Using 21st century technology to transform the assessment process

The rapid advancement of new technology continually affects how we live, work, play, and learn. While the tools and activities of our daily personal and work lives have been dramatically affected by computers, mobile devices and the linkage of information through the Internet, changes in how we teach and assess students in formal learning contexts has been relatively slow to change.

However, through the use of technology, new approaches to assessing knowledge, skills, and abilities are emerging to improve both teaching and learning and help students prepare for success in the 21st century workforce and as global citizens.

Adding new networking and communications technology into the already complex student assessment process raises a number of questions.

- To what extent does technology improve methods of skills assessment?
- How does the use of technology extend the possible types of assessments we can offer?
- Does technology-enabled feedback enrich the learning process?
- Can technology help assess 21st century skills such as critical thinking and problem solving?
- Can technology-enabled assessments scale successfully in a large, global setting?

This paper will explore how the Cisco Networking Academy® program has embraced some of the latest advances in technology to address these issues in the context of our global information and communications technology (ICT) education program. We will introduce the assessment methodologies and offerings we have developed and deliver through our online tools and global partnership network in 165 countries, to help measure and improve student outcomes around the world.
Cisco Networking Academy Point of View
Advancing Assessment with Technology

The Role of Technology in Assessment

New technologies and the tremendous amount of computing power that is now widely available create enormous potential for assessment. Despite the range of capabilities afforded by new technologies, many assessment developers still create computer-based assessments that are based on paper-and-pencil tests that have been administered for decades and have failed to consider the opportunities available in the new digital world emerging around us.

The potential for technology-enabled assessment goes far beyond current testing models. The same computing power and systems that can deliver rich interactive social and gaming environments, provide book recommendations based on your interests, and return accurate web search results, can also be used to deliver rich, integrated assessment activities and provide greater visibility into how learners solve problems and arrive at answers, and the paths they take to explore possibilities.

Computer-based assessments can immerse students in simulated environments that mirror the complexity of the real world. Students’ varied and creative approaches to complex tasks presented in these simulated environments can be recorded and analyzed in detail. Instead of administering only periodic tests, performance data can be gathered on a regular basis, stored, and automatically analyzed to gain insight into how students are learning.

Assessment in Networking Academy

Networking Academy students encounter a comprehensive learning experience based on, and delivered through, the latest networking and cloud-computing technologies, designed to help them acquire the fundamental skills needed to design, build, and manage computer networks. The Networking Academy program includes instructor-led classroom sessions, web-based course content, interactive learning activities and tools, online assessments, hands-on labs with real equipment, and innovative simulations.

This technology-enriched approach is particularly apparent in the area of assessments. Online courses enable sophisticated assessment features that make it possible for the program to track student performance and collect data. Students receive personalized online feedback to monitor their progress through formative and summative assessments integrated throughout the curricula.

The cloud-based, multilingual assessment infrastructure developed by Networking Academy provides immediate, rich feedback; enabling students to monitor their progress and learn from their mistakes, while generating automated data to help teachers evaluate students’ knowledge and skills. Globally consistent online assessments also allow instructors to compare their students’ progress with similar Networking Academy classes around the world. Results help instructors address individual learning needs in a timely manner and help course designers improve the effectiveness of the curricula.
Focus on Student Outcomes

With 1 million students engaged in learning this year, Networking Academy is helping to alleviate the global shortage of ICT professionals in a broad range of industries and providing opportunities for both personal and community-based economic growth.

The curriculum helps students prepare for industry-standard technical certifications and delivers a wide range of technical and business skills that can support students as they further their educations, advance their careers, or start their own businesses.

The scalable and global online system is available 24/7 and delivers an average of one million student assessments each month. Depending on the objective and type of material being taught, assessment tasks range from true/false and multiple choice questions to complex troubleshooting activities on a simulated network, where answers may vary as a student’s problem solving and analytical thinking skills are tested.

A full suite of formative and summative assessments are offered to enhance the learning process by providing multiple types of feedback, from immediate and focused evaluations of learning progress in a chapter to broad overviews at the end of a course. In some cases, assessment activities are provided solely to help students review their progress. Other assessments allow students to practice for hands-on summative course exams and industry certification exams. Our range of assessment offerings includes: 1) chapter quizzes, interactive tasks, and simulations embedded throughout the curricula, and 2) skills review exams, chapter and final exams, practice final exams, and practice certification exams delivered through our assessment infrastructure.

Technology-Enabled Assessment Requires New Ways of Thinking

The use of technology for fundamentally changing assessment is in its infancy, as educators are only beginning to fully understand and consider its capabilities. Networking Academy envisions the transformation of education as moving from a “digital desert,” with relatively scarce data on examinees, to a rich “digital ocean” environment that offers the ability to take advantage of large amounts of persistent performance-based data gathered while learners complete simulated activities. Software can capture a digital record of learners’ responses to complex prompts, and then integrate that data to provide personalized feedback for both formative (practice and support to help students master critical concepts and skills) and summative (reflection of students’ overall progress in acquiring knowledge and skills) purposes.

The shift to optimized, technology-enabled assessment requires a flexible model for assessment delivery. High volumes of data and the ability to simulate real-world environments can present thousands of variables for assessment, as well as multiple paths for learners to achieve success. Many current assessment methods are based primarily on presenting a question, obtaining an answer, and generating a score. However, if you are assessing a complex task consisting of multiple steps, there can be multiple answers, depending on varying conditions, and a single correctness score may not accurately represent a student’s knowledge, skills, and abilities.

Because of this, Networking Academy found that traditional assessment language was inadequate for assessing complex networking tasks. For example, continuing to use terms such as “items” and “item scores” tended to limit an assessment designer’s thinking. Assessment designers and instructors could easily create real-world tasks and valid scoring systems in complex physical or on-line environments. However, the open-ended structure of activity-based work is
Collaborative Effort

From its inception, the Networking Academy program was designed as a collaborative activity between Cisco and educators in our global partnership network. In the assessment arena, this is done in three ways:

1. The content development for assessments is completed primarily by academy instructors working at universities, colleges, and secondary schools around the world.
2. Several academy instructors are engaged to review new assessment content prior to general release.
3. We provide mechanisms for instructors to continually submit feedback to the assessment development team.

a poor fit for the multiple-choice language and technologies that characterize traditional large-scale testing systems. The language of “question,” “answer,” “correct,” and “incorrect” responses does not fit into the fluid, seamless experience of working on computer networking equipment or other open ended tasks. What is needed is a way to assess a person’s work on the task and translate it into a meaningful performance summary.

Using New Assessment Models

Moving beyond the traditional “question-answer-score” model requires new ways of thinking about assessment. Networking Academy responded to the challenge by developing comprehensive assessment models for teaching networking skills, and in the process, incorporated a broad range of tools including technology, Evidence-Centered Design (ECD), and current research to develop assessment approaches that both measure and reinforce networking skills.

Implementing a new model of assessment that would enable us to provide targeted, accurate feedback to Networking Academy students and instructors on a range of knowledge, skills, and abilities was crucial. The model needed to be easily implemented in a standard way while being sufficiently abstract so that it could be extended as new task types and technologies are developed.

The resulting model is especially valuable for describing the structure of complex environments and tasks, like those in the Networking Academy curricula, and provides a principled framework for developing advanced forms of simulation-based assessments.

Implementing a Comprehensive Assessment Model

Since the Networking Academy program began in 1997, over 110 million online exams have been administered to help evaluate the knowledge, skills, and abilities of more than four million students. We have learned how important it is for our educational ecosystem to afford instructors the ability to enable exams for all the students in their classes simultaneously, and provide automatic grading, feedback, and inclusion of data in an online grade book. Statistical analysis of assessment tasks allows for continuous improvement of the exams and provides beneficial insights into the Networking Academy curricula, quality of instruction, and programmatic effectiveness. At the end of each semester students also use the assessment system to answer questions regarding their experiences with the curriculum, instruction and facilities. These data are used to monitor program health and give feedback to instructors and administrators.

While all of our assessment types have used digital technology to some extent, the development of simulation-based performance assessments in particular exemplifies the potential of technology-enabled assessment.
Simulation-Based Assessment

The principle that students learn best by doing has long been an accepted part of technical education, so schools offering technical courses include a core bundle of computer networking hardware. However, students often have limited access to physical equipment and laboratory environments. While the Networking Academy program requires the use of real equipment to provide opportunities for students to develop hands-on skills, having enough equipment and space for student practice can be costly for some schools. Many lab exercises require significant time investments, and students may need to wait their turn or visit the lab at inconvenient hours to participate. Even when equipment needs are met, adequately assessing a student’s mastery of networking skills presents a number of unique challenges.

We decided to tackle these challenges the same way we tackle our business – by applying Cisco® technology and expertise. The latest advances in ICT hardware and software were leveraged to create a powerful simulation and assessment software program called Cisco Packet Tracer, which allows us to present rich scenarios and automatically score complex assessment tasks. Networking technology advances enable local instances of the software to communicate with systems worldwide, facilitating distribution and aggregation of assessment opportunities.

Building a Simulation Environment

When designing Cisco Packet Tracer, our goal was to build a powerful, accessible network simulation and visualization program that would allow students to experiment with network behavior in a virtual environment and explore “what if” questions. As an integral part of our curricula, Packet Tracer provides simulation, visualization, authoring, assessment, and collaboration capabilities to help simplify the process of teaching and learning complex technology concepts.

Packet Tracer supplements physical equipment by allowing students to create networks with hundreds of virtual devices, encouraging open practice, discovery, and troubleshooting. The simulation-based learning environment also helps students develop 21st century skills such as decision making, creative and critical thinking, and problem solving.

Packet Tracer also provides an opportunity for instructors to enhance their classroom learning experience by creating their own complex, simulation-based assessments. Built-in assessment capabilities support simultaneous, multiuser testing and student evaluations. The Packet Tracer Activity Wizard enables instructors to author customized, guided activities that provide immediate feedback and facilitate ancillary learning activities.
such as homework assignments and student competitions. By choosing from hundreds of existing activities and making incremental improvements, localizing data, or authoring new activities, instructors are using Packet Tracer to develop customized exams for their Networking Academy classrooms. Packet Tracer activities are integrated into the Networking Academy curricula and with Packet Tracer software, which is freely available to all Networking Academy instructors and students, installed on a local computer at school or at home, students can gain valuable practice and feedback in a virtual environment as they read and study.

The widespread deployment of Packet Tracer to millions of Networking Academy students and instructors around the world has resulted in tremendous opportunities for skills assessment. It enables us to standardize and provide Packet Tracer practice activities, authored by Cisco experts, to the entire community and leverage deep feedback based on observations of behavior from students around the world. Feedback provided by Packet Tracer can also be used to identify patterns of misconceptions and reinforce individual topics as needed.

Packet Tracer Skills Assessments
Our latest offering, Packet Tracer Skills Assessments, extends these capabilities so that instructors can enable their students to take a Packet Tracer-based skills exam using their locally running instances of the Packet Tracer software and link to our globally available assessment delivery service. These connections now provide powerful data for improving course design and adjusting instruction. The benefits of Packet Tracer’s simulation environment for assessment have enabled the Networking Academy to standardize and scale skills assessment in a way that was not previously possible, and provides a scalable and replicable example of integrating 21st century assessment with networking technology curriculum:

• Each exam consists of a simulated micro-world combined with an assessment scoring framework, providing a flexible and extensible system where the authoring of new assessment or related activities can be constructed in scalable ways.
• A distributed architecture reduces costs while providing global scalability. A web interface launches the exam session and invokes a locally running instance of Packet Tracer software. The interface sends checkpoint data back to Cisco’s network, which then returns grading, feedback, and interaction recordings.
• The assessment delivery system is available globally around the clock, with high reliability.
• Administration of the assessment delivery system is centralized and simplified through a web console.
• Students are assessed in the same familiar simulation environment used in their coursework.
• Scoring is automated and integrated with an online grade book. Students receive rich, immediate feedback and can review each step to see if their actions were correct.
Packet Tracer Skills Assessments are comparable to flight simulator assessments; they are not meant to replace the need for performance evaluations on real networking equipment, just as flight simulations cannot fully substitute for the demonstrated ability to fly an aircraft, but they provide a powerful adjunct to it.

Games as Assessment

Assessments and computer games share many similarities. For example, both assessment and gaming systems present tasks, score the work, and provide feedback. Rich presentation environments such as Packet Tracer are well suited for use in gaming configurations. Technology now allows aspects of gaming such as competition, scoring, surmounting a series of challenges, and playing against the clock to be integrated into the curricula. With such teaching tools, students feel they are playing, not studying.

Game-based assessments provide feedback in ways that static tests cannot, because they mimic actual experiences in real-world environments. Advantages include the following:

- **Authenticity** - Advances in rich media enable visual detail, three-dimensional rendering, and access to remote data sets within realistic virtual environments. In addition, students can be linked remotely to live networks to perform assessments.

- **Use of knowledge representations** - Knowledge representations model the context in which students work and enable them to express their actions. Because memory and performance are strongly tied to specific situations and stimuli, it is important to maintain consistent knowledge representations in learning environments and in assessments, to help ensure validity.

- **Complexity** - Assessment models that present and integrate complex and
broad-based tasks are still rare, whereas games commonly employ simulated environments and complex scoring mechanisms. Likewise, tasks assessing performance in complex and evolving situations should allow for both task evolution through complex scenarios and for computational performance models that can integrate the new capabilities.

- **Tiered competency** - Games allow players to learn and experiment with new concepts and then as they become proficient they advance to more challenging levels. In the same way, assessments can help students broaden their skill sets by presenting increasingly complex tasks in simulated worlds. In computer network design, for example, tasks may progress from identifying devices in a system, to establishing degrees of interconnectivity, and finally demonstrating knowledge of terms and protocols by designing complex networks that satisfy set requirements.

**Cisco Aspire: A Networking Game Used for Assessment**

Networking Academy is in the early stages of experimenting with games as assessment platforms and is using Packet Tracer to support a concept called Curricula Assessment Gaming Integration (CAGI). We recently released an educational networking game called Cisco Aspire, which uses a powerful networking simulation and visualization engine based on Packet Tracer that has been customized and optimized for game play.

The game presents activities that require varying levels of proficiency and creates a hierarchy of achievement levels, similar to a typical video game. However, behind the game interface is an assessment layer that enables scoring and performance evaluations of students’ play. While playing the game, students become owners of their own small networking company, and must make both business and technical decisions to complete projects for clients.

Aspire presents a visually rich interface that allows navigation, interaction with characters in the game, decision making (sometimes in the form of multiple choice questions), and complex scenarios that combine numerous task requirements. The optimized version of Packet Tracer that supports game play renders and simulates computers, networking devices and systems and provides an ECD-based scoring architecture.

The Packet Tracer simulation environment is ideal for implementing game-based assessments—simultaneously encouraging high levels of student engagement and rewarding learning. The Aspire game includes a networks simulation protocol suite, programmable game state machine logic for scripting quests, and customizable web
Cisco in Education

Cisco’s commitment to education is evident through a variety of initiatives in regions around the world. All of these engagements share an entrepreneurial approach, a focus on our core competencies in ICT, and adherence to the principles of 21st-century education.

In addition to the assessment work conducted within Networking Academy, Cisco is also working with other industry partners to help improve global assessment. In January 2009, Cisco, Intel, and Microsoft announced a research initiative called Assessment and Teaching of 21st Century Skills (ATC21S) aimed at improving global education effectiveness by clearly defining the skills needed by 21st century learners and developing strategies for measuring students’ progress with the aid of information technologies.

Cisco has developed a global education transformation website, GETideas.org, a central point of connection for education system leaders and academics to exchange ideas about challenges and opportunities associated with educational transformation.

In addition, Cisco participates in a wide range of educational programs and initiatives, including the 21st Century Schools Program, the New York City iSchool initiative, and the City Year service organization.

Cisco also administers an education research collaborative at research.netacad.net.

Vision for the Future

Networking Academy’s vision for the future is the integration of curriculum, assessment, and gaming. As we have alluded to throughout this paper, technology allows us to track student performance through participation in a wide range of learning activities. Data collected from these activities allows for ubiquitous, unobtrusive assessment of student learning. We believe this integration will help change our conceptions and models of “assessment” while improving our ability to make detailed inferences about student learning and optimize instructional methods.

We are currently engaged in research on how to use our technology capabilities to gather performance data as students complete various activities and begin to chart proficiencies in different areas. For example, as students encounter new concepts, they might complete a simulation activity, take a short quiz, or answer a drag-and-drop problem. Students may begin at level one, knowing how to assign an IP address on a computer. As they progress through the activities and reach higher levels, the course might suggest additional activities to help them refine their skills. The data generated could be incorporated into feedback for students and instructors about where students are in their learning trajectories. Although these capabilities are not fully realized today, this is the direction in which the Networking Academy program is moving.

Join the Conversation

We believe the Cisco Networking Academy principles of integrated, technology-based assessment can be adapted for use in nearly any subject matter area. To learn more about the technology trends and research that inform our assessment practices, we encourage you to join the conversation about advancing assessment with a global community of education leaders at GETideas.org. Cisco has developed the global education transformation (GET) online community platform at GETideas.org for education system leaders and academics to exchange ideas about 21st century learning and the opportunities and challenges associated with educational transformation.