

# THE FUTURE OF TECHNOLOGY EDUCATION

HOW GOVERNMENTS CAN HELP CLOSE  
THE 21ST-CENTURY SKILLS GAP

The Boston Consulting Group  
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# INDEX

## TOPICS

1. The Future of Technology Education	2
2. New Skills for the 21st Century	5
3. A New Model for Technology Education	8
4. Integrating Higher Order Skills into the Curriculum	9
5. Keeping Pace with Changes in Technology	11
6. Leveraging Technology Across the Curriculum	12
7. Lessons Learned	16
8. How Governments Can Help Close the 21st Century Skills Gap	17
9. Conclusion	19



# 1. The Future of Technology Education: How Governments Can Help Close the 21st-Century Skills Gap

## Abstract:

With the rise of the Information Age and end of the Industrial Era, many education systems have come under increased pressure to re-examine and adjust the way they are preparing students for the economy ahead. Given the outsized role technology has played in changing the landscape around us, two key questions arise: what should technology education look like for students in order to drive future growth, and how can technology be leveraged in the education process itself to accelerate success in the 21st century? This paper examines both these questions, as well as a third: what role can and should governments play to ensure that students will thrive in the 21st-century labor market? We conducted research to analyze how digital tools are being deployed in education and to assess the future of work. This study revealed that many of the most innovative approaches to technology education teach more than just mastery of technical skills. Innovative educators are integrating higher order skills, such as collaboration, creativity, and problem-solving.

While technology education is obviously critical in preparing the future computer programmers of the world, it can complement existing pedagogical approaches across the entire curriculum. Not only does technology offer opportunities for students in non-technical classes to practice the higher-order skills so badly needed in today's labor market, it also allows students to benefit from adaptive and personalized learning. What's more, online classes also broaden educational access, thereby helping more students prepare for the new economy. Governments can support these initiatives in several ways: establish uniform standards around 21st century skills, ensure that higher-order skills are embedded in the curriculum, and provide both the funding and test environments needed for further research. Given the rapid changes in economies globally, it is imperative for governments to take action.

## Introduction:

The digital revolution has dramatically changed the nature of work and the skills required to succeed in the 21st century—but the educational curriculum is struggling to keep pace. For

generations, the educational system has focused on core, foundational skills in literacy, mathematics, and science. While this approach offered decent preparation for a wide variety of careers in the pre-digital, pre-globalization era, the landscape has since changed dramatically.

Jobs in manual labor and manufacturing have steadily declined, while science and technology careers are in high demand. In the US, science, technology, engineering, and math (STEM) jobs are expected to grow by 18% through 2018, while non-STEM jobs are predicted to grow just 10%.<sup>1</sup> Meanwhile, routine jobs are on the decline, being replaced by increasingly complex jobs that draw on higher order skills. Nearly every industry on earth has been transformed by digital, and employers are looking to hire workers with the skills needed to thrive in a fast-paced, dynamic, technology-rich environment.

While education systems have implemented incremental changes over the years—by bringing iPads into the classroom or offering computer science classes, for example—the curriculum itself remains largely unchanged and focused on foundational skills in numeracy and

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<sup>1</sup> Langdon, David, George McKittrick, David Beede, Beethika Khan, and Mark Doms. STEM: Good Jobs Now and for the Future. Rep. U.S. Department of Commerce, July 2011; World Economic Forum “New Vision for Education: Unlocking the Potential of Technology.”

literacy. As a result, few students are prepared for employment in the modern economy and many nations face large skills gaps that they cannot fill, particularly in technical fields and positions that require advanced social and emotional skills.

As government leaders strive to close the skills gap, they must address two key questions: 1) What technical skills, competencies, and character qualities are required for students to thrive in the digital age? 2) How can technology be deployed throughout the education system (in both technical and non-technical subjects) to accelerate success in the 21st century?

In this report, we argue that technology education—which we define as the [teaching of modern technologies and technological skills](#)—needs a significant overhaul. It is not enough to equip classrooms with iPads and smart boards. The curriculum itself must change. A computer science class (or any class, for that matter) must provide students with ample opportunity to acquire and develop essential higher-order skills, such as critical thinking, collaboration, and perseverance. These skills, which can be integrated into the instruction process, reflect what employers want and need from their workforce.

In this report, we also look at the ways that digital tools are currently being deployed across the entire curriculum, not just in technology-related

classes, to bridge the skills gap. We found several areas where technology can effectively deliver personalized education, support the development of higher-order skills, and facilitate broader access to learning.

All education systems are under increased pressure to re-examine and adjust the way they

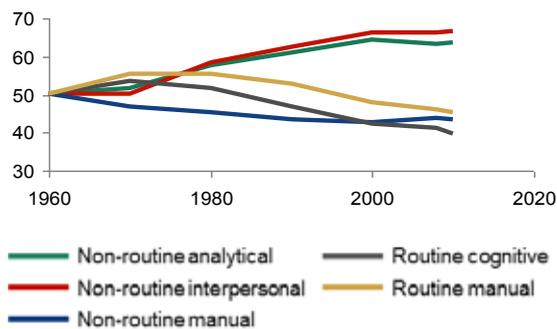
prepare students for the economy ahead. This report offers a new educational model where students are fully equipped with the skills they need to thrive in the 21st century.

## 2. New Skills for the 21st Century

Over the past half-century, as the job market has shifted away from manual labor, we have seen a corresponding increase in jobs that require higher-order skills. Where the job market once demanded workers with routine cognitive skills, the nature of tasks has changed. The demand for non-routine analytical and interpersonal skills is badly needed in many industries. (See Exhibit 1.)

literacies, competencies, and character qualities. (See Exhibit 2.)

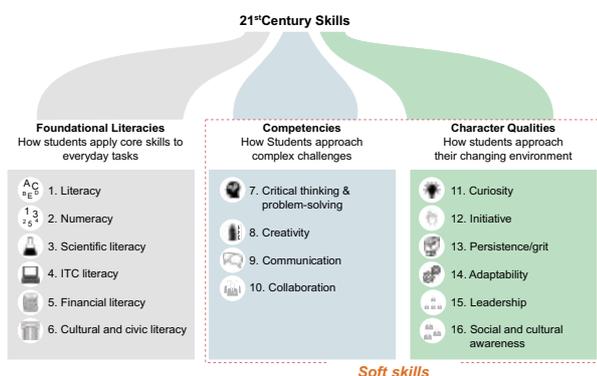
Exhibit 1 | Task input in percentiles US economy 1960–2009<sup>2</sup>



What are the most important proficiencies that students need to thrive in the 21st century? In a 2015 report, “New Vision for Education: Unlocking the Potential of Technology,” BCG and the World Economic Forum conducted a meta-analysis of research about 21st-century skills in primary and secondary education. Our research revealed that students need to learn 16 skills in three broad categories: foundational

<sup>2</sup> World Economic Forum, “New Vision for Education” (2015)

Exhibit 2 | Students require 16 skills for the 21st century<sup>3</sup>



- Foundational literacies, such as literacy, numeracy, and scientific literacy, reflect the core skills that students can apply to everyday tasks. This type of learning has been at the heart of educational curricula for generations, but in the digital era, these skills are not sufficient by themselves. Students must supplement these basic skills with the necessary competencies and character qualities that employers want and need.
- Competencies are the means by which students approach the complex challenges in today's interconnected, fast-paced, global economy. Critical thinking and creativity are essential skills that allow workers to take the initiative and devise innovative solutions to difficult problems. Communication and collaboration allow teams to work

<sup>3</sup> World Economic Forum, “New Vision for Education: Unlocking the Potential of Technology “ (2015).

together effectively in the workplace or online, whether they are colleagues, clients, or customers.

- Character qualities describe how students approach their changing environment and respond to setbacks or obstacles. The digital economy prizes curiosity, initiative, adaptability, and other personal qualities that will advance an innovative and flexible business strategy. Think of the qualities that were traditionally expected of workers on the manufacturing line versus the qualities a product manager at a startup today would expect from her app developers. On the manufacturing line, workers were traditionally expected to reliably perform the same rote work every day, while a product manager today needs app developers to think independently, pivot rapidly, and contribute bold insights and ideas that will lead to a breakthrough product—all while interacting with others in socially, ethically, and culturally appropriate ways.

Education systems have traditionally employed models focused on foundational literacies, but have given less attention to building competencies and character qualities. Naturally, this makes it extremely difficult for employers to fill certain positions. Employers in the Americas were surveyed to understand which positions were the most difficult to fill. The results showed that among the hardest

positions for employers to fill were sales representatives, engineers, and management or executive positions. (See Exhibit 3.) These positions typically require not only moderate to high technical skills, but also a high level of the competencies and character qualities discussed above.

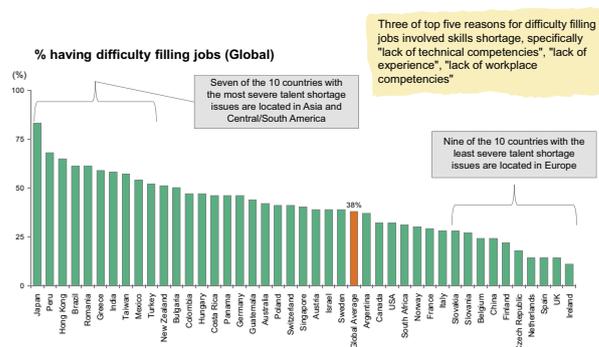
Exhibit 3 | Hardest positions for employers to fill<sup>4</sup>

	#1. Skilled Trade	#2. Sales Reps.	#3. Engineers	#4. Technicians	#5. Drivers	#6. Mgmt/ Execs
Intensity of Technical Skills	High	Med	High	High	Med	High
Intensity of Soft Skills	Med	High	High	Low	Low	High

Educational systems are also lagging in their ability to provide the technical skills employers need in the digital age. In 2015, ManpowerGroup conducted a survey of more than 40,000 employers in 42 countries to determine the extent of the talent shortage. (See Exhibit 4.) The results varied considerably, from a severe talent shortage in Japan (where 83% of employers report difficulty filling jobs) to a relatively low skills shortage in Ireland (11%). Notably, when employers were asked why they had trouble filling jobs, more than one in three cited a lack of candidates with technical skills.

<sup>4</sup> 2015 Talent Shortage Survey; Sources: Manpower Group, ENOE (INEGI)

Exhibit 4 | Percent of employers having difficulty filling jobs, by nation<sup>5</sup>



Given the many ways that career opportunities and employers' needs have evolved in recent years, education systems must adapt accordingly. Students not only need to understand how to leverage technology effectively, but they must also be equipped with the complex analytical and social-emotional skills to be successful.

<sup>5</sup> Talent Shortage Survey (Manpower Group, 2015)

# 3. A New Model for Technology Education

The most innovative approaches to technology education focus on much more than just the mastery of technical skills. (We define technology education as instruction that specifically prepares students for jobs in technology-related fields, such as computer programmers, data scientists, or graphic designers. In this paper, as we think about the changes in our modern economy, we are not referring to technical classes that prepare students for traditional skilled trades, such as becoming an electrician.) For students to be prepared for the labor market of tomorrow, computer literacy must be taught in a way that incorporates higher-order skills, such as critical thinking, creativity, and adaptability.

This is important for several reasons. First, today's employers place a premium on higher-order skills. In a digital world, the pace of change is faster than ever before. To stay competitive, companies need their employees to take initiative, anticipate potential disruption from competitors, and propose innovative solutions to complex problems.

Second, we know that a large number of students must be prepared for jobs that do not exist yet.

As advances in artificial intelligence and machine learning continue to drive massive changes to the way we live and work, many new career opportunities will emerge over time. Students who are curious and adaptable are more likely to thrive in this environment than those who simply obtain technical skills.

Finally, the nature of technology itself will always change. Years ago, programmers could build careers around the likes of Fortran and COBOL, the programming languages once favored to build core infrastructure for large businesses. These days, programmers flock to cutting-edge languages, like Elixir and Swift, to build everything from apps to websites to point-of-sale products. Ten years from now, who knows how many of these languages will still be in use? In an environment where programming languages grab the spotlight only to fade into obscurity, the value of learning a specific language is never guaranteed. Students who excel at creativity, problem-solving, and taking the initiative can ride the technology wave wherever it leads, rather than getting left behind with only rote technical skills that may quickly lose relevance.

# 4. Integrating Higher-Order Skills into the Curriculum

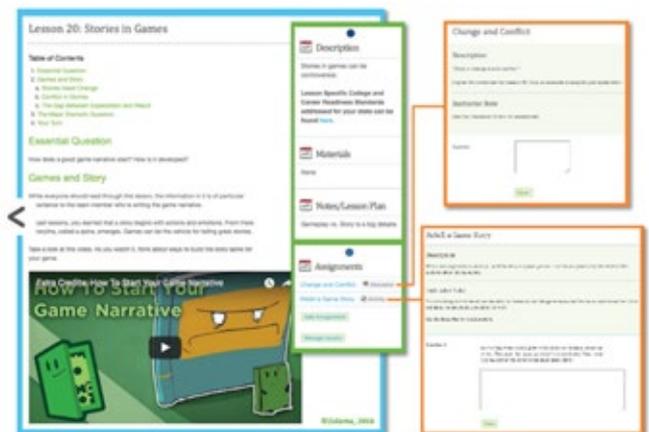
So how can these higher-order skills be incorporated into the curriculum? First, coding involves a significant amount of trial and error, for example, and instructors have ample opportunities to incorporate lessons on the value of resilience and perseverance. Beyond this, however, the most innovative instructors use new pedagogical approaches, such as applied learning and project-based learning, to ensure that students are prototyping and building products within many varied contexts to address a diverse range of modern challenges.

To foster the development of higher-order skills, some courses offer a comprehensive learning experience that closely mimics what students can expect to encounter in the workplace. Zulama, a program created by educators at Carnegie Mellon's Entertainment Technology Center, offers a range of classes for teenagers. The classes support technical skills, like programming and digital art, as well as higher-order skills, like collaboration and perseverance. For example, they offer a game design course that begins by asking students to identify an open-ended question around a relevant issue, debate, or problem in society. Students design and build the game, while

also practicing skills around storytelling, adaptability, and working collaboratively.

Once they have a prototype, students share the game with users to test the concept, get real-world feedback, iterate, and successfully market the product. (See Exhibit 5.)

Exhibit 5 | Zulama sample curriculum<sup>6</sup>



These types of enhanced, project-based learning programs can begin very early in a child's educational journey. Scratch, a free educational programming language and online community, allows children, primarily between the ages of 8 and 16, to create their own interactive stories, games, and animations. Scratch is developed by the Lifelong Kindergarten Group at the MIT Media Lab,<sup>7</sup> and teaches students basic computer programming

<sup>6</sup> Zulama website – <http://zulama.com>

<sup>7</sup> See <http://scratch.mit.edu>

skills, but also incorporates higher-order skills, such as creative thinking, collaboration, and problem solving. Students share work with other Scratch members to get feedback and learn from

each other, and because the program has more than 15 million registered users in over 150 countries, students can collaborate with other members who may have very different backgrounds, ages, and interests.

# 5. Keeping Pace with Changes in Technology

Literacy, math, and science tend to remain relatively stable and predictable over the years, but the same cannot be said for coding. Because so many programming languages are open source—meaning they are developed by thousands of programmers spread across the globe—they can evolve rapidly.

With programming languages evolving so quickly, coding instruction must be equally dynamic. Standard textbooks will quickly lose relevance; therefore, the most innovative coding instruction is being delivered via short, competency-based courses. Bitsbox, a startup that teaches children to code, provides monthly coding projects for elementary school students and offers one example of how coding instruction can be kept agile. Every month, a new box arrives with “recipe cards” that kids can use to build an app. Younger children learn to play with code and get comfortable with the basics. As children progress to higher levels, they learn new computer science concepts and eventually learn to build an app from the ground up. The monthly subscription model allows instructors to stay up to date with the latest tools and techniques and children can learn to code in a way that is engaging and dynamic.

There is another reason why it is important

for technology education to be flexible. As technology evolves, employers’ needs evolve along with it; therefore, it is critical that students are learning the skills that are in high demand. General Assembly offers an example of how technology instruction can keep pace with changes in workplace demands. The startup works with over 300 companies, including one third of the Fortune 100, to develop training programs in coding, digital marketing, design, and data that deliver the specific skills employers want and need. By working closely with employers, the organization adapts course content to suit evolving employer demand and ensure that new potential hires and existing employees are equipped with the skills they need to succeed on the job. While a host of coding boot camps have struggled to keep their doors open, General Assembly’s employer-focused approach and fast-growing Enterprise business have enabled the organization to thrive.<sup>8</sup>

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<sup>8</sup> New York Times, “As Coding Boot Camps Close, the Field Faces a Reality Check”, August 24 2017.

# 6. Leveraging Technology across the Curriculum

Digital tools have extraordinary potential to enhance the entire academic curriculum, not just technology-related courses, from math and science to literature and music. The best online tools offer three key benefits: personalized education; the development of higher-order skills; and broad access for historically underserved student populations.

**Access to personalized education:** One of the most exciting aspects of digital technology is the way it can deliver personalized learning, a teaching approach that uses technology to meet the specific needs of individual students. Students can proceed through course material at their own pace, advancing to the next level once they have demonstrated mastery of key concepts. Personalized learning programs can also identify specific skills that individual students have not yet mastered and provide additional opportunities for practice.

AltSchool, an educational technology startup based in San Francisco, offers a useful example of the way technology can be used to deliver a personalized curriculum for individual students. Each student works from a "playlist," - a set of tools that manage each child's personalized learning activities and goals - and the program adapts to differences in students' abilities and interests, allowing students to learn and grow at their own pace.<sup>9</sup>

**Development of higher-order skills:** As innovative companies have explored the myriad learning opportunities that come with digital technologies, their content has begun to expand to higher-order skills today's employment

Personalized learning can focus on whole-child education providing opportunities for students to develop social and emotion skills such as gratitude grit, optimism and self-control. Students' progress in each of these social-emotional characteristics can be measured over time, with students expected to demonstrate competency in these areas.

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<sup>9</sup> AltSchool website; [www.altschool.com](http://www.altschool.com).

A small but growing number of software providers are embedding higher-order skills, such as critical thinking and social emotional learning, into their games. ZooU, an online game for children in grades 2 – 4, supports the development of six social and emotional skills: communication, cooperation, emotion regulation, empathy, impulse control, and social initiation. Students immerse themselves in various scenarios—from inviting a friend to play to practicing impulse control—in order to learn appropriate behaviors. By embedding these higher-order skills into products that support foundational skills, such as literacy and numeracy, students can address skills gaps while interacting with online content in a highly engaging way.<sup>10</sup>

**Broad access to education:** Online instruction allows a much broader population to access education than ever before. Because teaching and learning can extend beyond the classroom setting, students can take courses no matter where they live or how busy they may be with other commitments—and at a significantly more affordable price. With so many digital tools available today, students can select from both online and in-person classes that fit their schedule. This is particularly important at the higher education level, where students often have to make the tough choice between paying for college and earning a living, and has benefited students at many institutions. For example, at the University of Central Florida (UCF), when students take

a larger percentage of their courses online, the time required to complete their degree drops. Students taking up to 80% of their courses online were able to graduate in under 3.5 years on average as opposed to 4.3 years for students not taking courses online. (See Exhibit 8.) When students can choose from online and in-person classes, they often complete degrees faster than they can through the standard, in-person, on-campus model.

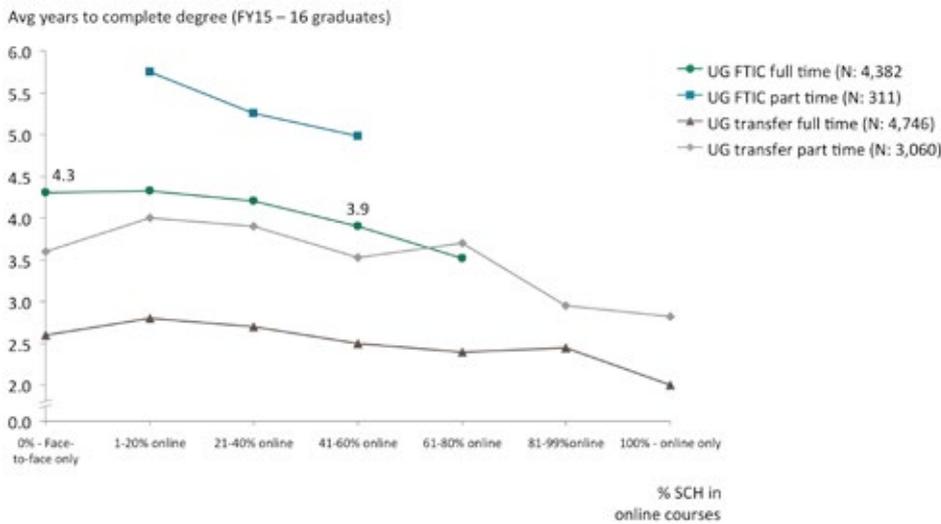
The reduced time seen at University of Central Florida is not an anomaly. In 2012 ITHAKA S+R conducted a study called “Interactive Learning Online at Public Universities: Evidence from Randomized Trials”. They found that students taking the hybrid or mixed-modality version of a course took approximately 25% less time to reach the same learning outcomes as face-to-face students.<sup>11</sup>

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<sup>10</sup> ZooU website; <https://www.centervention.com/zoo-u/>

<sup>11</sup> The Boston Consulting Group, “The Value of Digital Learning in Higher Education”, 2018

Exhibit 8 | Average years to complete degree at UCF, by % courses online<sup>12</sup>



Digital tools also foster broader access to education by lowering the financial burden for students. Educators have access to an increasing array of open educational resources (OER); that is, high-quality teaching, learning, and research materials that anyone can use at no cost. Some community colleges now offer zero-cost degree programs using freely available OERs as their course materials. This opens up a new world of opportunities for students who are unable to take courses because they cannot afford to purchase books and other materials.

<sup>12</sup> The Boston Consulting Group, “The Value of Digital Learning in Higher Education”, 2018

# 7. Lessons Learned

Although digital tools have been instrumental in advancing personalized learning, student acquisition of higher-order skills, and broader access to education, there are also some obstacles that need to be overcome.

- **Complexity of courseware:** There is a wide variety of adaptive personalized courseware available, and programs can range from very simple to incredibly complex. With the latter, instructors and students may find the technology confusing, both to set up and to use. This difficulty becomes especially problematic if courses are not good at routing students effectively to the next level and both students and educators are unable to understand when students should progress.
- **Need for professional development:** When educators first begin to use digital tools, they will need professional development and support. Higher education professors have reported it takes approximately three instances of teaching a course digitally before they figure out how to adapt their instruction.
- **Value of mixed modality:** It is important not to rely exclusively on digital tools,

but to leverage educator interventions to improve student outcomes. A BCG study found that at UCF, students taking hybrid courses had higher course success rates (% of students earning an A, B, or C grade) by ~4 percentage points over just face-to-face instruction.<sup>13</sup> For example, instructors at UCF developed an innovative way to successfully leverage mixed modality for their students. Professors used a digital platform, but they actually turned off its adaptive functions so that students only used adaptive functions within a physical classroom. Teaching assistants then monitored progress and routed students through the course pathways, instead of routing being determined by the adaptive program. These types of innovations are key to the success of mixed modality teaching and learning. For technology education to succeed, the instructor must think creatively about how best to leverage digital tools and structure the course accordingly.

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<sup>13</sup> The Boston Consulting Group, “The Value of Digital Learning in Higher Education, 2018

## 8. How Governments Can Help Close the 21<sup>st</sup> Century Skills Gap

Governments can play a critical role in helping to prepare students for the jobs of the future. For developing countries, in particular, there is a massive opportunity to leapfrog; that is, leverage new technologies to accelerate the evolution of the education system and help skip over development stages that had previously been unavoidable. Because education systems in emerging economies are generally less established and therefore less burdened by deep-rooted processes and policies, they are in a good position to experiment with new techniques.

That said, developed countries also have an incredible opportunity to leverage technology education to address skills gaps. The younger generation is already online and becoming more technology-savvy all the time, and globalization will only continue to multiply the reach and impact of technology. With an advanced education system in place, developed countries are poised to improve outcomes for students at every level, from elementary school to post-secondary education.

The opportunity is immense, but governments must make the right moves to support education systems in their efforts to

bring the most effective education technologies to more students. To help close the 21<sup>st</sup> century skills gap, governments must take action in a few key areas.

- ***Invest in teachers' professional development.*** Governments that run educational institutions should invest in high-quality professional development to help educators learn how to effectively leverage technology in their classrooms. Many digital online tools are available to support teachers' professional development as they strive to build their toolbox of instructional strategies or improve their ability to execute on these strategies. Although professional development requires an investment, the costs are reasonable on a per-student basis when provided at scale. An investment in digital education typically provides its own source of revenue to offset costs. Schools have the opportunity to reach and serve more students than ever before, but online education does not require any new buildings or facilities; therefore, schools do not have to concern themselves with the capital expenditures or maintenance costs typically associated with enrollment growth.

***Shape the curriculum to promote technology education.***

The technology education market is highly fragmented with many traditional companies developing digital tools, as well as many new entrants offering a wide range of innovative products. It is often difficult for education providers to sort through the available options, and know which ones are high-quality. Governments can set standards, endorse or rate products, or make purchases for institutions they run, as a way to help ensure the tools being leveraged are of the highest quality. Governments can also develop policies to ensure that educational standards and objectives are aligned with 21<sup>st</sup> century skills. Similarly, regulating bodies can make an effort to support the dissemination of digital tools, through either standards setting, endorsement, or direct purchase.

- **Support developing technology markets.** Adaptive technologies are still evolving. Many companies in this space are still quite small and do not yet have the capability to scale. There are some high-quality programs that have not yet gained a strong following simply because it can be difficult to stand out in such a highly fragmented market. For companies to refine their approaches, they require investment and opportunities

to leverage scale. Governments can help by identifying high-quality programs and either investing in them directly or helping them access a larger audience in order to test and accelerate development.

- **Support flexible financial mechanisms.** Personalized and adaptive content offers students the opportunity to learn at their own pace and advance once they have mastered specific skills. However, educational funding has traditionally been term-based, which limits students' ability to progress through learning at an advanced pace. Governments should consider experimenting with more flexible funding mechanisms that support students as they pursue less traditional educational journeys (where students progress from one course to another based on demonstrated mastery rather than rigid spring and fall terms).

## 9. Conclusion

To thrive in the 21<sup>st</sup> century workforce, students will require a new set of skills. Governments have the opportunity to support the development not only of technical skills but also the higher-order competencies and character qualities—such as leadership, teamwork, and global citizenship—that are increasingly vital in the labor market.

Policy makers must work hand-in-hand with other key stakeholders, including teachers, principals, school administrators,

technology education providers, and funders to identify skills gaps, realign educational systems and standards to support the development of 21<sup>st</sup> century skills, and create a more open, flexible, and innovative learning environment for students. Governments have an opportunity to help design the future of education. With bold action, countries can close the twenty-first-century skills gap and create a brighter future for their citizens.

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