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Cisco Networking Academy

Next-generation assessments and their implications for K–12 education

By Meredith Liu

CLAYTON CHRISTENSEN INSTITUTE
for DISRUPTIVE INNOVATION

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To illuminate the possibilities for next-generation assessments in K–12 schools, this case study profiles the Cisco Networking Academy, which creates comprehensive online training curriculum to teach networking skills. Since 1997, the Cisco Networking Academy has served more than five million high school and college students and now delivers approximately one million online assessments per month in a variety of formats. Its advanced and highly integrated assessment system offers lessons for K–12 technology and assessment.

INTRODUCTION

In 1996, Cisco Systems, Inc., an American multinational corporation headquartered in San Jose, Calif., that designs, manufactures, and sells networking equipment, discovered that although the computer networking industry was booming, there was a shortage of qualified candidates to design, build, manage, and secure computer networks. In response, the company integrated backward and founded the Cisco Networking Academy (NetAcad), a comprehensive online training curriculum offered to third-party education institutions to help high school and college students acquire the fundamental skills needed to design, build, and troubleshoot computer networks. NetAcad employs a system of assessments to help drive consistent learning across its training sites around the world.

NetAcad launched in October 1997 at 64 educational institutions in seven U.S. states. Since its launch, the program has expanded to more than 9,000 high schools, colleges, technical schools, and community organizations in 50 U.S. states and 170 countries with its curriculum taught in 16 languages. More than five million students have participated in NetAcad courses and collectively taken 143.2 million online assessments.

Cisco Systems credits its strong public-private partnership model for NetAcad's rapid growth. From the outset, the company envisioned a distributed delivery structure in which it would reach more students by partnering with existing educational institutions. As George Ward, former Cisco Systems engineer and founder of NetAcad, said, "Cisco [Systems] knows networking, teachers know education. By partnering, students win." Cisco Systems provides NetAcad online

content, lab materials, and instructor training for free to institutional partners, which in turn provide classroom space, computer lab equipment, and qualified instructors.[1]

How NetAcad works

Networking proficiency requires an array of hardware and software skills. The initial version of NetAcad offered a four-course sequence that provided students with the practical systems networking skills needed to obtain the Cisco Certified Network Associate (CCNA) Certification, a certification for entry-level networking jobs that an independent group separate from NetAcad administers.[2,3] Today, NetAcad's instructional model combines face-to-face facilitation by instructors; in-person, hands-on labs; and online learning. Cisco Systems provides participating educational institutions with a comprehensive package of instructional tools and curriculum, including hands-on lab materials; online practice activities; a simulation tool; a visualization and assessment engine called Cisco Packet Tracer; and educational games. The program also offers participating educational institutions discounted equipment bundles and a range of support services, including a global 24/7 NetAcad help desk.

Cisco NetSpace

NetAcad delivers its online curriculum and assessments through a cloud-based learning management system (LMS) called Cisco NetSpace. On Cisco NetSpace, students can navigate through online course material, complete assignments and assessments, and communicate with their instructors. The portal is available at all times so that students can complete activities at their convenience.

On the back end, instructors use Cisco NetSpace to manage their courses. The site also serves as a management system for NetAcad administrators and has the functionality to simplify common administrative tasks such as enrollment tracking, scheduling, and managing equipment inventory.

Because the system is cloud-based, it also supports the needs of curriculum and assessment developers at Cisco Systems. As developers change or create curriculum or assessment items, they can distribute these materials quickly and cost effectively across NetAcad's 9,000 sites, which ensures consistency across the academies.

Cisco Systems designed the NetAcad curriculum and instructional model to ensure that students develop a range of systems networking competencies, while accounting for different teaching and learning styles across the academies worldwide. With students in 170 countries, NetAcad seeks to be both "globally consistent and locally relevant."[4] Even though the content and tools are standardized across sites, NetAcad recognizes the need for instructors to add context and additional information appropriate to their local economies. As such, the NetAcad curriculum is

designed to be instructor-facilitated—that is, instructors create classes in Cisco NetSpace, enroll students, and provide instruction. NetAcad designs tools for its instructors to manage each course and assign the online content and activities that align with their in-person sessions. Instructors can also use Cisco NetSpace tools to supplement the curriculum with activities and assessments that they build themselves.

ASSESSMENTS

Besides its impressive scale and distributed model, what sets Cisco Systems' network training curriculum apart is its emphasis on online assessment tools. As Cisco Systems developed NetAcad, it sought to rethink what it viewed as the traditional, flawed assessment paradigm. In many educational settings, assessments are used solely for accountability, grading, or promotion. Instead, NetAcad designers wanted assessments to provide instructors with feedback on student learning that they could use to inform instruction in real-time and provide students with up-to-date information on their progress and understanding of the material.

NetAcad designers reframed the use of assessments as primarily for learning (formative) rather than evaluation (summative). Summative assessments allow instructors to evaluate student learning and award course credit; they remain critical to the goal of ensuring that NetAcad course completion and the subsequent certification is meaningful beyond the walls of the classroom. Formative assessments, on the other hand, help students, instructors, and administrators collect, analyze, and use information about student learning progressions to continuously drive and improve learning. To shift to primarily formative assessment, Cisco Systems built a broader and deeper portfolio of assessments, designed new technologies to assess how students grapple with content in real-time, and honed a process for creating consistently high-quality assessments.

Today, NetAcad delivers more than one million assessments to roughly one million students each month. The following sections describe the new methods of assessment that Cisco Systems pursued in its expanded assessment portfolio; the design principles and data-driven cycles of improvement that guided this process; and the costs associated with NetAcad.

Assessment portfolio

Since launching NetAcad, Cisco Systems has developed a wide range of assessments that are flexible enough to meet the diverse needs of its students and instructors. Instructors have full discretion over how they use the assessments, including which assessments to deliver and whether to use a given assessment for formative or summative purposes depending on the needs of the course. Building an assessment portfolio was not a small task: computer-networking skills are fluid and

complex and thus can be challenging to assess. NetAcad students must not only learn the necessary content knowledge, but also the technical skills to design and construct physical networks, such as the organization and layout of hardware and cables, as well as business and problem solving skills that are more conceptual in nature. NetAcad's assessments vary in complexity, length, and type. The assessments use constrained response (multiple choice, matching/drag and drop, fill-in-the-blank) to evaluate a learner's content knowledge and skills; rubric-graded, in-person hands-on exams to assess manual skills; and simulation-based performance exams to evaluate more advanced problem solving skills. ***Table 1*** summarizes the current assessment portfolio.

NetAcad's formative assessments are primarily intended to gauge progress, not evaluate performance. Much like quizzes in traditional courses, students take NetAcad quizzes that are embedded in the online curriculum after completing specific sections of content. Unlike quizzes in traditional courses, however, NetAcad created these quizzes for student self-assessment; they

Table 1. NetAcad's assessment portfolio *(Source: Cisco Networking Academy)*

ACADEMY ASSESSMENT ITEM/TASK TYPE	FORMATIVE ASSESSMENTS		SUMMATIVE ASSESSMENTS	
	Understanding →	Performance*	Understanding →	Performance*
Student- initiated assessments	Topic, section, and chapter quizzes	Packet Tracer labs		
	Testlets	Packet Tracer modeling and simulation activities		
	Interactive media (e.g., drag-and-drop, syntax checker, etc.)	Skills integration challenge		
	Learning checkpoints	Packet Tracer-based learning checkpoints		
Instructor-initiated assessments	Course chapter exams	Hands-on practice	Course midterm checkpoint	Packet Tracer-based skills assessments
	Pre-tests	Packet Tracer multi-user game skills check	Course final	Hands-on equipment skills assessments
	Practice finals	Aspire game skills check	Certification practice exams	

To triangulate what students know, a student, their instructor, and NetAcad can draw upon this Assessment toolkit.

Moving toward ubiquitous formative assessment

Focus on knowledge and skills acquisition.

* Performance of networking skills is based on understanding.

are optional and not registered in an online grade book (although the instructor can change the attributes of the quiz to meet her classroom needs). Additional learning activities—such as short questions that check for understanding, modeling activities, reflections questions, and mini simulation exercises—are also interspersed throughout NetAcad's online curriculum.

On the back end, the NetAcad assessment system requires a large amount of processing power and sophisticated infrastructure to operate smoothly. As students complete summative and formative assessments in educational institutions across the world, data is immediately collected and then transferred back through the cloud. Students receive their scores within minutes. The grades also go directly to a database that instructors can access through the online grade book. NetAcad's goal behind these short quizzes and activities is to make assessment as seamless as possible by tracking student performance during the learning process rather than after the fact.

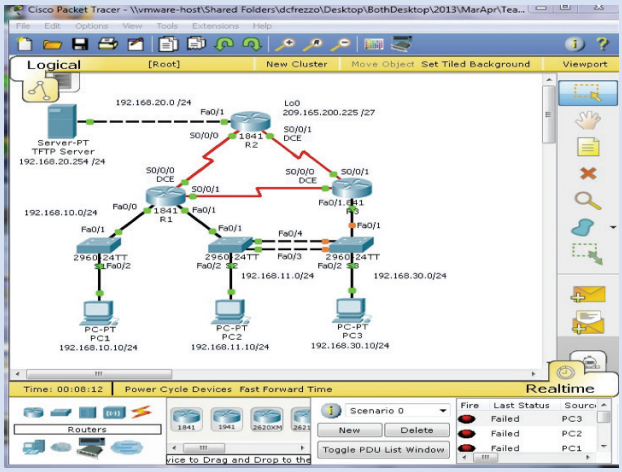
Other assessments may be used as either formative or summative. For example, some instructors use end-of-chapter tests as a formative exercise in the form of homework, whereas others use them as part of summative student evaluation as part of a student's final grade. At the end of a course, NetAcad final knowledge exams provide summative assessments on the entire course content. Both end-of-chapter tests and final knowledge exams are taken online and scored automatically. In addition, students are required to complete a hands-on final exam under the observation of a supervisor.

Performance assessments and simulations

Although online assessment has always been a cornerstone of NetAcad courses, the assessments have evolved significantly since the program's inception. NetAcad's initial model used a simple, fixed-response assessment system—single-answer, multiple-choice exams that tested content knowledge at various points in the course including a final exam at the conclusion. These online tests were complemented with an in-person, hands-on skills exam. As described above, some assessments were used formatively and others provided end-of-course summative evaluations. As the program developed, however, Cisco Systems sought to go beyond fixed response items to create performance-based tasks that could be scored automatically. Although scoring complex simulations can be challenging, these assessments present the potential for far more useful and extensive data.

To assess and gather multiple forms of student data, Cisco Systems developed Cisco Packet Tracer[5], a network simulation program that allows students to experiment with network behavior and ask "what if" questions. Cisco Packet Tracer is locally installed software that connects with the NetAcad cloud.[6] The technology offers a sophisticated simulation environment that presents a wide range of complex scenarios to students. In the Cisco Packet Tracer "micro world," students can use numerous virtual devices to create and troubleshoot an infinite number of model

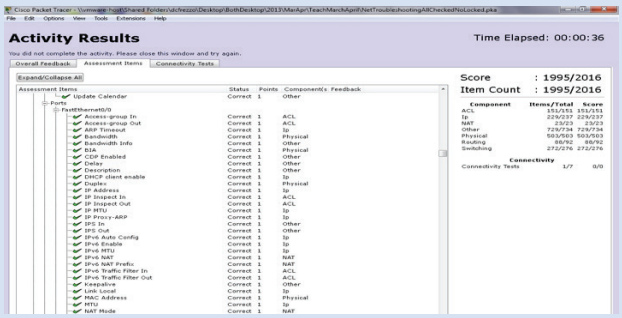
Figure 1. Example of a Cisco Packet Tracer activity



networks. Cisco Packet Tracer provides a graphical interface that allows students to design and build networks using simple drag-and-drop functions so that students can visualize processes that would otherwise be hidden in physical systems.

A Cisco Packet Tracer activity that might be completed in a few hours* is shown in ***Figure 1***. ***Figure 2*** shows the "answer network" tree, which illustrates some of the aspects of the network model being assessed. For the network topology shown in ***Figure 1***, there are over 2,000 components that can be assessed. Instructors can use Cisco Packet Tracer for demonstrations, homework, and assessments.

Figure 2. Example of the "answer network" tree for a Cisco Packet Tracer activity



In 2010, Cisco Systems introduced the Cisco Packet Tracer Skills Assessments, which builds on the Cisco Packet Tracer simulation program to include standardized, simulation-based assessments. These assessments generally begin with either a network that is missing devices and has incorrect configurations that students must fix or an entirely empty starting point from which students must build a network from scratch. Unlike the open-ended Cisco Packet Tracer simulations, these assessments ask

* The time frame of the learning activities varies depending on what the student is doing as well as on the student's skills-level and fluency. Some learning activities—such as simple verification, configuration, or modeling tasks—could take a few minutes, whereas others—such as end-of-course skills assessments in the more advanced courses—could take a few hours.

students to achieve a particular outcome, sometimes while operating with constraints on the ability to use certain features and tools.

Cisco Packet Tracer Skills Assessments are powerful formative assessment tools, as they provide students and teachers with a clear sense of how students are moving through material and solving problems of complex design, configuration, and troubleshooting tasks. ***Figures 3 and 4*** show the types of feedback that instructors and students can receive from Cisco Packet Tracer Skills Assessments. All of a student's activities or "moves" in the system can be recorded in a time-stamped log to provide data on how the student built or manipulated a network. Both students and instructors can obtain and analyze these log files. The system also compares students' completed networks to an "answer network" that identifies specific, desirable features in the environment. The system awards credit for ranges of correct answers, rather than simply right or wrong responses. The system then provides each student with rich feedback outlining the specific competencies the assessment tested and how he or she performed on them.

Figure 3. Example of feedback instructors and students can receive from Packet Tracer Skills Assessments

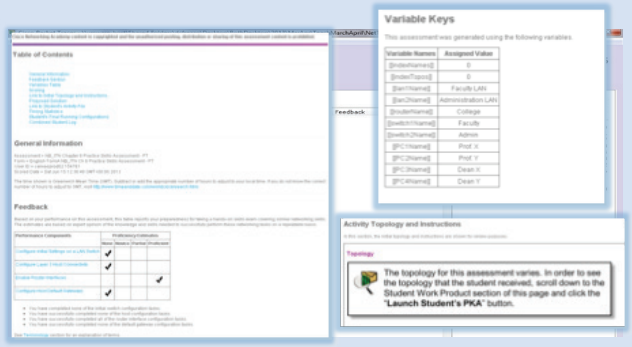
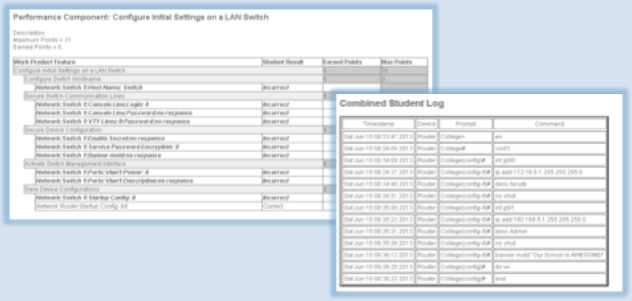
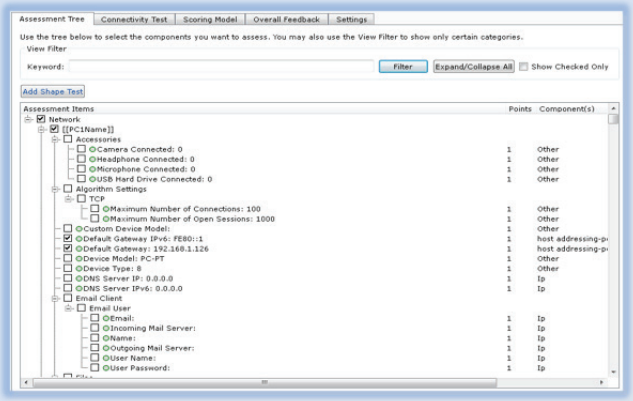


Figure 4. Example of feedback instructors and students can receive from Packet Tracer Skills Assessments



Instructors not only can select from the NetAcad-provided assessments but also design their own assessments and activities through both a multiple-choice quiz generation tool as well as the more sophisticated Cisco Packet Tracer Wizard, to design activities and assessments within the simulation system. The Cisco Packet Tracer Activity Wizard allows the instructor to control the instructions presented to the student, timing of the activity, initial network (from completely empty network to an almost complete one), and final network states (with thousands of student

Figure 5. Example of how instructors can specify which aspects of a model are assessed



work product features that can be scored). Instructors can use these activities to supplement the standard NetAcad curriculum and assessments. ***Figure 5*** shows how instructors, by simply placing check marks next to specific model features, can specify which aspects of a model are assessed.

Cisco Systems found that simulation software like Cisco Packet Tracer allows students to experiment with how networks operate, which enhances their hands-on work in the physical labs. Cisco Packet Tracer may also mitigate resource constraints among some NetAcad partner educational institutions. Although NetAcad requires that partner institutions use physical equipment to train students, schools may have fewer laboratory tools than students. Students often have to wait to use equipment and are constrained to practicing when they are on site. Simulated performance exams can therefore greatly expand access for students who are working remotely or for resource-strapped partners with crowded labs.

Assessment design and development

Evidence-centered design

As NetAcad embraced the task of building a rich portfolio of formative and summative assessments, the assessment team sought to identify a methodology that could tie together and standardize all its assessments, as well as ensure that the assessments were of consistently high quality. The method also needed to be sufficiently flexible and abstract to apply to all types of assessments, including as the assessments grew in technological sophistication over time.

NetAcad's assessment team adopted an approach called evidence-centered assessment design (ECD) to develop the assessments. Researchers at the Educational Testing Service (ETS)—the author of the SAT, GRE, and other standardized entrance exams—introduced the ECD framework. ECD is organized around answering the question, "how do we know what students know?" The framework focuses on examiners presenting the right activities to find evidence of student knowledge and skills in a way that supports fully the underlying purpose of a given

assessment. It allows assessment designers to start by asking what skills and knowledge should be assessed, then understanding what behavior will reveal them, and finally developing situations that elicit that behavior.

Although ECD is not prescriptive, it does lead to specific ways of iterating to design, define, develop, analyze, and refine the assessment. The flexibility of the framework makes it particularly relevant for a more fluid and activity-based domain such as networking. As such, ECD has been critical to building the complex assessment tasks, in particular the Cisco Packet Tracer simulations.

Designer capacity

To populate its wide portfolio of assessments using ECD, NetAcad employs instructors from across the world as consultants to create and develop the assessments. The consultants receive extensive training from NetAcad in the design of high-quality assessments, including the conceptual understanding of ECD. Consultants develop items virtually through a cloud-based, assessment-authoring software—available in 19 languages—that facilitates broader participation by a global base of instructors. The individual who prepares each assessment activity documents the particular curricular goal that the question should address and drafts the initial assessment item. Then each item is reviewed in a multi-stage process to assess quality. The online system allows developers to work on assessment design together, manage workflow, and offer feedback and review in an online community. This collaborative process ensures that there are multiple eyes on every question and facilitates ongoing debate, which increases the overall quality of assessments. Small focus groups of instructors also test items before Cisco Systems launches the items to the entire academy.

Data and feedback

Two lead NetAcad researchers, John Behrens and Kristen DiCerbo, have described the shift from simple assessments to simulation tasks as moving to a "digital ocean," where assessment data, rather than being scarce and difficult to obtain, is ubiquitous. NetAcad's assessment system produces an enormous amount of data about the students, instructors, and curriculum itself. NetAcad uses this data to make improvements at the student, classroom, and academy level. Because the majority of assessment takes place online, student performance data is available instantaneously. All NetAcad authored assessments are graded automatically and scores can be included in the online grade book, depending on the assessment's purpose. Instructors can review detailed scoring and performance data through Cisco NetSpace. They can view the data at multiple levels—from aggregated class-level information to detailed item-level performance by a student that shows what skill the item was intended to test and how the student performed on it. The system

Figure 6. Example of an instructor's view of a student performance summary

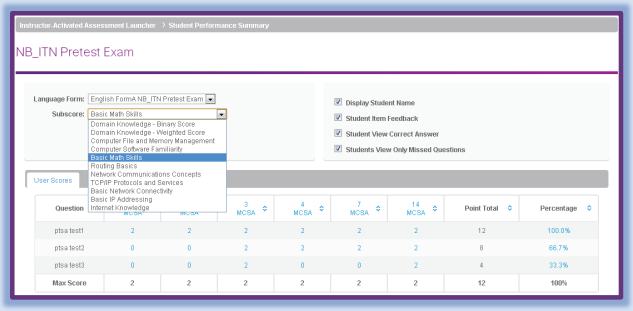
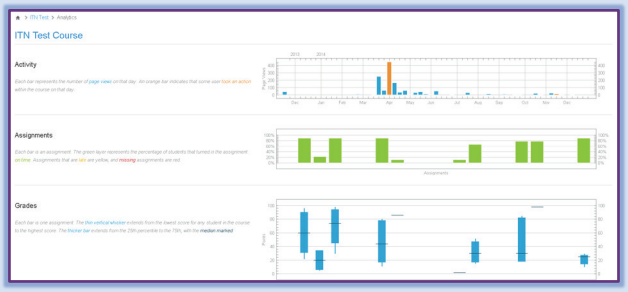


Figure 7. Example of an instructor's view of course analytics



even automatically scores and provides feedback on Cisco Packet Tracer Skills Assessments, including final network and log files. ***Figures 6 and 7*** show an instructor's view of a student's progress in Cisco NetSpace.

Assessment consistency across the entire network also facilitates greater data use among instructors. Assessment sequences across courses are unscarefully planned so that practice opportunities, skills integration challenges, and chapter exams all build toward preparing students for the end-of-course online multiple-choice, simulation-based performance, and hands-on performance exams. Instructors can compare their students' progress with similar academy classes around the world, which gives them a better sense of how their students should be performing along the way.

Student performance data provides a means to identify strengths and weaknesses in NetAcad's program as a whole. Cisco Systems' assessment team uses standard psychometric statistical processes to identify in which content areas students are struggling as well as which assessment questions are confusing or can be improved. NetAcad makes the results of these analyses available to developers and consulting instructors to inform future assessment development.

NetAcad also uses data to manage quality at the site level. Given the decentralized nature of the academy—thousands of sites across hundreds of countries—it is difficult to monitor all sites to ensure that high-quality standards are maintained across the network. To supplement more traditional support, the central Academy Quality Assurance Team uses the information collected from online assessments to scan for site-specific issues. This group also monitors student performance on a class level to identify trends in the data, such as consistently low scores for students at a given academy site, which may indicate institutionally weak instruction. Regional support teams also receive this data, which allows them to target their support to individual sites.[7]

In addition to the quantitative data analysis, instructors can submit feedback to the assessment development team. For example, if a particular question is confusing or inaccurate, instructors can flag it for review in the online system. If the issue is found to be valid, then the assessment development team updates the item or exam and the instructor is informed. Designers can use this data to adapt the program with greater accuracy and speed than if they had to wait for the completion of an annual assessment cycle, and they can take advantage of the on-the-ground expertise of the academy instructors. Also, because exams are launched online, Cisco Systems can seamlessly pilot the introduction of new questions to a small group and also make replacements once improvements are identified. Cisco Systems also uses student perception data to improve the academy. At the end of each course, students use the assessment system to complete a survey that provides feedback on the course and the instructor. This data influences refinements to the course as a whole as well as provides feedback for each instructor and site.

Assessment data provides useful feedback for students as well. Students can view the results of their assessments online and use the results to understand better what material they need to review. Furthermore, students receive a personalized-learning report after taking a chapter and practice final exam or a Cisco Packet Tracer Skills Assessment, which provides detailed information on performance and refers the student back to the curriculum.

COSTS

As of 2011, Cisco Systems had invested $400 million in NetAcad since the program's inception in 1997. This includes the cost of curriculum and assessment development, technology, marketing, and general operations, as well as in-kind contributions from Cisco Systems of more than $212 million. Although the per-course costs were hundreds of thousands of dollars in initial investment, recent engineering and process improvements have substantially decreased this cost and also established the technical basis for substantial reuse.

Although these initial investments may seem high, Cisco System's quality assurance measures save the company tremendous money in translation and maintenance. Even though the development and automatic scoring of assessments require significant upfront programming costs, they scale well—because the assessments are standardized across all sites, the marginal cost to deliver and score assessments for a new site is minimal. This allows Cisco Systems to invest the majority of its funds in developing the best possible assessment content and ensuring that the technology, both the student-facing software and backend infrastructure, is robust and sophisticated enough to handle the desired system elements. When spread across NetAcad's approximately 10,000 sites and million students, these investments yield a low cost per student and course.

The additional variable costs per new site are small and covered primarily by the sites. Nonprofit organizations that serve as local academies pay nothing for access to the curriculum and assessment—they only pay for their own networking equipment and for training and support costs. As part of its corporate social responsibility program, however, Cisco Systems subsidizes the costs of NetAcad to participating educational institutions. This makes it easier for more educational institutions, particularly those in developing nations, to participate in the program and serve increasing numbers of students.

Because few, if any, educational programs can boast the scale of NetAcad, other organizations may have difficulty replicating the sophistication of the assessment program at a reasonable cost per site. But many key elements of the model—such as network-enablement using high-quality cloud technologies, centralized experience design and psychometrics, and local delegation of instructional decisions—are plausible for smaller sites to consider.

7 TAKEAWAYS FOR K–12 EDUCATION

Although the NetAcad system of learning and assessments is not perfect, it offers several lessons for improving learning and assessment in the K–12 education system.

1. Integrate assessment with curriculum and instruction

NetAcad demonstrates the importance of aligning assessment with curriculum and instruction. Assessment is not an afterthought, but is considered an integral part of the NetAcad curriculum. The individuals that work on each component work closely together to ensure that there are strong links and that assessments not only accurately reflect the content, but also fit with the instructional delivery. NetAcad also relies heavily on the input of instructors in the initial assessment design and ongoing refinement process. This ensures that assessments are tied to the realities of what is happening in the classroom.

Because NetAcad provides all of the components of a comprehensive online curriculum, Cisco Systems is able to accomplish this tight integration between assessment and instruction; it develops the standards for what students should learn in each course, the content for the courses, and the associated assessments. In our K–12 education system, these components are developed separately and often do not align perfectly to reinforce one another. External vendors generally create both summative and formative assessment products outside of the context where the instruction actually happens. Although summative assessments may be successfully executed without being highly integrated with instruction, this is not true of formative assessments. When formative assessments are done well, they are embedded in the instruction to both reinforce learning and inform instruction.

2. Leverage an online delivery system

NetAcad's online-delivery system is the backbone of its assessment program. As opposed to traditional pencil-and-paper assessments, the online portal delivers assessments with greater ease and lower marginal costs. This saves time for instructors and encourages them to use the optional assessments in a more frequent, formative manner. In addition to the day-to-day delivery and scoring of exams, the online system supports the mission of continuous improvement, discussed more below, by allowing updates to assessments to be rolled out seamlessly. Such an approach would shorten the development cycle for K–12 assessments, which can lag updates in curricular content.

Another benefit of NetAcad's online system is its instantaneous scoring and feedback. Because Cisco Systems sees assessment as primarily learning-based rather than evaluative, it seeks to deliver better data—particularly through the scoring of complex tasks through its simulation program—that can be used quickly. In the traditional K–12 classroom, teachers struggle to find the time to grade complex tasks. But with automatic scoring and the appropriate analytical tools, teachers could learn rapidly about what their students know and adjust instruction quickly.

3. Deploy a cycle of continuous improvement

NetAcad uses a continuous feedback loop to improve the quality of its assessments. Because Cisco Systems views assessments as key to the efficacy of the academy, it has invested heavily in bringing top talent and resources to assessment development—both to develop new, innovative types of assessments as well as to improve individual items.

Assessment is also critical to improving the broader instructional program at NetAcad. At the classroom level, assessment provides the data for teachers to determine what concepts they must reteach and identify ways to support individual students. Instructors also use assessment data to gauge their practice by seeing how their students are performing relative to students at other sites. Academy administrators can also review the assessment data to monitor course quality and provide support to struggling teachers. In the K–12 space, this notion has become a political battleground because under new teacher evaluation regimes, the use of data has been perceived as punitive in nature. NetAcad, however, encourages transparency and uses assessment data for instructors as it does for students—to understand strengths and weaknesses and inform strategies for improvement moving forward rather than merely for accountability.

4. Develop a diverse assessment system

NetAcad uses a diverse portfolio of assessments to achieve its instructional goals. The multiple types of assessment vary not only by content tested but also by question type, delivery mechanism, duration, and instructor versus student control. Each assessment is targeted at a particular learning need and serves a specific purpose. Using a range of assessments also allows for the possibility of multiple measures to evaluate student learning. The assessments form a system that can address different needs, but is still cohesive and aligned to clear learning outcomes.

Most of the energy in the K–12 education sector has historically been focused on summative exams, in particular statewide standardized assessments to evaluate learning at the end of a school year. Formative assessments, however, are increasingly recognized as a necessary tool to continually improve learning.

Ultimately, NetAcad's diverse assessment system and its flexibility should be an entrée to move toward a competency-based learning system in which time is variable but learning is constant. In this system, assessments could simultaneously and interchangeably be used both for learning—formative—as well as for determining mastery and progression—high stakes or summative. These "moderating" assessments could help break false trade-offs in assessment that exist because of today's current system that holds time as a constant and learning as a variable.

5. Invest in new ways to assess complex tasks

NetAcad's assessment portfolio also includes tests that are both objective and subjective in nature. Subjective assessments allow for a wider range of answers, which in turn can account for more complex tasks—such as writing, critical reasoning, and other 21st-century learning skills—and can adjust for differences among students. Most standardized assessments test simple content knowledge and factual recall but have trouble assessing complex skills.

NetAcad's Cisco Packet Tracer simulations and games provide better visualization of the networks than physical equipment because they can show the logic that underlies the actual equipment. And, unlike a physical network, the simulation offers instant support and troubleshooting to remedy issues even without the instructor present. Furthermore, the simulated world allows students to experience the large and complex networks that students may encounter in the real world. Cisco Packet Tracer can encourage experimentation and discovery, which allows students to test their understanding in a safe learning environment with endless possibilities for scenarios, which can make for even more robust learning.

Because these elaborate simulations can be scored automatically, Cisco System's simulations lend hope to the K–12 education system that we can measure things that were previously too expensive or challenging to evaluate. Advancements in technology are making it possible to deliver and score such exams at reasonable costs.[8]

6. Use a rigorous but flexible design process

NetAcad uses a design process—evidence-centered design (ECD)—to enable assessment developers to create accurate assessments of all types. ECD is a framework, not a prescriptive model, which is flexible enough to be useful even as the program changes and new assessment formats are developed. This is particularly relevant to the K–12 education system as new school models have the potential to change the nature of education. A flexible design process ensures that assessments can keep up with educational innovation. Notably, the two major Common Core assessment consortia—the Smarter Balanced Assessment Consortium and the Partnership for Assessment of Readiness for College and Careers (PARCC)—are using ECD as the framework to design their assessments.

7. Balance standardization with local customization

NetAcad's largely centralized development of curriculum and assessments offers a number of advantages. First, it maintains the quality of courses by providing standard measures for student and teacher performance. Second, it allows individual academies and instructors to measure their progress against other sites. Third, it reduces costs because individual instructors do not have to develop their own assessments. Historically in the U.S. K–12 education system, such standardization would have been difficult because each state had different academic standards. With the emergence of Common Core in English language arts (ELA) and math, however, there is some momentum—although it is hardly universal—for common assessments. The K–12 education sector can look to NetAcad for how to facilitate local customization even within a common assessment system. NetAcad recommends but does not require any assessments, thereby allowing instructors to select which assessments are appropriate for their students. Instructors can also develop their own formative and interim assessments on top of the standard course exams.

CONCLUSION

NetAcad leverages advanced technology not only to rethink content development and distribution, but also to rethink how to assess student learning and instructor and course efficacy. Using next-generation technologies to deliver continuously formative assessments represents a radical shift in learning and assessment. The K–12 education space is witnessing growing enthusiasm for using technology to deliver and score assessments online. Indeed, many states participating in Common Core will opt for the associated assessments to be taken online. These efforts may have the potential to reduce costs to scoring summative assessments. But they will not confer the potential benefits of ongoing formative assessment if these online assessments simply replicate traditional pen-and-paper tests in an online format. Cisco Systems' experience suggests that next-generation assessment at scale is possible—if not expensive and contingent on strong integration of content, assessment, and instructor training.

NOTES

[1] After a major course revision cycle that finished in November 2013, NetAcad's course offerings include Information Technology Essentials, Introduction to Networking, Routing and Switching Basics, Routing and Switching Essentials, Scaling Networks, and Connecting Networks.

[2] Cisco Systems has developed a rigorous, industry-standard system that confirms the ability to build, operate, and troubleshoot computer networks. There are five levels of certification representing increasing expertise and nine different content paths such as Routing and Switching, Design, Network Security, Voice, and Wireless.

[3] In order to ensure practical relevancy, Cisco Systems developed the content for each course by identifying the competencies required for each job in the evolving information and communications technology market. Given the continually changing nature of the industry, NetAcad updates its curriculum and course offerings every three to four years and makes smaller updates on an ongoing basis.

[4] "Cisco Networking Academy Program at a Glance," Cisco Networking Academy, http://www.cisco.com/web/about/citizenship/socialinvestments/docs/NetworkingAcademy_External.doc (accessed September 16, 2014).

[5] Cisco Packet Tracer Skills Assessments, along with the NetAcad online curriculum, is hosted on Cisco Systems' learning management system (LMS), NetSpace, through its satellite system Virtuoso Delivery System. Cisco NetSpace offers extensive tools to manage assessments at the site level, including the ability for instructors to administer exams to any selection of students in their classes and the automation of grading and other administrative tasks. Virtuoso Delivery System has additional features to increase ease of assessment delivery, such as allowing the instructor to distribute students the same questions but in random order.

[6] When running locally, Cisco Packet Tracer can interact with the cloud-based Virtuoso Delivery System, a satellite system that delivers all non-quiz assessments.

[7] The size and scope of NetAcad necessitates a tried delivery model for instructor training and site support—train-the-trainers. Cisco Systems selects and prepares Cisco Academy Training Centers that provide training and support to regional academies that in turn provide support to local academies. Both regional and local academies are educational institutions that offer courses to students; regional academies are local academies that were promoted based on their performance and capacity to support additional academies. This model ensures that there is appropriate support for all academies, no matter how many sites, and also that training achieves a balance between global standardization and local customization. The instructors receive suggestions and some guidance from the Networking Academy Instructor material, but are directed to implement their instruction following their own local conditions, constraints, and resources.

[8] Hewlett-Packard's recent competition to develop a technology to analyze and grade student-writing samples is an encouraging step in this direction. See "Hewlett Foundation Sponsors Prize to Improve Automated Scoring of Student Essays," The William and Flora Hewlett Foundation, January 9, 2012, http://www.hewlett.org/newsroom/press-release/hewlett-foundation-sponsors-prize-improve-automated-scoring-student-essays (accessed September 16, 2014).

About the Institute

The Clayton Christensen Institute for Disruptive Innovation is a nonprofit, nonpartisan think tank dedicated to improving the world through disruptive innovation. Founded on the theories of Harvard professor Clayton M. Christensen, the Institute offers a unique framework for understanding many of society's most pressing problems. Its mission is ambitious but clear: work to shape and elevate the conversation surrounding these issues through rigorous research and public outreach. With an initial focus on education and health care, the Institute is redefining the way policymakers, community leaders, and innovators address the problems of our day by distilling and promoting the transformational power of disruptive innovation.

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About the author

MEREDITH LIU is a visiting research fellow at the Clayton Christensen Institute. She has worked with a diverse range of organizations in the K–12 education space, including nonprofits, school districts, state education agencies, and charter management organizations. Most recently, she served as chief financial officer at Match Education, an innovative charter school network and teacher training program. She began her career as a consultant at Bain & Company. Meredith is currently leading a new initiative at Startup:Education. She holds a BA from Dartmouth College and an MBA from the Harvard Business School.