The Future of Learning and Assessment in a Changing World

Eva L. Baker
Distinguished Professor and Director
University of California, Los Angeles
National Center for Research on Evaluation, Standards, and Student Testing (CRESST)
First World Future Education Symposium, June 2012
Beijing Empark Grand Hotel, Beijing, People's Republic of China
The National Commission of the People's Republic of China for UNESCO

Introduction

I am Eva Baker from UCLA. I am honored to be here in China, at this conference, in this beautiful hotel and collaborating on this important topic. Thank you for inviting me to meet the essential leaders of teaching and learning.

I will begin with a few words about me and my organization to explain why I see the future as I do. I have worked at UCLA in a Research and Development Center, called the National Center for Research on Evaluation, Standards, and Student Testing (CRESST), with about 100 faculty, students, researchers, and other staff. Our work is financially supported from many sources. We have created our mission and it emphasizes the following points:

Mission of CRESST/UCLA

- CRESST is devoted to conducting research and development to add to new knowledge, improve practice, and assist policymakers and the public.
- CRESST specializes in the areas of innovative measurement and statistics, the development of learning systems, evaluation of programs and policies, and the development and evaluation of new technologies.

- CRESST is committed to design and assure the validity, credibility, and fairness of its assessments, whether they are used in classrooms to improve learning, for accountability purposes for individuals or institutions.
- CRESST works to set the national and international agenda in research and development in these areas.
- CRESST emphasizes the importance of students who need extra support because of English language learning, economic background, or other matters

The CRESST staff includes quantitative specialists, anthropologists and linguists, psychologists specializing in teaching, learning, and assessment design, evaluators, and technologists developing games and simulations for learning and assessment. Our new Co-Director is a brilliant scholar, Li Cai, from the PRC.

At CRESST we depend on the many teachers and principals on our staff. I taught English and History many years ago in secondary schools. Our work is devoted to learners of all ages, from young children to adults in careers such as medicine or engineering. Because CRESST is my home I could speak much more about it, but I want you to know that we do very innovative research and make products usable in schools and other sectors. Our work involves very fundamental research and practical innovation involving education and training, both of formal and informal types. It is my long experience in the assessments and technology worlds that influences my remarks today.

My comments will rely as much as possible on research and experience in the United States and elsewhere in the world. I am the President of the World Education Research Association and have been consultants to many governments. But obviously I

am an American, and I will see the world from the educational perspective I know best. It is a limitation, I know.

As an overview, I will discuss where learning and assessment are today, the changes that we may expect in the short and mid-term from new technology and from new job opportunities. I will suggest strategies I hope will secure the best future for all of our students. Of course, as this conference attests, we are all mindful of the impact of globalization.

Where Is Learning Today?

The majority of education for children takes place in schools dedicated to those purposes. These are formal systems with goals and standards, curricula in many subject matters, professional teachers, buildings with desks and computers, as we all know. The purpose of schools may differ, the atmosphere may vary, the students may differ, but one thing is common. All formal schools assert authority and manage the learning options available to students. In many countries, my own especially, accountability of schools and teachers is of continuing importance. Much of accountability is focused on students' test performance. There is a controversy among educators and in the United States that the public and teachers have strong views about different types and frequency of testing and assessments. Many argue for less testing and some strongly prefer more.

Despite the common emphasis on assessment and accountability, in the U.S., as elsewhere, there are substantial differences in the educational quality of schools and the instruction received by our students. Many reasons are given for these differences, and they include those related to student background, such as language or dialect in the home, financial constraints in the educational arena, uncertain student motivation to put forth

effort, and the need to improve goals and teaching in certain subject fields. Achievement differences persist among sub-groups of students, for instance, on our National Assessment of Educational Progress (NAEP) and on our state tests, we find different attainment of Black and Hispanic students compared with White and Asian students. This is one problem the U.S. system has not yet solved.

When people think of education or training, they first think of teachers, a most important feature of our educational systems. But as educational goals change and students come with many different backgrounds and experience, it is important that instruction conforms to the needs of students and raises their performance, their self-efficacy, and their interest in learning. However, it is very difficult to help some teachers learn how to adapt instruction to fit different students. Such adaptation requires an incredible effort, to adjust learning to the progress of each and every student. This may be only a U.S. view. One educator (November, 2009) has said that in the U.S., the *teachers* are expected to work harder than students. In many Asian countries, the *students* are expected to work as hard as the teachers. I do not know if this picture is accurate, but it seems that it might be correct.

An early sign of our collective educational future is the growing role of informal education or information learning outside of schools. Informal education includes after-school, summer, and on-line education programs, as well as those that give students substantial choice over what they learn. Students in the U.S. now spend more time on the Internet than watching television, and more on either than homework. Much of computer and smart phone use is for communication by texting and for playing games, as 97% of students at the 4th grade level and above play video games regularly. In the U.S., as

elsewhere, games are being developed intended to help students learn important objectives and to assess their emerging competency.

Where is Assessment Today (at Least in the U.S.)?

Although I have done much work outside of the U.S. on testing policy and practice, I will focus my comments on the United States once again. Tests in the United States focus primarily on content addressing different kinds of knowledge in school subject matter.

The content goals for learning derive from standards developed separately by each of the 50 states. However, now many states have joined together to adopt the "Common Core State Standards" and have agreed to use one of two sets of assessments (Partnership for the Assessment of Readiness for College and Careers [PARCC] and the Smarter Balanced Assessment Consortium [SBAC]) developed to measure progress in English Language Arts and Mathematics. Policymakers and practitioners want goals and standards, aligned to curriculum and teaching, and to the learning measured by tests and assessments. In the past, test content and format have strongly guided what is taught in schools, even though those tests were usually administered for accountability purposes once a year. In the new plans for testing, there is renewed emphasis on formative assessment or the use of assessments during the instructional process, to identify students' strengths and weaknesses and to help the teacher develop optimal plans for each student. Formative assessment is important in both public and independent schools.

Many of our tests use multiple-choice formats, although some ask students to complete essays and conduct projects. It is often said, "You get what you test." As a result, there is concern among educators that there is too much attention given to multiple

choice tests, although these tests are faster to administer and can be easily scored. Performance-based tasks, requiring more steps and longer administration times, are once again surfacing. It is an area where I have worked for many years. To meet this challenge, new approaches have been developed for computer-based test administration, scoring, and reporting. I believe this technology emphasis is a worldwide phenomenon.

Changes to Expect from Emerging Technologies

My comments at this point must necessarily be speculative, as I have not yet seen the future, except in my dreams. Let us consider both learning and assessment changes inspired by technology.

Learning. First, in the area of learning, there will be a greater dependence or desire for informal learning to supplement instruction given by formal institutions. This change is a result of Internet experience and the individual way in which such experiences affect students. In technology language, people describe the special "remix" or the set of particular music, books or pictures meaningful to technology users, for instance, on iPods, iPads, or iPhones. Students' personal interests or particular areas of need may motivate such learning. There will be many options from which to choose, including games, cooperative projects on the internet, creating new applications, simulations, and intelligent tutoring systems, where the learning system adapts to each student's needs. These may occur on computer or mobile platforms. Because of the diversity of options available, there will be less gate keeping by the schools and teachers about content, at least in the United States. The result is that learning goals and processes may be far more personalized than standardized, although standard expectations will remain as well.

Assessment. In assessment, technology will help design, score, and monitor different student activities through the analysis of web experience (data mining) and determining through the statistics of learning analytics the types of progress students are making along differing goals and content trajectories. There will be a greater emphasis on cognitive or thinking skills, but more about that topic later. Various statistical summaries allow the combination of student data in different settings, for instance, classrooms and mobile phones, into different indicators used to give students feedback, teachers' guidance, and parent information. We are also using sensors, gestures, and other information to understand student engagement, attention, and persistence. These sensor systems are also used to assess proficiency in application areas, for instance, collecting scientific data on a field trip or to determine how groups function. Social media is another source of information.

There are a few limitations of technology-based assessment. One limitation of these kinds of data is whether the students are aware of the data collection when it happens. Now, for the most part, students know when it is time for a test, so we can see their "best" performance. In these systems, if assessment is embedded in other activities, such as games or social networks, we will be looking at their "average" performance. A second concern is privacy and whether students want everything they do available for the rest of their lives. In the U.S., we see some young people writing the wrong thing on Facebook or on e-mail. Data from these sources could follow students forever, and limit their ability to reinvent themselves as they mature. In some European countries, there is a mechanism to allow students to erase formally earlier performance, so when they look for a job, they can put forth their best efforts. A third limitation is test security. Test

security assumes that access to the test is fair for all students, but we have seen in the U.S., some cases of inappropriate practice of test content. With tests administered by computers, there is a strong chance that hacking of computer systems will occur. My solution is usually not liked by policymakers. It is to make test items and tasks available to all *before the test is given.* To make this work, the testing tasks should be very hard, differ in format, consist of thousands of particular items, and published with no answers given. I think students who learned all of them, in an individual or collaborative way would be better off than having students break into computer systems. I have great confidence that students who seem to be able to get into banking systems will have little trouble with our State examination technology.

On the more positive side, in the U.S., copying from other countries, there is renewed interest in developing a system of badges or achievements to denote particular accomplishments. These badges require specific completion of identified tasks, for instance making a website, solving complex mathematical problems and applying them to a useful purpose, or designing a community science center. Each of the tasks has to be completed at a pre-specified level of excellence. These are accumulated in a resume or portfolio and in addition to test performance, may be presented to universities or employers as indicators of achievement. In other countries this approach is more advanced. It uses teachers, community members, and businesses to help students achieve the badges' requirements. In the U.S., most early badges are developed in an informal learning setting and use technology as ways to assist and validate performance. Great investment, as elsewhere, has been made in automated scoring (using computer

technology) of student's work, and studies of their validity and fairness must occur. The badge movement may ultimately supplant testing in the U.S., as we know it today.

Changes in Knowledge and Career Options

As everyone knows, knowledge is expanding at an unprecedented rate. Even in Alexandria thousands of years ago, no one could know everything, and as knowledge grows, for instance, in the sciences, we can no longer teach content that we are sure will not change, with the exception of literacy, history, and some mathematic areas.

As the academic knowledge changes, even more does the expectation for jobs and careers. In many areas, there are new jobs that no one could have imagined, ten years ago. We are told that in five years, half of the top ten jobs for adults may not yet have been invented. This change in part is caused by the globalization of businesses, and the interdependence in some areas. While there will always be a combination of global and local components in jobs and careers, the shared components will change what is required to learn in school. Furthermore, as one goes through life in the near future, we are seeing that people have many jobs. My son has had 12 different employers (he works in internet games and systems) since he finished the University. I have had three, but with many consulting opportunities, short-term.

Even those who stay working for one business for a long time have their work change. I can remember twenty years ago, when secretaries typed my work. Now most people do their own text, answer their own phones, and take care of their own schedules. I have had to learn much about computers, graphics, and software that earlier would have been the province of experts. The point is that people will continue to learn in their careers to a greater extent than at the present time. Further changes in careers and work

will be prompted by changes in demography in various countries and regions. Immigration shifts jobs at all levels of activity, from the most routine to those demanding the highest level of creativity. The proportion of youth to age, the birth rates in many developed countries is rapidly changing and will require new configurations of work or partnerships on a regional or international level. Obviously, language and cultural differences between young and old and among different groups come into play.

What may be critical is the development of multiple pathways to college and career that addresses changing expectations and emerging compositions of nations and regions. As change in demography is always a fact of life, cycles will occur where new compositions of population, requirements, and opportunities develop.

Strategies for Improving Student Education

What shall we teach and what should students learn? In the previous analyses of the future, now compared to the present, it is possible to see the steps that should change. If content knowledge in many areas will change, how can the education sector keep up with new information and expectations? An approach begun at CRESST in 2000 and very much evolved over the last 12 years is to focus on the underlying architecture of learning. This architecture is not as deep as brain physiology and function, but begins to address skills that underlie the types of learning that are required today and can be required in the future. Our research and development work has led us to adopt a strategy where the core skills are taught as they are incorporated in different subject matters, for instance, mathematics or literature. Then our assessments and instruction (in our case games and simulations) are built first on using these components, before adding subject matter, game context and particular mechanics of play. These skills will be useful for

any future that can be considered. They fall into three major families. The first are cognitive skills that require thinking. The second set also requires thinking but is focused on social skills, and depend upon learning from one another and how to work together. The third set of skills, self-management, involves how an individual reflects and affects his/her own thinking and behaviors. All of these are most powerfully learned and assessed when they are applied to previously unencountered, novel situations involving the integration of learning in unpredictable ways. This phenomenon is often called "transfer and generalization" and is the major way to teach these abilities so that they can be applied in the unpredictable future.

Cognitive Demands or Intellectual Skills

Cognitive demands are skills required to complete serious intellectual work. In our analysis, they are skills that can be taught and learned, rather than those that depend only on individual talents.

Adaptive Problem Solving

Adaptive problem solving is one such skill. It has four major pieces. Adaptive problem solving means that a student can be given a situation, identify the problem and its constraints, represent the problem so that it can be solved, figure out alternative solution options, implement one strategy, and evaluate the adequacy of the solution or solutions. What is adaptive about problem solving is that students may need to be flexible in the ways they find and represent the problem and the ways they go about solving it. This approach is not the same as solving a given problem using a just-learned procedure, like combining fractions with different denominators. Instead the student has

to draw from previously learned patterns or schema, adapt them to the problem at hand, and perhaps invent something new in order to reach a solution.

Notice in the attached slides how complex problem solving could be, especially when integrated systematically in subject matter discussed in a later section.

The representations you see have been separately completed for each cognitive demand we will consider and some that we will not discuss. Essentially, the representation or ontology is used as a guide for the design of assessments and games or for classroom understanding. The idea is that the explicit elements here should be represented as selected by teachers or other educators. Not all are appropriate for every grade or task, but if common elements were used for instance across subjects and as students grow they will build a good foundation for applying such skills in the future.

The graphs or maps we use have been developed by experts and through the use of natural language processing by intelligent computer systems. These systems can take information and extract its key elements and put it in the graph. Obviously, experts must review this imported material.

Many people think cognitive skills vary as individuals do, that some are better problem-solvers than others. While traits of cognitive skills differ, I am not talking about finding people who happen to have good skill, but teaching and assessing students who need to learn the skill. Moreover, I am not talking about teaching problem solving on sets of unrelated and irrelevant "toy" problems. The problems should be relevant to the specific content domain of interest, such as biology, or should be embedded in an integrated field, such as environmental learning. Here is a model of problem solving.

We have built applications that help teachers to design or evaluate assessments to determine which of the attributes they have.

Situation Awareness. Another type of cognitive skill is situation awareness. It requires perception, cognition, and interpretation. An example might be looking at a site before you design a playground. The learner would need to perceive the aspects of the land and the surrounding area, for instance, where the lights are, where the traffic is, and how much space there is available. Then the student would need to think about these aspects singly and in a group, before coming up with an interpretation that leads to a design or conclusion. Situation awareness depends a good deal on perceptual skills and the importance of seeing (or hearing) the important elements in a scene. If elements are partly hidden, or if distractions such as bright colors or irrelevant movement are present, like on a video screen, the learner must take these into account and know which elements to ignore.

Content Understanding. Schools focus on subject matter, and for most of us, such traditional learning is obvious. There are refinements about knowledge classification that may be helpful to teachers and definitely to assessment and game designers. One is familiar, dealing with different types of operations on knowledge, including memory (recall or recognition), comprehension, concept learning, principle learning, application, analysis, synthesis, and evaluation. A simpler system involves learning declarative knowledge, meaning WHAT ideas, facts, or information; procedural knowledge, denoting HOW one uses or applies information, procedures, or general methods; and strategic knowledge, referring to understanding WHY the content has importance, relevance to problems or analyses, and its role in larger systems. At CRESST, for the

new standards developed for the United States, we have created ontologies to serve as an explicit bridge between written standards and the design of assessment and instructional options. These maps have been developed by experts, many of whom wrote the standards themselves. They help commercial and educational personnel see relationships among standards better and identify subtasks that should or could be taught in a special order. We have used them successfully with classroom teachers and with students who have some latitude on how they go about teaching and learning and may miss important pieces. Although "alignment" between standards, teaching, materials, and assessment is an important idea, these approaches allow relationships to be designed in at the beginning rather than looked for, and rationalized, at the end of a process.

There are other cognitive demands found in types of communication, such as listening and writing, or in decision-making. But because of time constraints I will omit them.

Social or Interpersonal Skills

There are skills that are critical to future success and to learning as it frequently occurs in both formal and informal educational settings. These skills involve interpersonal activities that interact to achieve particular goals. While these skills may overlap with individual differences among people, for example, outgoing, shy, or a good listener, they as cognitive and intellectual skills can be taught. Some skills consist of part interpersonal skills and part intellectual skills, for instance, the ability to communicate to one another. One must interact on a topic that has content, opinions, or new ideas, but the interaction itself will require the participants to look for facial cues (situation awareness), process and understand what is being said, content understanding, and grasp

the essence of what is communicated (problem finding). All must occur in a transaction that is comfortable for both persons, and may require not giving a complete opinion, leaving time for the other to talk, and modulating the conversation by type of language and amplitude appropriate to your conversational partner. These skills are usually learned informally, through watching others and trying out alternatives.

The social or interpersonal skills I focus on are those that have use in learning and in future work. Let us consider collaboration and teamwork. Collaboration means working together in general or on a common goal. The group of individuals may have a specific task or tasks given to them, or modified or generated by the group. They may or may not have a leader, chosen by the group of an external process. To be a good collaborator is an extension of communication, but the purpose of the collaboration is far clearer than that of most conversations. It might be to solve a problem; it might be to come up with an opinion or a plan of action for others. It could be a task that ends with making a completed object, like an essay, research report, mural, or music.

Some educators have differentiated group work—where all people work together in similar roles—from teamwork, where there are specific roles related to part or elements of the task. An easy way to look at these differences is to think about group work as something an individual could complete alone, and teamwork where each member probably makes a unique contribution. Many researchers have developed alternative theories about teamwork. For example, teamwork requires the agreed assignment of individuals to subparts of a task. In a research project, someone may be responsible for outlining the work, others for finding and authenticated resources, another may be tasked to write examples, or in the case of education, to come up with outcome

measures. Someone may be responsible for editing text or compiling the references. The whole team might then review and refine the finished work, or that might be left to one or two people. Teams can be like collaborative groups if there is a relatively flat organization, or more like formal teams in sports where there may be a particular leader. Unlike collaboration, team members need to play their part, as in football or soccer where a goalie and a striker have very different roles. Teams can be put together based on expertise and particular parts. For instance, at my center CRESST, we have people who are especially good working with young children, those who write narrative, those who do illustrations, those who design assessments, and game developers who put the package together. In some cases where expertise is not so special, team members may volunteer or be assigned to roles, with the idea that they will learn to be more expert in their given role, such as finding relevant information.

Teams require certain common functions, many of which can be taught, or at least further developed. In an intellectual task, for instance, where one team is negotiating with another to avoid penalties and get the best benefits or "deal," team members may differ in behaviors. One may set the goal and get agreement; another may provide feedback to the group if they are moving off topic and getting distracted. A third can provide or ask for clarification if the use of terms gets confusing or it isn't clear what is required. Another member may take on the role of summarizing progress, and the team leader who set the goal, may identify next steps. Someone may be responsible for the interaction or conversation with the opposing team. Teamwork skills have been taught in schools and in business environments. Most businesses list teamwork among their top three goals for new recruits. Good teamwork requires flexibility, and teams fail when

different people think they have the only way to solve the problem or create the object that may be the goals of learning. To be sure, some people start at this better than others, and it is also true that true leadership is sometimes hard to achieve. But most students can become better if teamwork and collaboration are systematically planned in academic topics, as it is in sports or other performance areas. Two points might be made here. The first is that using groups or teams of students is very sensitive to group composition, at least in the United States. A group of all boys and one girl at certain age ranges inhibits the performance of the girl. Similarly, groups that include only one or two children from a different language or social-economic-status (SES) group may limit full participation and best success. Second, there is always a question about group and teamwork measurement and evaluation. Do you look at the individual's contribution, or do you look at the finished product and give all the same grade? It is difficult to manage the individual contributions, unless we now use more sophisticated technology to help, through monitoring social networks or keeping track on a dashboard system. More simple approaches include 360-degree ratings, where everyone rates each participant. But these are subject to friendship patterns, and may only be useful for feedback rather than grading performance. Nonetheless, teamwork and collaboration depend on explicit skills that can be taught and learned.

Self-Management

As a team profits from planning, monitoring, and feedback, so do individuals. Known by many names, the skills of self-management can result in life-long abilities to use learned procedures to help achieve complex, new or particularly challenging goals. Among the other names you may be familiar with are self-regulation, learning to learn, or

metacognitive skills. We have used most interchangeably. Today I want to talk about the intellectual part of self-management, or metacognition, and the more emotional part, that involves reactions and feelings involved in learning.

Intellectual or Metacognitive Management

Many elements have been identified for metacognition, including goal setting, planning, self-assessment, feedback, and decision-making. Some outcomes associated with metacognitive (internal behaviors) included better learning and a greater sense of self-efficacy. Among the components that students can address in the use of these skills are goal setting for learning, time planning, putting forth more effort, and providing self-rewards for staying on the path. Some people profit from using lists or software that help them internalize these goals. Others can be taught by the modeling of others. We know when metacognition occurs by asking students or by doing studies involving students who talk aloud through the process they are going through to solve a complex or multistep task.

A student is directed, for instance, to plan a task by a teacher. Planning involves identification of goals, subtasks, figuring out needed resources, coping with constraints, such as time, and access to desired information. The study is expected to monitor the plan to be sure that the steps are accomplished and to look critically at the work of each stage. Students are self-assessing, and if they do it well, they will give themselves feedback. This feedback may cue them to stay on the same path, revert to an early stage of the task to improve it, or to take a new approach altogether. If students are asked systematically to do this type of work, they will get better at it. One American has said that using metacognition is one way to equalize intellectual differences, because very

smart students use these processes automatically. Others see these tasks as an internalized version of study skills, useful in classrooms, doing homework or projects, studying for examinations, and moving on to higher levels of education.

Emotional Self-Control

While not strictly dealing with emotions, this type of self-regulation includes planning, self-assessment, and feedback. The difference is that the focus is on emotional states rather than largely intellectual processes. Each of us knows these cannot be neatly separated, but for discussions sake I will. Let us consider three areas related to school learning. The first is the management of stress and anxiety, skills good to know for teachers, principals, and university professors too. Stress and anxiety relate to the feeling of being overwhelmed by too many requirements, a fear of not being able to succeed, or to fail dramatically—anger at the lack of control over the situation and the feeling of helplessness—and stress and anxiety may be a matter of temperament. We all know people who seem to be calm, no matter what the situation. They may actually feel tranquil, or they may give that appearance and be seething inside. In fact, some say those who externalize or show their fear and anger end up healthier, although that may not be true of the people who must work or live with them. Again, however, there are individual differences, or traits on these dimensions of fear and anger. There is also the idea of "state" anxiety. This may be associated with particular situations, like taking an essay examination, seeing a spider, or having to give a public talk. However, there have been developed good and systematic programs to reduce state anxiety, especially in test anxiety. The elements of worry (uncontrolled thinking of what will happen if I do not do well, attention to failure rather than good responses) distract the learner from the work at

hand. Emotional responses, like feeling afraid with physiological symptoms of sweaty palms, rapid breathing, and such also lead to distraction from the task. These concerns have been shown to be relieved by two processes. The first is to monitor worry and instead substitute positive self-talk, saying internally, I can do this, that wasn't so hard, I will succeed on the next one. Emotionally, the ancient practice of volitionally slowing down rate of breathing is effective in reducing fear and substituting a neutral process to attend to.

Other types of goals using emotions as well as metacognitive skills may be those related to perspective taking, that is, in a dispute putting yourself in the mind of the other person using empathy to diffuse the problem. This approach is especially effective for dealing with unfamiliar individuals. A third area of interest in the U.S. is self-protective behaviors when a student is bullied or aggressed by another, either verbally or physically. There are systematic processes taught to young children, for instance, to recognize the bullying, say stop, move away, and if necessary seek help. This contrasts with giving in, being afraid, and potentially getting hurt emotionally or physically. The result of this training is developing greater resilience in the face of future unkind interactions.

The use of emotional self-management has a larger goal of seeking a better balance among activities, mental, emotional, and physical, so the person feels more in control and more comfortable with his life. Of course, school or formal education can only do so much, and here collaboration with family may be an important element for success. All self-management skills may be called into play when approaching a major life event, like seeking a job, changing schools, or joining an unfamiliar group at a distance from home. Now to the general measurement strategies needed for the future.

Transfer and Application to New Situations

If the future is unpredictable, and we know it is from the speed and surprise of change, then we need to provide intellectual and emotional coping skills to undress unforeseen situations. Although many psychologists wish to test transfer of learning to new situations as a dependent measure for their research, in practical settings it is clear that if students are expected to confront new situations and apply or adapt their learning to new expectations, they need to be given some practice doing it, and transfer should be treated as a learning goal rather than a surprise to students. Certainly we are not at all able to anticipate the forms or constraints of new situations, that is the very essences of unpredictability, but we can help them become familiar with the need to extend and expand their learning in previously unforeseeable ways.

In the simplest case, transfer will mean an opportunity using all the cognitive and metacognitve skills listed above, and sometimes the social skills as well. The student will need to figure out the situation. As in problem solving, this means, he will need to understand the constraints, barriers, and new options presented in the task. For instance, if a student had been taught about fish in local waters and were given a chance to observe the sea life off the coast of Chile, the student would need to see what elements in the marine ecosystem were similar or divergent from what he or she had learned, to determine the temperature and flow of the currents, the difference in location on the globe as it influenced tides, and so on. To do this the learner would recognize new barriers to his knowledge or ability to solve a problem, and most importantly determine what elements that had been already learned were applicable. This task means applying schema or pattern analysis to look for familiar relationships. For those that were

unfamiliar, the student would need to access resources and reason or hypothesize relationships. The point here is that unpredictable events will always be partially solved by accessing learned schema or patterns. This is why many psychologists worldwide argue for teaching schema and patterns rather than small snippets of information. The teaching and learning of schema are also more efficient with respect to storing in short-term or working memory in the brain, and have been shown to be more rapidly accessed than procedures or processes that had been learned step-by-step. At CRESST, we are now working on a way to represent situations, from those close at hand to the learners' experience to those far afield, including the simple or complex use of cognitive demands or deeper learning and the involvement of complex knowledge.

Summary

This paper covers a lot of ground, but focuses on the movement from the present to hypotheses about the future. It circles back to describe how learning, technology, and assessment will interact. Few technical details have been given about the measurement of these skills but all nations are working on them. Our contribution can be deep and wide. We will continue, at UCLA, to work on problem solving and metacognition and priority areas for design and assessment, and we will strive to use the new technologies well in worthwhile games and simulations for all levels of students.

References

November, A. (2009). *Creating a new culture of teaching and learning*. Available at http://novemberlearning.com/wp-content/uploads/2009/02/creating-a-new-culture-of-teaching-and-learning.pdf