K-12 BLUEPRINT

Hardware and Software for Computational Thinking

Without the right hardware and software, it's a challenge to create the rich and immersive learning experiences necessary to build computational thinking and other key competencies such as digital content creation, simulation and modeling, artificial intelligence and machine learning, data science, and design thinking.

Choosing the appropriate technology to support computational thinking in the classroom is crucial for competency and skills development. Engaging students by actively working with various types and levels of technology, such as computers and programming languages, virtual labs, design and simulation labs, artificial intelligence projects, 3D modeling, data science and others, will put their creative, math, and science skills in a living context that will help them evolve their skills in preparation for tomorrow's workforce.

Hardware Considerations

Hardware provides the foundation for 21st century learning. And Intel processors support secure, reliable and scalable learning environments.

Educational hardware should also be future proofed. Since educational resources drive the capabilities needed in a learning device, processor considerations should allow for increasingly more challenging workloads as computational thinking skills are developed. This may require more computing power such as that provided by the Intel® Core™ i5 and i7 family of processors. For example, digital content in later grades, such as simulation and modeling labs will need more powerful processors to run the complex math and rich visualization. Workloads that rely on collaborative involvement and communication with team members also can demand more powerful devices. Likewise, educators will need more power to create content for immersive experiences relying on rich, processor-demanding multimedia applications.

Hardware-enabled security is more secure and faster than software-enabled security. And the hardware-enhanced features of the Intel® vPro™ technology, including hardware-enabled security and manageability, help protect information and ease a school or district-level IT department's burden of maintaining devices across the facilities. Hardware-enhanced features accelerate background computer tasks so the hardware doesn't slow down the learning environment. These are standard capabilities in Intel® vPro™ technology.

- **Hardware-enhanced security:** Encryption is the standard for securing data, but the process can slow down other computing tasks. Intel® security integrates hardware-accelerated encryption in every processor to speed up encryption operations.
- **Hardware-enhanced manageability:** Computers distributed around a school district need to be centrally managed, so technicians don't have to travel unless absolutely necessary. PCs with Intel® Core™ vPro™ processors support secure remote manageability to respond to problems without visiting the school or other site.
- **Hardware-enhanced video:** With network-based and locally stored video a central part of learning today, processing video can slow down a laptop. Intel® video technologies accelerate video decoding so other tasks are not slowed down.
- **Other hardware-enhanced technologies:** Intel® processors have many built-in technologies to accelerate commonly used functions so it doesn't slow down when software applications need the CPU.

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Software Considerations

In many modern industries, nearly everything is simulated and designed and sometimes 3D printed before it is built. In science, when it's too expensive, impractical, or impossible to perform experiments, most of our deepest insights come from simulation and modeling. And, in high-tech industries, modeling is used to develop smart, autonomous robots, or to extract behavioral patterns from vast and unstructured user data.

There are a wide range of possible learning resources that allow students to develop their reasoning, problem solving, perception, learning, and planning skills. These skills may require the creation and manipulation of digital media, sophisticated simulation and modeling, utilizing artificial intelligence technology and programming languages, defining and extracting data, and using logic, science, and math to construct systems that solve problems.

Much like with hardware, the software used by teachers, students, and school leaders needs to be powerful, secure, and future-proofed to withstand the demands of the education environment.

The technology employed must support skill building through tools and workloads requiring optimum processor performance. These technologies include:

- **Virtual Reality.** Virtual Reality (VR) may involve immersive experimentation and modeling, immersive game-based learning, and immersive skills training. Some popular virtual reality solutions include: Enduvo, Engage, Robo-Engineers, HoloLAB Champions, VictoryVR, Lifeliqe, and SpringboardVR.
- **Digital Media Creation.** The process of digital media creation helps support vital skills such as creative thinking, collaboration, and digital expression. Some popular digital media creation solutions include: **tinkercad.com**, **bookcreator.com**, explaineverything.com, **spark.adobe.com**, **canva.com**, and **moovly.com**.
- **Virtual Science Lab Software.** This type of software supports experimentation and modeling as well as concept simulation. Some popular virtual science lab software solutions are **prepmagic.com** and **labster.com**.
- **Game-Based Learning.** Game-based learning often supports strategic and analytical thinking, problem solving, and experimentation. **Minecraft.net** is an example of a popular game-based solution that has translated well to the classroom.
- **Programing and Coding.** Programming and coding help build and support computational thinking, modeling and experimentation, as well as creative thinking. Popular programming and coding solutions include: **unity.com/education**, **codakid.com**, and **scratch.mit.edu**.
- **3D Modeling.** 3D modeling involves design and modeling, collaboration, and the expression of creativity. Some popular solutions include: **freecadweb.org**, **makerbot.com**, **tinkercad.com**, and **swappsforkids.com**

Most 3D software packages contain integrated modules for modeling, texture mapping and animation at a minimum. Some of these solutions include:

- Autodesk Maya*
- Autodesk 3D Studio Max*
- Maxon Cinema 4D* (standalone or bundled with Adobe After Effects CC*)
- Autodesk MotionBuilder*
- Pixologic ZBrush*
- Autodesk Mudbox* (digital sculpting and painting)
- Rhino 3D*

Some free solutions include:

- Blender*
- Clara.io*
- Houdini* (Apprentice version free with limitations)
- Daz 3D Studio*
- Sketchup* (free to $299/year)

Photo editing software allows students to optimize and work with a wide range of image files and formats. Some of these solutions include:

- Adobe Lightroom CC*
- Adobe Photoshop CC*
- Luminar*
- DXO Photo Lab* (includes former Nik Collection*)
- Affinity Photo*
- ON1 Photo Raw*
- Capture One Pro*

Some free solutions include:

- PhotoLemur* (free with watermark or paid)
- Raw Therapee*
- Dark Table*

Sound editing software is capable of both editing and optimizing audio files. This includes voiceover narration, music and sound effects. Some of these solutions include:

- Adobe Audition CC*
- Steinberg CuBase Pro*
- Reaper*
- Avid Pro Tools*

Video editing software allows students to edit various kinds of video and still imagery together with sound files in order to create a variety of projects.

- Adobe Premiere CC*
- Adobe Premiere Rush*
- Final Cut Pro X*
- Vegas Pro 15*
- Avid Media Composer*
- Corel Video Studio Ultimate*

Some free solutions include:

- DaVinci Resolve*
- Lightworks* (free and paid versions)
- Shotcut*
- Movie Maker*
- iMovie* (Mac)

"There's that hurdle of professional learning, where a teacher doesn't feel comfortable introducing something that they are not terribly familiar with. The lowest bar thing a teacher could do is getting up to speed on block-based programming languages. The original one is MIT Scratch: it's visual programming. Through that, kids can do game design, storytelling, modeling, simulation…there's an awful lot you can do with MIT Scratch. And for teachers to get over their lack of confidence or lack of understanding, I think one of the best resources is Hour of Code. Teachers don't have to have any experience at all to get their kids started in the Hour of Code exercises."

—**Jane Krauss**, *co-author of Computational Thinking and Coding for Every Student: The Teacher's Getting-Started Guide.*

Technology Adoption Stages

Schools may be at different points in their stages of technology adoption. Some schools may be in the early stages, while others might be in the middle or later stages.

Example Stages of Technology Adoption for Industry 4.0 Competencies and Skills Development

Beginning Stage	Intermediate Stage	Advanced Stage
Technology Beginning to be Integrated with Teaching and Learning: Teachers with Core i5 full-featured laptops and interactive whiteboards COW with Core i3 laptops for select grades	*Technology Partially Integrated with Teaching and Learning:* Teachers with Core i7 full-featured laptops COW with Core i5 laptops for primary school students 1:1 full-featured laptops for high school students	*Technology Fully Integrated with Teaching and Learning:* Teachers with Core i7 full-featured laptops 1:1 Core i5 standard laptops laptop for primary school students 1:1 Core i7 full-featured laptops for high school students
Innovation Center for high school students (including Core i5 full-featured shared laptops)	Innovation Center for all students	Innovation Center for all students
Technologies: Simple Programming and Coding, Basic Digital Content Creation (PowerPoint, photo editing, podcasts), and beginning Robotics	*Technologies:* More advanced Programming and Coding, more advanced Robotics, more advanced Digital Content Creation (web sites, eBooks), Simulation and Modeling, Virtual Labs, Collaboration, and Game-Based Learning	*Technologies:* Advanced Programming and Coding, advanced Robotics, advanced Digital Content Creation (video production and editing with a green screen, etc.), AI and Machine Learning, Data Science, VR, HPC, Immersion, and IoT
100% on-premises infrastructure (including servers) Security and privacy considered	Hybrid (60% on-premises and 40% cloud) infrastructure Emphasis on security and privacy	Hybrid (90% on-premises and 10% cloud) infrastructure Much greater emphasis on security and privacy
Internet and electric power may not be reliable	Internet and electric power are reliable	Internet and electric power are robust
Some impact on competency and skills (such as remembering and understanding) development First steps toward Personalized Learning	Significant impact on competency and skills (such as applying and analyzing) development Personalized Learning partially enabled	Greatest impact on competency and skills (such as evaluating and creating) development Personalized Learning fully enabled