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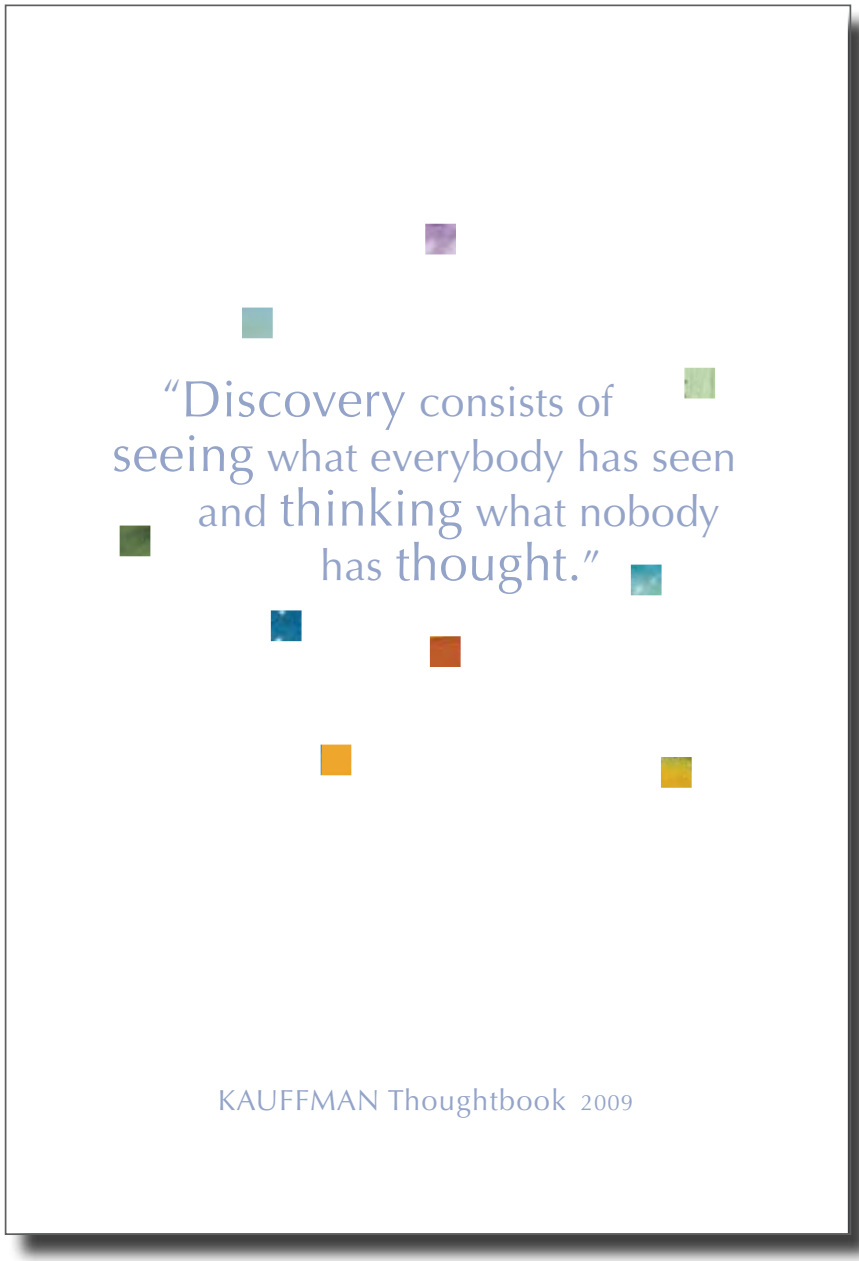

Fourth in an ongoing series, the *Kauffman Thoughtbook 2009* captures what we are thinking, learning, and discovering about education, entrepreneurship, and advancing innovation. This collection of more than forty essays is written by the talented Kauffman Foundation associates, partners, and experts who are pursuing the principles and vision set by our founder, Ewing Kauffman.

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How can we spur the next generation of entrepreneurs and skilled workers for our global economy?

What innovative, alternative learning environments will engage students?

How can we instill a love of discovery, exploration, and inquiry?

Learning vs. Education:

A New Way to Think About Preparing the Next Generation

DENNIS W. CHEEK, Ph.D.
Vice President, Education, Ewing Marion Kauffman Foundation

Learning is at the very core of what it means to be human. Even before we are born, our senses are already at work as we process information from the outside world. An intricate dance begins between our inner self as known through thought, emotions, and self-regulation, and our outward self as known through perception, speech, and behaviors.

The late Jonas Salk, physician and inventor of the polio vaccine, wrote in 1972's *Man Unfolding* of the complex interplay among chance, choice, change, and challenge that animates and makes possible all of life and that enriches and characterizes human life throughout the lifespan. Before a child enters kindergarten she has already mastered at a highly proficient level at least one language (often two or three), grasped in amazing detail fundamental aspects of the social and physical world, formed friendships and bonding relationships with others both near and far, and learned important life lessons. Above all, one is impressed by the seemingly endless curiosity of children about the world, the ways in which it seems to work, and that endless query to others—"why?"

Educational programs at the Kauffman Foundation seek to prepare the next generation of entrepreneurs and skilled workers for success in the economy, society, and daily life. While we cannot identify in advance which young people

will become the next wave of successful entrepreneurs, nor at what age the "entrepreneurial spirit" will seize them (up to age eighty and beyond), we believe that the dispositions, habits of mind, skills, and knowledge they acquire will benefit everyone. The success of these future entrepreneurs will require fluidity in skills, concepts, problem solving, decision making, and judgment that are daily applied in the realms of the sciences (including mathematics), engineering, and technology and design. Both tacit and explicit familiarity with and understanding of the human-designed world (i.e., the world of technology) is fundamental knowledge essential for life and active participation in the world as an entrepreneur, leader, and economic, spiritual, and social contributor to society.

While we cannot identify in advance which young people will become entrepreneurs . . . we believe that the dispositions, habits of mind, skills, and knowledge they acquire will benefit everyone.

This brings us to the question of how such skills, capacities, dispositions, and knowledge are to be encouraged and developed among students. We find it helpful to always keep the concept of *learning* as the central focus of how we think about, evaluate, plan, and execute our grantmaking related to children and youth.

Learning is a concept with much broader connotations and applicability than education—a word that conjures up immediately a particular set of structures and functions that are the serendipitous outcome of history, culture, political power, geography, economics, and sociology. Learning is a fundamental aspect of human life throughout our days on Earth and provides a point of linkage among our lives as citizens, employees, business owners, and social creatures.

There is much we do not understand about how people learn, whether at the fundamental physiological level of perception, attention, and memory or in the more cognitive dimensions of goal orientation, problem solving, information processing, organizing, and decision making. Proceeding from what we do know, the Kauffman Foundation seeks out or develops programs or strategies that involve children and young people in real-world, active dimensions of learning such as:

- hands-on, minds-on programs like Project Lead the Way, U.S. FIRST Robotics, and U.S. FIRST LEGO® League;
- internships and job shadows through UpLink, Kansas City's regional hub for the formulation and provision of teacher externships, career speakers, student internships, job shadows, and mentoring;
- immersive and other online experiences like GeoWorlds, The JASON Project's Operation: Resilient Planet, or VISTA's Year in Health Sciences; and
- mobile learning through programs such as Sports Bytes, which uses cell phones to engage young people in learning mathematics, engineering, technology, and science (METS) content related to sports.

Yet just innovating at the program level fails to move systems and learning as a whole forward in ways commensurate with the learning challenges we face in America and around the globe. In this vein, we seek to leverage leadership capabilities, targeted research, ideas, partnerships, and extensive social networks, such as:

- Tackling complex problems related to advancing learning that require significant changes in how policymakers think about learning in highly structured environments such as schools. As an example, we supported the creation of the first-ever set of tools to improve school boards' understanding of teaching and learning in METS. (See the essay by our partners in this venture on page 32.)

- Defining significant problems and organizing one or more coalitions to enable this vague concept of immersive education environments to materialize. If we can make it real, we will have a large and immediate impact on learning. (See the essay by our director of Future of Learning Initiatives on page 26.)
- Undertaking a thorough analysis of existing research, and setting a new and powerful research agenda to seek fuller answers on how to develop the next generation of entrepreneurs within a framework that pays serious attention to the developmental sciences, as well as learning and performance across the lifespan.
- Creating a new vocabulary that facilitates thinking about, planning for, and bringing into existence new learning environments and new conceptualizations about how people, ideas, and systems can be organized to maximize human learning potential.

We are daily renewed by the challenges and opportunities before us as we join with others of like mind to create new and more powerful ways to advance learning and improve the human condition through the not-yet-fully realized power of entrepreneurs and entrepreneurial grantmaking.

Want to Truly Scale a Learning Program? Try Gaming.

MERRILEA MAYO, Ph.D.
Director, Future of Learning Initiatives, Ewing Marion Kauffman Foundation

Think big, really big.

Every year, the higher education system in the United States produces about 350,000 bachelor of science students. Every year, ten million people, or twenty-eight times as many, are playing World of Warcraft. Even small games you've never heard of, like Dofus, attract 450,000 players (see *mmogchart.com*).

But, when we speak of education interventions in this country, we think of one or ten classrooms at a time: a summer camp for students, teacher training experiences that serve fifteen teachers a year, innovative curricular materials that make it into five or ten or maybe forty classrooms. Nothing we do has the scale to make a difference on the national scorecard.

Video games might.

But—Don't Video Games Rot Your Brain?

Maybe not. There is a burgeoning field that goes by various names—immersive learning, 3D Internet-based learning, Serious Games, to name a few—that has embraced the vision of games and virtual worlds as authentic and powerful learning experiences. Certainly, from a theoretical point of view, games have many features that cry out for application to learning. To wit:

- Goals: Research has shown that students persist longer in a task if working toward a goal. Games, almost by definition, have goals.
- Self-Efficacy: Another key to learner persistence is the learner's own perception of how well he or she is doing. Games foster self-efficacy by rewarding the player immediately for even the tiniest successes, through progressive accumulation of points and level.
- Feedback: In a typical classroom, a student gets to ask 0.11 questions an hour (J.D. Fletcher, 2001). He is given feedback on performance at a rate as slow as two exams a semester. Game feedback is continuous, immediate, and on the scale of seconds.
- Collaboration: Collaborative learning yields, on average, a 50 percent improvement over solo learning (D. Johnson, 1981). Many of the massive multiplayer online games have collaborative problem solving hardwired into their architecture.
- Inquiry: Games, particularly those set in virtual worlds, are designed explicitly for user-directed exploration.
- Brain Chemistry: the encoding of memory is enabled by dopamine production in the brain; the work of M. Koepp et al (1998) showed video games generate almost double the levels of dopamine experienced by humans at rest. Performance doubled as well.

Sports Bytes: Engaging Students In the Science of Sports Via Mobile Phones

In 2008, the Kauffman Foundation teamed up with Hot Lava Software to test a proof of concept among United States youth: Would they use their mobile phones to take quick math and science quizzes connected to sports at sporting venues?

Through July, August, and September, this concept was tested at all home games held in a half dozen independent and minor league baseball parks and at three major league soccer games. During the games, a stadium announcer dressed as a quirky professor encouraged fans to take out their cell phones to register and interact with the Sports Bytes module. The goal was to have 100,000 registered users take at least one quiz in the module. That goal was met during the three-month testing period, and a total of 300,000 people registered on the site.

Why test this concept? Well, as Kauffman continues to explore new avenues of learning, we understand that many other countries are ahead of the United States in how mobile phones are used for supplemental education. Because students in Asia, Europe, and South Africa are much more likely to have a mobile phone rather than a computer, students in those countries are more adept at using the phones for learning modules, accessing the Internet, and advanced text messaging. In the United States, mobile phones are still primarily used for voice calls and limited text messaging.

At Kauffman, we understand that young people can learn anywhere, not just in a classroom, so we wanted to find out if American students would use their mobile phones to do so, as many of their European, Asian, and South African peers already do.

So, the Foundation teamed up with Hot Lava Software, the company with the most experience in developing learning modules for mobile phones and hand-held devices. Most of Hot Lava Software's business is overseas. As an example, Hot Lava Software works with Vodacom, the South African mobile phone company, which added a library of learning modules that help phone users become educated in basic skills and in health issues. In the United States, Hot Lava Software works with kajeet, a pay-as-you-go cell phone service that markets their phones and services primarily for young people, and has added a number of learning modules for free on their phones. kajeet also donated a number of phones for the Sports Bytes test in the summer of 2008.

Hot Lava Software has a history of developing mobile phone learning modules for public schools, as teachers use mobile phone quizzes to prepare students for standardized tests. Hot Lava Software quickly got on board with the Sports Bytes project, and assembled a content development team to develop questions that meet academic standards for middle school students.

Ultimately, Kauffman is exploring various ways to get more students engaged in METS subjects. Linking science concepts to sports activities is one way to reach them, especially as they use their mobile phones to take the quizzes. Sports Bytes may be an example of how more and more students will learn in the future.

Can We Prove It?

What proof do we have that any or all of this is true, that games can produce superior learning outcomes? Well, the proof is precious little because the field is so new, but at least it is positive. Witness these games:

- Supercharged! [electrostatics]—a 28 percent increase in learning outcomes over lecture (K. Squire et al, 2004).
- Geography Explorer [geology]—a 15 to 40 percent increase in learning outcomes over lecture (P. McClean et al, 2001).
- Virtual Cell [cell biology]—a 30 to 63 percent improvement in learning outcomes over lecture (ibid).
- Dimenxian [algebra]—an average increase of one test grade (e.g., from B to A) for most kids, up to three grades for underachieving kids (N. Etuk, 2006).
- River City [ecology, scientific inquiry]—a 370 percent increase in test scores over lecture for D students; a 14 percent increase in test scores over lecture for B students (D. Ketelhut, 2007).
- NIU Torcs [numerical methods]—twice as much time spent by game-playing kids on their homework, much more highly detailed concept maps (B. Coller, 2006).

A key distinction between the games above and the so-called edu-tainment games of yore is the player's direct engagement in the content, rather than a game-like "test" of content learned elsewhere.

Why Aren't We There Yet?

Every parent's dream would be to have their kid as addictively engaged in their own education as they are in their video games. If the technology is here, and the content is here, and the audience is here, why aren't these products available?

Lack of a for-profit model. Large game companies (Sony, Nintendo, Microsoft) swore off education-related games with the edu-tainment bust. And, let's face it, even in the pencil-and-paper world, education is not a big moneymaker.

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Lack of sustainability in the not-for-profit model. Government agencies (NSF, NIH, DOD, NASA, NOAA) and several foundations, including ours, MacArthur, and Hewlett, are stepping up to the plate. But, in the grant-based model, there is no financial allowance for product marketing, distribution, or product existence after the life of the grant. "Dissemination" usually amounts to putting the game on the developer's obscure Web site, trafficked only by graduate students and/or professional colleagues. Meanwhile, all the kids who could benefit from it are over at *Disney.com*. That's OK. (I should note that we collaborate with *Disney.com* on the Hot Shot Business online youth entrepreneurship game at *hotshotbusiness.com*) Yet, in most grant-based models, the software will be rendered obsolete by the new Windows release, anyway. There's no provision for compatibility upgrades after the grant is over.

Technical barriers that dramatically limit usability. Imagine an Internet without search (no Google), without copy and paste, that only ran on some computers and not others. How would you do anything? Not easily. The technical prowess to solve these deficiencies in 3D worlds exists; the leadership to coordinate the effort does not.

Uncertainty about quality and relevance. How can I tell if this game really teaches? That it will be fun? Are the games designed to adhere to state standards? Can they be taken apart into modules of less than forty minutes? Is there a teacher guide? Consumer acceptance issues have not been worked through, for the most part.

We have a ways to go. However, the combined scale and effectiveness of game-based learning far exceeds many other educational innovations. For this reason, the Kauffman Foundation is committed to solving the above-identified infrastructure issues of dissemination, sustainability, usability, and adoption through targeted projects. Within the next five to ten years, games should be available that allow you to learn what "you" want to learn.

Helping Local School Boards Understand the Importance of METS Education

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Deputy Executive Director, National School Boards Association

PEYTON M. WEST, Ph.D.
Senior Program Associate, Program of Dialogue on Science, Ethics, and Religion,
American Association for the Advancement of Science

There are 14,600 local school boards across the United States, each independently addressing one of education's most critical challenges: how to improve the teaching of mathematics, engineering, technology, and science (METS). Some have led their districts to innovative partnerships and brilliant solutions; others have made disastrous decisions costing their districts thousands of dollars. But none of them has had a central place to go to for resources and support.

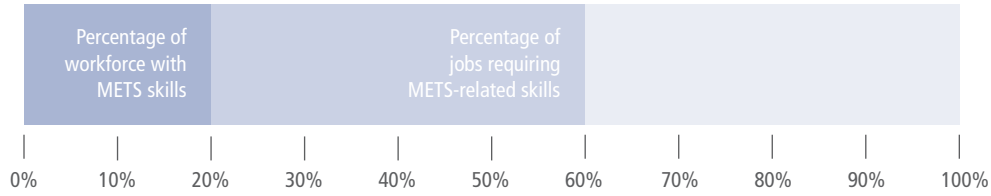
Beginning in 2007, a new partnership between the National School Boards Association (NSBA) and the American Association for the Advancement of Science (AAAS) was created to address this gaping need. The AAAS/NSBA Science, Mathematics, and Technology Education Project marks the first time a national science organization has reached out proactively to local school boards, and the first time that NSBA has directly addressed its constituents' needs with respect to METS subjects. The project's goal is to determine what school boards want and need to know about METS education and to address those needs head-on.

Why Local School Boards?

Educational and professional experts agree that U.S. public school education in METS fails to address society's growing need for literacy in these subjects. Dire statistics include those from a recent U.S. Department of Labor report indicating that 60 percent of jobs in the 21st century economy will require skills that only 20 percent of the workforce currently has—and those skills are largely related to METS subjects. In the rush to address various aspects of the problem, a key player in the debate is often overlooked. The local school board is ultimately responsible not only for how these subjects are taught in public schools but also for garnering and ensuring community support for decisions about public school education. Yet school board members often know very little about METS education.

Typically, national science societies and organizations have interacted with local school boards only when boards institute policies that threaten science education. There are a number of examples, such as the Dover, Pennsylvania, school board's decision to undermine the teaching of evolution by encouraging students to look into "intelligent design." While weighing in after these decisions is important, preventing decisions like this in the first place would clearly benefit students as well

21ST CENTURY JOBS



as science education in general. The AAAS/NSBA partnership believes that helping school boards understand what science is and why METS education is so important will help prevent controversial issues from gaining traction while simultaneously addressing the larger issue of improving U.S. public METS education.

Where to Begin?

Each of the U.S. local school boards faces a unique set of issues due to the highly localized structure of the U.S. public school system. Districts vary considerably in size, urbanization, and socio-economic variables, and board members represent a wide array of experience, education, and viewpoints. This means that a "one size fits all" approach is unlikely to meet all needs. To address this concern, the AAAS/NSBA partnership, with support from the Kauffman Foundation, designed a project that focused initially on the Kansas City metropolitan area. This region, in addition to being the headquarters of the Kauffman Foundation, encompasses a varied group of school districts that effectively function as a microcosm of the U.S. school districts in general. Furthermore, many Kansas City area school districts have had direct experience with controversies about evolution.

> The most striking aspect of the AAAS/NSBA partnership has been the enthusiastic and appreciative response from Kansas City area school board members.

Our first challenge was to discover what school board members and their communities feel that school boards should know in order to address METS education. With the help of Public Agenda, we surveyed Kansas City area school board members, school administrators, teachers, parents, and students, and we soon

had some answers. First was the fact that Kansas City area school board members do not want to talk about evolution—they're sick of it, and they have more important concerns. Instead, school board members are worried about the state of METS education in general, and, while wary of being asked to become "educational experts," they need more information in order to be effective community leaders on this issue. These results reflect the larger school board community's feelings as well; a survey of school board members from across the country who attended our session about METS education at NSBA's 2007 Annual Meeting revealed similar concerns.

Meeting Identified Needs

Our next challenge was to meet the needs revealed by our surveys in a way that would benefit school boards across the country as well as those in Kansas City. Our solution was to present a seminar for Kansas and Missouri school boards where experts addressed key questions, and to videotape the seminar and extract the best clips for dissemination to a broader audience. Accordingly, we offered the "AAAS/NSBA Science, Mathematics, and Technology Education Seminar" to approximately one hundred Kansas and Missouri school board members in June 2007. We have since been working to adapt the material to create resources for a broader audience. These will include training materials that state associations of local school boards can customize to offer boards the opportunity to learn more about METS education and a Web site that addresses specific questions board members have about METS education. We introduced preliminary iterations of these resources to the executive directors of the state associations of local school boards at a reception in February 2008, and they were met with widespread enthusiasm. The final resources debuted at the annual conference of state association trainers in June 2008.

Next Steps

The most striking aspect of the AAAS/NSBA partnership has been the enthusiastic and appreciative response from Kansas City area school board members. As a result, AAAS is considering how to tailor more of its available resources to a school board audience, and NSBA is contemplating incorporating METS education more directly into its own work. This has been the best kind of partnership—the two organizations have learned from each other, and we are now inspired to look for ways to continue to work together beyond the scope of the original project.



Students Explore Real Earth Virtually

An Interview with:

CAROLINE DAVIES, Ph.D.

Associate Professor and Director of Environmental Studies Program, Department of Geosciences, University of Missouri–Kansas City

IRIS TOTTEN, Ph.D.

Assistant Professor, Department of Geology, Kansas State University

DONNA RUSSELL, Ph.D.

Assistant Professor, School of Education, University of Missouri–Kansas City

It is well known that the United States faces a crisis in science education, particularly among minorities and underrepresented groups. The GeoWorlds Project is an innovative new program funded by the Kauffman Foundation. It integrates collaborative virtual learning environments with problem-based pedagogy. It is designed, using the Second Life immersive education platform, to engage urban students in Earth science while enhancing their problem solving skills and content knowledge. This project, which is being piloted in Kansas City area schools, focuses on developing the potential of urban minority and underrepresented groups in urban and suburban schools. These schools represent 51 percent of all students in the United States. (NEAR, 1998).

Problem-based learning in the sciences has been demonstrated to be a successful educational approach to increase knowledge level and student engagement. The teacher/facilitators in each classroom are being trained in the problem-based approach where Earth science content is based in the national and state science education standards. However, the power of collaborative virtual

learning to engage students and increase their problem solving skills and content knowledge has not been fully researched. This project offers one opportunity to do that type of research. The integration of these tools has enormous potential to increase interest in the sciences and for education worldwide.

The following interview with the developers of this innovative new curriculum offers insight into how GeoWorlds uses bold new ways to engage students in learning Earth science.

How does this project provide new ways for students to learn geoscience content?

Russell: The GeoWorlds project is foremost an examination of the impact of virtual learning environments on higher order thinking skills of urban high school students. In order to evaluate any impact on learning, we first had to build a problem-based virtual curriculum around Earth science content that is engaging to high school students. This was our focus the first year. The scenarios and virtual simulations in GeoWorlds provide students with opportunities to explore science-based virtual worlds and conduct problem-based learning activities, either as individuals or as group activities.

How does the program work?

Davies: The first island, TerraWorld, presents 3D visualizations of the major characteristics of four specific geologic time periods: Cambrian, Permian, Cretaceous, and Eocene. These scenarios provide, through their virtual visualizations, chronologic position in geologic time, environmental information, dominant life forms, location of the continents, and critical changes or adaptations in life history. Each of the four scenarios has interactive exploration and knowledge building built in, as well as larger picture relational understanding between the scenarios. These relational

pieces include having students learn to recognize and order the events of geologic time by life form development, environmental development, or critical life history events.

GeoWorlds uses an immersive environment where students learn by having their avatars explore different aspects of the program.

As students travel through the scenarios, they identify organisms, learn to classify organisms into taxonomic hierarchies, and learn the associated environmental characteristics, such as oxygen levels, ozone availability, etc. These activities build the foundational knowledge they will use at the end of the scenarios to identify unknown species and make correlations between species and environmental changes. In the process, students are exposed to specific Earth science information such as the importance of the Burgess Shale, the development of an oxygen-dominated atmosphere, and the development of land plants and animals.

How is this different from a teacher-led lesson?

Totten: Students explore the 3D scenarios following their own direction, but with set goals to attain specific pieces of information that will contribute to the whole understanding. They can work in groups that require sharing of information and developing new groupings of information. They develop complex linkages through randomly encountered information. The information comes in a wide variety of forms—written explanation, visual, short videos, touching, and clicking for data.

What are the challenges you have overcome in building such an environment in Second Life?

Davies: The challenges to building the GeoWorlds first island, TerraWorld, can be broken down into two components—virtual curriculum development and technological.

Totten: In developing this unique collaborative virtual learning curriculum and environment, we first encountered our own boundaries of how curriculum is developed. In a traditional setting, one develops the learning goals and outcomes first, then the specific course layout and classroom activities and assessments that support those goals. However, because we were new to virtual environments, we did not initially know the full range of capabilities of the environment. Therefore, we spent much time initially designing the island layout and "landscaping" the curriculum. We were building from the island up versus designing the curriculum from the goals down. To some extent, this process was necessary, but with additional

scenarios and experience gained, we can now design virtual curriculum from the goals down.

The second biggest challenge has been translating our curriculum ideas into virtual curriculum, not just a three-dimensional rendering of classroom active learning modules. As we move from designing active classroom curriculum to virtual, we have become much less linear in our concepts (difficult also because geology conceptually is very linear) and much more network, linkage based. Students can move throughout the scenarios in random and unpredicted patterns; they attain information in more random sequences, and it requires that they make strong linkages between this information.

The GeoWorlds Experience— Explore, Engage, Inquire, Create

In traditional classroom instruction, students see information from one source—the teacher—presented in a manner that can be as linear and as invariant as the ordering of chapters in a textbook. In contrast, GeoWorlds is highly participatory and non-linear, using the teacher as a guide and the terrain as the content.

For example, within each time period of geologic history, students may wander around and freely explore the plant, animal, and geographic features of the time. Students may participate in scavenger hunts for note cards that provide needed information about the world around them. They may chat with each other and the teacher to share perspectives as new challenges arise, and form teams in pursuit of academic goals set within the world.

Students can literally design and create creatures to populate the virtual world—under the constraint that those creatures be accurate representations of life forms that did actually exist at the time. Virtual field trip activities are particularly easy in virtual worlds: students can count, first-hand, the local population densities of life forms around them in GeoWorlds, and arrive at results that are scientifically accurate, thanks to the accuracy of the underlying simulation. But, students also can conduct experiments not even possible in the real world, for example, changing the oxygen or carbon dioxide content of the atmosphere in the Permian era and watching its effect on the population density of differing life forms. Beyond the textbook, beyond the classroom, virtual worlds are a learning environment rich with opportunities for exploration, engagement, inquiry, and creativity.

What types of technical challenges did you encounter?

Russell: Initially we had to address our own abilities to function in Second Life, so we had sufficient knowledge about the environment to be able to better dialogue with our design team. Experiencing this learning curve first-hand is important since most of the end-users will be teachers and students with no background in Second Life, and among urban students, many will have had little computer experience.

In any technical design there are always communication issues to overcome when you have several very different technical fields conversing. In our case, Earth science, they were virtual design coding and curriculum assessment. These were worked out in weekly meetings.

What is it like to work with Second Life, especially as it was experiencing a phenomenal rate of growth and expansion?

Davies: There have been technological issues working with a company, Linden Lab (LL), that experienced 400 percent growth in one year. Initially it took four months to get our first island established. There was much confusion with LL about the purchasing process of the island. The organization has since established a concierge service just for education research projects.

We also began to encounter with our first live student demonstrations the technological challenges of integrating virtual curriculum into urban schools. Schools have varying degrees of hardware, software, and support. On the Second Life Teen Grid, we have built in firewall barriers that keep

anyone not involved with the program from gaining access to the island. We can see these will be challenges to be addressed early in the coming year as we move to full implementation in several schools.

Despite the early stages of our project, the response we had from a school district science coordinator and its head technology director was tremendously positive. They are actively seeking out participation in the project.

A World of Difference for Kansas City Students:

Project Lead the Way

With the rapid advancement of technology in today's society, it is difficult to stay current. Project Lead the Way (PLTW) makes a world of difference in enabling Kansas City area teachers and students to stay the course.

Nationally acclaimed, PLTW seeks to increase the number, quality, and diversity of engineers and technical professionals through collaboration with K–12 education, higher education, and industry. By engaging students in hands-on, real-world projects, PLTW helps them understand how the skills they are learning in the classroom can be applied in everyday life.

PLTW uses a four-year sequence of courses and labs that include several areas of engineering—structural, civil, mechanical, and electrical—giving students a taste of each discipline. Students take courses such as Introduction to Engineering, Principles of Engineering, and Digital Electronics, and use software including MD Solids, Robopro, Westpoint Bridge Design, Revit, and Inventor to design and model projects. The classes are challenging. For example, in the first assignment in the Principles of Engineering class, students are asked to do the following:

> *Design and build a modifiable device that will launch a ping pong ball into a ten-inch bowl with 100 percent accuracy. On launch day, the distance will be varied by the instructor within a range of five to fifteen feet.*

Projects like this challenge students to apply the skills they are learning in other classes to solve problems. Teachers and students report they are learning a great deal in the PLTW curriculum and are noticing the difference PLTW is making in the learning environment and energy at their schools.

A grant fund at Kansas City's Metropolitan Community College Foundation helps local schools implement the curriculum, train teachers, and connect with employers. Funds come from the Kauffman Foundation and other locally based companies including: Black & Veatch, Burns & McDonnell, Cerner Corporation, Sprint Foundation, and the Society of Manufacturing Engineers Foundation. Some 4,600 students in more than forty middle and high schools in metropolitan Kansas City benefit from Project Lead the Way classes.

Attesting to those benefits are a Kansas City area teacher and two students, whose insights follow:

Stephen T. Schlutow, PLTW Teacher, Ruskin High School

> As a teacher, I have noticed that PLTW strengthens the standard school curriculum for students who wish to pursue their studies in the engineering field. This program has a real-world, project-based curriculum that complements math and science core courses by allowing students to create projects utilizing knowledge learned in both core courses and in PLTW. In other words, PLTW helps answer the question most commonly asked by students: "Why do I need to know this, and when will I ever use it?" Being a math/physics/PLTW teacher, I get to experience both sides of the curriculum with the students; PLTW students make connections more quickly.

During the previous school year, a visiting engineering professor from Missouri University of Science and Technology visited our classroom and was amazed to discover that as freshmen, students were doing the same bridge truss work assigned to college students in Statics and Strength of Materials courses at the university. Knowing that has been an incredible motivator for my students.

Danielle and Dominique Roe, PLTW Students, 10th Grade, Ruskin High School

As students, we have learned how to apply our math and physics skills to a project that uses skills and knowledge learned in our algebra, geometry, and freshman physics courses. When we built our ping pong ball launcher, we used physics and trigonometric concepts; we were able to calculate the velocity of the object at any point in time during its flight by the initial angle of launch and the distance traveled. These principles are continued in the Introduction of Statics and Mechanics of Materials, which incorporates algebra and trigonometric concepts to develop vector and moment equations. These equations are used to calculate various forces that are being applied to beams and the stress and strain within the beam. We found that MD Solid software can perform the same task in a matter of seconds! Other topics in PLTW are statistics and reliability, small machines, and the construction of a marble sorter utilizing Fischertechnick material and Robopro software, in which students write the program.

In our IED class, we are learning how to make 3D sketches using Inventor software. Our first project is to design a puzzle cube. Our next project will be the reverse engineering of a particular object. We will have to take it apart, measure it, and design it using Inventor.

PLTW has made a dramatic difference for us and others in our classes. We have learned how to work through problems and to work cooperatively with other people.

A CDF Freedom Schools scholar transforms into an astronaut to learn about the science of space exploration.

Photography by Mark McDonald

Discovering the Possibilities in Technology and Engineering

AN ESSAY IN PHOTOS

Kansas City area children were able to picture themselves as astronauts, aeronautical engineers, and architects during the fourth annual Kauffman-sponsored, Children's Defense Fund (CDF) Freedom Schools™ Discovery Day on July 7, 2008. More than 1,850 children and nearly 200 interns explored twenty stations, staffed by volunteers from local organizations, that exposed them to the fields of technology and engineering. From robots, space shuttles, and paper airplanes, to architecture, weather, and electricity, the Freedom School "scholars" experienced these industries with a variety of hands-on activities.

The CDF's Freedom Schools program is an inventive, creative approach to summer education enrichment designed to serve children, ages five to fifteen, in urban communities. Revitalized under the leadership of Marian Wright Edelman, founder of the Children's Defense Fund, the program uses teaching techniques developed to nurture both the mind and the spirit. The curriculum is activity-based, emphasizing reading, writing, multigenerational mentoring, leadership, conflict resolution, and promoting social, cultural, and historical awareness.

CDF Freedom Schools represent one of the innovative programs the Kauffman Foundation has committed to revitalize and bring to scale. With Kauffman support, Kansas City's first CDF Freedom Schools program opened in 1995. The Kansas City movement has since grown with a multi-million dollar Kauffman grant to serve two thousand children at nineteen sites, and is recognized by the Children's Defense Fund as the most successful Freedom Schools initiative in the nation.

A scholar learns about wind force, gravity, and lift by making and flying a paper rotocopter.

Scholars learn that when hot and cold water, or air, meet, hot air rises and cold air descends.

The traditional song and dance of Harambee got everyone energized for the day.

Marian Wright Edelman, founder of the Children's Defense Fund, greets a scholar upon arrival at Discovery Day.

A group of scholars learn what it's like to be an astronaut in a space shuttle simulator.