K-12 BLUEPRINT

The Right Chromebook* for Virtual Learning	Commissioned by Intel®
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The Right Chromebook* for Virtual Learning

How processor performance effects teaching and learning

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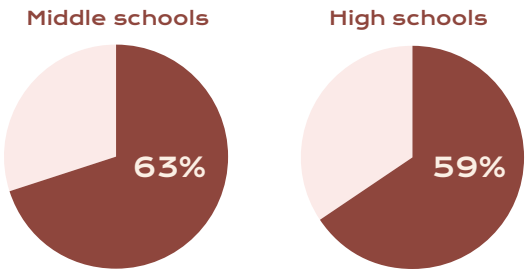
Less Waiting, More Learning with Intel®-powered Chromebooks*

The need for affordable and sustainable technology solutions that improve learning outcomes and better connect and engage students has led many U.S. educational institutions to implement widespread device adoptions. Based on CoSN's Annual Infrastructure report, 59% of high schools and 63% of middle schools report that 100% of their students have access to non-shared, or 1:1 devices during the school day[1].

Schools reporting all students have access to non-shared, or 1:1 devices



Source: CoSN's Annual Infrastructure report

Never has the need for 1:1 devices and access to reliable internet been more important than now, during the COVID-19 pandemic. While technology implementation models vary both at state and district levels, the goal during this time has remained the same: *to use technology and other tools to better engage and connect students and improve learning outcomes.* To support virtual teaching and learning, schools must be even more aware of their students' device needs, instructional goals, and the specific curricular demands on the technology.

In order to reduce equity gaps by equipping students and educators with the tools they need to be successful, many school districts have selected Chromebooks* as their preferred device for students. In the past, Chromebooks* were only able to run Chrome* web applications, G Suite* for Education add-ons, and browser extensions, limiting their usability as compared to other devices and operating systems. With the addition of Android* application support, Chromebooks* are becoming an even more powerful option for K-12 education. These applications can enhance student and educator experiences by adding new and practical uses for the Chromebook*[2]. Due to the increased capability of Chromebooks* that support Android* applications and devices with more powerful configurations including faster processors and increased memory and storage, more and more districts and schools are looking to refresh their deployments of devices for blended and virtual learning with the latest generation of Chromebooks*.

Choosing the Right Chromebook* for Virtual Learning

Accomodating the needs of all stakeholders for meaningful virtual teaching and learning experiences presents many challenges. Selecting the right Chromebook* for students and educators can be tough given the ever-increasing number of devices and configuration options. In order to help educators separate the wheat from the chaff, Intel® commissioned the education-technologists at Clarity Innovations to evaluate four different Chromebooks* and test their effectiveness at common learning and professional development scenarios. As part of our testing, we selected typical tools used in blended and virtual learning approaches such as G Suite* for Education along with a variety of Android* applications. We found that devices powered by Intel® technology allow students and educators to complete learning tasks using educational Android* applications faster than devices with MediaTek* or AMD* processors.

[1] Source: **CoSN's 2018-2019 Annual Infrastructure Report**

[2] Source: **Android apps for Chromebooks: The essentials from Computerworld**

Devices Used in this Study

Lenovo* Chromebook* Duet
MediaTek* Helio P60T

Lenovo* Chromebook* S345
AMD*-A6-9220C

HP* Chromebook* X360
Intel® Celeron® N4020

ASUS* Chromebook* Flip C436
10th Gen Intel® Core™ i3-10110U

Complete details on device specifications and configuration are available in **Appendix A**.

Results of Our Testing

When it comes to teaching and learning, whether it is an in-person, blended, or virtual model, one of the most valuable resources in any classroom is time. During the adoption process, especially one that is expedited due to emergencies like COVID-19, purchasing low cost devices may seem like the best deal; however, the hidden cost of lost learning time can have detrimental effects on both students and educators. Chromebooks* with processors powered by Intel® technology save important teaching and learning time by reducing delays and allowing students and educators to spend less time waiting for the processor to keep up with learning that requires multitasking.

When testing the processing time for using Android* applications to complete more complex tasks like creating and exporting 360° image projects and building and exporting 3D models and simulations, we discovered significant differences as a result of processor speed resulting in more learning time saved. The table on the following page illustrates the estimated total learning time saved over the four-year life of the device by using a Chromebook* powered by an Intel® processor and the total learning time of the test scenarios we developed.

The Value of Time Saved

Educator Professional Development Scenario	**AMD*-based device**	**Intel® Celeron®-based device**	**Intel® Core™ i3-based device**
	307.9 secs/day	219.3 secs/day	114.4 secs/day
Total learning time saved (as compared to the AMD* device)		7.4 hrs/year	16.1 hrs/year
Over the 4-year life of the device		29.5 hrs	64.5 hrs
Value of time saved		$ 870.84	$ 1,904.04
Middle School Scenario	**MediaTek***	**Intel® Celeron® N4020**	**Intel® Core™ i3**
	412.5 secs/day	346.6 secs/day	199.2 secs/day
Total learning time saved (as compared to the MediaTek* device)		5.5 hrs/year	17.7 hrs/year
Over the 4-year life of the device		22 hrs	71.1 hrs
Value of time saved		$ 649.44	$ 2,098.87
High School Scenario	**AMD***	**Intel® Celeron® N4020**	**Intel® Core™ i3**
	501.8 secs/day	200.9 secs/day	180.6 secs/day
Total learning time saved (as compared to the AMD* device)		25.1 hrs/year	26.8 hrs/year
Over the 4-year life of the device		100.4 hrs	107.2 hrs
Value of time saved		$ 2,963.80	$ 3,164.54

Calculations above are based on middle and high school teachers employing similar learning scenarios as those outlined in this report, twice a week in five separate classes for 30 weeks. Total learning time saved is based on comparison with the slowest device. **See Appendix D for additional details on average U.S. teacher salary**.

Overall Test Results

The learning scenarios we developed and tested were created to realistically simulate what most students and educators experience when using technology during blended and virtual learning experiences. Most lessons require the use of a web browser for access to information, resources, and research, as well as simple collaborative authoring tools like those offered in G Suite* for Education, and applications that allow for creating multimedia content. As the complexity of the learning scenario tasks increased – such as through 360° image creation or 3D object modeling – the value of the more powerful processors had a significant impact on the time it takes to complete learning experiences.

	MediaTek* Helio* P60T-based device	AMD*-A6-9220C-based device	Intel® Celeron® N4020-based device	10th Gen Intel® Core™ i3-10110U-based device
Educator Professional Development	**282.4 secs**	**307.9 secs**	**219.3 secs**	**114.4 secs**
			40.4% faster than the AMD*-based device	169.3% faster than the AMD*-based device
			28.8% faster than the MediaTek*-based device	147.0% faster than the MediaTek*-based device
Middle School	**412.5 secs**	**400.8 secs**	**346.6 secs**	**199.2 secs**
			115.6% faster than the AMD*-based device	201.2% faster than the AMD*-based device
			119.0% faster than the MediaTek*-based device	207.1% faster than the MediaTek*-based device
High School	**274.2 secs**	**501.8 secs**	**200.9 secs**	**180.6 secs**
			249.8% faster than the AMD*-based device	277.9% faster than the AMD*-based device
			136.5% faster than the MediaTek*-based device	151.9% faster than the MediaTek*-based device

Complete testing results are available in **Appendix B**.

Learning Scenarios and Outcomes

Learning Scenarios and Outcomes

The following sections outline typical K–12 learning scenarios that compare the learning experience for educators or students using devices with the four featured processors. The learning scenarios include educator professional learning, middle school earth science, and high school journalism and newspaper production. Each scenario explains the educator or student tasks involved in the activity and then gives the outcomes and highlights of the test results, in addition to the functionality differences and the timed results for performance. For all timed-test results and step-by-step test procedures, see **Appendices B and C**.

Scenario 1

Educator Professional Learning

At a Glance

Grade Level: Professional Learning

Subject Area: AR/VR

Class: Online MOOC

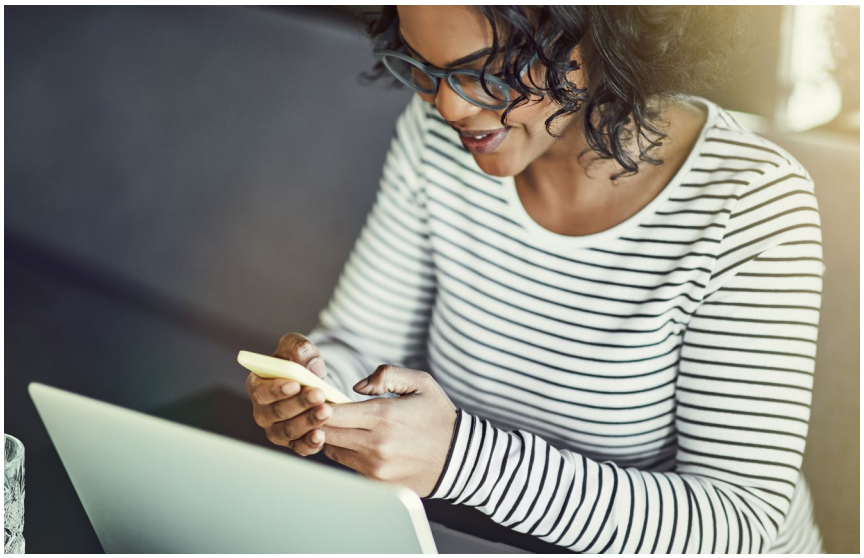
Lisa Camerena, a high school US History teacher, is interested in exploring immersive learning experiences — VR, AR, and 360° photo and video — through the online MOOC she is enrolled in. She is excited to learn more about building these immersive experiences on the Chromebook* and will design a project where her students are able to show their understanding of current and historical events using immersive technologies to engage their audience.

Learning Skills Addressed

- Graphic Design
- Digital Content Creation
- Digital Communication and Collaboration

Apps and Tools

- Polish*
- Bimostitch*
- Google Drive*
- Story Spheres*
- Online Voice Recorder*
- Chrome* browser



Virtual Reality Professional Development

High school US History teacher, Lisa Camerena, is interested in exploring immersive learning experiences through the online MOOC (Massive Open Online Course) she is enrolled in. Her coursework includes learning about virtual field trips using augmented and virtual reality technology to make student learning immersive without having to leave the classroom. Lisa is excited to explore building these immersive experiences on the Chromebook* and will design a project where her students are able to show their understanding of current and historical events using immersive technologies to engage their audience.

Linda logs into her Chromebook* and opens the course in the Chrome* browser. She creates individual new tabs for all of the course materials and the discussion board. For this particular session, Lisa is exploring how to upload individual images and stitch them together into one 360° immersive experience. To begin, Lisa opens the Polish* app and imports her photos saved on her Chromebook*. She applies filters, does touch-ups, and crops her images. When she's done editing, Lisa uploads her images into a Google Drive* folder she created for this project. Next, she opens Bimostich* on her Chromebook* and imports the images she has saved in Google Drive*. After importing her images, Lisa stitches them together to make a 360° image, adjusting and cropping as she goes. She then downloads her finished 360° photo as a high resolution file and saves it to her project folder in Google Drive*.

To begin creating an experience that offers 360° views and accompanying audio, Lisa uses an online recorder to capture audio to caption her image. She opens Online Voice Recorder* in her browser and records and edits audio files that she will place throughout her 360° experience. Once she has recorded an audio file, she clicks save and it is instantly downloaded as an mp3 file onto her device. Now Lisa is ready to put together her immersive experience using the Story Spheres* website. She opens the tool in her browser and logs into her account. She works through the steps of uploading her 360° image, all of her accompanying audio files, placing the audio in the right location on the image, and saving her story sphere. She then shares her story sphere link on the MOOC discussion board to solicit feedback from her classmates.

Faster Processing for Photo Editing and 360° Image Creation

While the three slower processors tested in this scenario are found in typical student devices, the 10th Gen Intel® Core™ i3 is the type of processor that most educators would have to future-proof the devices they use daily for teaching and learning. The fastest processor, a 10th Gen Intel® Core™ i3, completed all the steps in this scenario 169.3% faster than the slowest processor, the AMD*-A6. The Intel® Celeron® N4020 processor completed the same tasks 40.4% faster than the AMD*-A6-based device.

The differences and effects of processor speeds are highlighted in how quickly each device was able to edit photos and stitch them together as a 360° image. The Intel® Core™ i3-based device performed photo editing tasks 180.5% faster than the slowest processor, the AMD*-A6. Likewise, when stitching photos together into a 360° image, it outperformed the MediaTek*-based device working 206.8% faster. The Intel® Celeron®-based device also provided faster processing speeds when editing photos, completing the tasks 58.2% quicker than the AMD*-A6-based device. And, when stitching photos together to create a 360° image, the Intel® Celeron®-based device performed 51.7% faster than the MediaTek*-based device.

	MediaTek* Helio P60T	AMD*-A6-9220 C	Intel® Celeron® N4020	10th Gen Intel® Core™ i3-10110U
Photo editing	34.4 secs	46.6 secs	29.4 secs	16.6 secs
Photo stitching	198.9 secs	180.3 secs	131.1 secs	64.8 secs

The Intel® Core™ i3 processor completed editing photos and using them to create a 360° image almost 3 times faster than the MediaTek* processor.

Scenario 2
Middle School Classroom Scenario

At a Glance

Grade Level: 7th grade

Subject Area: Science

Class: Earth Science

As a part of their current project based learning unit on climate change, Michael Dorning's 7th grade Earth Science students will design something that helps communities affected by natural disasters. They identify and research the impact of natural disasters, interview experts, and formulate designs for their solutions. After sharing their designs and receiving feedback, students print a 3D model to present to an authentic audience for whom they outline their solution.

Learning Skills Addressed

- Simulation and Modeling
- Design Thinking
- Digital Content Creation
- Digital Communication and Collaboration

Apps and Tools

- SketchUp Viewer*
- Google Drawings*
- Google Drive*
- Tinkercad*
- Padlet*
- Google Poly*

3D Design and Print

As a part of their current project based learning unit on climate change, students in Michael Dorning's 7th grade Earth Science classes are exploring the devastating effects of natural disasters. As a culminating project, students will design something that helps communities affected by natural disasters. Students identify and research the impact of natural disasters, interview experts, and formulate designs for their solutions. After sharing their designs and receiving feedback, students print a 3D model to present to an authentic audience for whom they outline their solution.

After concluding their research and interviews, students view 3D models of machines in SketchUp Viewer*—examining the components and noticing how each part can be viewed easily in 3D. Next, students use Google Drawings* to brainstorm and sketch their ideas for what they will create to help these communities. They document and organize their plans by drawing and labeling schematic sketches and diagrams that capture all aspects of their design. Once they have settled on their design, students utilize Tinkercad* to create a 3D model of their solution. When they are done, they export these models as obj files and save them on their devices. After exporting, students open Google Poly* in the browser. This tool allows students to share and showcase their 3D models. Students export this model from Google Poly* onto their devices as a gif file.

Before their presentations, Michael uses Padlet* to create a wall where students share their gifs. They upload their files to the wall using the Padlet* app and add commentary on each other's posts to offer actionable feedback. Once receiving feedback, students make any changes to their files in Tinkercad* and export their finished model to an SD card for 3D printing.

Speed and Efficiency with Modeling and Simulation

The fastest processors, both powered by Intel® technology, completed all the steps in this scenario on average faster than the MediaTek* and AMD* processors. The Intel® Celeron® processor, one commonly used to power student devices, completed all the learning tasks in this scenario 65.9 seconds, or 119%, faster than the slowest device powered by the MediaTek* processor. While the Intel® Core™ i3-based device, the fastest of the four overall, outperformed the MediaTek*-based device by 207.1%, or 213.3 seconds.

The differences in processor speeds are clearly demonstrated in each device's ability to create, render, and export a 3D model. Overall, the Intel® powered processors outperformed both the MediaTek* and AMD* processors. The Intel® Celeron®-based device was able complete tasks using a 3D modeling application 104.3 seconds, or 56.7%, faster than the slowest device powered by a MediaTek* processor. Likewise, the device powered by an Intel® Core™ i3 processor, completed the same tasks 158.9%, or 177.0 seconds, faster than the MediaTek*-based device, proving the ability of Intel® powered technology to multitask faster and more seamlessly across learning experiences that involve 3D modeling and simulation.

	MediaTek* Helio P60T	AMD*-A6-9220 C	Intel® Celeron® N4020	10th Gen Intel® Core™ i3-10110U
Creating and exporting a 3D model	288.3 secs	226.2 secs	184.0 secs	111.4 secs

Intel® powered devices prove more efficient when creating and exporting 3D models, with the Intel® Celeron® processor performing 1.6 times faster than the MediaTek*-based device.

Scenario 3

High School Classroom Scenario

At a Glance

Grade Level: 11th grade

Subject Area: Journalism

Class: Journalism II - Newspaper Publication

As a fun way to celebrate this year's graduating class, journalism students are designing a digital senior newspaper. As students work collaboratively on their publication, they will utilize design and publication tools to include multimedia elements that make the newspaper more engaging for readers. The final product will be shared digitally through the school's social media accounts and available for viewing during the senior yearbook signing party.

Learning Skills Addressed

- Design Thinking
- Graphic Design
- Video Production
- Digital Content Creation
- Digital Communication and Collaboration

Apps

- Live Board Interactive*
- Google Drive*
- Google Docs* (Voice Typing)
- Google Assistant*
- Adobe Photoshop Express*
- KineMaster*
- Canva*

Digital Publication Project

As a fun way to celebrate this year's graduating class, Elaina Baker's journalism students are designing a digital senior newspaper. They curate information from seniors like what they are moving onto after high school; their fondest memories of the past four years; tributes to their favorite teachers; and, seniors' advice to underclassmen. This digital publication will also offer embedded videos, voice overs, and other rich media that can be played right from its pages. Their newspaper will be shared digitally through the school's social media accounts and available for viewing during the senior yearbook signing party.

Students begin by working collaboratively in teams. They utilize Live Board Interactive* to brainstorm layouts, share and edit copy, solicit feedback on photos, and create next steps. This app allows student teams to work synchronously from various locations. As they are working on their content, students utilize Google Assistant* to set calendar reminders for meetings and approaching project deadlines. Live Board Interactive* also gives students the ability to capture their session as a video artifact to export and share with Elaina through Google Drive*.

Students use Google Docs* to collaboratively write and edit copy for each of the newspaper pages. Students use options such as Voice Typing in order to quickly add their thoughts, ideas, and compiled research and notes to the document. They also use Adobe Photoshop Express* to create assets for their digital publications. These apps allow photo editing, cropping, enhancing, as well as graphic design for assets like icons and logos. In addition to images, students use KineMaster* to create rich media content like videos that they will seamlessly embed into their newspaper. Students export all of their assets to their team's project folder in Google Drive*and use Canva* to create each of their newspaper pages.

Processor Speed and Creating and Exporting Media

Both of the devices powered by Intel® technology, completed all the steps in this scenario's learning tasks faster than the MediaTek* and AMD* processors. The Intel® Celeron® N4020 processor, the one commonly found in student devices, was able to multitask and perform 300.9 secs, or 249.8% faster than the slowest processor, the AMD*. While the Intel® Core™ i3 processor was 321.2 secs, or 277.9%, faster than the AMD*.

The ability of each device to create and export media, demonstrates the power of Intel® processors to save students time when creating work and exporting it to share with others. Both Intel® powered devices were able to create images and digital publications, and export this media faster than the devices with MediaTek* and AMD* processors. When creating and exporting images using a photo manipulation application, the Intel® Celeron®-based device performed 1.5 times faster than the MediaTek*-based device and 2 times faster than the AMD*-based device. Likewise, the Intel® Core™ i3-based device outperformed both the MediaTek* and AMD* processors, with processing speeds 1.8 times faster than the MediaTek* and 2.6 times faster than the AMD*. The Intel® powered processor speeds hold true when completing similar tasks with digital publications. Both the Intel® Celeron®-based and the Intel® Core™-based devices were faster than the slowest processor, the AMD*, performing 2.7 times and 3 times faster respectively.

	MediaTek* Helio P60T	AMD*-A6-9220 C	Intel® Celeron N4020	10th Gen Intel® Core i3-10110U
Photo manipulation and exporting	63.6 secs	93.7 secs	41.1 secs	35.4 secs
Digital content creation and exporting	177.3 secs	385.2 secs	144.1 secs	131.5 secs

The Intel® Celeron® processor allows for faster media creation and exporting speeds, performing 2.6 times faster than the AMD* processor.

Appendix

A. Device Specifications

Device	Lenovo* Duet	Lenovo* S345	HP* Chromebook* X360	ASUS* Flip C436
Model Number	ZA6F0016US	S345-14AST	1A767UT#ABA	90NX0PS2-M00600
Operating System	Chrome OS* version 83	Chrome OS* version 83	Chrome OS* version 83	Chrome OS* version 83
Processor	MediaTek* Helio* P60T	AMD*-A6-9220C	Intel® Celeron® N4020	Intel® Core™ i3-10110U
Processor Frequency	2 GHz	1.8 GHz	1.1 GHz	2.1 GHz
Storage	128 GB	32 GB	32 GB	128 GB
Memory	4 GB	4 GB	4 GB	8 GB
Battery Capacity	36 Wh	57 Wh	60 Wh	42 Wh
Display Size	10.1" touchscreen 1920 x 1200	14" no touchscreen 1920 x 1080	14" touchscreen 1366 x 768	14" touchscreen 1920 x 1080
Graphics	ARM* G72 MP3	AMD* Radeon™ R5	Intel® UHD Graphics	Intel® UHD Graphics
Camera	Integrated Webcam	Integrated Webcam	Integrated Webcam	Integrated Webcam
Audio	Stereo speakers	Stereo speakers	Stereo speakers	Stereo speakers
Networking	802.11ac	802.11ac	802.11ac	802.11ax
USB	USB-C Gen 2	2 x USB-C 3.1 Gen 1 2 x USB-A 3.1 Gen 1	2 USB 3.1 Gen 1 Type-C	2 x USB 3.2 Gen 1 Type-C
Bluetooth	Bluetooth® 4.2	Bluetooth® 4.1	Bluetooth® 4.2	Bluetooth® 5.0
Price at Time of Purchase	$299.00	$279.99	$324.82	$799.00
Weight	Tablet Only: 0.99 lbs Tablet + Full Keyboard: 2.03 lbs	3.27 lbs	3.7 lbs	2.58 lbs

B. Device Test Results

Scenario 1 - Educator Professional Learning (1 of 2)

		MediaTek* Helio* P60T-based Device				AMD*-A6-9220C-based Device				Intel® Celeron® N4020-based Device				Intel® Core™ i3-10110U-based Device			
	Test	1	2	3	avg	1	2	3	avg	1	2	3	avg	1	2	3	avg
Google Chrome Browser Workload	Load Browser Tabs	26.7	25.9	22.3	25.0	45.5	47.8	50.7	48.0	36.7	39.8	34.7	37.1	19.8	18.6	14.4	17.6
	Download Image	4	2.5	3.2	3.2	2.7	2.6	2.8	2.7	1.9	1.7	2.2	1.9	1.9	1.9	2.9	2.2
	Show in Finder	3.2	2.9	2.9	3.0	3.1	3	3.3	3.1	2.1	1.7	2.2	2.0	1	1.7	1.5	1.4
	Display Image	3.1	4.7	3.2	3.7	3.5	3.3	3.4	3.4	2.6	2.6	2.8	2.7	1.2	1.4	1.3	1.3
	Total for all subtasks	37	36	31.6	**34.9**	54.8	56.7	60.2	**57.2**	43.3	45.8	41.9	**43.7**	23.9	23.6	20.1	**22.5**
Photo Editing App	Open app	3.3	2.6	2.9	2.9	2.8	3.7	3.1	3.2	2.6	2.4	2.8	2.6	2.1	2.3	2	2.1
	Open Image	2.6	2.6	2.4	2.5	5.5	6.1	5.4	5.7	3	3	3.3	3.1	1.6	1.7	1.6	1.6
	Apply Changes	10.4	10.5	9.9	10.3	13.2	13.7	12.4	13.1	8	8.8	8.5	8.4	4.3	4.9	4.3	4.5
	Upload Collage Photos	6.1	5.4	4.6	5.4	8.7	9.9	8.4	9.0	5.8	4.8	4.4	5.0	2.4	3	2.7	2.7
	Apply Collage Filter	4.2	4.6	3.9	4.2	6	6.5	5.6	6.0	3.9	4.2	3.4	3.8	1.7	2.2	2.1	2.0
	Save Collage	9.1	9.3	8.7	9.0	9.6	9.9	9.2	9.6	6	6.6	6.8	6.5	3	4	3.9	3.6
	Total for all subtasks	35.7	35	32.4	**34.4**	45.8	49.8	44.1	**46.6**	29.3	29.8	29.2	**29.4**	15.1	18.1	16.6	**16.6**

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Scenario 1 - Educator Professional Learning (1 of 2)

		MediaTek* Helio* P60T-based Device				AMD*-A6-9220C-based Device				Intel® Celeron® N4020-based Device				Intel® Core™ i3-10110U-based Device			
	Test	1	2	3	avg	1	2	3	avg	1	2	3	avg	1	2	3	avg
Bimostitch	Stitch photos	200.4	199.3	197	198.9	179.5	179.1	182.3	180.3	127.5	125.6	140.2	131.1	63.4	65	66.1	64.8
	Total for all subtasks	200.4	199.3	197	**198.9**	179.5	179.1	182.3	**180.3**	127.5	125.6	140.2	**131.1**	63.4	65	66.1	**64.8**
StorySpheres	Upload 360 image	10.8	9.8	9.7	10.1	19.1	18.7	16.8	18.2	10.7	10.3	10.6	10.5	7.3	6.7	7.5	7.2
	Upload audio files	4.2	4.4	4	4.2	5.5	5.9	5.5	5.6	4.6	5	4.2	4.6	3.2	3.2	3.3	3.2
	Total for all subtasks	15	14.2	13.7	**14.3**	24.6	24.6	22.3	**23.8**	15.3	15.3	14.8	**15.1**	10.5	9.9	10.8	**10.4**
Scenario Total (Seconds)					**282.4**				**307.9**				**219.3**				**114.4**

Scenario 2 - Middle School Classroom Scenario

		MediaTek* Helio* P60T-based Device				AMD*-A6-9220C-based Device				Intel® Celeron® N4020-based Device				Intel® Core™ i3-10110U-based Device			
	Test	1	2	3	avg	1	2	3	avg	1	2	3	avg	1	2	3	avg
SketchUp	Download model	11.1	11.3	11.7	11.4	15.3	16.8	14.8	15.6	6	19.5	12.5	12.7	3.5	2.3	4.5	3.4
	Open model	24.9	19.9	21.4	22.1	23.1	22.9	26.6	24.2	12.6	20.6	17.8	17.0	7.1	6.5	6.3	6.6
	Total for all subtasks	36.0	31.2	33.1	**33.4**	38.4	39.7	41.4	**39.8**	18.6	40.1	30.3	**29.7**	10.6	8.8	10.8	**10.1**
TinkerCad	Open 3D View	29	41.4	26	32.1	24.9	26	37.9	29.6	27	27.3	25.7	26.7	24.1	24.6	23.4	24.0
	Open Tinker Mode	22.7	23	22.9	22.9	28.2	27.6	27.9	27.9	17.3	21.1	18.8	19.1	14.3	16.3	14.6	15.1
	Render Brick-mode	235.6	229	235.4	233.3	169.9	162.7	173.6	168.7	136.6	141.8	136.4	138.3	70	75.5	71.3	72.3
	Total for all subtasks	287.3	293.4	284.3	**288.3**	223.0	216.3	239.4	**226.2**	180.9	190.2	180.9	**184.0**	108.4	116.4	109.3	**111.4**
Google Poly	Upload an OBJ file	25.3	25.5	21.6	24.1	25.7	24.3	27.7	25.9	28.5	46.3	14	29.6	16.7	16.8	17.5	17.0
	Publish Poly	16.5	13.2	14.9	14.9	14.9	19.9	16.2	17.0	11.3	22.4	19.8	17.8	18.2	12.9	18.4	16.5
	Create a GIF from Poly	44.1	43.9	43.2	43.7	85.5	81.1	81.4	82.7	73.6	72	88.4	78.0	42.8	32.7	33	36.2
	Total for all subtasks	85.9	82.6	79.7	**82.7**	126.1	125.3	125.3	**125.6**	113.4	140.7	122.2	**125.4**	77.7	62.4	68.9	**69.7**
Padlet	Upload a GIF	7.7	7.8	8.6	8.0	9.9	8	9.6	9.2	5.7	9.8	7.1	7.5	8.5	8	7.8	8.1
	Total for all subtasks	7.7	7.8	8.6	**8.0**	9.9	8	9.6	**9.2**	5.7	9.8	7.1	**7.5**	8.5	8	7.8	**8.1**
	Scenario Total (Seconds)				**412.5**				**400.8**				**346.6**				**199.2**

Scenario 3 - High School Classroom Scenario

		MediaTek* Helio* P60T-based Device				AMD*-A6-9220C-based Device				Intel® Celeron® N4020-based Device				Intel® Core™ i3-10110U-based Device			
	Test	1	2	3	avg	1	2	3	avg	1	2	3	avg	1	2	3	avg
LiveBoard	Prepare PDF for Export	5.3	4.4	5.1	4.9	4.3	3.6	3	3.6	1.8	1.9	1.9	1.9	2	2.1	1.9	2.0
	Export to Google Drive	12.7	16.7	12	13.8	5.5	5.6	5.8	5.6	4	3.4	4.6	4.0	3.6	4.1	3.6	3.8
	Export Recording to Drive	13.3	14.1	16.5	14.6	12	16.5	12.2	13.6	10	9.6	10	9.9	4.9	8.9	10	7.9
	Total for all subtasks	31.3	35.2	33.6	**33.4**	21.8	25.7	21	**22.8**	15.8	14.9	16.5	**15.7**	10.5	15.1	15.5	**13.7**
Adobe Photo Express	Import Image	7	6.9	8.1	7.3	21.8	20.7	21.1	21.2	9.7	9.5	9.9	9.7	4.5	4.2	4.4	4.4
	Export to Gallery	3.9	4.1	4.3	4.1	32.3	33.3	33.3	33.0	14.3	14.2	13.9	14.1	9.3	9.8	9.5	9.5
	Export to Google Drive	42.3	58	56.1	52.1	38	45.9	34.7	39.5	16.9	18.7	16.2	17.3	21.1	25.3	18.1	21.5
	Total for all subtasks	53.2	69	68.5	**63.6**	92.1	99.9	89.1	**93.7**	40.9	42.4	40	**41.1**	34.9	39.3	32	**35.4**
Canva	Upload Video Asset	19	21.3	24.6	21.6	28.4	24.5	28.1	27.0	13.1	11.6	11.3	12.0	13.6	12.4	10.7	12.2
	Prepare Video for Export	102.5	102	103.4	102.6	295.2	294.6	290.3	293.4	108.6	107.6	106.9	107.7	101.4	101.8	99.4	100.9
	Export to Google Drive	52.6	51.8	54.6	53.0	68.2	68.2	58.2	64.9	25.5	24.2	23.4	24.4	36.4	31.2	36.3	34.6
	Total for all subtasks	174.1	175.1	182.6	**177.3**	391.8	387.3	376.6	**385.2**	147.2	143.4	141.6	**144.1**	97.6	151.4	145.4	**131.5**
	Scenario Total (Seconds)				**274.2**				**501.8**				**200.9**				**180.6**

C. Scenario Testing Details

Scenario 1 – Educator Professional Learning

Simulating the Browser Workload

Testing Loading Time

1. Log in to Chromebook*.
2. TEST: Open Chrome* web browser set to startup with the following tabs:
   - StorySpheres*
   - Online voice recorder*
   - Coursera* Virtual Reality Mooc
   - Youtube*
   - Gmail*
   - Facebook*
   - Pixabay*

Downloading Image Files onto Chromebook*

1. Log into Pixabay*
2. Navigate to the following image: **https://pixabay.com/photos/mountains-bergsee-lake-1645078/**
3. Click "Free Download"
4. Select the option for 5472×3147
5. TEST: Press Download and wait for the download to complete
6. TEST: Press the option "Show in folder" and wait for the Finder to appear
7. TEST: Click the downloaded image and wait for the Image to appear

Photo Editing with Polish*

Opening Polish*

1. Bring up the Chromebook* App menu
2. TEST: Open the Polish* / Photo Editor Pro app and wait for it to open

Importing Image

1. Choose "Photo"
2. TEST: Choose the downloaded Pixabay* image and wait for it to load

Editing Image

1. Press "Effect" option
2. Press "Neon" option
3. Select the "LI4" Filter
4. TEST: Approve the changes by clicking the checkmark icon and wait for changes to finish loading
5. Press the "Save" button to save the image
6. Press Home Button
7. Press Collage button
8. Select **these 18 photos** from the photo finder
9. TEST: Press "Next" and wait for the collage to load
10. Choose "Filter" button
11. TEST: Press the "Latte" filter and wait for it to apply to the collage
12. Press the checkmark icon to apply the changes
13. TEST: Press "Save" and wait for the collage to save

Creating 360° Photo with Bimostich*

Importing Images

1. Bring up the Chromebook* App menu
2. Open Bimostich* app
3. Open the System Picker
4. Select **these 18 photos**
5. TEST: Press "Open" and wait for the Pano image to load

Creating StorySphere*

Creating the Project

1. Open Story Spheres* in the Chrome* web browser and log into account.
2. Press "Create"
3. Enter a Title and Description and agree to terms
4. Press "Next"
5. Press "Upload 360 image"
6. Select **this 360 image** from the finder
7. TEST: press "Open" and wait for the 360 image to load
8. Press "Next"
9. Press "Upload audio files"
10. Select **these 5 audio** files from the finder
11. TEST: press "Open" and wait for the audio files to load

Scenario 2 - Middle School Classroom Scenario

Simulating the Browser Workload

Testing Loading Time

1. Log in to Chromebook*.
2. TEST: Open Chrome* web browser and create a few new tabs to mimic the types of tabs a typical student would have open.
    - Facebook*
    - Gmail*
    - Youtube*
    - TinkerCad* homepage
    - TinkerCad* sample project
    - TikTok*
    - Twitch*
    - Google Hangouts*
    - 3D warehouse*

View Data Visualizations with SketchUp Viewer*

Loading 3D Model

1. Open SketchUp Viewer* app.
2. Press the cloud icon and Choose "3D Warehouse"
3. Search for the project "4 bedroom penthouse" by Sympa D.
4. TEST: In the popup modal click the Download icon and wait for the model to download
5. TEST: Press the Open icon and wait for the model to load

Creating 3D Model with Tinkercad*

Loading a Project

1. Open the browser tab containing the 1950's Ford project: **https://www.tinkercad.com/things/8UxM2OgAAHZ-1950-ford**
2. TEST: Click "View in 3D" and wait for the 3D view to fully load
3. TEST: Click on "Copy and Tinker" and wait for the project to fully load
4. Press the Bricks button
5. TEST: press the "3X Design size" option and wait for it to fully load
6. Click back to Design Mode

Creating a GIF with Google Poly*

Uploading obj File

1. Open the browser tab with Google Poly*
2. Press the Upload icon
3. From file finder, locate and select a 72 MB .obj file
4. TEST: press Upload and wait for the upload to complete

Publishing gif File

1. Publish a 3D file
2. Enter project description
3. TEST: press Publish and wait for the file to fully publish
4. Press the "Create GIF" button
5. Choose 16:9 Aspect and 1x Speed
6. TEST: Press Download and wait for the GIF to fully download

Publishing 3D Model on Padlet*

Upload gif File

1. Open Padlet* app
2. Press the "Make A Padlet*" option
3. Choose a Wall-type Padlet*
4. Press the + button
5. Press the Upload icon
6. Select a 3.5 MB GIF file
7. TEST: press Open and wait for the GIF to fully load

Scenario 3 - High School Classroom Scenario

Simulating the Browser Workload

Testing Loading Time

1. Log in to Chromebook*.
2. TEST: Open Chrome* web browser and create a few new tabs to mimic the types of tabs a typical student would have open.
    - Facebook*
    - Gmail*
    - Youtube*
    - TikTok*
    - Twitch*
3. Open Adobe Photoshop Express* and KineMaster* apps to run in the background *(the idea here is that students will be going back and forth between Live Board Interactive* and the other apps to share ideas and edit assets as they work).*

Collaborating with Live Board Interactive*

Open App

1. Open Live Board Interactive* app.
2. Create board
3. Choose Landscape + Create
4. Choose the Import icon and Choose Photo
5. Create five slides with this 54MB image once on each page

Record and Export Collaborative Session

1. Record Live Board Interactive* for 1:00 minute then Stop recording
2. TEST: Choose Export as PDF
3. TEST: Upload the PDF into a Google Drive* folder.
4. TEST: Export the recording as a PDF

Voice Typing in Google Docs*

Use Voice Typing to add Text

1. Open Google Docs*.
2. Choose Tools > **Voice typing**.
3. Click microphone to begin voice typing. Click microphone again when finished.

Using Google Assistant*

Set a Calendar Reminder

1. Open Google Assistant* on Chromebook*.
2. Set a meeting reminder on the calendar

Editing and Exporting Photos in Adobe Photoshop Express*

Import Images

1. Switch to Adobe Photoshop Express*.
2. TEST: Import 39 mb image asset from File Finder.

Export Images

1. Choose Export
2. Set JPEG Quality to Maximum
3. TEST: Press Save To Gallery
4. TEST: Upload image file to a Google Drive* folder.

Editing and Exporting Video Using KineMaster*

Import and Edit Video

1. Switch to KineMaster*
2. Import video asset.
3. Apply editing features.

Export Video

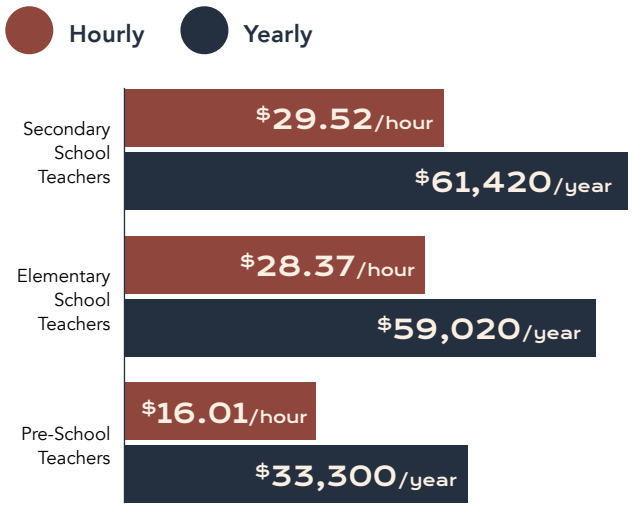
1. Press Export
2. Set Resolution to 720p and Frame Rate to 30 (~210MB export size)
3. TEST: Save and download asset onto Chromebook*.
4. TEST: Upload video file to a Google Drive* folder.

Creating Digital Publication in Canva*

1. Import Media and Save to Google Drive*
2. Open Canva*.
3. TEST: Upload this video to a video template.
4. TEST: Save As > Download
5. TEST: Save to Google Drive*.

D. Average U.S. Teacher Salary

Hourly Wages for Teachers



Source: Based on 2018 data collected by the U.S. Bureau of Labor and Statistics as summarized in the **Houston Chronicle**.

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Any change to those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products.
For more complete information about performance and benchmark results, visit **www.Intel.com/benchmarks**.

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