



# Set up students and teachers to excel now and in the future with Intel processor-powered ChromeOS devices

## We compared system performance on four ChromeOS devices powered by increasingly powerful Intel processors

Artificial intelligence (AI) isn't new. It's been around in one form or another since the 1960s, when Joseph Weizenbaum introduced the Eliza chatbot, a software program that "looked at the user input and applied a set of rules to generate a plausible [psychotherapist] response."<sup>1</sup> Although student use of AI may raise concerns about cheating, it's clear that recent technology advances are accelerating the use of AI in the classroom:



Teachers are already using AI to deliver targeted learning, automate grading, planning, and administrative tasks, create adaptive learning methodologies, and more.<sup>2</sup>



According to Google, educators can use the Read Along reading app integration to help students build their literary skills in Google Classroom.<sup>3</sup> Additionally, Google will be adding accessible built-in features to the Chrome browser soon—so students will be able to use the reading mode tool to make text larger, change fonts, and remove distractions. These are just two of the recent Google-driven AI advances: This trickle will become a tsunami as more resource-intensive apps join the Google for Education App Hub.<sup>4</sup>

One of the biggest obstacles to harnessing AI in ChromeOS™ education environments is that AI technology is resource-intensive, consuming valuable, limited compute power. The good news is investing in ChromeOS devices with more powerful Intel® processors can reduce session-restore wait times for students. When we tested two scenarios on four standard (non-AI) ChromeOS devices with increasingly powerful Intel processors, we saw that the time it took to restore over a dozen open apps and tabs after a shutdown decreased with each step up in the processor ladder. In this report, we provide a frank look at how four different Intel processor-powered ChromeOS devices could affect the classroom experience both today and in the AI-enabled future.



**Save up to 1 minute and 32 seconds in a traditional session-restore scenario\***



**Save up to 1 minute and 38 seconds in a session restore scenario featuring AI\*\***

\*Restoring over a dozen open apps and tabs after a shutdown

\*\*Restoring over a dozen open apps and tabs, including a placeholder AI component, after a shutdown

This project was commissioned by Intel.

## How we tested

We set up a realistic school Chrome environment with four managed, enrolled ChromeOS devices. Then, we created two student learning scenarios that stressed the Intel processors in the ChromeOS devices. The traditional session-restore scenario represents the repopulation of over a dozen open tabs and apps after a shutdown. This is a processor-intensive task any student (or adult) with active tabs might require on a day-to-day basis. In the traditional session-restore scenario, we set up on each ChromeOS device under test, and then we:

- Loaded an Econ 101 assignment in Google Classroom
- Accessed the Economics Classroom folder in Google Drive
- Viewed the Economics Classroom folder in My Google Drive
- Pulled up infographic templates on the Slidesgo website
- Opened a Jamboard digital whiteboard
- Opened an Economics textbook in Google Docs
- Opened a Bard chatbot (without engaging it)
- Accessed Wikipedia
- Accessed a website with streaming video
- Accessed Gmail
- Opened Google Calendar
- Accessed YouTube and left an education video playing
- Opened two textbook PDF files from the desktop download folder
- Accessed the Squid interactive learning platform and opened a Squid Note
- Opened the Kahoot! game-based learning platform and clicked the join button

For the session restore scenario featuring AI, we also started a Google Meet session, turned on the microphone and camera, and added AI-based background blur effects. We used this current AI-based task to simulate a future AI workload for students. In all of our comparisons, the session restore scenarios featuring AI took longer than the traditional scenarios because we added this processor-intensive task.

Once everything was in place, we performed a hard shut down on each ChromeOS device without closing any apps or tabs. Finally, we measured the time it took all of the apps and tabs to regain full functionality after hard shutdowns in both scenarios.

### Why this testing matters

We pretended we were a high school student getting ready for an economics class. While the steps we followed are specific to our two session-restore scenarios, we chose this example because a student prepping for class might leave lots of browser tabs open—and doing that all day, every day, stresses processors from multiple directions. For both scenarios, we didn't stop with static webpages or documents; we also left an education video running on YouTube on one tab. Watching a video by itself is resource-intensive, doing this while also having over a dozen tabs open is even more intense. Then, as a placeholder for future AI applications, we started a Google Meet call, where we turned on the microphone and camera and added AI-powered background blur effects. Adding this AI-enabled task to our traditional scenario, which was already stressing the Intel processors we tested, slowed session-restores across the board.

## What we tested

On the following pages, we present our findings through the lens of fictional teachers who are coping with real-world classroom challenges. Both our hands-on results and the fictional storylines we chose show how investing in devices with better Intel processors can improve classroom experiences. These are the four ChromeOS devices on which we ran tests:



### Hypothetical District A

Chromebook powered by an **Intel Core™ i3-N305 processor** with 8GB memory and 128GB eMMC storage. Screen resolution: 1,920 x 1,080.\*



### Hypothetical District B

Chromebook powered by an **Intel Processor N200** with 8GB memory and 128GB eMMC storage. Screen resolution: 1,920 x 1,080.\*\*



### Hypothetical District C

Chromebook powered by an **Intel Processor N100** with 4GB memory and 32GB eMMC storage. Screen resolution: 1,920 x 1,080.\*\*\*



### Hypothetical District D

Chromebook powered by an **Intel Celeron® N4500 processor** with 4GB memory and 32GB eMMC storage. Screen resolution: 1,366 x 768.\*\*\*\*

\*Lenovo® IdeaPad® Slim 3i Chromebook

\*\*Lenovo 14e Chromebook Gen 3

\*\*\*Lenovo 14e Chromebook Gen 3

\*\*\*\*HP Chromebook x360

## The future of Chromebooks

The ChromeOS devices we tested didn't include AI-enabled infrastructure. The future however, holds more embedded AI options for ChromeOS. In October 2023, Google announced that the Chromebook Plus—powered by Intel processors and containing a minimum of 8 GB of memory, 128 GB of storage, and Full HD display—is available with AI-enabled software to help streamline educator workflows. AI features restricted to adult users include built-in writing assistants, image-generation capabilities for wallpaper and video-call background personalization, and AI-based enhancements to help streamline lesson planning and grading.<sup>5</sup> To learn more, read the Chromebook Plus blog: <https://blog.google/products/chromebooks/chromebook-plus/>.



## Hypothetical District A

### Foster curiosity and help students become more engaged

District A embraces an adaptive curriculum approach to learning. Mrs. Lopez, the language arts teacher for eighth graders, uses AI algorithms to determine where students are floundering and where their understanding is solid. Her students are coping with puberty, peer pressure, and attention spans of 10 to 12 minutes.<sup>6</sup> Of the four ChromeOS devices we tested, the Chromebook powered by an Intel Core i3-N305 processor delivered the fastest session-restore times under our heavy workloads. If they start class by opening their laptops, this kind of Intel processor firepower could really help Mrs. Lopez and other eighth-grade teachers make the most of those 10 to 12 minutes.

#### Traditional session-restore scenario

Lower is better | mm:ss

Device with Intel Core i3-N305 processor	1:54
Device with Intel Celeron N4500 processor	3:26

Figure 1: Time to transition between shutdown and full functionality in the traditional session-restore scenario. Source: Principled Technologies.

#### Session restore scenario featuring AI

Lower is better | mm:ss

Device with Intel Core i3-N305 processor	2:21
Device with Intel Celeron N4500 processor	3:59

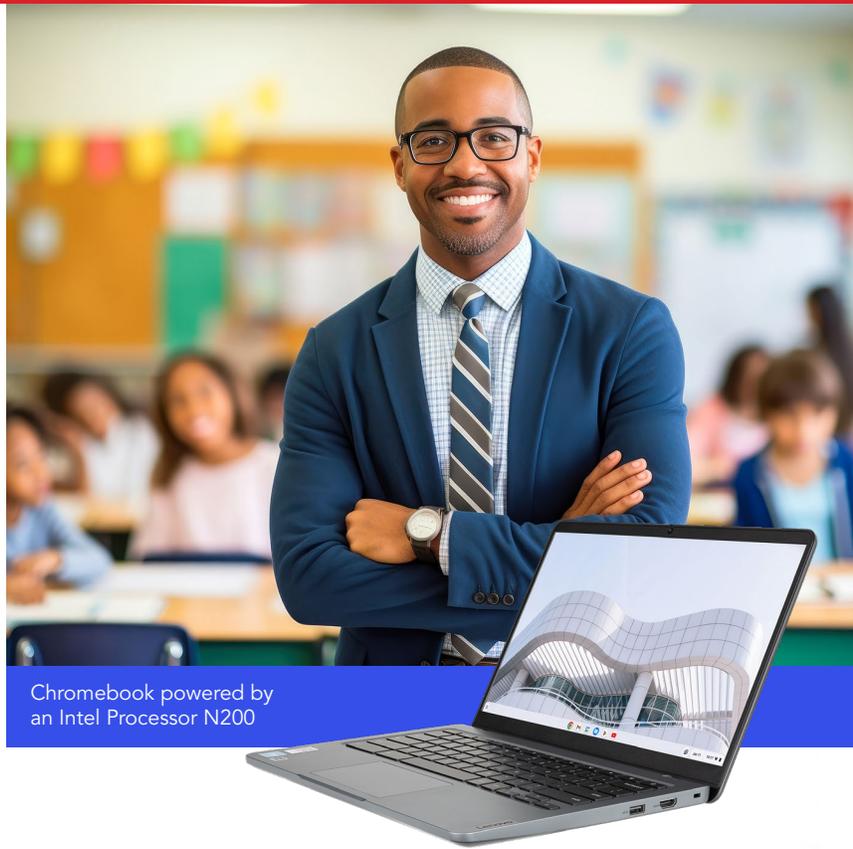
Figure 2: Time to transition between shutdown and full functionality in the session restore scenario featuring AI. Source: Principled Technologies.



## Hypothetical District B

### Remove barriers to student success

Mr. Lawrence, a middle school math teacher, holds review sessions, issues practice tests, and runs an after-school study group to improve test scores. In this instance, the Intel Processor N200 powering this Chromebook shaved off over a minute of wait times in both of our session-restore scenarios versus the Intel Celeron N4500 processor-powered Chromebook. Faster session-restores have the potential to make learning more accessible, increase student engagement, and remove barriers to student success.



Chromebook powered by an Intel Processor N200

#### Traditional session-restore scenario

Lower is better | mm:ss

Device with Intel Processor N200	2:20
Device with Intel Celeron N4500 processor	3:26

Figure 3: Time to transition between shutdown and full functionality in the traditional session-restore scenario. Source: Principled Technologies.

#### Session restore scenario featuring AI

Lower is better | mm:ss

Device with Intel Processor N200	2:41
Device with Intel Celeron N4500 processor	3:59

Figure 4: Time to transition between shutdown and full functionality in the session restore scenario featuring AI. Source: Principled Technologies.





Chromebook powered by an Intel Processor N100

## Hypothetical District C

### The threat of teacher burnout is real

District C had to increase class sizes and assign more duties to faculty because of teacher shortages. And Ms. Adams, a high school science teacher, is feeling the crunch. Our tests show that stepping up from a ChromeOS device powered by an Intel Celeron N4500 processor to one powered by an Intel Processor N100 can save 43 seconds in our traditional session-restore scenario and over a minute in our session restore scenario featuring AI. Those time savings can ultimately help teachers like Ms. Adams prioritize time spent teaching students in the classroom instead of trying to keep students engaged while they wait for learning tools to load.

#### Traditional session-restore scenario

Lower is better | mm:ss

Device with Intel Processor N100	2:43
Device with Intel Celeron N4500 processor	3:26

Figure 5: Time to transition between shutdown and full functionality in the traditional session-restore scenario. Source: Principled Technologies.

#### Session restore scenario featuring AI

Lower is better | mm:ss

Device with Intel Processor N100	2:56
Device with Intel Celeron N4500 processor	3:59

Figure 6: Time to transition between shutdown and full functionality in the session restore scenario featuring AI. Source: Principled Technologies.



## Hypothetical District D

### Excellent classroom management skills can only get teachers so far

District D's cloud-based classroom management solution enables Mr. Dunphy, a sixth-grade teacher, to guide classroom learning and keep students safe with web-limiting and screen-monitoring functions.<sup>7</sup> However, these tools do not help him when students are waiting long minutes for their devices to restore a session. In our tests, the Chromebook powered by an Intel Celeron N4500 processor was the slowest to repopulate open apps and tabs after a hard shut-down. It required almost four minutes to get up to speed when we engaged the background blur feature in the Google Meet app. That's over a minute and a half of additional waiting versus the Intel Core i3-N305 processor-powered Chromebook.



#### Traditional session-restore scenario

Lower is better | mm:ss

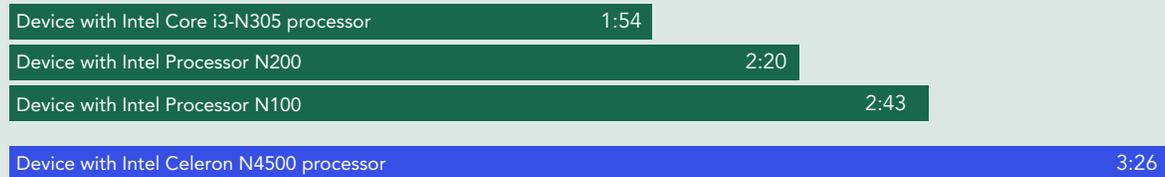


Figure 7: Time to transition between shutdown and full functionality in the traditional session-restore scenario. Source: Principled Technologies.

#### Session restore scenario featuring AI

Lower is better | mm:ss



Figure 8: Time to transition between shutdown and full functionality in the session restore scenario featuring AI. Source: Principled Technologies.



## Conclusion

AI technology, on ChromeOS devices equipped with powerful Intel processors, could be the steppingstone your district needs to make learning more accessible, increase student engagement, and remove barriers to student success. In our hands-on tests, each step up in the Intel processor upgrade story resulted in quicker open app and tab recoveries after shutdown in a traditional session restore scenario and a session restore scenario featuring AI. Don't miss this opportunity to help teachers and students reach their potential.

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3. Google, "New Google for Education tools for how you teach, learn and manage," accessed January 2, 2023, <https://blog.google/outreach-initiatives/education/google-for-education-iste-2023/>.
4. Google for Education, "The power of great apps and Google," accessed January 2, 2024, [https://edu.google.com/intl/ALL\\_us/get-started/apps/](https://edu.google.com/intl/ALL_us/get-started/apps/).
5. Maginative, "Google's New Chromebook Plus Brings Generative AI to Educators in the Classroom," accessed January 2, 2024, <https://www.maginative.com/article/googles-new-chromebook-plus-brings-generative-ai-to-educators-in-the-classroom/>.
6. Educational Innovation 360, "Why Is Middle School So Hard; What Are Some Problems Students Face?" accessed January 4, 2024, <https://www.educationalinnovation360.com/blogs/why-is-middle-school-so-hard-what-are-some-problems-students-face>.
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Read the science behind this report at <https://facts.pt/JSKyN6k> ▶



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