# 10

# Rewards and Digital Learning

Children today are much more comfortable using information technology than those of previous generations. Many grow up playing video games offering strong visual and audio stimulation, instant feedback on decisions, and nonfinancial rewards for achievement such as winning competitions, accumulating points, or being able to move to the next level of a game. The popularity of such games confirms what parents and good teachers know instinctively: that children can acquire knowledge and learn new skills at seemingly phenomenal speeds when they are fully engaged in the learning experience.

Technology applied to learning, also known as digital learning or online adaptive instruction, has vast potential to transform schooling. Terry Moe and John Chubb have made a strong case that technology will cause the "creative destruction" of America's K–12 school system.<sup>1</sup> Either by itself or "blended" with traditional classroom teaching, digital learning is building a record of results substantially superior to traditional teaching and potentially far cheaper when used on a large scale.<sup>2</sup>

Digital learning stands on its own or adds great blended value because it can adapt to the capacity and speed of individual learners, provide minute-by-minute feedback on learning progress, and provide rewards suitable for individual learners. It is similar to an imaginary inexhaustible, highly skilled tutor. Even the impressive results documented later in this chapter are likely to be quickly surpassed since designers of digital courses can use billions of student responses not only to provide exemplary tutoring tailored to individual students' needs but also to continuously improve each step in the lessons.

Digital learning during childhood has the additional advantage of leading to mastery of skills, technological and other, that are necessary for further learning in subsequent grades, in college, and on the job. A survey of 300 professionals, for example, showed they spend 40 percent of their time in online communities interacting with others, and some 80 percent participate in online groups sharing information, ideas, and experiences.<sup>3</sup>

In this chapter we review how digital learning works and then look at three examples of its successful use: Rocketship Education, Khan Academy, and massive online open-enrollment courses (or MOOCs). We then review the scholarly research on the effects of technology on academic achievement and present best practices for removing institutional obstacles and implementing new learning technology.

# **Online Adaptive Instruction**

Online adaptive *testing*, which was the subject of Chapter 8, becomes a part of online adaptive *instruction* when computer programs and technology measure a student's progress while also selecting the next educational steps and lessons – sometimes called the student's "playlist" – that meets the student's specific instructional needs. Instead of passively listening to other students responding to questions asked by a teacher, each student actively responds at each step in a lesson. If the student is correct, the lesson immediately proceeds to the next step much like a tutor; if incorrect, the technology quickly remediates, making sure the student does not have to struggle with more advanced steps and lessons that rely on a piece of information or skill not yet acquired or, even worse, repeat and even practice mistakes. In these ways, technology resembles a skilled tutor but at a vastly lower per-pupil cost.

Online adaptive instruction can be "blended" with classroom instruction to create "hybrid" schools such as the Rocketship Education charter schools described below.<sup>4</sup> Computer-based instruction can offer sounds, memorable images, and animated graphics; interpret written, typed, and spoken input such as dictation; and deliver instant feedback to student responses. Integrated data management systems can continuously update students' records on multiple devices enabling students, parents, and teachers to each view a "dashboard" presenting data in ways best suited to their needs. Students spending time in a computer lab can be supervised by older students or teacher aides, freeing teachers to spend time in smaller seminar-style meetings or one-on-one tutorial sessions with students. The result is a boost in teacher productivity as well as in student learning.

Students can use online programs inside and outside school, effectively expanding the school day and school year.<sup>5</sup> The Internet delivers lessons 24 hours a day, seven days a week, 365 days a year, something even the most dedicated teacher cannot do. Since programs and data are stored and retrieved from a central location, software need not be downloaded to desktop or laptop computers, allowing the use of increasingly convenient, cheap, light, and powerful devices such as tablets and smart phones. Learning can take place in school, at home, and elsewhere.

Education technology entrepreneurs are rapidly expanding the kind of adaptive software and "cloudware" available. They are producing programs for classroom management and behavior tools as well as course content. Launched in 2011, for example, ClassDojo<sup>TM6</sup> is an online program that allows teachers to continually track and manage student behavior in class, award points for specific good behavior like attentiveness and politeness and subtract them for poor behavior such as being disruptive or not turning in homework. Teachers can choose to make students' points visible to the class throughout the day, providing greater motivation to some students to behave well.

Goalbook<sup>7</sup> is a similar program, this one for students with special needs. It allows all of a child's teachers and assistants to update the child's Individualized Education Plan simultaneously, if they like, keeping everyone informed about the child's progress and difficulties without requiring constant conversations and paperwork. Goalbook allows teachers to set personal learning goals for each child, such as reading a third-grade-level book or mastering the nine-times multiplication tables, and to track learner progress. The system also allows for instant reports on the child's progress.

Adaptive instruction can be successful even without expert teachers. In one program, high-school students were recruited to teach reading to Head Start preschoolers in a low-income, half-minority Georgia community using a computer program called Funnix.<sup>8</sup> Funnix uses a step-by-step, sequential approach to teaching phonics that is highly scripted but also personalized through the computer program.<sup>9</sup> The high-schoolers were more successful in teaching reading than the regular teaching staff that used traditional methods. Halfway through the year, the Funnix group had reached reading levels of about a year ahead of the control group and was better at skills like

naming letters, identifying the initial sounds of words, and reading words. Based on similar research, schools from California to Maryland are beginning to use the same type of instruction.

The three programs just described and the programs examined next use technology to solve problems that otherwise reduce the effectiveness of reward systems: difficult and time-consuming collection of accurate data regarding outputs; too much time between an action and a reward or penalty; goals that don't accurately reflect the learner's current interests and abilities; and reliance on rewards that haven't been proven to motivate learners. Experience demonstrates that automating achievement testing and adapting instruction to the learner's progress is enormously motivating for students as well as teachers. Digital learning solves the problems identified by Alfie Kohn and other critics of rewards. (See Chapter 1.)

# **Rocketship Education**

Rocketship Education charter schools provide an example of the use of online adaptive learning that appears to be economical, works for students from all backgrounds, and can be adopted on a large scale.<sup>10</sup> Founded in San Jose, California in 2006, Rocketship Education charter schools offer "hybrid" learning to their K–5 students, some 90 percent of whom are poor and minority. Rocketship opened its first school, Mateo Sheedy Elementary, in 2007. It has since opened six additional K–5 elementary schools serving low-income and minority students in San Jose. An eighth Rocketship school, Rocketship Southside Community Prep, opened in Milwaukee, Wisconsin in August 2013. Rocketship's founders aspire "to ultimately open regional [school] clusters in 50 cities, effectively changing the lives of over 1 million students."<sup>11</sup>

Rocketship students spend two hours a day in the Learning Lab, a computer lab where they work on software that teaches basic math and literacy skills.<sup>12</sup> Computerized instruction focuses on repetitive and drill-intensive tasks such as basic arithmetic and spelling and gives teachers up-to-the-minute assessments of each student, which they then use to guide one-on-one and small group sessions with students during the rest of the school day. Rocketship says the time its students spend in the computer lab allows the company to hire between five and six fewer teachers in a school, about 25 percent of the total teaching staff, generating an annual savings of about \$500,000.<sup>13</sup> Some of the savings is used for higher pay for teachers and to pay for the aides who act as coaches in the computer labs, but more

importantly the savings make the model financially sustainable and scalable since charter schools typically receive per-pupil stipends that are less than what traditional public schools spend. In 2013, Rocketship Education announced plans to modify its system by placing teachers in addition to aides in the Learning Labs, with one teacher for each group of 90 students.<sup>14</sup>

Data from the California Department of Education confirm the success of the Rocketship model. In 2012, Rocketship Mateo Sheedy Elementary, the first of the Rocketship schools to open, scored 924 on California's Academic Performance Index (API), well above the state average of 815.<sup>15</sup> The five Rocketship schools enrolling students at the time the state tests were administered achieved an overall performance of 855, despite the lower socioeconomic status of their students.

Rocketship Education Charter Schools 2012 Performance on California Academic Performance Index			
Rocketship Los Sueños	793		
Rocketship Discovery Prep	805		
California Statewide Average	815		
Rocketship Sí Se Puede Academy	861		
Rocketship Overall Average	855		
Rocketship Mosaic Academy	872		
Rocketship Mateo Sheedy Elementary	924		
Source: Rocketship Education, "Academic Performance," http://www.rsed.org/ about/Academic-Performance.cfm, viewed on June 13, 2013.			

"School Quality Snapshots," a website maintained by the California Department of Education, also confirms the Rocketship schools' high performance.<sup>16</sup> On the math portion of the 2011–12 California Standards Test, for example, 80 percent of Rocketship students scored Proficient or Advanced, on par with the ten most affluent school districts in California.

In 2011, SRI International, a nonprofit research and development organization, conducted a 16-week study of Rocketship's use of DreamBox

Learning, an online math tool. Students in kindergarten and first grade used the program. The study found, "Rocketship students who received additional online math instruction through the DreamBox Learning program scored substantially higher on an independent mathematics test than similar students who did not receive the additional online instruction time. For the average student, these gains would be equivalent to progressing 5.5 points in percentile ranking (e.g. from 50 percent to 55.5 percent) in just 16 weeks."<sup>17</sup> If that performance enhancement were continued over the course of a student's entire K–12 career, the difference in academic standing at graduation would be huge.

"The SRI study confirms Rocketship's core belief that adaptive, online learning positively impacts students' overall academic achievement," said Chief Schools Officer Aylon Samouha. "The use of highly effective, cost-efficient individualized instructional programs like DreamBox Learning is allowing Rocketship to realize its mission of closing the achievement gap."<sup>18</sup>

While many charter schools now incorporate adaptive instruction into the school day, Rocketship has concentrated on creating a business model that will enable it to produce hundreds of schools each generating superior results at a lower per-pupil cost than public schools. This requires designing schools that do not rely on charity or exceptional leaders or teachers willing to work 70 hours a week or longer and do everything from raising funds and recruiting and managing staff to providing after-school counseling to students.

## Khan Academy

Khan Academy is not a school, yet more than 200 million students have taken one or more of the lessons it offers. Hosting a free online library of more than 3,300 videos that are now being used by charter and traditional schools across the country and around the world, Khan Academy demonstrates how technology can transform education through adaptive instruction and the enormous reach of the Internet.

Khan Academy started in 2004 when Salman Khan started filming himself giving short lectures on math in a closet in his home and posting them on the Internet. Khan noticed the growing popularity of his videos and the short quizzes he wrote for each one and, with the help of philanthropists such as Bill Gates, was soon able to dramatically ramp up the number of videos and pay technical experts to make them compatible with adaptive

testing and instruction programs.

How does Khan Academy work? Let's take learning math as an example. Students first watch free ten-minute videos on core math concepts starting at the beginning with addition, subtraction, and the idea of numbers. They then take tests to determine how well they have understood the material. Online adaptive tests track the errors the students make and cue up the next set of videos and concepts to target the students' strengths and weaknesses. As students progress, they earn badges and points – familiar examples of rewards described throughout this book – for concepts they have mastered.

By 2012, Khan was providing free access to more than 3,300 free micro-lectures, many interactive, on mathematics, physics, chemistry, organic chemistry, biology, astronomy, cosmology, American civics, art history, finance, economics, computer science, and health care and medicine.<sup>19</sup> A growing number of schools, now numbering in the thousands, use this online instructional library to supplement regular courses by viewing the videos in class or assigning them as homework. Khan also has expanded to offer free online college-level courses.

An online library of educational videos, even when accompanied by adaptive testing and instruction, is not a complete solution to what ails K-12 education in America. Like other activities in a computer lab, it provides a component of a blended model where teachers can help young learners keep track of time, answer questions, provide guidance, and offer encouragement. But streaming video to 100 or more computer workstations requires substantial bandwidth, which can be expensive or not available in some schools. And the Khan Academy library has not yet been completely built out, leaving gaps in some subjects and not much depth to some of the quizzes.

What is so surprising about Khan Academy isn't that it has faults and limitations, but that something like it exists at all. It came out of nowhere less than a decade ago and is now part of the educational experiences of millions of students in the U.S. and millions more around the world. The videos and tests it makes available for free are genuinely revolutionizing learning for students of all ages and backgrounds, from the children of Bill Gates (and Gates himself, who reported using Khan videos to brush up on his math skills) to the most disadvantaged children in inner cities. It does this for a tiny per-pupil cost. The success of Khan Academy shows that, despite the resistance of the public education establishment to changes to

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its delivery model, a single person has the power to go around that inertia and dramatically change the educational opportunities for millions of children by coming up with an innovative idea, using modern technology to implement that idea quickly and inexpensively, and then using the Internet to freely publish that idea for education-hungry children around the world.

# Massive Online Open-Enrollment Courses (MOOCs)

In 2011, Stanford University professor Sebastian Thrun taught 160,000 students a course on artificial intelligence using uploaded videos of himself lecturing and drawing diagrams on a napkin.<sup>20</sup> He had opened the class to anyone in the world and placed all the assignments and tests online for anyone to take. Students located all around the world took the course. More students from Lithuania enrolled in his class than were enrolled in Stanford. Some students wrote him to explain that they lived in war-torn countries like Afghanistan and had to dodge flak to search for an Internet connection to complete their assignments.

Of that first class, 23,000 students finished the course and 248 never scored a single wrong answer on any of the class tests. Not one of those 248 students attended Stanford. Thrun's physical class of 200 students at Stanford dwindled until only about 30 students attended class regularly. The rest preferred to watch his video lecture online because they felt the online instruction was more intimate and helped them learn better. Thrun is now developing a free online university following a similar pattern. He plans to offer a master's degree for \$100, in contrast to a typical current cost of around \$45,000.<sup>21</sup>

Thrun's course and efforts are part of a global phenomenon called massive online open-enrollment courses, or MOOCs. Thrun launched Udacity in January 2012 and two of his colleagues launched Coursera three months later. Udacity's most popular course, on computer science, has enrolled more than 270,000 students. Some 74 universities around the world have signed up to provide courses.<sup>22</sup> The courses feature some of the world's most renowned experts delivering lectures and participating in online conversations with millions of students who otherwise would never have the opportunity to attend college, much less take courses taught by such eminent scholars. Adaptive testing and instruction technologies work as well as part of MOOCs as they do for Khan Academy and the blended classrooms of Rocketship and other charter schools, freeing lectures from

the drudgery of repeating lectures and answering predictable questions while greatly accelerating students' learning. Social networking tools such as online discussion forums can create the sense of community and connectivity that brick-and-mortar campuses promise but don't always deliver.

MOOCs seem to be taking off in higher education because private and public universities genuinely compete for students and tuition and their faculties are largely non-union and so tend not to organize to oppose labor-saving technologies.<sup>23</sup> Lack of competition and the presence of strong teachers unions pose obstacles to their adoption at the K–12 level, but as these barriers are overcome, success should be even greater than in higher education due to the much larger size of the market and the subject matter being simpler. The number of lessons for K–12 education in English, mathematics, science, civics, major foreign languages, art, music, and perhaps a few other subjects would be less than the thousands of specialized courses universities provide.

If MOOCs can drive down the cost of a two-year college masters degree from \$45,000 to \$100, what could it do for K–12 schooling? Yes, K–12 schools perform a custodial function that colleges do not, so there may be continuing demand for "real" schools. But technological innovations such as the Khan Academy and MOOCs are genuinely transformational, pointing to an educational model that is fundamentally different from today's K–12 classroom.

# **Digital Learning and Achievement**

Online adaptive instruction can provide in one package the goals, activities, tests, and incentives needed to accelerate student learning. Students receive feedback as they move through a set of activities that the program customizes to their individual abilities. Many programs utilize algorithms grounded in psychological research on common errors students have made in face-to-face settings. Such research makes it possible to offer detailed cues for what to do next and prompt the user to move on to more difficult levels or repeat a lesson perhaps from another perspective when appropriate.

A meta-analysis of 20 years of research conducted by Mickey Shachar and Yoram Neumann in 2010 showed adaptive online education programs on average provide better learning results than traditionally taught classes.<sup>24</sup> As the table on the following page demonstrates, most studies across

various time periods showed superior results for the online programs. While 70 percent of all studies found online classes to be superior, 84 percent of studies published after 2002 found online superiority, suggesting (as we would expect) that online performance is improving over time.

Studies after 2002 showed not only superiority but a very large average additional effect of +0.403, corresponding roughly to what is learned in four-tenths of a school year, which means the typical online education student exceeds 66 percent of traditionally taught students. Many of the studies in Shachar and Neumann's analysis were conducted before or shortly after the Internet became such a widespread means of communicating across the world. Today's online programs are significantly superior to those of five years ago and getting even better, and more students, homes, and schools have the bandwidth to access the most advanced forms of online instruction.

Meta-Analysis of Online Education Effects				
Implementation Period	Number of Studies	Average Effect Size	Percentage Above Control Group Average	
1991–1998	38	.266	61%	
1999–2000	33	.068	53%	
2001–2002	29	.310	62%	
2003–2009	25	.403	66%	
<i>Note</i> : The data in this table are derived from Mickey Shachar and Yoram Neumann, "Twenty Years of Research on the Academic Performance Differences Between Traditional and Distance Learning: Summative Meta-Analysis and Trend Examination," <i>MERLOT Journal of Online Learning</i> <i>and Teaching</i> 6, no. 2 (June 2010): 318–34. The effect sizes are averaged across all studies conducted in the period indicated. The final column is the percentage of traditional students exceeded in achievement by online				

Most of the studies reviewed by Shachar and Neumann reported the effects of a single unit or at most a year of study. If these effects could be achieved each year over a student's K-12 career, the result would be

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students.

transformational. American students would easily rank first rather than as low as 32nd in international achievement surveys. Many, moreover, would be ready for college-level work after as little as nine years of schooling rather than the usual 12.

Another meta-analysis of online learning studies conducted for the U.S. Department of Education and published in 2010 provides further evidence of the superiority of digital learning, though its findings were couched in cautionary language.<sup>25</sup> The researchers found 50 experimental or controlled quasi-experimental studies comparing the learning effects of online versus face-to-face instruction, including only five published studies involving K–12 students that met their meta-analysis criteria. Students who engaged in only online learning exceeded the achievement outcomes of students receiving only traditional instruction with an average effect size of +0.20. Students in blended learning environments benefitted from an average effect of +0.35. Earlier reviews of distance education also showed substantial effects.<sup>26</sup>

While there are obstacles to the spread of digital learning, cost is not one of them. The per-pupil costs of online schooling, which requires fewer teachers, have only recently been compared to that of traditional classroom instruction. According to a study by the Thomas B. Fordham Institute, full online learning on average costs about \$4,300 annually less than traditional schooling while the blended model saves about \$1,100 per student per year.<sup>27</sup> These cost savings are likely to increase over time as the technology improves and as educators gain experience in its use. Requiring nine rather than 12 years of schooling would reduce costs substantially more.

## **Best Practices**

Digital learning is spreading quickly as parents, students, and educators recognize its transformational potential. Some obstacles need to be overcome such as certification requirements that block entry into the teaching profession by talented and motivated individuals, seat-time and class-size requirements that make school schedules rigid and unable to accommodate computer lab sessions, and opposition from teachers unions.<sup>28</sup> A rapidly growing community of educators with experience using digital learning tools and a literature describing best practices are available to reformers who want to accelerate this progress.

The Digital Learning Council, a nonprofit organization launched in 2010 to integrate current and future technological innovations into public

education, has produced a series of publications (all of them available online) to help parents, educators, and policymakers find and use the best practices for digital learning. The council has proposed "10 Elements of High Quality Digital Learning," which it describes as "actions that need to be taken by lawmakers and policymakers to foster a high-quality, customized education for all students. This includes technology-enhanced learning in traditional schools, online and virtual learning, and blended learning that combines online and onsite learning."<sup>29</sup> Those actions appear in the table on page 145.

In 2011, the American Legislative Exchange Council (ALEC), a respected membership organization for state legislators, adopted a model resolution endorsing the "ten elements" approach.<sup>30</sup> In 2012, ALEC created and endorsed model legislation, the Statewide Online Education Act, that provides a detailed template for states to follow to remove roadblocks to expanding digital learning.<sup>31</sup> The National Conference of State Legislatures (NCSL), another organization of state legislators, also has endorsed expanding the use of digital learning and provides case studies of its successful implementation.<sup>32</sup>

An implementation guide for blended learning produced by the Digital Learning Council recommends state government policies that support fulland part-time access to online learning by eliminating seat-time requirements, providing end-of-course tests on demand, making funding portable (following students to the schools or colleges that offer online courses), shifting from traditional textbooks to digital instructional materials, and supporting expanded broadband access for schools.<sup>33</sup> At the school level, the authors stress that simply adding computers to classrooms doesn't accelerate learning unless those computers "change instructional practices, schedules, relationships, and resource allocations."<sup>34</sup>

The Clayton Christensen Institute for Disruptive Innovation, formerly the Innosight Institute, is another good source of best practices.<sup>35</sup> The nonprofit think tank was founded by Harvard professor Clayton M. Christensen, author of the 2008 best-seller *Disrupting Class: How Disruptive Innovation Will Change the Way the World Learns.* The organization conducts original research on the cutting edge of digital learning, consults with elected officials, and provides speakers for public events. Researchers affiliated with the organization have created a "blended-learning taxonomy" that distinguishes among the various ways of blending digital learning with traditional schooling, such as Station

Rotation, Lab Rotation, Flipped Classroom, Flex, A La Carte, Enriched Virtual, and Individual Rotation models.<sup>36</sup>



## Conclusion

Digital learning – the combination of online adaptive testing and instruction made possible by new technologies, software, and the Internet – is beginning to transform K–12 education. It accelerates learning for a number of reasons, but an important one is because it makes rewards for learning more accurate, timely, and attuned to the interests and abilities of students. It promises to deliver the "creative destruction" required to substantially improve America's failing elementary and high-school system.

ClassDojo, Goalbook, and Funnix are three examples of the rapidly growing number of software programs available to educators to bring digital learning into the classroom. Rocketship Education, Khan Academy, Coursera, and Udacity illustrate the variety of new institutions that are using digital learning to transform traditional teaching methods. Given the pace at which software is improving and institutions are evolving, these examples may seem out-of-date in a few years.

Research described in this chapter shows substantial positive achievement effects of online education in pre-Internet days and larger effects in recent years. More advanced technologies used on a much wider scale promise even larger achievement effects, lower costs, and a greater variety of incentives, curricula, and teaching methods from which parents, students, and educators can choose. Obstacles in the path to increased use of digital learning can be removed by parents and policymakers working together to adopt the policies recommended by pioneering leaders in the field, the Digital Learning Council, and other groups supporting this disruptive innovation likely leading to far more effective education.

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