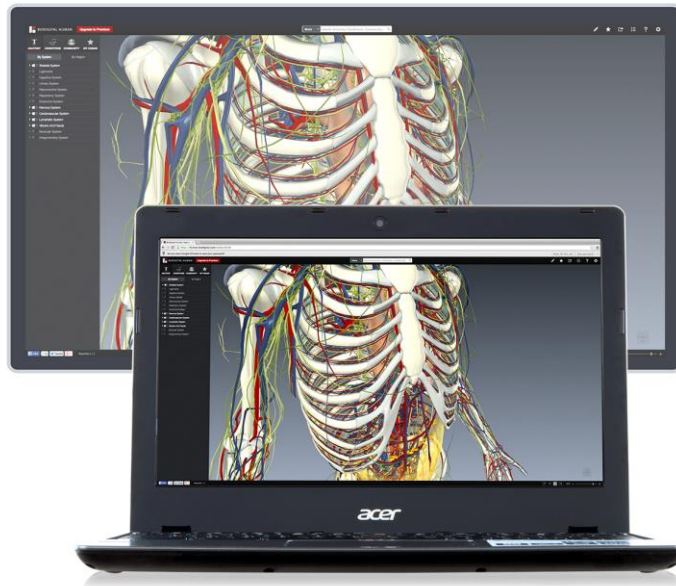




A better teaching experience with Chromecast™ on an Intel® Core™ i3 processor-powered Chromebook™



Up to
2.5^x 
more frames per second in BioDigital Human™

More than
45% 
less waiting in science class

Save over
22 seconds 
when opening BioDigital Human
versus an ARM® processor-based Chromebook

As more Chromebook™ models enter the market, it's becoming harder for schools to choose the best one to meet their needs. Which one has the power to run the latest online educational content such as Kno™ online textbooks and BioDigital Human™? Which one offers the best visual experience when using Chromecast™ in the classroom? Each model delivers a different experience for teachers teaching and students learning in the classroom.

Here in the Principled Technologies labs, we put on our teacher hats and looked at an Intel® Core™ i3 processor-powered Chromebook and an ARM® processor-based Chromebook. We performed tasks a science teacher might include while giving a lesson in the classroom, such as using a Kno online textbook and looking at different 3D anatomy models in BioDigital Human. We measured aspects of user experience that would matter to students and teachers—time to complete tasks and frame rate.

Which Chromebook is the better choice for teaching in the classroom? We found that the Intel Core i3 processor-powered Chromebook outperformed the ARM processor-based Chromebook across the board, delivering up to 250.0 percent more frames per second than the ARM processor-based Chromebook when using BioDigital Human with Chromecast. The Intel Core i3 processor-powered Chromebook also took just over half the time to complete a series of tasks, including opening BioDigital Human over 22 seconds faster than the ARM processor-based Chromebook.



WHICH PROCESSOR IS IN YOUR CHROMEBOOK?

There are many different Chromebooks on the market. To help with the buying decision, we compared two models, one with an Intel Core i3 processor and one with the latest ARM processor. We chose two systems that were as comparable as possible. The systems share the same display size, display resolution, and amount of memory. They differ in storage and battery capacity; the Intel Core i3 processor-powered Chromebook has twice the amount of storage (32 GB) and a battery with a slightly smaller capacity (3,950 mAh) than the ARM processor-based Chromebook. For more information on the two systems, see [Appendix A](#). For more on how we tested, see [Appendix B](#). For detailed results, see [Appendix C](#).

TEACHING WITH CHROMECAST

With Chromecast, Mrs. Howard can take visual content such as BioDigital Human and easily use her Chromebook to display that content on a larger screen. Mrs. Howard can teach from a single visual reference point while her students follow along on their own systems and take notes. We looked at the following science class scenario in our lab:

Mrs. Howard greets her students at the beginning of the period, and dives right into the day's lesson. She pulls up the Kno biology textbook on her Chromebook, and then casts the tab to the classroom TV. She reviews the last night's reading assignment and switches to flashcards to quiz the class. Switching gears, Mrs. Howard opens BioDigital Human, and then casts that tab to the classroom TV to look at 3D anatomy models with the class.

A BETTER VISUAL EXPERIENCE

We compared the experience the Intel Core i3 processor-powered Chromebook and ARM processor-based Chromebook could deliver when casting a tab with BioDigital Human to a Chromecast. We measured the frames per second during animations to capture the quality of the visual experience that Mrs. Howard's students would have during the lesson.

As Figure 1 shows, the Intel Core i3 processor-powered Chromebook delivered more frames per second across the board than the ARM processor-based Chromebook—from 73.9 percent more frames per second after loading the default rotating human skeleton to 250.0 percent more frames per second when rendering

Alzheimer’s disease. These numbers mean that the Intel Core i3 processor-powered Chromebook would deliver a much more engaging visual experience for Mrs. Howard’s students in the classroom. Her students would likely notice much smoother animation with the Intel Core i3 processor-powered Chromebook and significantly choppy animation with the ARM processor-based Chromebook.

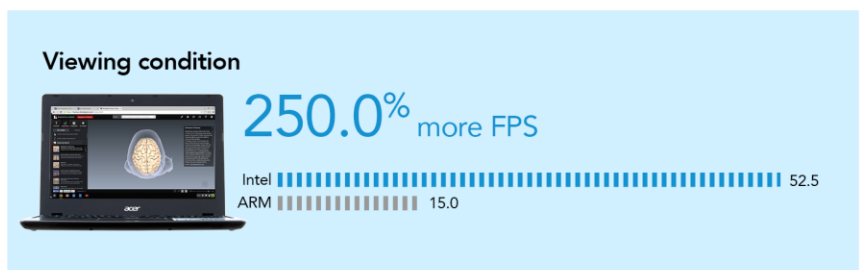
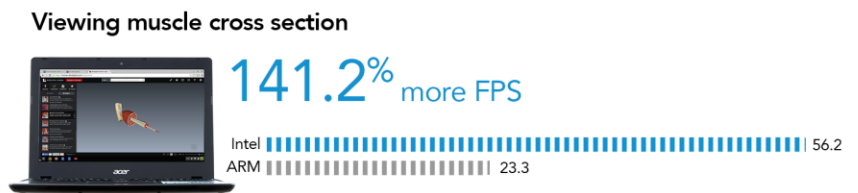
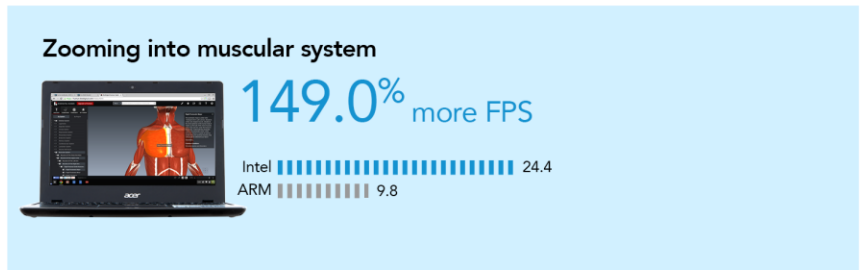
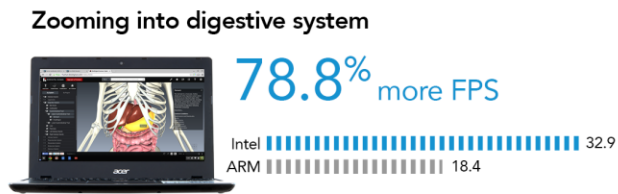
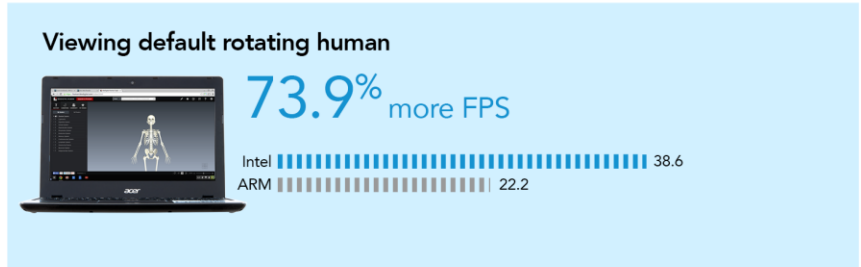


Figure 1: How the two Chromebooks compared while using BioDigital Human with Chromecast, in frames per second. Higher numbers are better.

WAITING LESS, TEACHING MORE

As Figure 2 shows, the Intel Core i3 processor-powered Chromebook completed the tasks in the scenario in just over half the time that it took the ARM processor-based Chromebook, saving Mrs. Howard and her class time with each task. For example, opening BioDigital Human on the ARM processor-based Chromebook took over 22 seconds longer than on the Intel Core i3 processor-powered Chromebook. That's valuable time that Mrs. Howard could either spend waiting or spend teaching.

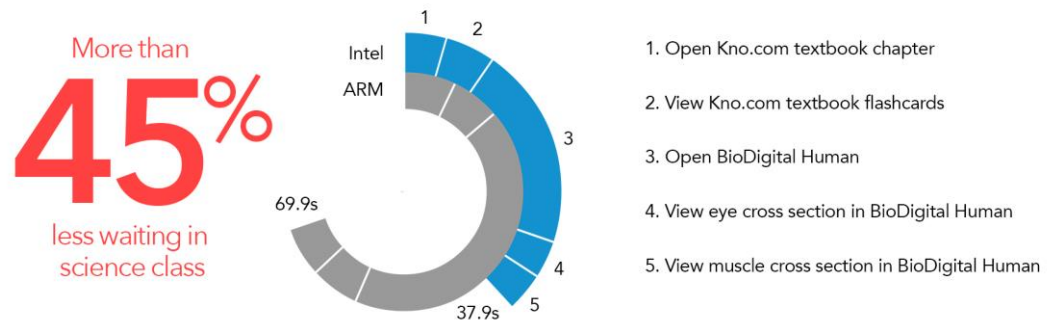


Figure 2: How the two Chromebooks compared while teaching a science lesson, in seconds. Lower numbers are better.

THE BOTTOM LINE

Which Chromebook would Mrs. Howard want in her classroom? We put two models to the test, and found that the Intel Core i3 processor-powered Chromebook offered a better experience with Chromecast than the ARM processor-based Chromebook. The Intel Core i3 processor-powered Chromebook delivered up to 250.0 percent more frames per second than the ARM processor-based Chromebook when using BioDigital Human with Chromecast. Not only did it deliver a better visual experience with Chromecast, the Intel Core i3 processor-powered Chromebook also took just over half the time to complete tasks in a science lesson. Mrs. Howard could save valuable time with the Intel Core i3 processor-powered Chromebook, and have more time to walk her students through 3D anatomy models.

APPENDIX A: DETAILED SYSTEM CONFIGURATION

Figure 3 presents detailed information on the two Chromebooks we tested.

System	Intel Core i3 processor-powered Chromebook	ARM processor-based Chromebook
Vendor and model	Acer C720-3605	Samsung XE503C12-K01US
Processor	Intel Core i3-4005U	Samsung Exynos® 5 Octa 5420
Processor frequency (GHz)	1.7	1.3 Quad + 1.9 Quad
Processor cores	2	4 + 4
Memory amount (GB)	4	4
Storage amount (GB)	32	16
Battery type	3 cell Li-Polymer	2 cell Li-Polymer
Battery capacity (mAh)	3,950	4,080
Display size and resolution	11.6" (1,366 × 768)	11.6" (1,366 × 768)
Wireless	802.11 a/b/g/n)	802.11ac (802.11 a/b/g/n compatible)
Bluetooth®	4.0	4.0
USB ports	1 × USB 3.0 1 × USB 2.0	1 × USB 3.0 1 × USB 2.0
System weight	2.76 lbs.	2.65 lbs.
OS	Chrome OS™ version 37.0.2062.119	Chrome OS version 37.0.2062.119
Firmware	Google_Peppy.4389.86.0	Google_Peach_Pit.4482.94.0

Figure 3: Detailed configuration information for the two Chromebooks.

APPENDIX B: DETAILED TEST METHODOLOGY

Before testing, we set up a Chromecast¹ on the same wireless network as the Intel Core i3 processor-powered Chromebook and ARM processor-based Chromebook. We also enabled the FPS counter in `chrome://flags` to measure the frames per second each system could deliver while casting to the Chromecast.

1. Open Google Chrome™ from the shelf, and type `kno.com` in the omnibox.
2. Select Course Manager.
3. Simultaneously start the timer and select the Campbell Biology textbook under My Stuff.
4. When the textbook is fully displayed, stop the timer, and record the result.
5. Select the Google Cast extension, and select to cast the tab to the Chromecast.
6. Simultaneously start the timer, and select Flashcards.
7. Select Chapter 1 from the drop-down list.
8. When the flashcards are fully displayed on the TV, stop the timer, and record the result.
9. Select the Google Cast extension, and select to stop casting.
10. Simultaneously start the timer and open BioDigital Human from the apps list.
11. When the page is fully displayed and the human begins to rotate, stop the timer, and record the result.
12. Select the Google Cast extension, and select to cast the tab to the Chromecast.
13. Start the timer.
14. Using a camera, capture the frames per second displayed in the counter at 20 seconds, 30 seconds, 40 seconds, 50 seconds, and 60 seconds.
15. Take the average of those five data points, and record the result.
16. Stop the timer.
17. Select By Region.
18. Simultaneously start the timer and select Eye Cross Section.
19. When the cross section is fully rendered on the TV, stop the timer, and record the result.
20. Select Reset System (or press Shift+R), and press Enter to accept the prompt.
21. Simultaneously start the timer and select Muscle Cross Section.
22. When the cross section is fully rendered on the TV, stop the timer, and record the result.
23. Select Reset System (or press Shift+R), and press Enter to accept the prompt.
24. Select by System, and select Digestive System.
25. To zoom in on the stomach and surround organs, double-click the stomach.
26. Take note of the lowest number of frames per second displayed in the counter during the zoom animation, and record the result.
27. Select Reset System (or press Shift+R), and press Enter to accept the prompt.
28. Select Muscular System.
29. To zoom in on the chest, double-click the right pectoralis major.
30. Take note of the lowest number of frames per second displayed in the counter during the zoom animation, and record the result.
31. Select Reset System (or press Shift+R), and press Enter to accept the prompt.
32. Select By Region, and select Muscle Cross Section.

¹ <http://www.google.com/chrome/devices/chromecast/>

33. Take note of the lowest number of frames per second displayed in the counter during the animation, and record the result.
34. Select Reset System (or press Shift+R), and press Enter to accept the prompt.
35. Select Conditions.
36. Select Brain and Nerves, and select Alzheimer's disease.
37. Take note of the lowest number of frames per second displayed in the counter during the animation, and record the result.
38. Select the Google Cast extension, and select to stop casting.
39. Complete steps 1 through 39 two more times.

APPENDIX C: DETAILED RESULTS

Figure 4 presents the detailed results, with rendering in BioDigital Human reported in frames per second and the time to complete tasks reported in seconds.

	Intel Core i3 processor-powered Chromebook	ARM processor-based Chromebook
Measuring visual experience		
Frames per second while viewing default rotating human (higher is better)		
Run 1	38.8	22.2
Run 2	38.1	22.3
Run 3	38.6	22.1
Median	38.6	22.2
Frames per second while zooming into digestive system (higher is better)		
Run 1	32.9	19.0
Run 2	33.8	17.7
Run 3	32.0	18.4
Median	32.9	18.4
Frames per second while zooming into muscular system (higher is better)		
Run 1	24.8	9.8
Run 2	23.8	9.7
Run 3	24.4	10.0
Median	24.4	9.8
Frames per second while viewing muscle cross section (higher is better)		
Run 1	56.2	23.6
Run 2	56.0	20.0
Run 3	56.3	23.3
Median	56.2	23.3
Frames per second while viewing condition (Alzheimer's disease)		
Run 1	52.5	15.0
Run 2	50.0	15.0
Run 3	52.5	15.1
Median	52.5	15.0
Measuring time waiting		
Time to open Kno textbook chapter (lower is better)		
Run 1	00:04.54	00:07.07
Run 2	00:04.48	00:07.08
Run 3	00:04.61	00:07.11
Median	00:04.54	00:07.08
Time to view Kno textbook flashcards (lower is better)		
Run 1	00:05.14	00:06.75
Run 2	00:05.15	00:06.85
Run 3	00:05.19	00:06.86
Median	00:05.15	00:06.85
Time to open BioDigital Human (lower is better)		
Run 1	00:20.62	00:42.87
Run 2	00:20.52	00:42.83
Run 3	00:20.56	00:42.87
Median	00:20.56	00:42.87

	Intel Core i3 processor-powered Chromebook	ARM processor-based Chromebook
Time to view eye cross section in BioDigital Human (lower is better)		
Run 1	00:03.71	00:06.25
Run 2	00:03.71	00:06.19
Run 3	00:03.79	00:06.31
Median	00:03.71	00:06.25
Time to view muscle cross section in BioDigital Human (lower is better)		
Run 1	00:03.92	00:06.87
Run 2	00:03.91	00:06.99
Run 3	00:03.96	00:06.78
Median	00:03.92	00:06.87
Total time for five tasks in the scenario	00:37.88	01:09.92

Figure 4: Detailed results.

ABOUT PRINCIPLED TECHNOLOGIES



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