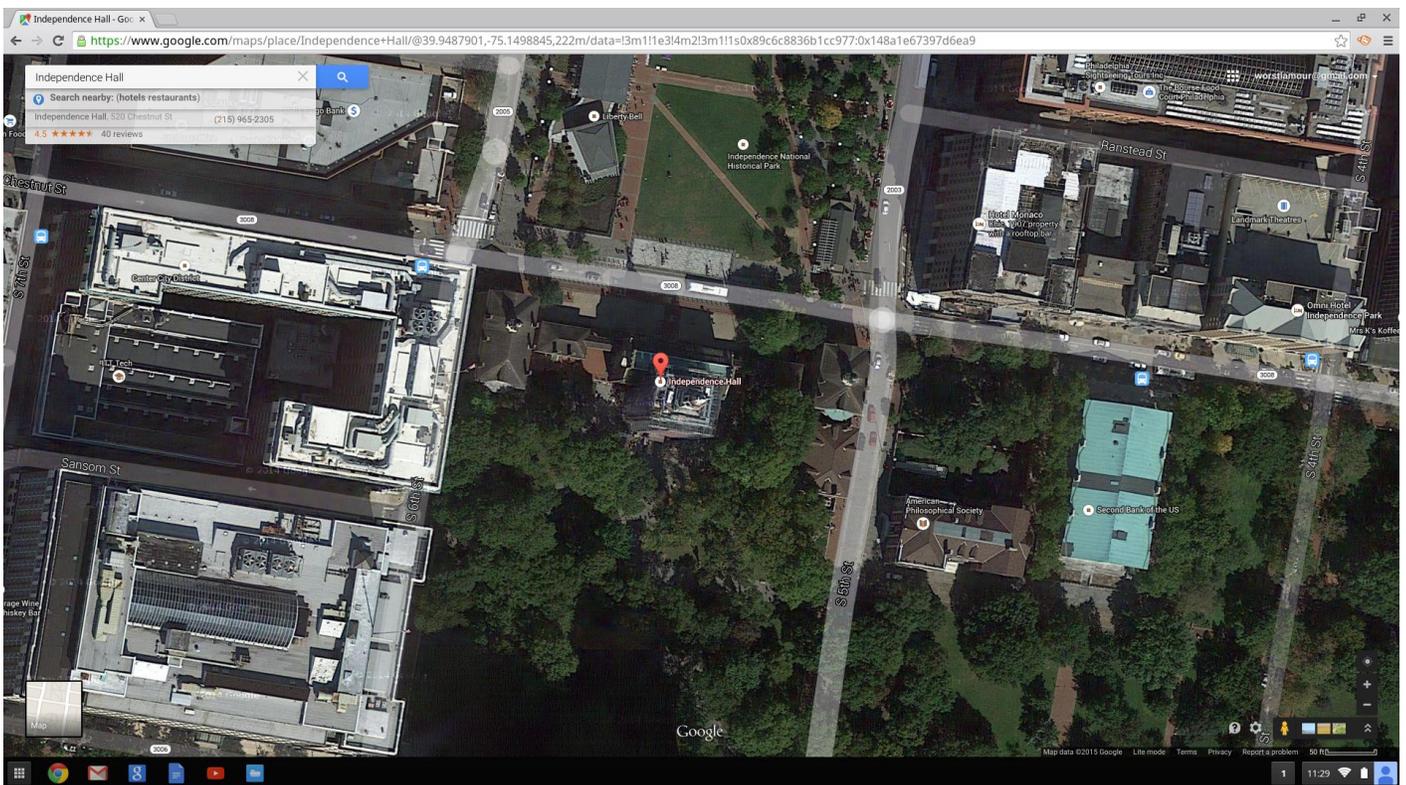


Figure 4: The NVIDIA Tegra K1 processor-based Acer Chromebook 13 limits users to Lite mode in Google maps.

## Less waiting while learning in science class with the Dell Chromebook 11



Sophia’s science class begins with an icebreaker: she and a partner have four minutes to name as many bones in the human body as possible. Sophia opens Google Docs and shares a new document with her partner, and they work together to complete the assignment. Sophia’s teacher starts a lesson on human anatomy, and Sophia follows along in a Google Slides presentation. After the lesson, Sophia’s class looks at BioDigital Human, and Sophia opens the app to view the Allergic Rhinitis condition with her class. While working in BioDigital Human, Sophia and her classmates use Glogster™ to create a Glog® about the conditions. At the end of class, Sophia and her classmates are given time to work on a section in Khan Academy®. Sophia opens Edmodo and checks her planner to open the link to the Khan Academy assignment.

### Less waiting = more time for learning in science class

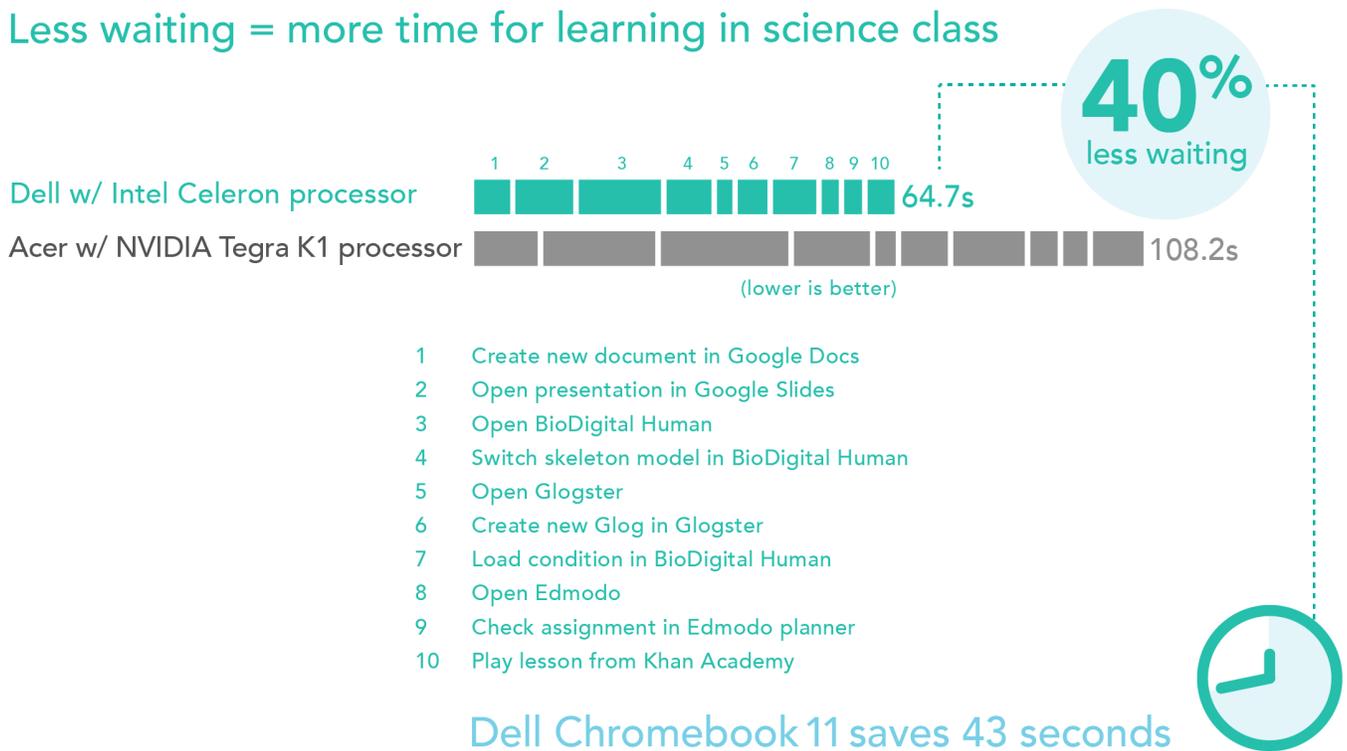


Figure 5: The Dell Chromebook 11 with an Intel Celeron processor outperformed the NVIDIA Tegra K1 processor-based Acer Chromebook 13 in our science class scenario.

Sophia would save well over 9 seconds each time she opens the Google Slides presentation with the Dell Chromebook 11.

As Figure 5 shows, Sophia and her classmates would save valuable time with the Intel Celeron processor-powered Dell Chromebook 11 while learning anatomy in science class—over 43 seconds in our scenario. For Sophia’s teacher, that time saved would quickly add up and ultimately mean more time for teaching the lesson. Sophia would save over 9 seconds each time she opens the Google Slides presentation with the Dell Chromebook 11. She would have to wait almost 8 seconds longer each time she opens BioDigital Human on the NVIDIA Tegra K1 processor-based Chromebook, and would also lose time switching the skeleton model or loading a condition.

## More frames per second = better visual experience in BioDigital Human



**Figure 6: The Dell Chromebook 11 with the Intel Celeron processor delivered more frames per second than the NVIDIA Tegra K1 processor-based Acer Chromebook 13 when rotating the skeleton model in BioDigital Human.**

As Figure 6 shows, the Intel Celeron processor-powered Dell Chromebook 11 also rendered up to 69 percent more frames per second when rotating the skeleton model in the BioDigital Human app to give Sophia a smoother and more responsive experience than with the NVIDIA Tegra K1 processor-based Acer Chromebook 13.

## CONCLUSION

Students are in class for a limited time, so you need to make each minute count. By choosing Chromebooks that can speed up common tasks for your students, you can make the most of class time.

Our hands-on tests showed that the Intel Celeron processor-powered Dell Chromebook 11 would save valuable time in the classroom by reducing the amount of time students would have to wait while learning. In our two scenarios, Jayden would spend 42 percent less time waiting while creating a history project, and Sophia would spend 40 percent less time waiting while learning anatomy in science class. That time saved with the Dell Chromebook 11 equals more time for learning. We also found the Intel Celeron processor-powered Dell Chromebook 11 provided a better visual experience in BioDigital Human and Google Maps, delivering up to 69 percent more frames per second.

Don't keep your students waiting on sluggish apps! By selecting the right Chromebook for your school, you can help students stay on task and reduce frustration, while also helping teachers make learning more fun and keep their students engaged.

## APPENDIX A – SYSTEM CONFIGURATION INFORMATION

Figure 7 provides detailed configuration information for the test systems.

System	Intel Celeron 2955U processor-powered Dell Chromebook 11	NVIDIA Tegra K1 processor-based Acer Chromebook 13
Vendor and model	Dell Chromebook 11	Acer Chromebook 13
Processor	Intel Celeron processor 2955U (Haswell microarchitecture)	NVIDIA Tegra K1 SoC
Processor frequency (GHz)	1.4	2.1
Processor cores	2	4
Memory (GB)	4	4
Storage (GB)	16	32
Battery type	3-Cell Li-ion	4-cell Li-ion
Battery capacity	51 Wh	47 Wh
Display	11.6" (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	Bluetooth 4.0	Bluetooth 4.0
USB 3.0 ports	2	2
System weight (lbs.)	2.86	3.16
OS	Chrome OS version 40.0.2214.93	Chrome OS version 40.0.2214.93
Release version	6457.83.0 wolf	6457.83.0 nyan_big

Figure 7: Detailed configuration information for the Chromebooks.

## APPENDIX B – HOW WE TESTED

### Configuring Chromebooks for testing

1. Power on the Chromebook.
2. Log in with a Google account.
3. In the bottom right corner, click the user account icon.
4. Click Settings.
5. Click Show advanced settings...
6. In the Powerwash section, click Powerwash.
7. Click Restart. The system will reboot into the Powerwash settings.
8. Click Powerwash.
9. Click Continue.
10. When the Powerwash is complete, the system will reboot to the initial setup wizard.
11. Set the language (English) and keyboard layout (US).
12. Select a network and enter the network credentials.
13. Click Continue.
14. Click Accept and continue.
15. Log in with the test account.
16. Click the Chrome icon to open Google Chrome.
17. Navigate to `chrome://system`.
18. Report the ChromeOS Version and ChromeOS Release Version for each system.
19. Close Google Chrome.

### Creating videos for a history project scenario

Prior to testing, we installed the following apps from the Google Chrome Web Store: WeVideo – Video Editor and Maker, PicMonkey, and PicMonkey Extension. We created test accounts and performed first-time logins for all apps. We closed or disabled any welcome screens.

1. Click the apps icon.
2. Simultaneously start the timer and click WeVideo – Video Editor and Maker.
3. When the page is fully loaded, stop the timer. Record the result.
4. Click New Project.
5. Enter a name for the new project (History Project).
6. Simultaneously start the timer and click Create.
7. When the project is created, hover over the project name and click Create New Video.
8. When the editor fully loads, stop the timer. Record the result.
9. Simultaneously start the timer and click the Google Docs icon in the shelf.
10. When the page loads, click the + icon.
11. When the new document is fully loaded (when the Comments button changes to the active state), stop the timer. Record the result.
12. Open a new tab and navigate to [Wikipedia.org](https://www.wikipedia.org).
13. In the search bar, type the phrase `Independence Hall`.
14. Simultaneously start the timer and press enter.
15. When the page is fully loaded, stop the timer. Record the result.
16. Click the apps icon.
17. Simultaneously start the timer and click Google Maps.

18. When Google Maps is fully loaded (when the Satellite/Earth box is loading), stop the timer. Record the result.
19. Search for Independence Hall.
20. Click and drag the Street View pegman to the Independence Hall marker.
21. Simultaneously release the pegman on the marker and start the timer.
22. When Street View fully loads and all page elements are displayed, stop the timer. Record the result.
23. Click Hide imagery.
24. Simultaneously click the PicMonkey Extension icon and start the timer.
25. Click the captured screenshot.
26. Stop the timer when the editor fully loads. Record the result.
27. Click Auto adjust.
28. Click Save.
29. Simultaneously start the timer and click Save to my computer.
30. Click Save.
31. When Masterpiece Saved appears, stop the timer. Record the result.
32. To return to Google Maps, close the tab.
33. Click the Show Imagery icon.
34. Click the Independence National Historical Park photo.
35. Click Hide imagery.
36. Simultaneously click the PicMonkey Extension icon and start the timer.
37. Click the captured screenshot.
38. When the editor fully loads, stop the timer. Record the result.
39. Click Auto adjust.
40. Click Save.
41. Simultaneously start the timer and click Save to my computer.
42. Click Save.
43. When Masterpiece Saved appears, stop the timer. Record the result.
44. Click the apps icon.
45. Simultaneously start the timer and click Files.
46. Click to select an image, and press enter.
47. When Gallery fully loads and all thumbnails are displayed, stop the timer.
48. In a new tab, navigate to drive.google.com.
49. Click to select the video.
50. Simultaneously start the timer and press enter.
51. When video playback begins, stop the timer. Record the result.
52. Close all tabs and exit Chrome.

### Measuring average FPS in Google Maps

For this test, we used Google Chrome's FPS tool and a photo intervalometer (time-lapse) application on a smartphone to take 25 photos of the systems' screens over the span of 60 seconds. We recorded and averaged the results of the 25 screenshots.

1. In Google Chrome, navigate to `chrome://flags`.
2. Under FPS counter, click Enable.
3. Click Restart Now.
4. Close Chrome.
5. Click the apps icon.
6. Click Google Maps.
7. Zoom all the way in.

8. Position the camera to take screenshots of the FPS counter.
9. Start the time-lapse. As the test is underway, click the – symbol to zoom out. As soon as the Maps imagery is fully rendered, zoom out again. When the maximum zoom level is reached, zoom in using the same process.
10. After 60 seconds have elapsed, stop the time lapse.
11. Record the FPS reported for each frame.
12. Navigate to chrome://flags.
13. Under FPS counter, click Disable.
14. Click Restart Now.
15. Close Chrome.

## Learning anatomy in science class scenario

Prior to testing, we installed the following apps from the Google Chrome Web Store: BioDigital Human, Glogster EDU, Edmodo, and Khan Academy. We created test accounts and performed first-time logins for all apps. We closed or disabled any welcome screens. For Edmodo, we created an additional Teacher account to issue assignments to Student accounts. For steps 5 through 7, we saved a Microsoft PowerPoint presentation as a Google Slides presentation on each system. We used the following presentation as our sample presentation:

[http://www.lavc.edu/instructor/watson\\_k/docs/Introduction%20to%20Anatomy.ppt](http://www.lavc.edu/instructor/watson_k/docs/Introduction%20to%20Anatomy.ppt)

1. Simultaneously start the timer and click the Google Docs icon in the shelf.
2. When the page loads, click the + icon.
3. When the new document is fully loaded (when the Comments button changes to the active state), stop the timer. Record the result.
4. Click the apps icon.
5. Simultaneously start the timer and click Google Slides.
6. When the page loads, click the Introduction to Anatomy presentation.
7. When the presentation is fully loaded (when the Comments button changes to the active state and all slide thumbnails are loading), stop the timer. Record the result.
8. Simultaneously start the timer and click BioDigital Human.
9. Click Log in.
10. When the model and list of systems are fully loaded, stop the timer. Record the result.
11. To select the current skeleton model, click the Male drop-down menu.
12. Simultaneously click Female and start the timer.
13. When the model and list of systems is fully loaded, stop the timer. Record the result.
14. Click the apps icon.
15. Simultaneously start the timer and click Glogster EDU.
16. When the page is fully loaded, stop the timer. Record the result.
17. Click Create New Glog.
18. Simultaneously start the timer and click the Experimental template.
19. When all graphics have finished loading, stop the timer. Record the result.
20. Click the BioDigital Human tab.
21. Click Conditions.
22. Simultaneously start the timer and click Ear, Nose and Throat.
23. Click Allergic Rhinitis.
24. When the condition animation completes, and the text description is fully loaded, stop the timer. Record the result.
25. Click the apps icon.
26. Simultaneously start the timer and click Edmodo.

27. When the page is fully loaded, stop the timer. Record the result.
28. Simultaneously start the timer and click the calendar (planner) icon.
29. Click on the assignment due tomorrow (February 3, 2015).
30. When the pop-up fully loads, stop the timer. Record the result.
31. Simultaneously start the timer and click the assignment link to the Anatomy of a neuron lesson (<https://www.khanacademy.org/science/biology/human-biology/neuron-nervous-system/v/anatomy-of-a-neuron>).
32. When the page loads, click the play icon.
33. When video playback begins, stop the timer. Record the result.

### Measuring average FPS in BioDigital Human

For this test, we used Google Chrome's FPS tool and a photo intervalometer (time-lapse) application on a smartphone to take 25 photos of the systems' screens over the span of 60 seconds. We recorded and averaged the results of the 25 screenshots.

1. In Google Chrome, navigate to `chrome://flags`.
2. Under FPS counter, click Enable.
3. Click Restart Now.
4. Close Chrome.
5. Click the apps icon.
6. Click BioDigital Human.
7. Click Log In, and enter user credentials if necessary.
8. Select the Anatomy tab.
9. Click Skeletal System.
10. Click Bones of the Upper Limb.
11. Click Bones of the Right Arm.
12. Position the camera to take screenshots of the FPS counter.
13. To begin model rotation and start the time-lapse, hold down the arrow key.
14. After 60 seconds have elapsed, stop the time-lapse.
15. Record the FPS reported for each frame.
16. Navigate to `chrome://flags`.
17. Under FPS counter, click Disable.
18. Click Restart Now.
19. Close Chrome.

## APPENDIX C – DETAILED TEST RESULTS

Figure 8 and 9 present the median test results for each task in our scenarios.

Creating videos for a history project scenario		
Task description	Intel Celeron 2955U processor-powered Dell Chromebook 11	NVIDIA Tegra K1 processor-based Acer Chromebook 13
Open WeVideo	00:02.41	00:03.94
Create new video project with WeVideo	00:08.12	00:12.25
Create new document in Google Docs	00:07.00	00:12.81
Search Wikipedia	00:01.28	00:02.74
Open Google Maps	00:04.87	00:08.56
Enter Street View on Google Maps	00:03.84	00:08.09
Capture first screenshot with PicMonkey Extension	00:07.47	00:14.62
Save first edited screenshot with PicMonkey	00:04.72	00:07.25
Capture second screenshot with PicMonkey Extension	00:07.82	00:14.75
Save second edited screenshot with PicMonkey	00:04.83	00:07.28
View images in Google Gallery	00:03.31	00:04.78
Play video in Google Drive	00:02.79	00:05.31
<b>Total</b>	<b>00:58.46</b>	<b>01:42.38</b>

Figure 8: Median results for each task in our history project scenario, in minutes:seconds. Lower numbers are better.

Learning anatomy in science class scenario		
Task description	Intel Celeron 2955U processor-powered Dell Chromebook 11	NVIDIA Tegra K1 processor-based Acer Chromebook 13
Create new document in Google Docs	00:06.28	00:11.09
Open presentation in Google Slides	00:10.10	00:19.59
Open BioDigital Human	00:14.37	00:22.31
Switch skeleton model in BioDigital Human	00:07.84	00:13.28
Open Glogster EDU	00:02.65	00:03.51
Create new Glog in Glogster EDU	00:05.15	00:08.13
Load condition in BioDigital Human	00:07.55	00:12.50
Open Edmodo	00:02.94	00:04.75
Check assignment in Edmodo planner	00:03.09	00:04.22
Play a lesson from Khan Academy	00:04.68	00:08.82
<b>Total</b>	<b>01:04.65</b>	<b>01:48.20</b>

Figure 9: Median results for each task in our science class scenario, in minutes:seconds. Lower numbers are better.

Figures 10 and 11 detail the FPS results for the 25 screenshots for each scenario.

Creating videos for a history project scenario – Google Maps		
	Intel Celeron 2955U processor-powered Dell Chromebook 11	NVIDIA Tegra K1 processor-based Acer Chromebook 13
Frame 1	41.2	34.7
Frame 2	48.6	22.5
Frame 3	47.2	35.2
Frame 4	48.2	41.3
Frame 5	45.2	32.7
Frame 6	44.3	40.3
Frame 7	51.2	43.6
Frame 8	44.3	31.9
Frame 9	45.2	31.5
Frame 10	47.2	32.4
Frame 11	51.1	24.7
Frame 12	36.4	27.8
Frame 13	40.3	28.1
Frame 14	38.4	29.5
Frame 15	49.3	36.0
Frame 16	47.4	31.9
Frame 17	40.7	52.0
Frame 18	51.1	49.4
Frame 19	50.2	29.1
Frame 20	50.6	15.0
Frame 21	45.0	36.2
Frame 22	45.2	38.1
Frame 23	55.1	34.4
Frame 24	32.7	29.1
Frame 25	55.1	27.4
<b>Average</b>	<b>46.0</b>	<b>33.4</b>

Figure 10: Frames per second for the 25 screenshots in our history project scenario. Higher numbers are better.

Learning anatomy in science class scenario – BioDigital Human		
	Intel Celeron 2955U processor-powered Dell Chromebook 11	NVIDIA Tegra K1 processor-based Acer Chromebook 13
Frame 1	47.3	30.0
Frame 2	53.2	28.0
Frame 3	52.2	28.0
Frame 4	46.5	29.5
Frame 5	52.3	30.0
Frame 6	54.2	30.0
Frame 7	47.3	30.0
Frame 8	51.2	29.5
Frame 9	55.1	30.0
Frame 10	49.2	30.0
Frame 11	49.4	30.0
Frame 12	52.2	30.0
Frame 13	51.2	28.0
Frame 14	48.4	29.5
Frame 15	50.2	30.5
Frame 16	52.2	30.0
Frame 17	47.3	30.0
Frame 18	48.2	30.0
Frame 19	53.2	30.0
Frame 20	47.3	30.0
Frame 21	47.5	30.5
Frame 22	54.2	30.0
Frame 23	49.2	29.5
Frame 24	46.5	30.0
Frame 25	54.2	30.0
<b>Average</b>	<b>50.4</b>	<b>29.7</b>

Figure 11: Frames per second for the 25 screenshots in our science class scenario. Higher numbers are better.

## ABOUT PRINCIPLED TECHNOLOGIES



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