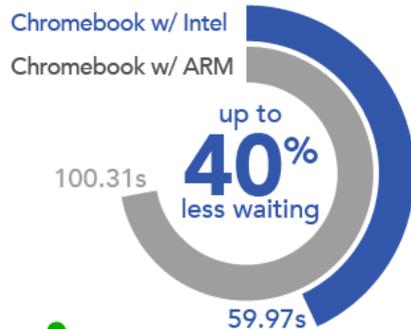
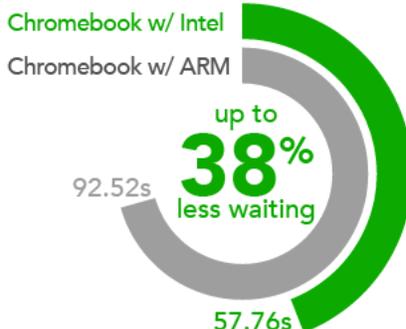


Less waiting, more learning with Chromebooks powered by Intel^{®*}

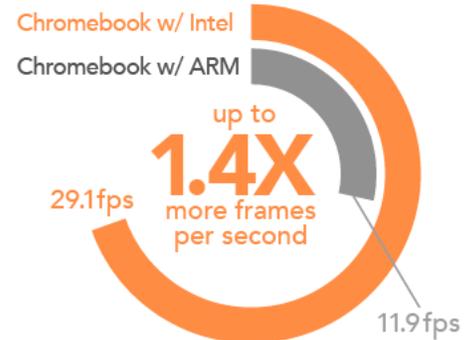
Working on a science presentation



Working on math assignments



A better visual experience



*Intel Celeron 3205U versus the Rockchip RK3288 SoC-based Chromebook

Choose the right processor. Both Intel processors provided better performance and ran more apps than the Rockchip RK3288 chipset. The Intel Celeron processor N2840 provides ample performance and the Intel Celeron processor 3205U gives you superior performance headroom for today and tomorrow.

The processor in a Chromebook™ matters: Processors that are more powerful can save time each class period, which lets students do more. Waiting for apps to load can distract and frustrate students; faster devices can keep students thinking, working, and learning. For teachers of students using faster Chromebooks, time saved on routine tasks can add up quickly and mean more time for finishing assignments or moving onto the next lesson.

In the Principled Technologies labs, we found that students using Chromebooks with Intel Celeron® processors could save up to 40 seconds while working on a science presentation and up to 34 seconds while completing assignments in math class compared to a system with a Rockchip RK3288. While these may not sound like much, when students repeatedly do these kinds of tasks during class, the time saved can really add up. The Chromebooks powered by Intel were also smoother and more responsive for students using Planetarium and GeoGebra, rendering up to 1.4 times more frames per second.

With two options to help speed things up in the classroom, the Intel Celeron processors we tested can provide the balance of performance and value in a Chromebook that's right for your school. The bottom line: in our tests, both Chromebooks with Intel Celeron processors provided a better learning experience when handling common classroom tasks that students work on nearly every day.



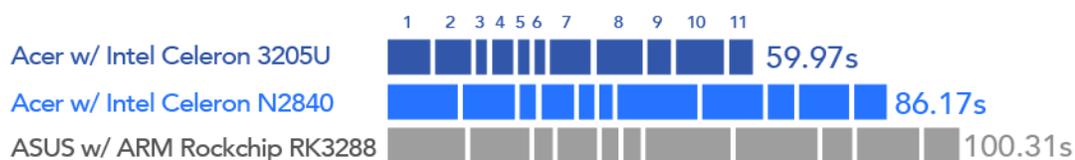
WHAT'S IN A CHROMEBOOK?

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 device choice for your school, we compared two Acer® Chromebook 11 models, one powered by the new Intel Celeron processor 3205U and one powered by the Intel Celeron processor N2840, against a Rockchip-based ASUS® Chromebook. 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 working on a presentation in science class

Anders and his classmates have been studying stars in science class, and today the class is divided between lessons with the teacher and group work on a presentation. During the lesson portions, Anders switches frequently among opening new lesson slides in Google Slides, taking notes in Google Docs, and using the Planetarium app to look for the constellations his teacher is showing. The rest of class is devoted to helping his group with their presentation. Their topic is the Sun's nearest neighbor, Proxima Centauri, and Anders is in charge of the images. Every time his group tells him they need a new picture, he takes screenshots of the Planetarium app with FireShot Lite, a Chrome extension that lets him capture screenshots. He crops and edits those images in Polarr, a photo editor. Then he adds the images to the group's presentation slides using the RealtimeBoard app. His teacher asks for regular updates from the group, so he uses Google Drawings to annotate the images and add them to a shared. When the class finishes, the presentation is nearly complete – all that's left is to practice!

Less waiting = more time for learning in science class



(less time is better)

- 1 Open existing presentation in Google Slides
- 2 Create new document in Google Docs
- 3 Open Planetarium app
- 4 Open Google Drawings
- 5 Take screenshot of Planetarium with FireShot Lite extension
- 6 Save screenshot as image with FireShot Lite extension
- 7 Load image in Polarr
- 8 Open RealtimeBoard app
- 9 Create new board with RealtimeBoard
- 10 Insert drawing into RealtimeBoard project
- 11 Insert screenshot into RealtimeBoard project

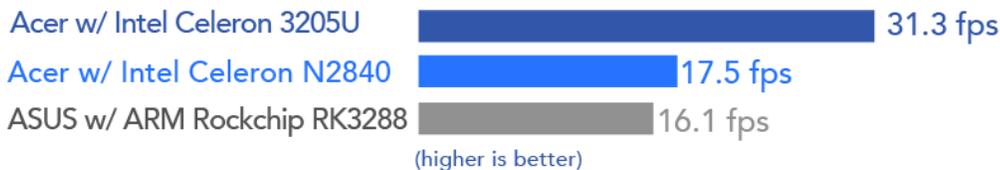


Figure 1: Both Intel Celeron processor-powered Chromebooks outperformed the Rockchip-based Chromebook in our science presentation scenario.

Anders would save 8 seconds each time he loads an image in Polarr with the Chromebook featuring the Intel Celeron Processor 3205U.

As Figure 1 shows, Anders and his classmates would wait up to 40 percent less time while working on their science class presentation with the Chromebooks powered by Intel Celeron processors. In our scenario, Anders would save over 40 seconds with the Chromebook powered by the Intel Celeron processor 3205U—valuable time that would add up over the course of a class period as he takes more screenshots and continues to give his teacher updates. Anders would save time during each step with either Chromebook powered by Intel, including saving over 8 seconds with the Chromebook featuring the Intel Celeron processor 3205U every time he loads an image in the Polarr app. With the Rockchip-based Chromebook, he would have to wait over 6 seconds longer each time he opened an existing document in Google Slides. When you have to do tasks like these over and over, those seconds add up to lots of wasted class time.

More frames per second = better visual experience in Planetarium app



up to
94%
more frames
per second

Figure 2: Both Intel Celeron processor-powered Chromebooks delivered more frames per second than the Rockchip-based Chromebook when looking at the Planetarium app.

As Figure 2 shows, the Chromebooks powered by Intel Celeron processors rendered up to 94 percent more frames per second in the Planetarium app. That gives Anders a clear view of the stars than with the Rockchip-based Chromebook, because his experience is smoother and more responsive.

Less waiting while working on assignments in math class

Debbie’s math teacher uses part of every class to let her students practice the material they’ve learned that day. In her in-class practice time, Debbie checks Google Keep™ to see what she needs to complete and uses Edmodo® to open her class notes. Her assignment is to use GeoGebra to turn a set of formulas into animations, which she will present to her classmates tomorrow. Seeing formulas in this way can help the class understand the lesson better, and having to present them helps Debbie grasp the concept too. While reviewing a Google Sheets assignment spreadsheet that her teacher uploaded, she looks in her Edmodo planner to see when the project is due. For each formula, she loads a function into GeoGebra to create the animation, then takes a screenshot of the function. When she’s done, she turns in the GeoGebra link through

Edmodo and uploads her screenshot to Google Keep. When she has a question about a formula, Debbie gets on Khan Academy and takes a related lesson in the geometry section.

Less waiting = more time for learning in math class

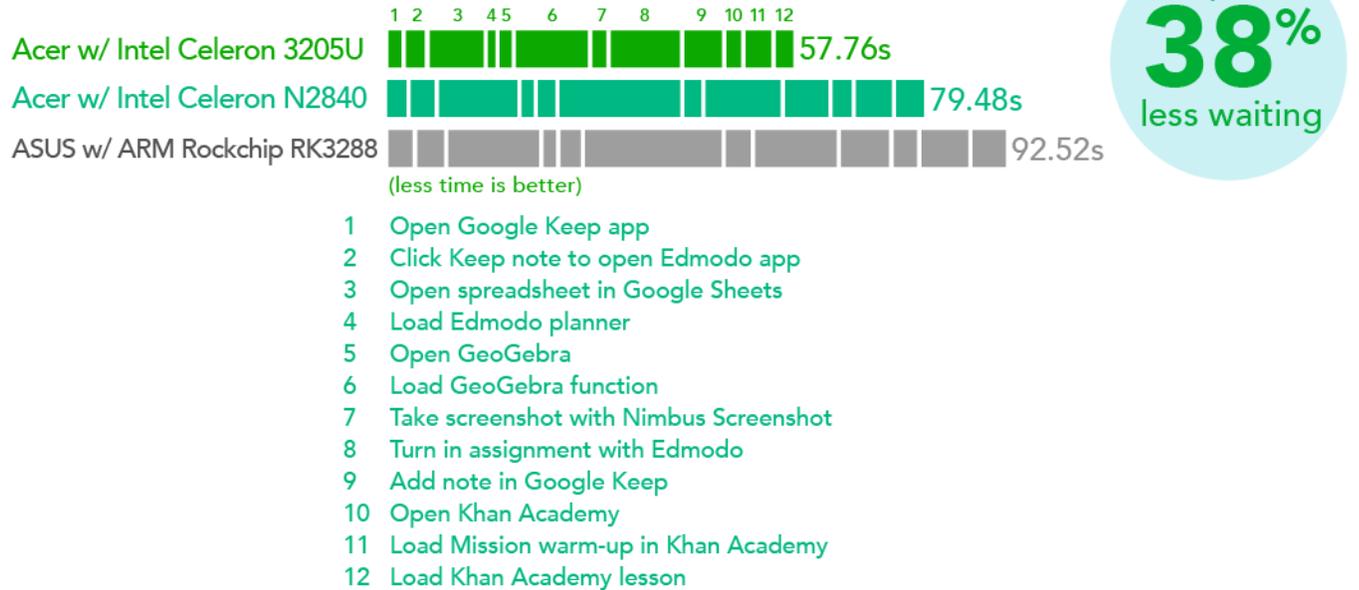


Figure 3: Both Intel Celeron processor-powered Chromebooks outperformed Rockchip-based Chromebook in our math class scenario.

Debbie would save 10 seconds each time she loads a function in GeoGebra with the Chromebook featuring the Intel Celeron Processor 3205U.

As Figure 3 shows, Debbie and her classmates would save valuable time with both Chromebooks powered by Intel—up to 34 seconds in our scenario. For Debbie’s teacher, that time would quickly add up, and it could mean that more students turn in their assignments on time. Debbie would save over 10 seconds each time she loads a function in GeoGebra with the Chromebook featuring the Intel Celeron processor 3205U. She’d have to wait over 6 seconds longer each time she opens an existing spreadsheet in Google Sheets with the Rockchip-based Chromebook.

More frames per second = better visual experience in GeoGebra app

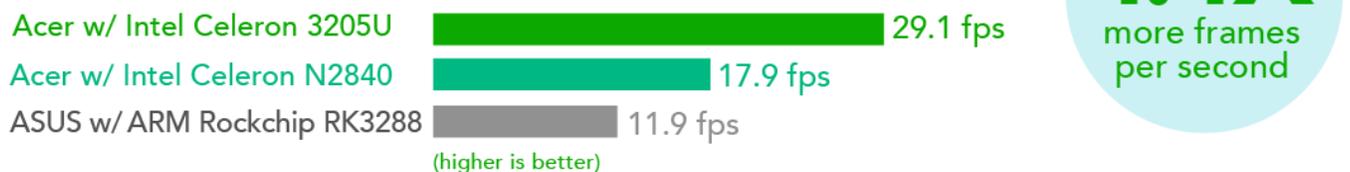


Figure 4: Both Intel Celeron processor-powered Chromebooks delivered more frames per second than the Rockchip-based Chromebook when animating a function in the GeoGebra app.

As Figure 4 shows, Chromebooks with Intel Celeron processors also rendered up to 1.4 times more frames per second when animating a function in the GeoGebra app to give Debbie a smoother and more responsive experience than with the Rockchip-based Chromebook.

Running more Native Client apps

Having up-to-date and functioning apps for Chromebooks can help students finish classwork or homework. Included in Chrome OS™ for Chromebooks is Native Client (“NaCl”), a recent technology that expands programming language options for use in Chrome™ apps. Google describes NaCl as “the means to fully harness the [Chromebook’s] computational resources for applications such as:

- 3D games
- Multimedia editors
- CAD modeling
- Client-side data analytics
- Interactive simulations.”¹

The Native Client technology is already included in Chrome OS, and does not require any additional software to be installed.

As more Chromebooks are entering the market, the number of NaCl apps is increasing. However, some processors are better equipped to handle NaCl apps. On the Chrome Web Store for both of the Chromebooks with Intel Celeron processors, we looked at two NaCl apps: Pixlr® Touch Up and Magisto® – Magical Video Editor. On the Rockchip-based Chromebook, we could not install the apps (see Figures 5 and 6 for the error screens we encountered when we tried).

¹ developer.chrome.com/native-client/overview

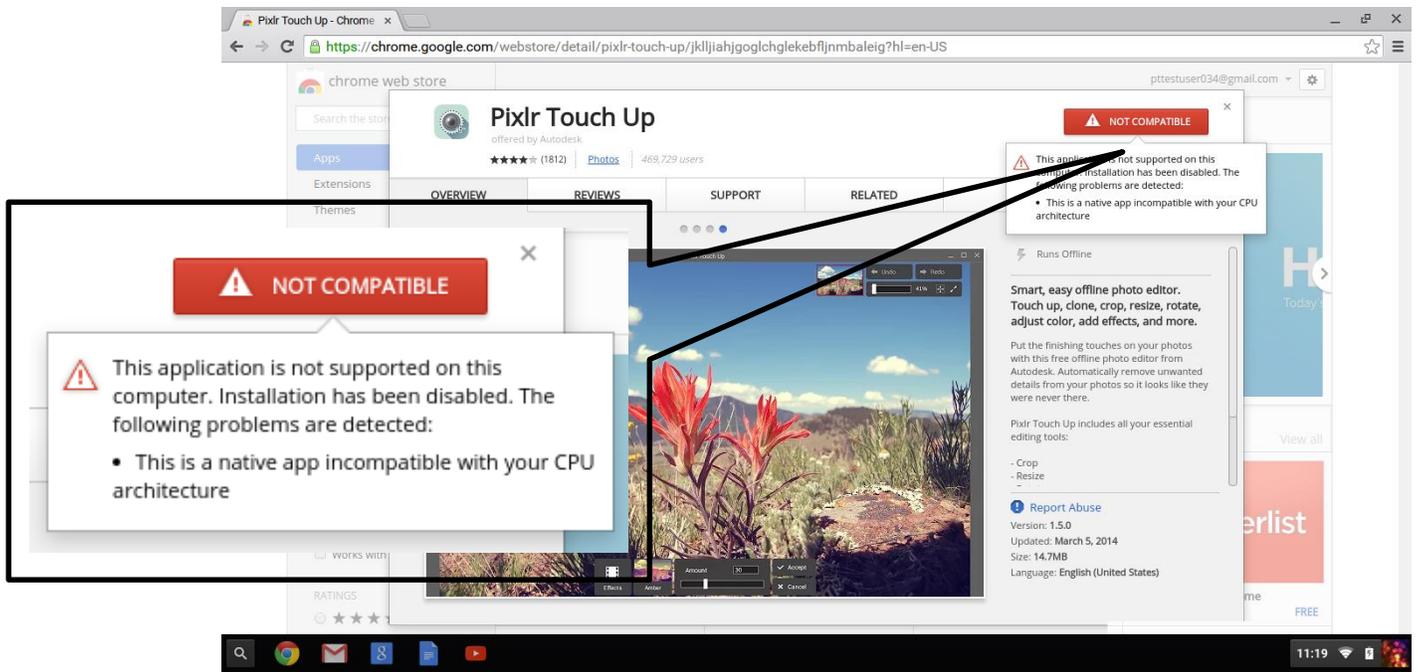


Figure 5: Trying to install the Pixlr NaCl app on the Rockchip-based Chromebook.

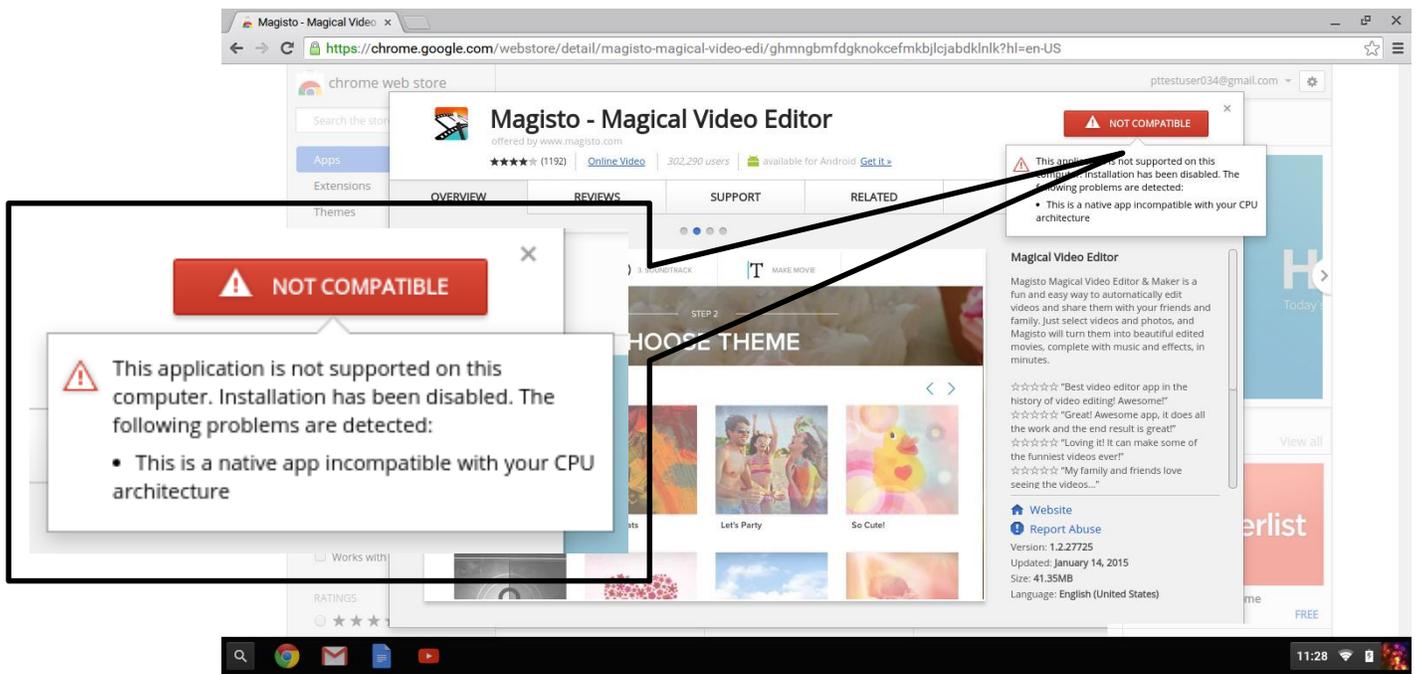


Figure 6: Trying to install the Magisto – Magical Video Editor NaCl app on the Rockchip-based Chromebook.

In addition to the troubles with the NaCl apps, we found that the Rockchip-based Chromebook struggled with 3D performance, while the Chromebooks with Intel Celeron processors had no problem handling these models. When we used the 3DView app, complex models rendered correctly on the Intel Celeron processor-based Chromebooks but produced odd graphical bugs that made it hard to interact with the app on the Rockchip-based Chromebook (see Figure 7 for a comparison). After using the app for some time on the Rockchip-based Chromebook, the viewing area turned grey and became unusable. Restarting the app prompted an error message (Figure 8).

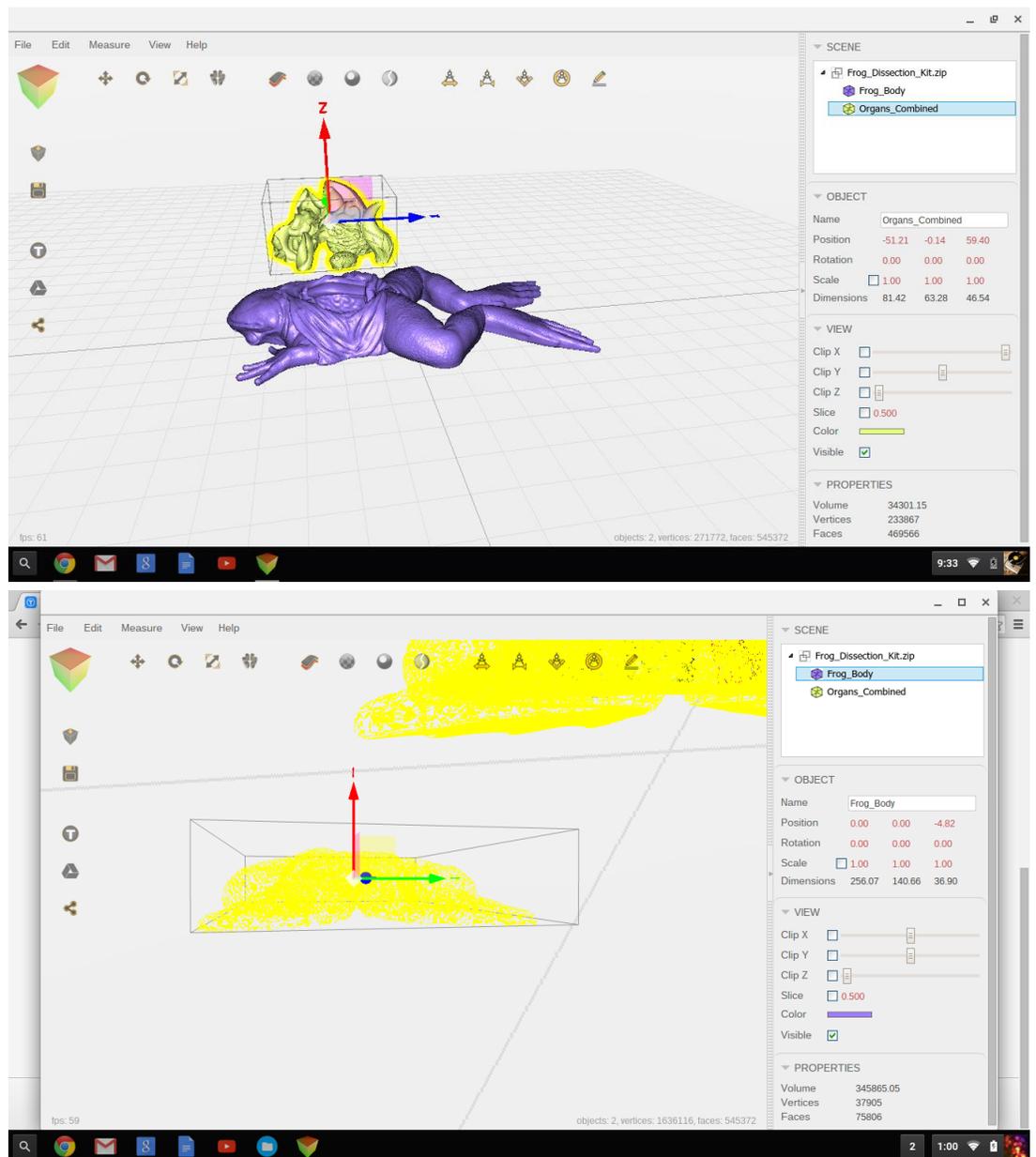


Figure 7: Using the 3DView app on the Intel Celeron processor-based Chromebook (top) and the Rockchip-based Chromebook (below).

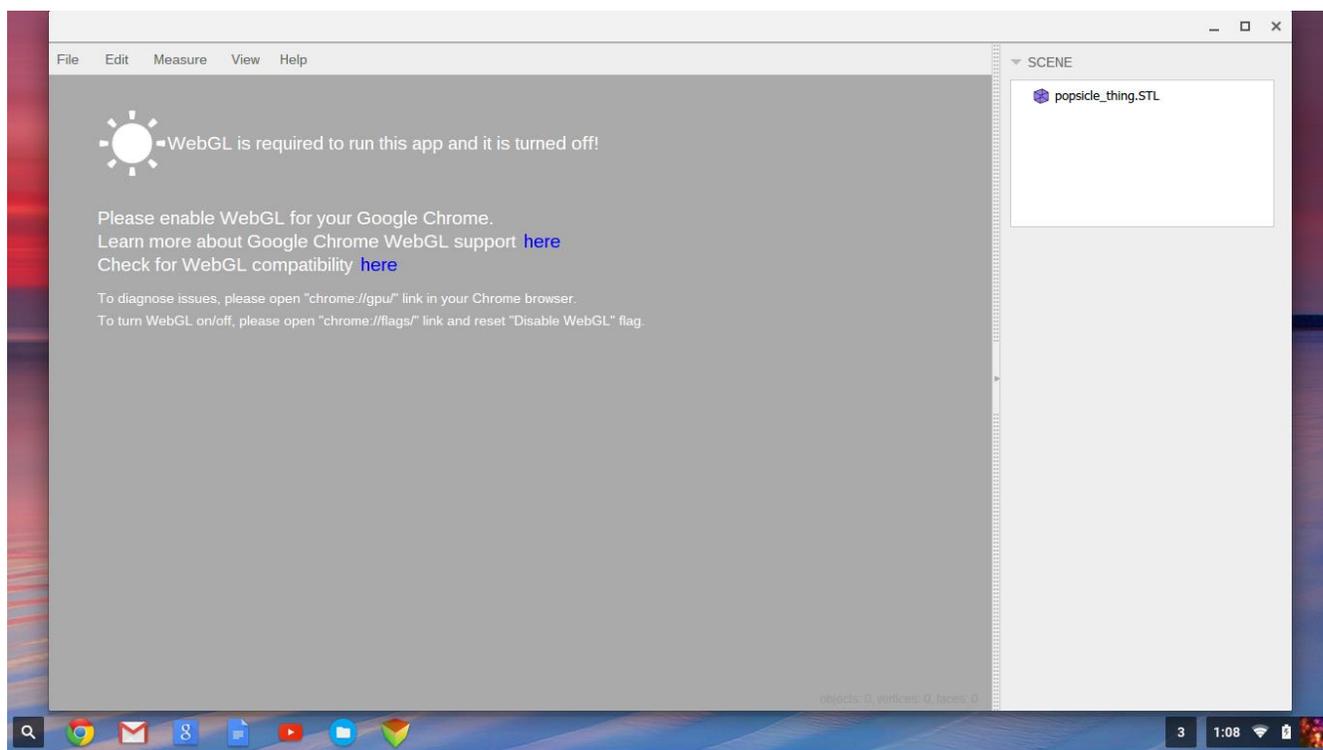


Figure 8: The error message on the Rockchip-based Chromebook after restarting the 3DView app.

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 both Chromebooks with Intel Celeron processors would save valuable time in the classroom by reducing the amount of time students would have to wait while learning. In our two scenarios, Anders would spend up to 40 percent less time waiting while creating a science presentation, and Debbie would spend 38 percent less time waiting while working on assignments in math class. That time saved with the Chromebooks powered by Intel Celeron processors equals more time for learning. They also provided a better visual experience than the Rockchip-based system in Planetarium and GeoGebra, delivering up to 1.4 times more frames per second. The Intel Celeron processor-based Chromebooks properly ran NaCL and 3D apps too, while the Rockchip-based Chromebook could not.

Don't slow your students down by making them wait longer on their systems. By selecting the right Chromebook for your school, you can help students stay focused and reduce frustration, while also helping teachers make the most of class time and keep their students active.

APPENDIX A – SYSTEM CONFIGURATION INFORMATION

Figure 9 provides detailed configuration information for the test systems.

	Chromebook featuring the Intel Celeron processor 3205U	Chromebook featuring the Intel Celeron processor N2840	Rockchip RK3288 SoC-based Chromebook
Vendor and model	Acer Chromebook 11 C740-C3P1	Acer Chromebook 11 CB3-111-C6EQ	ASUS Chromebook C201P
Processor	Intel Celeron processor 3205U	Intel Celeron processor N2840	Rockchip RK3288C SoC
Processor frequency (GHz)	1.50	2.16	1.80
Processor cores	2	2	4
Memory (GB)	2	2	2
Storage (GB)	16	16	16
Battery type	3-Cell Li-Polymer	3-Cell Li-Ion	2-Cell
Battery capacity	3,920 mAh	3,220 mAh	38 Wh
Display	11.6" (1,366 × 768)	11.6" (1,366 × 768)	11.6" (1,366 × 768)
Wireless	802.11 a/b/g/n/ac	802.11 a/b/g/n/ac	802.11 a/b/g/n/ac
Bluetooth	Bluetooth® 4.0	Bluetooth 4.0	Bluetooth 4.1
USB ports	2	2	2
System weight (lbs.)	2.74	2.36	2.16
OS	Chrome OS version 42.0.2311.153	Chrome OS version 42.0.2311.153	Chrome OS version 42.0.2311.153
Release version	6812.88.0	6812.88.0	6812.88.0

Figure 9: Detailed configuration information for the Chromebooks.

APPENDIX B – HOW WE TESTED

Configuring Chromebooks for testing

Prior to testing, we created a new Google account for each system.

1. Power on the Chromebook.
2. Log in with a Google account.
3. Click the user account icon in the bottom right corner.
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. Uncheck Optional: Help make Chrome OS better by automatically sending usage statistics and crash reports to Google.
15. Click Accept and continue.
16. Log in with the test account, and close the Welcome screen.
17. Click the Chrome icon to open Google Chrome™.
18. Navigate to `chrome://system`
19. Report the ChromeOS Version and ChromeOS Release Version for each system.
20. Close Google Chrome.

Prior to testing, we downloaded and installed every app for each of the systems to use in the test scenarios. We performed first-time logins for all apps, and we closed or disabled any welcome screens. We pinned the downloaded apps to the shelf.

Creating a presentation in science class

For the presentation in Google Slides, we downloaded the following PowerPoint® presentation to each of the Chromebooks and saved it in their Google Drives:

earthweb.ess.washington.edu/roe/Web_page_314/ESS314/Week_2_files/space_weather_into.ppt.

1. Click the search icon in the bottom left corner, click All Apps, and open Files from the app drawer.
2. Click My Drive to change the current directory to My Drive.
3. Right click the presentation to open the context menu.
4. Simultaneously start the timer, and click Slides from the context menu.
5. Stop the timer when the presentation has fully loaded.
6. Simultaneously start the timer and click the Google Docs icon from the shelf.
7. When the recent documents page finishes loading, click the red + icon to create a new Google Doc.

8. Stop the timer when the page has fully loaded.
9. Simultaneously start the timer and click the Planetarium app icon from the shelf.
10. Stop the timer when the app fully loads.
11. Simultaneously start the timer and click the Google Drawings icon from the shelf.
12. Stop the timer when Google Drawings fully loads.
13. Click the Planetarium tab to return to the Planetarium app.
14. Click the FireShot extension icon.
15. Simultaneously start the timer and click Capture entire page.
16. Stop the timer when the capture is complete.
17. Simultaneously start the timer and click Save as Image.
18. When the Save dialog appears, click Save. Stop the timer when the Save window fully closes.
19. Simultaneously start the timer and click the Polarr app icon from the shelf.
20. When Polarr fully loads, click the Import button, select the captured screenshot, and click Open.
21. Stop the timer when Polarr loads the screenshot.
22. Simultaneously start the timer and click the RealtimeBoard app icon from the shelf.
23. Stop the timer when the app fully loads.
24. Simultaneously start the timer and click Create.
25. Stop the timer when the new project fully loads.
26. Simultaneously start the timer and click the + icon, and click Google Drive.
27. Select the drawing, and click Select.
28. Stop the timer when the image is fully loaded.
29. Simultaneously start the timer and click the + icon, and click Upload.
30. Select the screenshot, and click Open.
31. Stop the timer when the image is fully loaded.

Measuring average FPS in Planetarium

For this test, we used Google Chrome's FPS tool and a stopwatch. We let the animation run for 30 seconds before recording the FPS score every 10 seconds for 100 seconds. We recorded and averaged the results of the 10 scores.

1. In Google Chrome, navigate to `chrome://flags`
2. Under FPS counter, click Enable.
3. Click Restart Now.
4. Close Chrome.
5. Click the Planetarium app icon from the shelf.
6. Click once in the app field to begin the animation.
7. Move the cursor to the top left corner of the window to continue the spinning animation.
8. Start the timer. When 30 seconds have elapsed, begin recording FPS scores starting at :30 and in 10 second intervals afterwards until you have collected 10 entries.
9. After recording 10 entries, stop the timer.

10. Navigate to `chrome://flags`
11. Under FPS counter, click Disable.
12. Click Restart Now.
13. Close Chrome.

Working in math class

For Google Keep, we entered notes to mimic actual usage, including a note for an Edmodo assignment. For Edmodo, we created an additional Teacher account from another system to issue assignments to Student accounts.

1. Simultaneously start the timer and click the Google Keep app icon from the shelf.
2. Stop the timer when the app fully loads.
3. Simultaneously start the timer and click the link to Edmodo from Google Keep.
4. Stop the timer when the Edmodo backpack has fully loaded.
5. Simultaneously start the timer and click the Google Sheets icon from the shelf.
6. Select the example spreadsheet from the recent documents.
7. Stop the timer when the spreadsheet fully loads.
8. Click the Edmodo tab to return to Edmodo.
9. Simultaneously start the timer and click the Edmodo planner icon.
10. Stop the timer when the planner has fully loaded.
11. Simultaneously start the timer and click the GeoGebra icon from the shelf.
12. Stop the timer when GeoGebra has fully loaded.
13. Simultaneously start the timer and navigate to `tube.geogebra.org/student/m243895` from the GeoGebra tab.
14. Stop the timer when the function fully loads.
15. Click the Nimbus Screenshot extension icon.
16. Simultaneously start the timer and click Entire page.
17. Stop the timer when the screenshot loads in a new tab. Save the image to the Downloads folder.
18. Click the Edmodo planner app to return to Edmodo.
19. Simultaneously start the timer, click on the assignment due today, and click Turn In.
20. Click the backpack icon, select the assignment to turn in, and click Attach to Post.
21. Click Turn in Assignment, click Turn in Assignment again, and stop the timer when the page fully loads.
22. Click the Google Keep icon from the shelf to return to the Google Keep app.
23. Simultaneously start the timer and click the Add image icon.
24. Select the screenshot, and click Open.
25. Click Done, and stop the timer when the blue loading bar disappears.
26. Simultaneously start the timer and click the Khan Academy icon from the shelf.
27. Stop the timer when the page fully loads.
28. Simultaneously start the timer and click Start under Geometry.
29. When the Mission warm-up prompt appears, click Get Started. Stop the timer when the first problem fully loads.
30. Click the X icon to close Mission warm-up, and click View full list of Geometry content.

31. Click Introduction to Euclidean geometry.
32. Simultaneously start the timer and click Euclid as the father of geometry.
33. Stop the timer when the page fully loads.

Measuring average FPS in Planetarium

For this test, we used Google Chrome's FPS tool and a stopwatch. We let the animation run for 30 seconds before recording the FPS score every 10 seconds for 100 seconds. We recorded and averaged the results of the 10 scores.

1. In Google Chrome, navigate to `chrome://flags`
2. Under FPS counter, click Enable.
3. Click Restart Now.
4. Close Chrome.
5. Open Chrome and navigate to `tube.geogebra.org/student/m84748`
6. When the animation begins, start the timer. When 30 seconds have elapsed, begin recording FPS scores starting at :30 and in 10 second intervals afterwards until you have collected 10 entries.
7. After recording 10 entries, stop the timer.
8. Navigate to `chrome://flags`
9. Under FPS counter, click Disable.
10. Click Restart Now.
11. Close Chrome.

APPENDIX C – DETAILED TEST RESULTS

Figures 10 and 11 present the median test results for each task in our scenarios.

Creating a science presentation scenario			
Task description	Chromebook featuring the Intel Celeron processor 3205U	Chromebook featuring the Intel Celeron processor N2840	Rockchip RK3288 SoC-based Chromebook
Open existing presentation in Google Slides	00:08.21	00:13.53	00:14.94
Create new document in Google Docs	00:06.87	00:09.97	00:11.40
Open Planetarium app	00:02.04	00:03.10	00:03.47
Open Google Drawings	00:04.00	00:06.21	00:07.57
Take screenshot of Planetarium with FireShot Lite	00:02.19	00:02.94	00:03.15
Save screenshot as image with FireShot Lite	00:02.00	00:02.53	00:03.30
Load image in Polarr	00:07.79	00:15.35	00:16.35
Open RealtimeBoard app	00:08.81	00:11.69	00:15.75
Create new board with RealtimeBoard	00:04.47	00:05.03	00:05.72
Insert drawing into RealtimeBoard project	00:09.14	00:09.59	00:11.94
Insert screenshot into RealtimeBoard project	00:04.45	00:06.23	00:06.72
Total	00:59.97	01:26.17	01:40.31

Figure 10: Median results for each task in our science presentation scenario, in minutes:seconds. Lower numbers are better.

Working on assignments for math class scenario			
Task description	Chromebook featuring the Intel Celeron processor 3205U	Chromebook featuring the Intel Celeron processor N2840	Rockchip RK3288 SoC-based Chromebook
Open Google Keep app	00:02.10	00:03.14	00:03.90
Click Keep note to open Edmodo app	00:03.03	00:03.84	00:04.35
Open spreadsheet in Google Sheets	00:08.78	00:12.78	00:14.81
Load Edmodo planner	00:01.16	00:01.91	00:01.99
Open GeoGebra	00:01.90	00:02.78	00:03.28
Load GeoGebra function	00:11.72	00:19.69	00:22.30
Take screenshot with Nimbus Screenshot	00:02.25	00:02.69	00:04.00
Turn in assignment with Edmodo	00:11.28	00:12.24	00:13.31
Add note in Google Keep	00:06.13	00:07.05	00:07.83
Open Khan Academy	00:02.37	00:03.03	00:03.74
Load Mission warm-up in Khan Academy	00:04.20	00:05.81	00:07.61
Load Khan Academy lesson	00:02.84	00:04.52	00:05.40
Total	00:57.76	01:19.48	01:32.52

Figure 11: Median results for each task in our math class scenario, in minutes:seconds. Lower numbers are better.

Figures 12 and 13 detail the FPS results for the 10 screenshots for each scenario.

Creating a science presentation scenario – Planetarium			
	Chromebook featuring the Intel Celeron processor 3205U	Chromebook featuring the Intel Celeron processor N2840	Rockchip RK3288 SoC-based Chromebook
Frame 1	33.5	17.7	15.8
Frame 2	31.0	18.1	17.2
Frame 3	31.5	15.9	16.3
Frame 4	31.0	18.1	15.4
Frame 5	31.0	17.4	15.6
Frame 6	30.5	17.1	17.2
Frame 7	31.0	17.1	16.3
Frame 8	31.5	17.7	16.2
Frame 9	31.0	17.8	15.0
Frame 10	31.0	17.7	16.0
Average	31.3	17.5	16.1

Figure 12: Frames per second for the 10 screenshots in our science presentation scenario. Higher numbers are better.

Working on assignments for math class scenario – GeoGebra			
	Chromebook featuring the Intel Celeron processor 3205U	Chromebook featuring the Intel Celeron processor N2840	Rockchip RK3288 SoC-based Chromebook
Frame 1	29.0	17.8	12.6
Frame 2	28.5	18.1	12.2
Frame 3	29.0	17.4	11.4
Frame 4	29.0	17.7	12.4
Frame 5	29.0	17.7	11.6
Frame 6	29.5	18.1	11.8
Frame 7	29.0	17.8	11.1
Frame 8	29.5	18.1	12.7
Frame 9	29.0	18.4	11.4
Frame 10	29.0	17.7	12.0
Average	29.1	17.9	11.9

Figure 13: Frames per second for the 10 screenshots in our math class scenario. Higher numbers are better.

ABOUT PRINCIPLED TECHNOLOGIES



Principled Technologies, Inc.
1007 Slater Road, Suite 300
Durham, NC, 27703
www.principledtechnologies.com

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