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America FORWARD

March 7, 2014

Ms. Cristin Dorgelo
Office of Science and Technology Policy
1650 Pennsylvania Avenue, NW
Washington, DC 20504

Docket ID: OSTP-2014-0001

Dear Ms. Dorgelo,

Thank you for the opportunity to comment on the Office of Science and Technology Policy's (OSTP) January 13, 2014 Federal Register Notice regarding "High Impact Learning Technologies."

America Forward (www.americaforward.org) is a nonpartisan policy initiative, spearheaded by the national venture philanthropy and social innovation firm New Profit Inc., that connects policymakers with high-impact organizations to champion effective solutions to our country's most pressing social problems. New Profit invests in a portfolio of leading social entrepreneurial organizations to strengthen, connect, and amplify their impact and increase social mobility. America Forward leads a Coalition of more than fifty innovative, impact-oriented organizations dedicated to driving systemic change in policy areas including Education, Pay for Success, and Workforce Development. We believe that transformative social change is possible even in times of limited resources. Organizations in communities across the country are achieving measurable outcomes every day, and innovative policy approaches and funding strategies like Pay for Success could translate these local results into national change.

We are very supportive of OSTP developing policies related to high-impact learning technologies outlined in the notice, and are especially eager to comment on the use of Pay for Success (PFS) as a 'pull mechanism' to accelerate the development, rigorous evaluation, and widespread adoption of high impact learning technologies. Below we seek to provide answers to a number of questions included in the Agency's Request for Information as you begin considering how pull mechanisms could be used to accelerate the development, evaluation, and adoption of learning technologies.

Question 4: Why would a pull mechanism in this area accelerate innovation in learning technology?

America Forward believes that innovation and evidence are essential in improving the effectiveness and efficiency of services and programs. We believe that innovation is not necessarily defined by something that is "new"; instead, innovation is better understood as a cycle in which a pattern-changing idea is developed, assessed, tested, and evaluated, and then refined if it successfully achieves greater value or abandoned if it does not. For this cycle to work effectively in the policy arena there must be clarity regarding the **outcomes** sought, **flexibility** to try new approaches and providers, a **measurement system** to determine if the approach is effective, and **resources that follow results**. Too often, outcomes are not clearly specified, approaches are too narrowly dictated and do not focus on prevention, the ability to measure results is severely limited, and resources are locked into specific providers or programs, even if others would yield greater value. As a result, the federal government may fund the same ineffective programs for decades without combatting the root cause of the targeted problem, costing taxpayers billions of dollars and wasting the potential of the people programs are intended to help.

As a “pull mechanism,” Pay for Success (PFS) is an approach that spurs the cycle of innovation, and would allow for the development and implementation of learning technologies, accelerating innovation and driving toward outcomes in the education technology space. Specifically:

Pay for Success contracting flips the equation, linking government payments to positive outcomes. Under this funding model, public dollars are tied to results, rather than based on the cost of services provided or the number of people served. Specific interventions are not spelled out, allowing providers the flexibility to adopt whatever strategies they determine will be most effective. In some cases, private sector funders may provide up-front financing, taking on the risk that the intervention won’t succeed and receiving benefits if it does.

Specifically we believe programs designed to “Pay for Success” have several advantages: (1) by emphasizing outcomes rather than rules and regulations, fewer resources are wasted on compliance and bureaucracy so more funds can go to program delivery; (2) by focusing on results and creating incentives for cost-effective interventions, programs will emphasize more effective prevention strategies over remediation and programs will tackle persistent issues in the learning and education fields; (3) by providing flexibility in choice of intervention and emphasizing results, these designs encourage innovation to identify the most effective strategies; and finally, (4) government, and therefore taxpayers, only end up paying for effective programs.

Since Pay for Success is also about **effectiveness** -- moving public funding to interventions that build and use evidence to deliver results that are better than those achieved by other programs -- this mechanism can be used to structure government contracting and funding in ways that incent these results, even if private sector investment is not involved. For example, government can provide funding for the evaluation required to build the evidence base, and for performance management systems that enable organizations to use evidence in program implementation. Government can provide financial incentives – bonus payments and the like – when programs demonstrate better than average, measurable impact. Government can also incent the leveraging of private philanthropy to provide matching funds that cover these costs.

Question 5: What role might different stakeholders (e.g. Federal agencies, state and local educational agencies, foundations, researchers, practitioners, companies, investors, or non-profit organizations) play in designing, funding, and implementing a pull mechanism for learning technology? What role would your organization be willing to play?

There are a number of roles that different stakeholders can play in the design, funding, and implementation of a Pay for Success pull mechanism. Because it takes multiple years to determine whether or not a service provider has successfully achieved a given outcome, providers must be able to finance program implementation for multiple years without any government funding. Social Innovation Financing arrangements allow these providers to raise the up-front working capital necessary to implement and scale their programs, bridging the timing gap between project implementation and government success payments.

The most common Social Innovation Financing arrangement today is a Social Impact Bond, an arrangement in which private investors including philanthropy, commercial lenders, and high net worth individuals provide the up-front funding for project implementation. Funding can be raised using various combinations of financial instruments from grants and low-interest loans to credit enhancements and guarantees. Depending on the funding agreement, investors may be repaid once success payments are made, or payments may be reinvested in the program to fund more services. The level of success payments is determined by the effectiveness of the program and the related government savings. This model was first adopted in the United Kingdom, and has since been actively developed in Canada, Australia, India, Brazil, and the United States, where the first projects have been launched in New York City, Salt Lake City, New York State and Massachusetts, and other projects are operating or being developed in Massachusetts, California, Illinois, South Carolina, Ohio, and in other states and local governments across the country.

There are many ways that Pay for Success programs can be constructed, from traditional pay for performance designs that offer bonuses for achieving specified outcomes to new forms that engage private sector funders. Specialized models include Social Impact Bonds, a version of Pay for Success that shifts early risk onto private sector investors, including philanthropy, business, and individuals. Modeled on a concept developed in the UK and currently being tested in the US, Social Impact Bonds save a government money by triggering payment only after a result has been achieved as determined by an independent evaluator. The more effective the program, the greater savings to the government and the more investors get paid. Pilot programs are now underway in Massachusetts, New York State, and New York City.

Federal policymakers can advance Pay for Success models by creating incentives for federal agencies or state and local government to develop model programs, providing funding for and encouraging technical assistance advisors to explore the feasibility and create pathways towards potential Pay for Success transactions, providing insurance against default by state and local governments, and addressing data systems and privacy issues. Already several states have begun pilot programs. Shifting resources from unproductive programs to Pay for Success models that pay based on the achievement of outcomes will ultimately make taxpayer dollars more productive and improve the lives of those whom these programs are designed to help.

As policymakers develop Pay for Success programs, we urge that they consider the following principles:

- Enable providers to participate even if they have not previously been a major recipient of public funding. If opportunities are limited to existing providers, innovative organizations that offer better outcomes will be excluded.
- Be cautious in replacing existing funding streams with Pay for Success models without transitional support. Organizations that have previously relied on public dollars may not be able to frontload funding of their services from private sources. This could cause many providers to fail financially. This concern does not apply in situations in which initial funding is available but re-funding is contingent upon achieving reasonable results in prior years.
- Be careful to identify a range of appropriate benchmarks rather than a single long-term outcome. Such benchmarks enable organizations to track their results and make adjustments as necessary.
- Develop systems that prevent providers from choosing only those clients who are easiest to serve, while also retaining flexibility for providers to serve multiple at-risk populations.
- Create opportunities and funding for government agencies to learn from others' experiences and build the capacity of providers, technical assistance advisors, and intermediaries to participate in Pay for Success programs.
- Include a partnership with a credible research organization to conduct a rigorous evaluation that measures the reform's impact on government spending (particularly entitlement spending) and

on participants' well-being (and any other key program goals), and that meets CBO and OMB's high evidence standards (including their priority for well-conducted randomized controlled trials), so that if entitlement savings are found, CBO and OMB will find the savings credible enough to count toward deficit reduction.

- Approve waiver applications across multiple federal departments meeting the above criteria, and provide appropriate technical assistance to awardees. The Department of Labor, the Department of Urban Housing and Development as well as the Department of Justice have already funded or begun the exploration of using Pay for Success and evidence-based strategies within its funding structures.

On behalf of the America Forward Coalition, thank you for the opportunity to respond to your requests for comments to inform OSTP's policy development related to high impact learning technologies. Please do not hesitate to contact me if you would like to discuss our responses further.

Sincerely,

Deborah Smolover
Executive Director, America Forward

America Forward Coalition

Acelero Learning

Alternative Staffing Alliance

America's Promise Alliance

AppleTree Institute for Education Innovation

AVANCE

BELL

BUILD

Child Mind Institute

City Year

College Forward

College Possible

College Summit

Eye to Eye

First Place for Youth

Generation Citizen

Genesys Works

Global Citizen Year

GreenLight Fund

iMentor

Invest in Outcomes

Juma Ventures

Jumpstart

KIPP Schools

LIFT

National Center for Learning Disabilities (NCLD)

New Classrooms

New Sector Alliance

New Teacher Center

Opportunity Nation

Peace First

Peer Health Exchange

Read to a Child (formerly Everybody Wins! USA)

Reading Partners

REDF

Roca

Root Cause

Save the Children

ServiceNation

Single Stop USA

Social Enterprise Alliance

Teach For America

The Children's Aid Society

The Corps Network

The Mission Continues

Third Sector Capital Partners

Turnaround for Children, Inc.

Twin Cities RISE!

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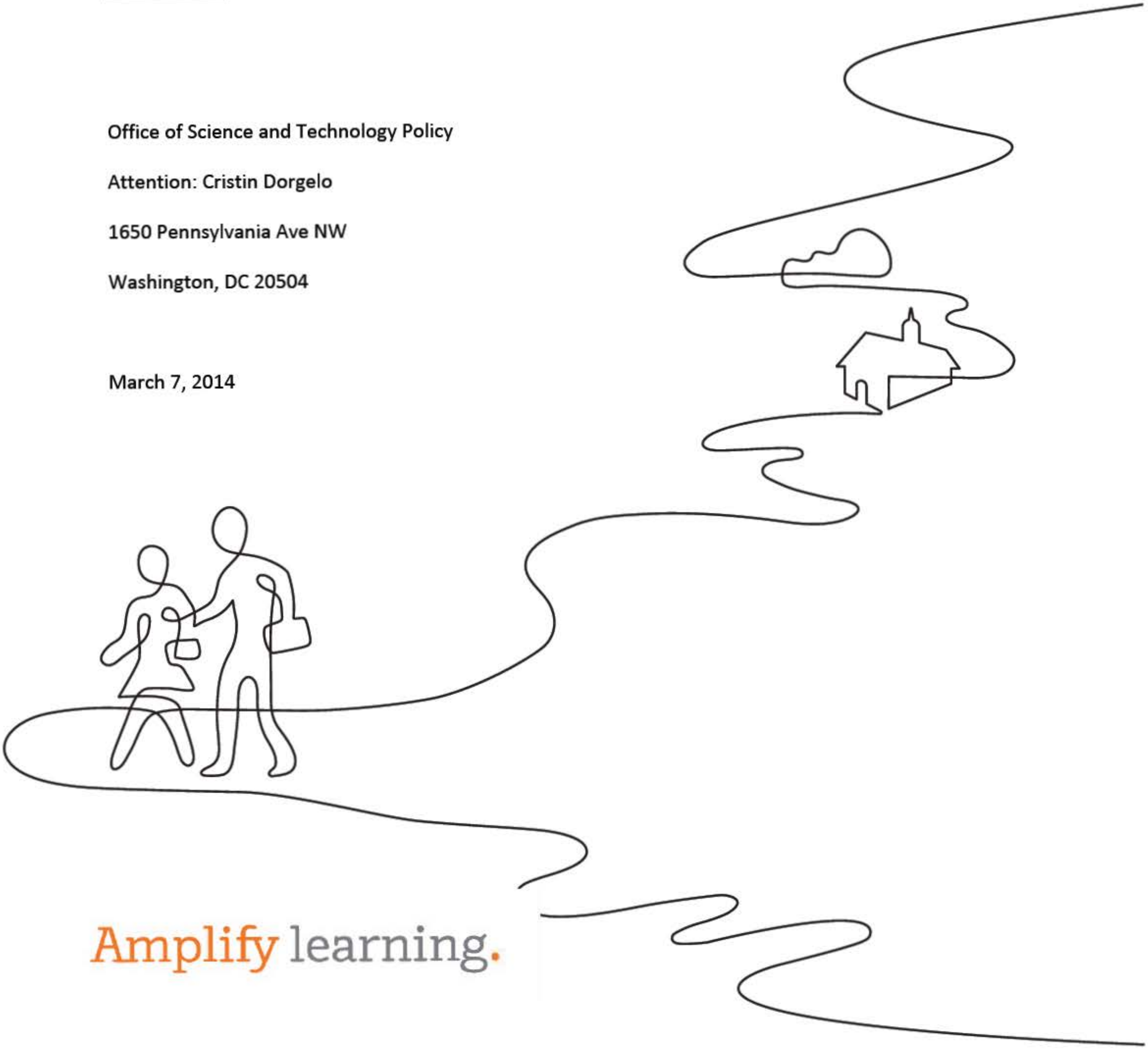
March 7, 2014



Amplify learning.

Introduction & overview

We appreciate the opportunity to respond to the Office of Science and Technology Policy's (OSTP) request for information on "pull mechanisms" to accelerate the deployment, evaluation, and adoption of high impact learning technologies.

At Amplify, we believe that education will be a primarily digital endeavor in five years. Devices are becoming less expensive, connectivity investments are increasing, and a generation of breakthrough educational software is in development. Children will still read books and work with physical manipulatives, but the power of real time feedback, multimedia, personalization, coaching, social networking, and simulation will make it compelling to transition from print materials and traditional classroom teaching to networked digital collaborations. Today's students can only meet tomorrow's expectations armed with the complex knowledge and skills that are best developed via learning technologies.

Over the next five years Amplify will build a comprehensive suite of instructional materials and tools in English language arts, Math and Science. We will also expand upon our tablet platform, which uniquely supports true one-to-one technology implementations. We believe Amplify is the largest concerted bet on digital technology in education. Original learning content, new digital learning tools, multiplayer games, device and classroom management software, and learning delivery platforms are part of this investment.

The more digital the education system becomes, the more data-driven it will become, and the more it will be possible to use data-informed approaches to improve teacher-student interactions. With time, training, and practice, the technology will recede and those teacher-student interactions – both in-person and technology-mediated – will be more central and meaningful.

We believe there are several key elements required to fully deploy high impact learning technologies in schools:

1. Always connected devices that are "ready at hand" - immediately on, convenient, able to directly deliver a learning experience or to sit "on the corner of the desk" supporting students and teachers interacting directly.

2. Platforms to manage, store, and deliver digital learning experiences, instructional materials, and tools to students and teachers.

3. A rich database of student information and an analytics engine that monitors student progress and ensures that students have the right learning experiences at the right time in the right groups.

4. Great learning experiences and instructional materials, from traditional texts to advanced interactive games and simulations. The providers of these experiences and materials should

be charged with demonstrating efficacy of their content with particular populations.

5. Learning Process Orchestration. This is our term for software that facilitates the intricate exchanges among teachers and students that shape good learning in the classroom. Tools that put students in the right place in a learning experience, that automate grouping, that provide differentiated feedback, that know when it is time to advise the teacher to move on and when it is time for the teacher to coach, and that support the social interactions of students.

6. Continuous improvement of the component parts and the overall orchestration based on formative and summative assessment as well as assessment embedded in learning.

7. Great teachers and leaders who know how to bring the overall teaching and learning experience to life, and who are well-supported throughout the adoption and implementation cycles.

The OSTP request for information is a perfect opportunity to share our learnings to date, to point to where we believe technology and education are headed, and to begin to establish the goals towards which we can collectively aspire. Below are our answers to the questions posed in the Federal Register notice with this frame in mind.

Response to specific questions

(1) What learning outcomes would be good candidates for the focus of a pull mechanism to catalyze the creation and use of new learning technology? These outcomes could be relevant to early childhood education, K-20, life-long learning, workforce readiness and skills, etc.

We think the following key learning outcomes here can be grouped into leading and primary indicators. Growth and advancement in the primary indicators will follow progress on the leading indicators:

- *Leading indicators* would include those indicators that are key to ensuring a positive, well-functioning and successful learning environment. Improvement on these indicators will set the foundation of learning to allow for growth on the primary indicators. The leading indicators that we would expect to move based on learning technology deployment would be:
    - Student productivity;
    - Student behavior;
    - Student engagement; and
    - Parent involvement.

- *Outcome indicators* would include those indicators that show mastery of content and the skills necessary to succeed in school or in career. These indicators are the ones on which students must show growth in to be competitive in today's education and workplace market places. They are:
    - academic achievement as measured by end-of-grade or end-of-course assessments; and
    - graduation rate.

(2) How are these learning outcomes currently measured and assessed?

On the indicators described above, our experience is that these outcomes are currently measured and assessed as follows:

- Leading indicators:
    - **Student productivity** metrics are not generally collected today, but can and should be collected in one-to-one implementations. Measures could include, for example, amount of reading (measured by words, "pages," or time on task); words written; or time on task outside the school day. Our ELA curriculum is designed to triple the amount of reading and writing that middle school students complete in a year. Our tablet team monitors the amount of time students spend working on their devices as a measure of implementation fidelity.
    - **Student behavior** is typically measured and monitored via two approaches: district-monitored statistics, such as suspension rates, disciplinary incident rates, etc; and school-level via formal methodologies for monitoring and improving in-class and in-school behavior.
    - **Student engagement** can be measured by means of classroom observations and surveys. Technology deployments also enable "collaboration" metrics – in-class or online academic contacts among students, between students and teachers, etc. Our ELA curriculum is designed to triple the amount of feedback that a student receives in a year, via in-person and online contact.
    - **Parent involvement** can be measured by surveys of faculty and of parents. Online metrics such as logins to a parent reporting portal, click-throughs on status emails, etc can also be monitored as a measure of the robustness of the school-to-home communications channel.

- Outcome indicators:
    - **Academic achievement as measured by end-of-grade or end-of-course assessments** is currently measured by states using assessments in grades 3-8, plus end-of-course, in compliance with NCLB's testing requirements. Many states will be transitioning to Common Core State Standard aligned assessments, either via one of the assessment consortia or via new content procured at the state level.
    - **Graduation rate** is currently analyzed and reported by states in accordance with the NGA Graduation Counts Compact.

(3) What information exists about current U.S. performance relative to this learning outcome? What information exists about the presence (currently available or potential given current trends or breakthroughs) or absence of effective interventions (technology-based, offline, or hybrid) to improve this learning outcome?

We believe that little information exists on performance against the leading indicators in the U.S. While some districts have started collecting information on student engagement and parent involvement, the current collections tend to be more retrospective than formative (e.g. reviewing suspension rates on an annual basis, or publishing previous-year parent survey data in an annual school report card).

One of the key promises of high impact learning technologies is the development of classroom-, school-, and district-level insight into the leading indicators around productivity, engagement, and involvement, and, over time, the cultivation and scaling of practices that positively impact these indicators. Appropriately, this work is local work, dependent on the goals and objectives of individual schools and districts. But by developing common language and comparison points on these indicators, we expect districts to begin to collaborate around them by asking and sharing "what works well for whom."

In terms of information currently available on the primary indicators: states are already tracking academic achievement and graduation rate data effectively, and are able to provide aggregated and disaggregated reporting on these data. At the local level, we recommend that districts begin to collect and inspect program participation and implementation data more closely. For example, if several classrooms in a school are experimenting with one-to-one, or if a grade level is testing a new digital curriculum, the short-cycle analysis of these efforts would provide valuable insight into the same question – "what works well for whom."

As for the presence or absence of effective interventions: the field has long had bright spots – specific interventions that produce evidence of academic gains in specific areas. For example, Amplify's Burst:Reading K-3 reading intervention program showed early promise and is now the subject of a three-year IES-funded research project. Similarly, Core Knowledge Language Arts demonstrated significant impact for K-2 students in a three-year study conducted in 10 public schools in New York City.

The record on the broader issue one-to-one technology implementations is just now developing. In many ways, K-12 education's experience tracks the productivity lag that American businesses saw in the implementation of technology – 10-15 years of deploying corporate IT with little objective evidence of productivity, followed by the surge of productivity in the past 10-15 years. The surge seems to be tied to the transition from automating pre-existing business processes and methods to re-engineering them – a transition that we believe K-12 education is just now making with the arrival of new technology-based instructional models.

(4) Why would a pull mechanism in this area accelerate innovation in learning technology?

Traditional procurement practices and policies, coupled with inflexible traditional funding streams, slow districts' ability to experiment, innovate, and re-allocate resources towards more effective approaches. (For more on this topic, see Digital Learning Now's *Smart Series Guide to Ed Tech Procurement*). Some pull mechanisms, as described in OSTP's RFI, show the promise of eliminating or minimizing these obstacles, especially to the extent they better align vendors' and districts' incentives. To this end, we believe the following pull mechanisms would accelerate innovation in learning technology:

- Buyer's consortia – This approach can specifically reduce friction related to procurement in the K-12 education environment, allowing for faster piloting and scaling up than would otherwise be possible. While there are already many state-level or inter-state buying consortia, such as the WCSA-NASPO Cooperative Purchasing Organization, which allow for more uniform pricing and easier procurement, we believe the promise of consortia really depends on the participants tracking and sharing "what works well for whom." Digital Promise, via its League of Innovative Schools, has begun to connect these dots with its DOCENT project. By leveraging not just buying power but collective wisdom on what works, schools and districts will better be able to maximize the impact of their dollars and efforts.

- Milestone-based payments – Establishing a milestone or learning outcome on which some part of payment is contingent effectively puts the client and vendor on the same side of the table. Both parties are able to collaboratively focus on implementation success and program results. As an example, Amplify has a state-level reading assessment contract that makes a percentage of the overall contract value dependent on the success of the implementation, including measurements of teacher satisfaction and of students' academic results.

On the other hand, OSTP also inquires about several pull mechanisms that seem promising, but present challenges to implementation:

- Advance market commitments – While it is inspiring to imagine a consortium of districts committing to purchasing, for example, 800,000 seat licenses for intervention software that improves 6th grade math scores, triggering massive investments in 6th grade math programs and a fierce competition among providers, we see two challenges. First, program development and validation takes many years – consider the example of the IES study on our Burst:Reading intervention. Would schools and districts be willing to essentially escrow their potential investments over three to five years to create a sufficiently significant investment pool to justify the private sector's investments? Second, the "what works where" question interferes with the idea of a single success criteria which would trigger the advance commitment. In our experience, district and school clients are more interested in experimenting with and investing in programs that have been used effectively in similar districts with like student populations. A program that emerged the winner in a randomized controlled trial, but that was tested among a largely non-ELL population might actually not be the best choice for a high-ELL district.

- Social Impact Bonds – in areas where educational outcomes obviously drive expenditures, we believe social impact bonds have tremendous opportunity to pull capital and human resources together to deliver significant student gains. The challenges with this model are how to integrate it with school finance practices and how to control for implementation in measuring success.

As an example, we have analyzed the impact of unnecessary referrals to special education – referrals that can be prevented by the implementation of "response to intervention" programs. Students who develop specific learning disabilities can cause additional expenditures for school districts. These expenditures can be avoided by a wise investment in early screening and intervention.

However, in investigating social impact bonds, we have identified two challenges. First, the K-12 system is not designed to "return savings" in the event of, for example, a reduction in special education referrals. It would be a challenge for states or districts to reduce expenditures on special education and put that money towards paying off a social impact bond. Second, we find that many of the innovations that can be applied to these challenges – including high impact learning technologies – depend substantially on implementation fidelity to achieve desired outcomes. We design for implementation fidelity, but if we were to make an entire contract's value dependent on educational outcomes, we would need to have such significant control of the implementation that we would essentially supplant the school's role. These are challenges that we believe could be addressed as the field matures over the coming years.

(5) What role might different stakeholders (e.g. Federal agencies, state and local educational agencies, foundations, researchers, practitioners, companies, investors, or non-profit organizations) play in designing, funding, and implementing a pull mechanism for learning technology? What role would your organization be willing to play?

Many of these entities have a role to play in advancing the utilization of pull mechanisms as viable options to drive results and reach outcomes utilizing learning technology.

- Federal agencies can incentivize and create the conditions for pull mechanisms to achieve desired results. Barriers in Federal programs that inhibit the use of these mechanisms can and should be eliminated.
- State agencies can work with their legislatures to address structural impediments to certain pull mechanisms – for example, enabling participation in inter-state purchasing consortia, or enabling social impact bonds. They can also experiment with adding milestone and outcome payments as part of future procurements.
- Local agencies can engage on and participate in purchasing consortia, contract with milestone and outcome payments, etc.
- Foundations can support the development of new approaches to purchasing consortia. They can also sponsor or backstop innovative social impact bond experiments.

Amplify is eager to participate in discussions with all stakeholders about the pull mechanisms previously discussed in this response. We believe we can play a role in helping to shape the use and effectiveness of pull mechanisms.

Paul Jesukiewicz

Vice President

Carney Labs, LLC

The promise of digital tutors and intelligent tutoring systems (ITS) has been around for over 30 years. Projects funded by DARPA, Office of Naval Research (ONR), and the National Science Foundation (NSF) have spent over $100M in research dollars yet these tutors are not main stream in the commercial market, nor are they widely adopted or affordable, and they don't scale outside of the research labs that create them. These tutors have been funded by government in stovepipes, and none have been developed in an interoperable environment.

ITS developers such as those funded by DARPA, ONR, and NSF often capture and store information about what each user knows and how they approach learning tasks, that information is generally only available during the current learning session or accessible only by the application that captured it. While this does allow for a certain amount of adaptability that can have a major impact on the effectiveness of the individual learning system, the captured information is not normally made available to any other learning systems or other applications. This means that each application can only access its own information, and the adaptability of any given system is often limited by practical constraints on how much assessment can be completed in a single application.

Research is needed to develop an open platform that allows virtually any software application to easily share observed user attributes with other systems to help create a better, more personalized learning environment for each learner, while protecting contributing organizations' investment and the intellectual property of the data they share with others. Emerging learning technology standards such as LTI and xAPI are not enough to solve this challenge.

Adaptability of learning software is often a key factor in the overall effectiveness of the software with regard to helping learners understand the material being taught in a reasonable amount of time. Many learning applications include introductory modules that perform some type of assessment about each learner before proceeding with the main material to be learned. The information gained in these introductory modules can then be used to tailor the presentation, contextual cues, and difficulty level to help ensure that each learner receives the proper material to help the learner grasp the material most effectively. Unfortunately, it is often not practical to provide extensive introductory assessments that include valuable, but tangential, assessments of variables such as effective reading level, personality traits, or cultural background. However, there are existing assessments that do a great job of evaluating those very attributes in the marketplace today. Learners should be able to use a common, secure learning environment to keep track of those attributes as they are observed in various assessment tools and then share those observations with other learning systems that can use them to improve and personalize the individual's overall educational experience.

Creating an open personalized learning platform would allow an ITS developer to create a STEM digital tutor in a subject such as science or math that is sensitive to cultural differences or different reading comprehension levels without having to be an expert in the evaluation of those attributes. The ITS developer can simply plug into an open personalized learning platform and retrieve the results of prior assessments for each learner when the learner launches the ITS. Now, the ITS developer can be more certain that the learner’s ability to understand, or misunderstand, presented material on science and math is actually based on the learner’s grasp of the underlying science and math principles, and not due to language comprehension or cultural differences.

In addition to gaining access to data from other applications within their own suite of applications, each learning system will have the ability to access data that has been provided by other assessment tools that are not specifically part of their suite of applications. Over the course of their lifetime, a learner may participate in many assessments of their cognitive skills and personality traits. They may also provide valuable information about different aspects of their lives via self-reporting applications; and of course, they may play serious games that capture interesting observations about them. All of this data can be available to learning system developers to help create adaptive systems.

The overarching goal of the open platform is to provide a secure data management capability that encourages developers to share useful data between applications while providing the compartmentalization of sensitive data to ensure that the source of each piece of data can control the access to the data it provides.

Finally, once the STEM ITS finishes teaching the learner, the ITS can generally draw some conclusions about each learner’s proficiency in science and math. Those conclusions and direct observations can be stored in the open personalized learning platform to help some other learning applications more effectively adapt to the learner. The open personalized learning platform is functioning as the middleware enabling interoperability of learner data across ITSs. The cycle of retrieving personalized adaptation data, adapting to each learner, and reporting observations continues over time with each consuming learning system also being a contributor of assessments and observations so that the learners’ learning cloud profile continues to be enhanced and become more and more accurate.

A need exists to leverage existing government funded research in ITSs by developing an open personalized learning platform that will allow interoperability of learner data across all digital tutors and ITS systems as well as enable a more adaptive and personalized learning experience based on the learner’s lifelong learning profile and attributes received from the digital tutors. Federal agencies need to work together on joint research and think outside the box using “grand challenge” type opportunities and not traditional procurement practices.

"

Center for 21st Century Universities (C21U)[1], Georgia Institute of Technology
Paul M.A. Baker, Ph.D.
Michael Madaio, M.Ed.

Comments in Response to the Office of Science and Technology Policy Request for Information (RFI) on Design and Implementation of ‘‘Pull Mechanisms’’ for High-Impact Learning Technologies

March 7, 2014

The Center for 21st Century Universities (C21U), submits the following comments in response to the Office of Science and Technology Policy Notice of Request for Information (RFI) requesting public comments to inform its policy development related to high-impact learning technologies. *Federal Register* Vol. 79, Number 8 (Monday, January 13, 2014) Pages 2201-2204.

Introduction

On January 13, 2014 the Office of Science and Technology Policy issued a Notice of Request for Information that “offers the opportunity for interested individuals and organizations to identify public and private actions that have the potential to accelerate the development, rigorous evaluation, and widespread adoption of high-impact learning technologies. The focus of this RFI is on the design and implementation of “pull mechanisms” for technologies that significantly improve a given learning outcome.”

C21U believes that the opportunity for students to have a greater degree of control over their education, at equal or lesser cost, as well as attaining greater student satisfaction, will potentially lead to better completion rates. Currently, there have been efforts to experiment with innovative approaches to learning among higher education institutions. Though somewhat limited in terms of university backing, examples of these include competency-based education, badges and alternative certification of learning, the increasing utilization of virtual educational experiences such as Massive Open Online Courses (MOOCs), and other online educational initiatives. The large numbers of students enrolled in such noncredit learning platforms as MOOCs, however, suggest that there is unmet demand for personalized learning options. The option for formalized certification and funding of alternative routes could help bridge the gaps of the traditional model. We propose development of a new funding mechanism: *Flexible Educational Spending Accounts,* which draws on market based pull mechanisms to accelerate the development, evaluation, and adoption of high-impact learning technologies.

Responses to Questions

Question (1) “What learning outcomes would be good candidates for the focus of a pull mechanism to catalyze the creation and use of new learning technology? These outcomes could be relevant to early childhood education, K-20, life-long learning, workforce readiness and skills, etc.”

We believe that two key outcomes -- increased access to a wide range of learning sources at the

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post-secondary education level, and improved college completion rates could be achieved by implementation of our proposal. With the large number of students enrolled in noncredit, online learning venues, many of these nontraditional students might otherwise have had difficulty remaining enrolled in a conventional, brick and mortar institution. We believe we would see an increase in student retention as well as improvements in student overall performance were they encouraged to enroll in a mixture of traditional courses and more personalized online options. This would apply both to traditional college students, as well as to students not able to attend standard semester-based classes and to lifelong learners interested in furthering their education at a pace and mode that is more amenable to their lifestyle.

(2) How are these learning outcomes currently measured and assessed?

Currently, institutions measure the retention and performance of students by their end-of-term grades in traditional, semester long, credit-hour based courses. Students successfully complete the required number of credit hours within a given time frame based on an in-person time-based attendance of courses. However, with a plan that incentivizes alternatives to traditional credit-hour approaches such as online courses, competency-based education, and degrees from multiple certified providers, the typical means of assessing student retention at a single institution will need to be rethought. In recent research on student persistence in primarily online institutions, large percentages of students were found to have "swirled" or, taken classes at multiple online institutions before committing to any one. With this in mind, the option for students to obtain financial aid and credit for taking various courses at multiple institutions would allow students to take the courses most suited to their interests, needs, and path to a learning objective.

(3) What information exists about current U.S. performance relative to this learning outcome? What information exists about the presence (currently available or potential given current trends or breakthroughs) or absence of effective interventions (technology-based, offline, or hybrid) to improve this learning outcome?

Overall, the use of learning analytics and adaptive learning technologies available in the newer online learning platforms can provide comparative information on effectiveness of learning approaches to improve student performance and student retention. Moreover, the ability to map individual learning plans against learning progress and tailor the educational choices in a way that reduces unnecessary course requirements has been shown to successfully improve student performance and retention in a number of brick and mortar institutions that augment traditional course delivery with online education components. The availability of educational coaches and tutorial services in connection with such approaches as online individual learning plans could potentially improve the learning experience for students, increasing their motivation to remain in a given course or institution, as well as improving their performance in the courses. Individually, we anticipate data collected by the service providers, such as competency-based learning assessments, would provide insights on the efficacy of different approaches or combination of approaches.

(4) Why would a pull mechanism in this area accelerate innovation in learning technology?

With a pull mechanism such as the *Flexible Educational Spending Accounts* described below, the educational innovators would have a greater incentive to create viable educational content for students to use, since students would be free to choose courses and learning experiences from a variety of providers. In order to provide a market for the provision of innovative learning experiences, we propose the creation of an alternative funding mechanism and an organization that would vet and catalog alternative service providers, help develop sets of alternative learning paths, and track progress toward a chosen learning objective.

(5) What role might different stakeholders (e.g. Federal agencies, state and local educational agencies, foundations, researchers, practitioners, companies, investors, or non-profit organizations) play in designing, funding, and implementing a pull mechanism for learning technology? What role would your organization be willing to play?

C21U proposes a market-based approach to the delivery of learning opportunities through the mechanism of a proposed experimental program, *Flexible Educational Spending Accounts (FESA)* [See APPENDIX: FESA/ERSC MODEL], based on the idea of the self-directed Health Savings Account (HSA). Under the FESA model, funds would be designated by a qualified individual learner to pay one or more certified educational service provider(s) as an alternative to the funds going directly to an accredited institution. Specifically, a new entity, the *Educational Resource System Certifier* (ERSC), would be developed with the objective of helping participating students develop an alternative learning plan, track fund allocations, disbursements, and outcomes; maintain a record of progress (e-portfolio), evaluate outcomes, and report findings back to the U.S. Department of Education.

The FESA is a market-driven approach that would: 1) provide stimulus to educational innovators to explore new technology driven methods of instruction, learning assessment, and certification of expertise; 2) increase awareness of new learning alternatives including competency based, and self-directed learning options; 3) offer students cost-effective paths to explore innovative and nontraditional approaches to higher education; and 4) increase the efficiency of the publicly funded loan system by stimulating competition among service providers and traditional higher education institutions.

We propose that the U.S. Department of Education fund an experimental FESA model as a demonstration program to test its feasibility. Along the lines of the self-directed Heath Savings Accounts (HSA), under FESA the Department of Education would permit loan or grant funds to be allocated by the individual student rather than going directly to an accredited institution. The student would have the option of how to invest the funds, under the parameters of an individually designed educational plan, to further their education, drawing upon a menu of services and educational opportunities, including those offered by eligible institutions of high education. The funds would be disbursed and monitored by a new third-party entity, an Educational Resource System Certifier (ERSC). The FESA model would provide a certified innovative alternative to the bundled learning experience characteristic of traditional institutions of higher education. The FESA model consists of the funding source (U.S. Department of Education, Title IV), the third party ERSC, specialized educational service providers, and the student.

Educational Resource System Certifier (ERSC), The key experimental FESA component, the ERSC, serves to: 1) review and certify educational service providers; 2) develop educational plan templates, in conjunction with one of several specialized third-party e-portfolio evaluators (e.g. Degreed or Edevate), 3) advise and help the student configure an individualized educational completion plan (path), 4) provide account management and track student allocation decisions, 5) monitor academic progress (e-portfolio), and 6) evaluate outcome and progress. The ERSC could make the funds available, either directly via a credit card mechanism, or indirectly by a designation/payment process, if the desired intent is to have closer monitoring of fund allocation.

The ERSC would develop, and maintain, a reference portal similar to the College Scorecard of service providers and other supplemental educational services. The central objective of the ERSC is to facilitate student choice and provide more options for student education, as well as assessment of prior and alternative learning. Depending on the student's plan, these could include:

- supplemental specialized service providers, such as academic and life guidance. These "coaching" or guidance functions could be called on as part of the initial plan or on as needed, ad hoc basis.
- instructional/learning technology providers such as online course providers, traditional or competency based instruction in eligible institutions, and tutoring services.
- alternative online competency and certification services (e.g. credentialing services, assessment services and other entrepreneurial entities)
- other innovative services such as e-portfolio and learning equivalency aggregators.

The catalog of ERSC certified service providers would be accessible via an online portal along with supplemental reference material. Following certification for student eligibility for Title IV funds, the ERSC would establish an automated process for assessing the student capabilities, interests and needs, and provide guidance and suggestions to the student on potential ways to use the loan funds, as part of the development of the individual student educational path plan (e-portfolio). The ERSC would also maintain ongoing fund balance and a dashboard of student expenditures. The student would determine an individual educational completion plan – a path to achieving the educational goal. A summary of student progress toward the planned education objective would be provided via an e-portfolio progress dashboard. There are currently several companies that have developed portfolio or experience tracking systems that catalog potential educational options, and learning experiences and aggregate them into a portfolio that can be used to demonstrate learning competencies.

Students would be selected based on application for participation in the FESA trial, and would have to fill out the standard *Application* for *Federal Student Aid* (FAFSA) required of all applications for federal funding. Upon qualifying, the students would be guided in the development of their proposed plan of learning. Access to information, path planning and selection of service providers would be via the ERSC portal. For students choosing alternative educational options and services an equivalency process needs to be devised to avoid problems should students choose to return to traditional educational options, and for students choosing hybrid non-traditional and traditional approaches. Upon completion of each individual learning event (e.g. a MOOC, or credit awarded by exam) the ERSC would check the item against the e-portfolio and provide summary feedback to the student. This might be a report of status against proposed completion, a suggestion that they are falling behind their plan, and offer to suggest tutors, or guidance coaches, or suggestion for a change of plan based of more rapid progress that might accelerate objective completion.

(6) What changes in public policy would facilitate experimentation with pull mechanisms at different levels of government?

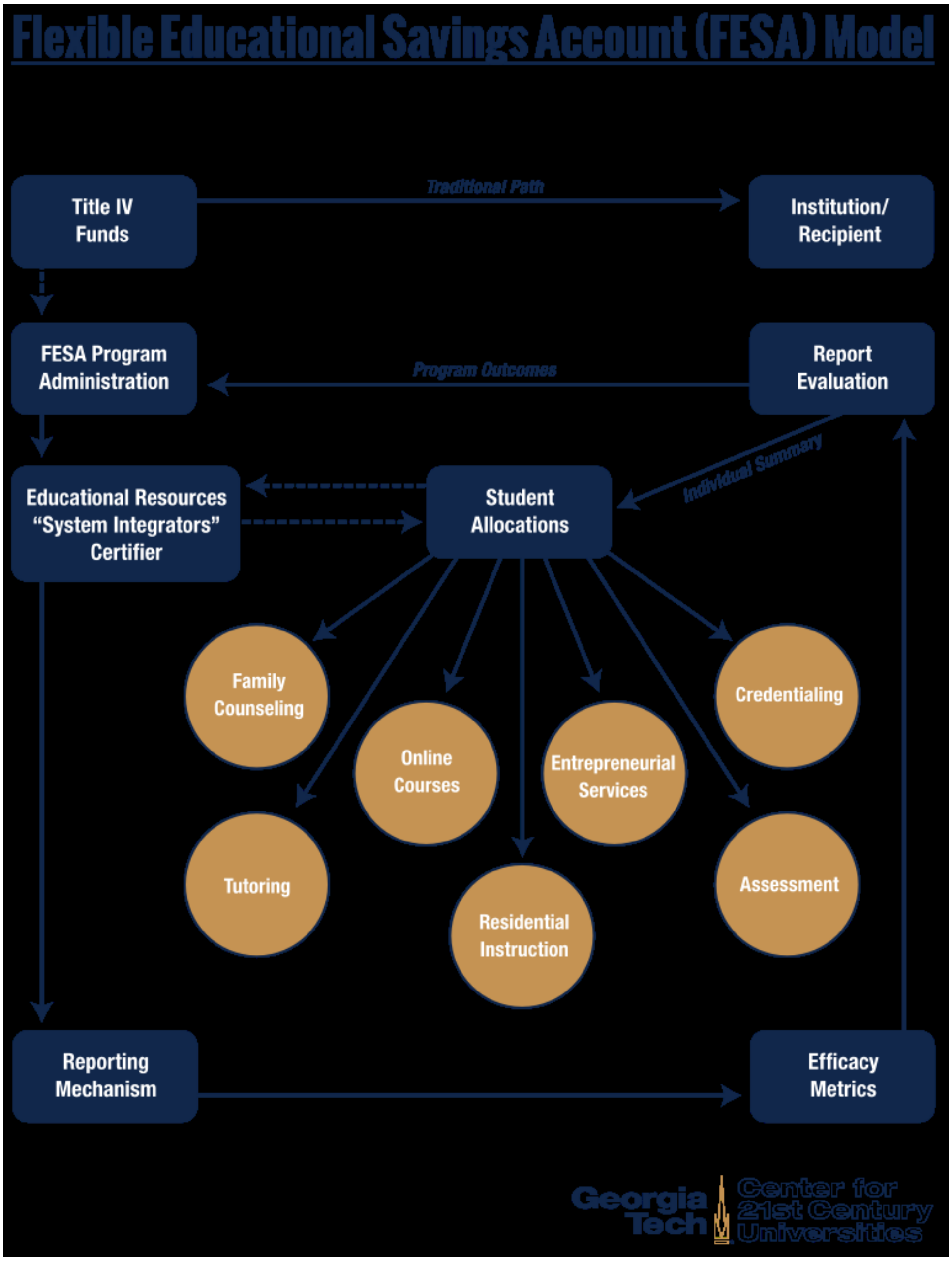
Student financial assistance programs, as currently structured under Title IV of the Higher Education act of 1965, as amended, have a number of restrictions that impeded the development of innovative options for higher education, such as the wide-spread adoption of high-impact learning technologies. As a rule, such federal funds can only be used at eligible institutions; those that come under the oversight of one of the federally recognized accreditation agencies. This limits the ability to offer unbundled educational services and develop individualized programs of education that might better suit student needs. Specific requirements which would need to be modified to allow the proposed FESA experiment to offer individualized learning opportunities and educational services include:

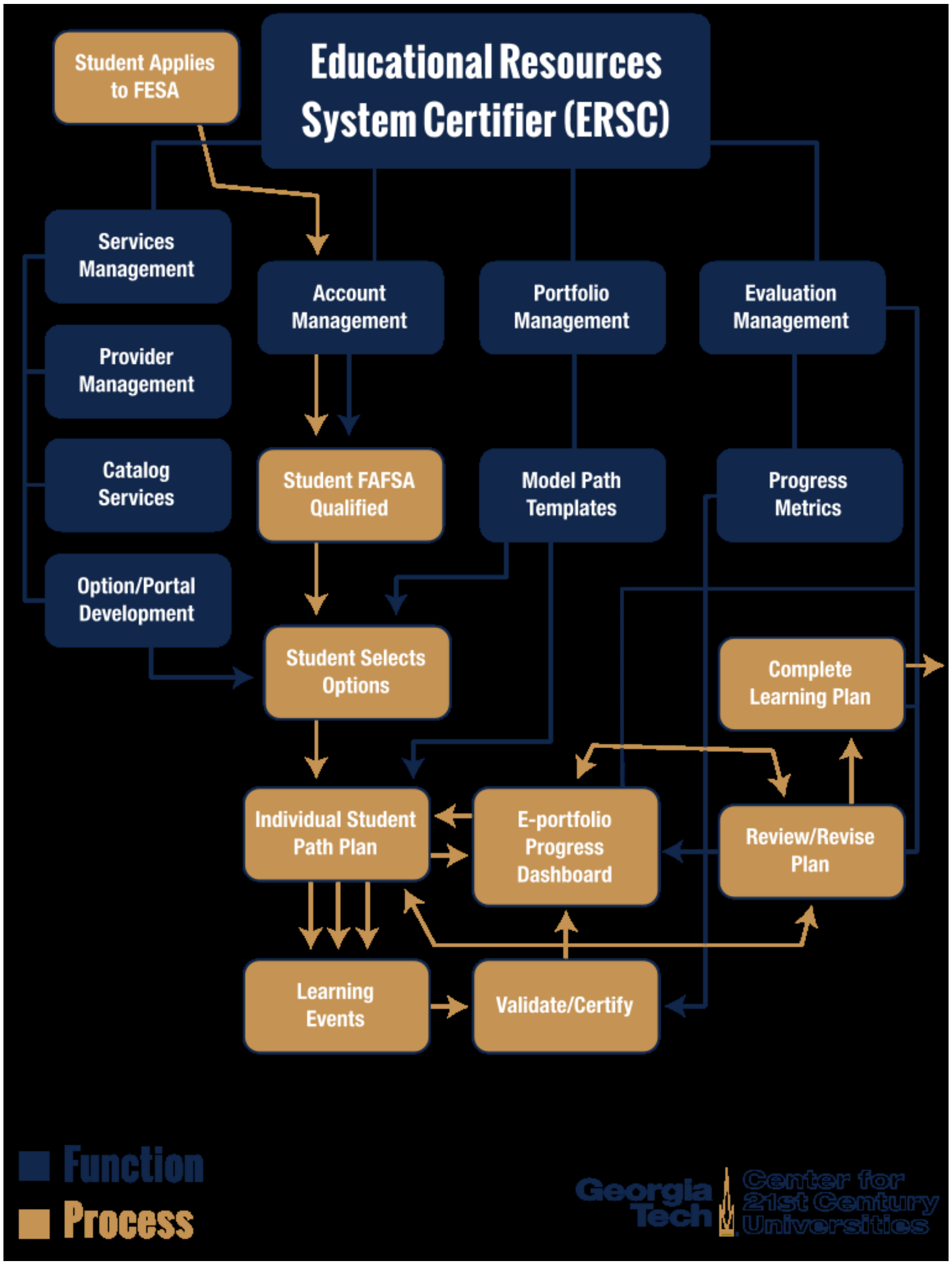
Scope: Under 34 CFR 668.1 (a) "To the extent that an institution contracts with a third-party servicer to administer any aspect of the institution's participation in any Title IV, HEA program, the applicable rules in this part also apply to that servicer. An institution's use of a third-party servicer does not alter the institution's responsibility for compliance with the rules in this part." This suggests that any third party (alternative) service provider would be subject to the rules that a participating institution follows including *Academic Year* (34 CFR 668.3), and *Payment Period* requirements based on a credit hour/formal academic term (34 CFR 668.4).

Eligibility: Nontraditional educational service providers, for instance a Massive Open Online Course (MOOC) provider might have problems with participation due to eligibility requirements under §668.5 "*Written arrangements to provide educational programs*" section (C) which essentially requires written arrangements between an eligible institution and an ineligible institution or organization to be approved by the eligible institution's accrediting agency. These regional accreditors have been somewhat reluctant to allow for certain types of discrete (i.e., course rather than program based) educational innovations.

Direct Assessment: While direct assessment programs (34 CFR 668.10) are allowed, (a)(1)) "an instructional program that, in lieu of credit hours or clock hours as a measure of student learning, utilizes direct assessment of student learning, or recognizes the direct assessment of student learning by others" it is *within* the context of an accredited (eligible) institution. Again, this would serve as a barrier to assembling an individualized educational plan that combines nontraditional educational experiences (e.g. badges, and certifications); competency based learning, and other demonstration of knowledge mastery such as proposed under the FESA/ERSC model.

APPENDIX: FESA/ERSC MODEL




Educational Resources System Certifier (ERSC)
Student Applies to FESA
Services Management
Provider Management
Catalog Services
Option/Portal Development
Account Management
Portfolio Management
Evaluation Management
Student FAFSA Qualified
Model Path Templates
Progress Metrics
Student Selects Options
Complete Learning Plan
Individual Student Path Plan
E-portfolio Progress Dashboard
Review/Revise Plan
Learning Events
Validate/Certify
Function
Process
Georgia Tech
Center for 21st Century Universities

Response to OSTP RFI on High-Impact Learning Technologies

David Goldberg[1] and Miriam Goldberg[2]

Very few, if any, high-impact educational technologies are currently in wide use. One of the most lauded frameworks – adaptive learning technology based on the zone of proximal development – provides, at best, modest improvements over classroom instruction[3]. Indeed, if many successful educational technologies were in wide use, the proposed initiative would not be needed.

The goal of the OSTP initiative should be to overcome the prior constraints that have frustrated the development and implementation of educational technologies, which makes it incumbent to try to identify and address these factors, which could involve at least:

1. The technology required is extremely hard and complex to develop
2. Most technology effort have pursued incorrect intellectual or pedagogical frameworks
3. Prior attempts have had low-impact because developers have aimed low or in the wrong directions
4. Prior attempts at high-impact educational technologies have had insufficient financial resources
5. The high-impact technologies exist, but developers have been poor at marketing and implementation
6. The educational establishment is structured so as to reject or frustrate high-impact technologies.

The first three factors deal with the development of new technologies, while the latter three deal with implementation of the technology. It is likely that all of these constraints have operated to one extent or another, and we have structured our comments to respond to them, including a laying out a structure for a "pull" system to encourage the development and implementation of high-impact educational technologies.

TECHNOLOGY DEVELOPMENT

Most educational institutions exist with strong accountability measures tied to standardized testing, whether Common Core (or state test predecessors), ACT/SAT, ACCUPLACER/COMPASS, GED, TABE/CASAS, WorkKeys and the like. Many of the technology development efforts with the biggest scope, therefore, have been directed to some extent or another at "test-prep" – teaching the content that the students would need to show proficiency in these tests. It should be noted that the efficacy of these technologies is generally evaluated on the basis of short-term effects on these or similar content measures, which creates a large bias against technologies with other goals, and especially longer-term goals that don't arise in short-term evaluations of technology efficacy. We believe that this is a fundamental and serious challenge to many high-impact innovations.

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[3] E.g., see the review of state-of-the-art adaptive learning system Cognitive Tutor by the US Dept. of Education's What Works Clearinghouse at http://ies.ed.gov/ncee/wwc/pdf/intervention_reports/wwc_cogtutor_012913.pdf

Breadth of impact

This limitation is key because, in our view, a core requirement of system transformation is designing technologies with widespread appeal and applications that span different "markets" (e.g. schools, colleges, adult education, workforce, etc.). Society currently divides educational problems into K-12, college, adult education and workforce problems, each with their own solutions, but these problems all have many features in common. However, each of the markets pursues solutions (whether technological or not), because of subtle differences in the standardized tests used for accountability. If the technologies are seen as test-prep, making sure that the alignment of the instruction with the assessment is "exact" is critical.

For the initiative, we would encourage the statement of the goal to encourage technologies that address many or all of these markets simultaneously. This could be technologies that can be easily customized so that they align with the different standardized tests, but we believe that a better framework for the technology would be one that recognizes the commonalities across these different contexts. Such single solutions allow for better scalability of implementation, and as will be seen below in the section on "Incentives for individuals and educational institutions", shared solutions may allow for system-wide effects.

Application in multiple markets would have a number of beneficial effects. The technology would have a larger potential total market, which would attract investors. The technology could have a variety of different market entry points, and could choose initially the most receptive, and then grow out from there, providing the most chances for success. Once established in one market, existing educational social networks would allow its introduction to other markets, and success in one market would provide the evidentiary data to speed introduction to other markets.

Finally, we strongly suggest that the educational technologies have application for the incumbent workforce. If we were to succeed at developing effective educational technology for first graders, it would take decades for that improvement to diffuse through the US economy. Simply, we don't have the time to wait, either in economic or social terms, and therefore, the highest impact will be felt through technology that transforms the existing workforce as well as the emerging one.

First, focus on learning to learn

What are the problems that are common across all of these different markets, and which are also addressable through technology?

We believe that the primary goal of the initiative should be to find technology that makes better learners, not that improves learning of specific content. All of the various markets face this same issue. Whether in a high school, an adult education program, or a community college, teachers frequently encounter students who don't have good learning skills – they aren't actively engaged with the material, and aren't exhibiting metacognition about their own learning process. While they also often are behind in content areas, this lack of active learning often underlies both their gaps, and their difficulty in catching up and learning new material.

Put another way, a good learner can learn from relatively poor curriculum and instruction – they pull knowledge "from the air", if they need to. Poor learners, on the other hand, don't learn even from excellent curriculum and instruction. If we had technology for making better learners, many of the deep problems affecting education would be solved – there could be no higher impact.

Note that making better learners would help not only with technology-based education, but would also transform conventional classroom education not directly tied to the educational technology innovation.

Second, focus on foundational skills

You can't teach learning without teaching content – the content is the context in which the learning about learning is occurring. While you can lecture students on what good learners do, the biggest effects will be by having students practice independent learning with authentic content, and giving them feedback as to how to improve.

Given that some content is necessary, we would suggest that deeply foundational content be emphasized. There is strong evidence[4] that many advanced secondary and college students, as well as adults who are successful in the workforce, lack basic math, literacy (reading instructional text and writing) and problem-solving skills. Note that most of these skills are pre-high school level. A likely culprit here is that the proficiency required at each stage of education is minimal – many students bring a "passing mentality" to their studies, and the multiple-choice formats of standardized testing with 60-70% passing scores (deriving from Item Response Theory and psychometric best-practices) require only familiarity with content, but not production-level fluency. Thus, students can progress through higher and higher levels of material without mastering the underlying basics.

Note that these foundational skills for the most part do not cover advanced mathematics (algebra) or literacy (poetry interpretation). Firstly, strong foundational skills are required to effectively learn the more advanced skills. Secondly, the advanced skills are not required in most workplaces – even most STEM occupations don't require significant, if any, algebra. As mentioned above, finding technologies that improve the performance of the incumbent workforce will have immense impact, and a focus on core workforce academic and decision-making skills should be of highest importance.

We would urge the initiative to focus on foundational math, literacy and problem-solving skills because they will have the widest reach across markets – they are the most used on a daily basis in school, college and work, and concretely represent true college and career readiness.

TECHNOLOGY IMPLEMENTATION

Incentives for individuals and educational institutions

We believe that a key impediment to high-impact technologies will occur in the implementation phases. The reasons for this include the lack of ready investment resources in the educational domain, and many

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[4] See, for example, OECD (2013), Time for the U.S. to Reskill?: What the Survey of Adult Skills Says, OECD Skills Studies, OECD Publishing. http://dx.doi.org/10.1787/9789264204904-en

of the technology developers may not be adept in implementation phases. However, we also believe that the educational "system" is biased towards test-prep technologies, and narrowly targets its interests and implementations to tools that directly respond to conventional accountability metrics.

This is a long discussion outside the realm of this white paper, but a successful high-impact educational technology will almost of necessity cause **system transformation**. System transformation, however, occurs either unplanned, simply as the consequence of technology introduction (DOS and PCs; cell phones), or is actually part of the technology development plan (Facebook, eBay, Amazon, etc.). We believe that educational technology will generally have higher impact if it plans for and shapes system transformation. In particular, in order to have reach and impact, the technology needs to be defined in a way that creates positive-feedback interactions that lead to self-sustaining growth.

Our preferred way of thinking about system transformation is that systems are, for the most part, reflections of the incentives that individual agents in the system use in making decisions – changing incentives organically changes the normal operation of the system. Currently, the most important factors shaping the educational system are: for individuals, the credentials that gate access to college and work; and for educational institutions, the accountability metrics often tied to standardized tests (Common Core, GED, Accuplacer/Compass, WorkKeys and the like). Any technology implementation that ignores this structure is, then, handmaiden to outside forces. Instead, to be positioned for high-impact, technology implementation should be framed in a way that understands and shapes these incentives.

In our own work (see the Appendix), we have found that credentials/badges/etc. can be a critical aspect of building a supply-and-demand system, where institutions graduate people with the new credential (supply), and other institutions use that credential in decision-making such as college access or hiring. With both supply and demand, mutually-reinforcing positive feedback can be instituted, leading to more pervasive and expanded use of the technology.

Furthermore, we mention above that high impact technology should preferably span many markets. Credentials, badges, certificates and the like serve as communication means across markets signaling the skills of individuals, and therefore are a key methodology for technologies that have wider and cross-market reach.

It should be noted that the OSTP RFI examples of "pull" related primarily to relatively crude purchasing commitments or financial rewards (e.g. "Grand Challenges"), but we believe that obtaining acceptance of credentials and the like is a more powerful mechanism to the same end, but will be more organic (shaping markets), more durable and will lead to expanding positive feedback.

Careful consideration of incentives, alignment with current assessments, business/revenue model and other non-technological aspects of implementation are critical, and technologies that result in high-impact will likely involve as much social and business engineering as technology engineering.

Fidelity of implementation

In most technology development, fidelity of implementation is at best an afterthought, but this is in many cases the most critical element in replication and scalability. From our own experiences, there are a few key lessons here.

Firstly, there needs to be careful thought to professional development. No matter what the technology is and how it is to be deployed, there will be teachers and administrators involved, whether directly or indirectly. Each of the high-impact technologies of the initiative will be shaped by a pedagogical framework that is often in conflict with current practices, and when placed in the hands of ill- or un-trained teachers, the benefits of the innovation will be reduced or eliminated. Fully-conceived processes and/or technologies for training teachers and administrators are critical elements of implementation.

Secondly, thought needs to be given to ensuring fidelity of implementation – this is not only a matter of professional development, but also the incentives of individuals, teachers and administrators. In our own case (see Appendix), we spent two or more years with poor fidelity of implementation as we hadn't attended to the incentives that guide use in real-world contexts. This requires not only an attention to incentives, but also means of monitoring the fidelity of implementation so that adjustments in professional development, incentives and more can be made.

STRUCTURE OF THE INITIATIVE

We would strongly recommend against using conventional goals and milestones, such as those which might be present at the core of a "grand challenge". While such goals and milestones work well where there is a clear-cut metric (so many miles a gallon, so high above the earth), in the case of education, accurate measurements are hard to make and often incommensurable (e.g. high school graduation versus college graduation). Fuzzy metrics will inevitably lead to "game playing" (e.g. choosing test populations, curricula, etc. that are focused on the challenge goals) with little systemic benefit.

Furthermore, many of the more important goals that we outlined above – e.g. making better learners – are in many ways poorly defined, and certainly don't have good assessments or metrics. Any goal with strong metrics is likely to devolve into some sort of "test-prep", which would undermine the impact.

Finally, the types of high-impact educational technologies that are at the heart of the OSTP RFI will take years to develop and introduce, and will require patience. Such patience, for example, is not a hallmark of venture capital, which is a major source of funding for the development of technology.

Suggested initiative structure

> *GOAL*: As indicated above, we believe that technologies funded through the initiative should be directed at fundamental challenges in multiple markets. Successful applicants would have technologies that would span at least two or preferably three markets, including primary, secondary, adult, college, workforce and business (i.e. incumbent workforce). Examples of fundamental challenges include teaching students how to be better learners, and/or closing the

skills gap in foundational math, literacy and problem-solving. Optimally, the technology will be applicable to millions of students. There is no advantage for the initiative to set small, easily reachable goals.

COMMERICIALIZATION REQUIREMENTS: A successful application would also need to include a business plan that includes a pro forma income statement, as well as marketing plan.

Unlike a conventional venture capital plan, an "exit strategy" (sale to a major publisher) should not be included in the commercialization plan. The funding should allow for that possibility, but the entity would still need a self-sustaining plan to commercialize the technology on their own, without an exit strategy (i.e. a structured plan for success, rather than hoping for a low-probability event).

THEORY OF CHANGE REQUIREMENT: A successful application would need to indicate how the technology or implementation approach addresses specific problems or limitations of prior attempts, and why the proposed approach is likely to overcome these problems or limitations. The Theory of Change will generally provide the best insights into the likelihood of success, and also be a key method for measuring progress of the technology development and implementation over time.

NUMBER OF FUNDED TECHNOLOGIES: Given the limited number of promising approaches that would fit the requirements above, as well as the need to provide significant, sustaining funding over a period of time, we'd suggest between 4 and 8 technologies.

FUNDING MECHANISM: We would suggest either a loan guarantee or direct venture investment in companies (even if a loan guarantee, the "style" of discussion should mimic that of an investor). If a research institution is the lead, it would need to create a separate company (non- or for-profit) to own the technology, so as to ensure that there was a "home" that would maintain and expand both the markets and the technology.

The scale of the investment should be potentially very large (millions or even potentially tens of millions in a single venture), but could be staged over time and the completion of milestones (which are not time-defined, as in SBIR projects). An advisory group with a wide range of backgrounds would need to be assembled to both select successful applicants, and decide when and the extent of follow-on funding.

We would strongly urge as well that the granting agency contract with an independent research team to have full access to each technology developer, and to document and study what goes right and what goes wrong. A very successful technology can fail for any number of reasons (financial, poor business decisions, marketplace mismatch, system push-back, technological/pedagogical flaws), and the lessons learned from these attempts will be important to instruct other technology development attempts (or future initiatives from the government). In particular, this research team should pay particular attention to the Theory of Change, to see which elements succeed or fail, as these will often be the most instructive to future efforts.

This rather specific proposal is not meant to be prescriptive for the initiative, and there are many, many other structures that would encompass many of the principles outlined earlier.

Conclusion

This white paper is only a brief discussion of larger principles, and should not be considered a full treatment of the issues involved. We appreciate the clarity and thoughtfulness of OSTP's efforts, and believe that a serious national initiative at addressing high-impact educational technology is long overdue.

The ideas above were generated through our experiences in developing and bringing to market a learning technology that would appear to be archetypal of the type of high-impact educational technology sought in the initiative. It encompasses most of both the technological components as well as applications listed in the RFI; it is directed at making better learners; it deals with foundational math, literacy and problem-solving skills; it has built-in incentives for system transformation; it's applicable to secondary, adult, workforce, college, CTE, and incumbent workforce education. A brief history of our experience is provided in the Appendix.

Appendix – A short history of Core Skills Mastery (CSM)

Our company, CSMlearn, has developed Core Skills Mastery (CSM), a free, web-based course for core workforce academic and decision-making skills. CSM, we believe, is an archetype of a high-impact learning technology:

- CSM incorporates a novel next-generation adaptive learning technology, which not only responds to issues in skills and cognition, but also to issues in learning strategies and academic traits (persistence, attention-to-detail, self-reliance, etc.). The emphasis of CSM is as much in the social-emotional as the cognitive domains of educational psychology, and instead of a skills training orientation (beneath the surface, most educational technology is simply "test-prep"), CSM emphasizes building better learners.
- CSM teaches a core set of math, literacy and problem-solving skills that are chosen due to their value in college completion and their importance to workforce performance and decision-making.
- CSM incorporates an entirely new approach to both teacher professional development and to computer interfaces for teachers, leading to more strategic teacher interventions and new ways of handling blended learning classrooms.
- CSM content applies equally to both workforce and academic contexts, and can be used across a variety of levels – the same curriculum can be used with 8th grade students in a turnaround school and college-graduate supervisors in the workforce. Overall, the goal is to create capable, confident and adaptable students and decision-makers.

More information on CSM can be found at www.csmlearn.com. Because of its wide reach, CSM addresses almost all of the example issues identified by OSTP in the RFI, including the improvement of math proficiency in secondary schools, better literacy among ESL secondary and adult ESL students, certification of skills for non-college bound students, increasing community college completion rates, building a "growth mindset", and providing students with a "personal tutor" – CSM is in current use in all of these areas, with a free, scalable, state-of-the-art technology.

Difficulties in CSM deployment

As we introduced CSM into the various markets in which we operate (secondary, adult education, workforce education, community colleges, and the business community), we encountered a number of hurdles.

One hurdle was that each of the markets, while intrigued by the CSM technology, was primarily driven by their own internal accountability measures – e.g. Common Core for secondary, GED® for adult, WorkKeys® for workforce, ACCUPLACER®/COMPASS® for community colleges, etc. Thus, for most users, completing the CSM curriculum was of little interest, while simply using CSM as an alternative (and free) training tool for their own endpoint was of great interest. We were initially satisfied with this use, but this generally led to implementations that lacked fidelity – for example, with insufficient intensity of use or completion of the curriculum – and fidelity is a critical issue in technology implementation.

A second hurdle that we encountered was that the effectiveness of CSM was not always apparent in short-term evaluations (e.g. pre-/post-tests of accountability tests), generally tied to conventional accountability measures. While a general method for improving student learning, such as CSM, has greater long-term benefits system-wide, it does not demonstrate well against highly-targeted test preparation technologies in short-term evaluations.

These difficulties are not absolute barriers in any sense, but they do limit the speed, breadth and pervasiveness of implementation, and required us to maintain larger marketing resources.

CSM's way forward

In light of the hurdles above, we are now engaged in community-wide uplift of skills, using a certificate model (based on completion of CSM) to build supply-and-demand networks. The supply of CSM graduates comes from many educational programs (secondary, adult, workforce, college or business), and the demand comprises incentives such as colleges using CSM as an alternative college placement metric (a course rather than a conventional test) or businesses guaranteeing job interviews to those with a CSM certificate and who otherwise qualify for the job. With these in place, CSM operates as a concrete college-and-career readiness indicator in a way not seen before.

Notably, since the CSM course is free, including professional development, this doesn't require a large infusion of resources, and the CSM Certificate provides communication between participating organizations, so that large amounts of coordination (top-down or peer-to-peer) are unnecessary. By working within a geographical community, gaining a critical mass is easier, and can build on existing social and functional networks (collective impact, P-16/20 councils, etc.).

We're still in the implementation phase, but what we've found is that pure technology development is not nearly enough to generate high-impact – that we have needed to focus large amounts of effort on incentives, on scalability, on fidelity of implementation, on marketing, on operations and more. In many ways, technology is "easy", as it's susceptible to engineering paradigms that are easily understood and controlled and can be studied in laboratory-like environments. Implementation aspects are much harder to understand and control, can be as or more expensive than the technology development, and also require different sets of management strengths and experience – the "landmines" are more numerous, less obvious, and just as deadly.

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DIGITAL LEARNING NOW!
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GETTING SMART

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Introduction

We are only just beginning to realize the potential for prizes to mobilize global expertise and accelerate innovation in education.

This brief, written response to the White House request, outlines ways that pull mechanisms could be used to encourage investment and innovation in categories not receiving sufficient attention—with the ultimate goal of accelerating the development of high-impact learning technologies.

In healthy markets, participants respond to incentives, invest in research, and development (R&D) and produce new innovations. Capital investments bring productivity to scale. In underdeveloped or inefficient markets, customers have few choices often controlled by bureaucratic mechanisms rather than market mechanisms and there is little investment in R&D. Underdeveloped markets suffering from a lack of investment and innovation can be addressed through direct investment (return-seeking or philanthropic), by advocating for better policies, or through pull mechanisms, which include:

- **Market development**: aggregated demand and advance market commitments;
- **Fast track policies**: cutting through the bureaucracy with accelerated approvals and proactive incentives; and
- **Inducement prizes**: rewards for successfully meeting a breakthrough challenge or outcome.
- **Level the playing field**: create a level regulatory space that invites non-traditional players to participate and offer solutions.

The following table summarizes the difference between direct investment ("Push") and pull mechanisms.

	Push	**Pull**
Investment	Up front	On Success
Common Mechanism	Grant	Inducement prize
Solution	Defined up front	Determined/created by participants
Mobilization	Low: only selected participants	High: participants respond to incentives
Leverage	Little; secondary outcome	Significant investment by participants

Advocacy	Traditional PR	Competition drama with potential breakthrough

Market development. The most common pull mechanism is the broad category of efforts to improve market efficiency by organizing buyers or addressing blockages. By aggregating demand, market facilitators seek better access to inexpensive supply. In global health, advance market commitments (AMC) guarantee purchase commitments for drugs over a period of time. The increased certainty enables drug manufacturers to make investments to deliver drugs or even develop new ones. In a recent paper, Smart Series Guide to EdTech Procurement, the authors described how aggregated purchasing is saving time and money for school districts.

Prizes. Inducement (or incentive) prizes are routinely used to promote private and public benefit. Awards recognize prior achievement while prizes induce future actions. Grants sponsor identified work by a named beneficiary, while prizes have the potential to mobilize an army of experts to work on a problem–and they only get paid if they achieve the goal.

Prizes can also be effective mechanisms to cultivate innovations by creating the financial incentives needed to attract a broad array of competing innovators. They can also be more efficient in the sense that the prize funding is only awarded when certain criteria is met. So the funders pay only for the output, not the inputs with the hope of a breakthrough.

There are no silver bullets in education but targeted incentives for innovation, like the Hewlett-sponsored essay scoring competitions last year can mobilize talent and resources to improve access and quality. Prizes could be used to boost literacy, middle grade math achievement, and language acquisition. Prizes could similarly be used to analyze big data sets and produce useful algorithms.

While not an exhaustive list, there are four types of prizes that could prove to be useful in education.

- **Design Prizes:** small prizes could be used to incentivize innovative designs for new schools, new school facilities, or new systems of education.
- **Intervention Challenges**: products, services, and strategies could be tested in comparable short cycle trails.
- **Data Competitions:** inviting data scientists globally to work on well defined problems.
- **Geo-Competitions:** invite districts, cities, or regions to compete on specific challenges over a specific period of time or to achieve a certain outcome.

A successful prize draws attention to the problem/opportunity, mobilizes significant resources (perhaps 10 times the prize purse), and solves the problem–or at least illustrates the path forward.

Why Pull Mechanisms?

Pull mechanisms develop markets where there is insufficient demand or inefficiencies that dampen R&D spending and innovation. As noted by the Global Health Technologies Coalition, "Pull mechanisms help overcome this barrier by creating or securing a market," and "are more appropriate for use in the later stages of R&D. The pull often provides the incentive to get products over the finish line."

The *Smart Series Guide to EdTech Procurement* offers details on the way in which prizes could be applied to move procurement beyond the traditional RFP:[1]

> Outside of the traditional procurement processes of RFPs, financing instruments such as prizes pay only if specific results are achieved. So instead of paying for inputs and process in the hope of a service being delivered, the pay out only occurs once a problem is solved or outcome metrics are met. As McKinsey & Company has explained, "[a] rule of thumb holds that prizes are useful tools for solving problems for which the objective is clear, but the way to achieve it is not."[2] The other advantage with prizes is that they attract a diverse talent pool—including experts who might not otherwise be tapped to build solutions. "By attracting diverse talent and a range of potential solutions, prizes draw out many possible solutions, many of them unexpected, and steer the effort in directions that established experts might not go but where the solution may nonetheless lie."[3]
>
> Governments have used prizes in the past. In the early 18th century, the British Parliament offered £20,000 (more than $1 million U.S. today) to anyone who could solve the problem of determining longitude at sea. The answer did not come from the expected set of experts or academic elite from that day, but instead from a little-known, self-educated clockmaker named John Harrison who invented the chronometer. And it was a $25,000 prize that not only drove Charles Lindbergh to make the first trans-Atlantic flight, but to do so with an engine design that defied the conventional wisdom.
>
> Prizes enjoy wide bipartisan support ranging from former house Speaker Newt Gingrich discussing them as far back as 2002, and more recently, President Obama. In 2010, the reauthorization of the America CoMPETES Act included language giving all government agencies legal authority to sponsor prizes of up to $50 million.
>
> States and districts should also explore the relatively new financing mechanism of Social Impact Bonds (sometimes called a Pay for Success Bond), which allows public agencies to partner with innovative providers and permits other investors or philanthropies to cover the upfront costs and assume performance risk. This helps ensure that taxpayers will not pay for the programs unless they demonstrate success in achieving the desired outcomes. This is a new and emerging area that could offer government agencies and even districts opportunities to explore new service arrangements.

Lessons from ASAP

Last year, sponsors of the Automated Student Assessment Prize (ASAP) published a case study that highlighted lessons from the ASAP competition.[4]

> Prizes are an efficient mechanism for focusing and accelerating innovation and automated scoring of student essays is fast, accurate, and affordable--those are two conclusions drawn from prize competitions sponsored by the William and Flora Hewlett Foundation in 2012. The Automated Student Assessment Prize (ASAP) demonstrated current capabilities and mobilized global talent to accelerate innovation in writing assessment.
>
> ASAP began in February of 2012 with a demonstration of capabilities of the eight largest testing vendors. The "bake off" was hosted on the Kaggle platform and, as Mark Shermis and Ben Hamner reported, demonstrated that scoring engines could match expert graders across eight sets of essays.
>
> Next was an invitation to data scientists worldwide to try to beat the best and win part of a $100,000 purse. None of the team members had a background in education. The competition drew more than 2,500 entries and 250 participants and inspired data scientists to develop innovative, accurate ways to improve on the current standard of essay- scoring technology.
>
> The level and diversity of talent mobilized was extraordinary — an actuary in Singapore, a weather scientist in Washington, a teaching assistant in Slovenia, and geologist in Canada, just to name a few. In 60 days, more than 20 teams had topped the best performance of the vendor demonstration. Jason Tigg, the British particle physicist turned high frequency trader who was a member of the first place team said, "I enjoyed working on a real-life problem that has the potential to revolutionize the way education is delivered." ASAP Phase Two took on the more difficult challenge of scoring short-form constructed responses (short answers). Luis Tandalla, a college student from Ecuador, won the $50,000 first prize a year after taking Andrew Ng's machine scoring MOOCs.

The ASAP case study reported five conclusions:

1. A sequence of small, targeted prizes can focus and accelerate innovation in a discrete category;
2. Learning and talent are global; good prizes mobilize global expertise;
3. Crowdsourcing works. Young men (yes, it still is mostly young men) from Slovenia to Singapore, from Pittsburgh to Poland poured 100 hours a week into the competition hoping to see their name creep up the leaderboard.

4. Most innovation is translational—something that worked in one field may work in another. Prizes are a super-efficient means of promoting translational innovation.
5. In Phase Two, competitors were required to open source their code (GPLv3 license) along with an instruction manual but there was no drop off in participation from the Phase One where competitors were able to retain their intellectual property suggesting the data world is becoming more open.

The two phases of ASAP established standards for the utilization of assessment technologies; advanced the field of machine scoring in the application of student assessment; and introduced new players with different and disruptive approaches to the field. Accordingly, the case study identified four benefits of well-constructed prizes, noting that such prizes have the potential to:[5]

- **Leverage funds.** Prizes motivate participants to invest time and energy in solving a problem they might not otherwise consider. Prizes are usually performance based and only paid out once a viable solution is demonstrated.

- **Mobilize talent.** Prizes spark the interest of diverse groups of professionals and students. Many prizes are won by scientists several degrees of separation from the subject sector. Prizes are an extremely efficient strategy for mobilizing diverse talent impossible to locate using conventional approaches.

- **Innovate.** The cross-pollination of participants from different backgrounds and with different skill sets unleashes creativity, allowing problem solvers to generate fresh ideas. The use of leader boards and discussion tools promotes transparency and competition, but it also inspires collaboration and innovative discovery.

- **Influence.** The results of prize competitions can garner public attention and influence key decision makers. Good prizes result in newsworthy mobilization and breakthrough outcomes that result in press coverage that can be worth more than the prize purse.

Key Outcomes

Questions: What learning outcomes would be good candidates for the focus of a pull mechanism to catalyze the creation and use of new learning technology? How are these learning outcomes currently measured and assessed?

Math. Many experts point to understanding and manipulating fractions as the big pre-algebra hurdle. Matthew Peterson, MIND Research Institute, notes that "place value is a major sticking point that often goes unfixed through high school." Fractions and place value are sufficiently discrete that goals for inducement prizes could easily be set for a bake-off style competition.

Peterson adds, "The ability to use math to model situations is one of the most important algebraic abilities and stumps most students." It could also stump prize developers; it could be approached as an application challenge with expert review (e.g., NYC Gap App Challenge) or as an algebra competition using traditional measures of success along with a student survey.

Peterson's suggestion about math modeling points to the central challenge of successful prize development--a well articulated and compelling goal with accurate metrics. Traditional metrics often fail to capture the benefit of a breakthrough innovation. Some prizes need to invent new metric to gauge desired performance (e.g., Automotive X Prize used 100 mile per gallon equivalent to compare multiple fuel sources). The following table outlines concepts that can be difficult to teach and may be candidates for intervention challenges.

20 crucial math concepts that can be difficult to teach:[6]

- Place Value and Base Ten Concepts
- Understanding Fractions as Numbers
- Regrouping in Multi-Digit Addition and Subtraction
- Arithmetic with fractions
- Sets of Numbers and the Real Number Line
- Inverse Operations and Relationships between Operators
- Arithmetic with Negative Numbers
- Revealing the Importance of Properties of Operations for Expression Manipulation
- Rates of Change and Linear, Quadratic and Exponential Growth
- Conceptual Understanding of the Long Division Algorithm
- Developing Proportional Reasoning
- Solving Inequalities with Absolute Value
- Solving Linear and Quadratic Equations and Systems
- Logical Reasoning – Inductive vs. Deductive Reasoning
- Solving Systems of Inequalities
- The meaning of equality and the equals symbol
- Factoring polynomials and Completing the Square
- Graphing Transformations of Functions
- Increasing Persistence and Creativity for Non-routine Problem Solving
- Developing Number Sense and Estimation Skills

Literacy. USAID recently announced a second round of funding for All Children Reading: A Grand Challenge for Development, explaining "The global grant and prize competition seeks innovative ideas that leverage the transformative power of technology to leapfrog existing infrastructure challenges and empower children to read." Specifically, Round 2 "seeks technology-based innovations that support improvements in basic reading skills with a focus on mother tongue instruction and reading materials, family and community engagement, and children with disabilities."

A previous round of this program has already started to produce results:

> World Reader: San Francisco-based-company using e-readers in Ghanaian primary schools to improve child literacy and close the gender gap.
>
> Planet Read: The simple idea of subtitling content in the same language as the audio, whether on TV programs, film songs, music-videos, folk songs, and movies. They are currently implementing the project in India using Bollywood films.
>
> Sesame Workshop India: Elmo is helping kids to read in Bihar – one of the poorest areas in India. The program integrates proven multi-sensory approaches, Sesame Street content, and ultra-low cost tablets to improve reading skills in Hindi and English. The program also empowers teachers through useful training materials.

USAID is also awarding $100,000 prize "to the organization or individual that develops a software solution to help writers create reading materials in local languages for children in developing countries."

Writing. According to the Pearson R&D team, another outcome that could be a good candidate for the focus of a pull mechanism is academic writing.[7] Specifically, they explain, "With regard to academic writing, our experience in large-scale assessment suggests students struggle with the sort of analytic writing (e.g., synthesizing evidence, weighing competing claims) that workplace success in a 21st-century economy demands. Other organizations have observed similar patterns." Academic writing in large-scale assessment is currently measured through periodic end of year assessments that might occur once within a grade cluster (elementary, middle, and high school). Additional measures of academic writing are conducted through classroom assessment throughout the school year. As writing is not a component of Adequate Yearly Progress evaluations and scoring written compositions is a costly proposition (especially when it is completed manually), many states are assessing it infrequently or not assessing it all. In addition, the process of assessing writing in the classroom can be burdensome and time-consuming for the teacher. As a result, the focus writing receives in academic instruction and assessment is far less than what is merited.

While many technologies exist which seek to make instruction and assessment of writing less burdensome and costly as well as more authentic for students, they are often implemented piecemeal and are not packaged together into a coherent and focused cross-grade strategy. A pull mechanism in this area would be ideal to incentivize an integrated digital approach to academic writing instruction and assessment throughout a student's K-12 academic career. This approach should leverage existing technologies such as writing apps delivered to student devices and automated scoring and feedback. It should include collaborative writing activities, which leverage peer review as a means of crowd-sourcing the feedback. Students should be encouraged to write for different audiences and purposes and should have authentic writing experiences. The goal should be to increase the overall frequency and quality of student writing using detailed and real time feedback. Furthermore, we need improvements in areas of persuasive and analytical writing.

Student engagement. The Pearson R&D team also believes student engagement and ownership for their own learning would make an interesting focus of a pull mechanism. With regard to student engagement, it is widely acknowledged that the level of engagement plays a significant role in academic accomplishment beyond raw academic talent. It is also widely acknowledged that students are bored and that classroom instructional practice has not kept up with innovations in technology and learning science.

Student engagement is not often directly assessed and when it is it is typically done through survey or other self-report measures. However, its effects are apparent in academic performance, such as incomplete or random responses on assignments or assessments. Student engagement is not easy to measure in a reliable way and methods for "teaching" students to be engaged are nascent at best. This is an often overlooked, but critical, element to academic success, and it does not receive focus because it is not easy to address.

The challenge of improving student engagement should not fall to educators alone. Students will be most engaged when they are partners in their own educational process and have ownership for how their behaviors impact outcomes. We would suggest that a pull mechanism be used to incentivize the development of a student oriented app that mines data from student work products to provide real time feedback about how student academic performance, behaviors (i.e. study skills), social interactions/collaborations, and attitudes impact their overall level of academic preparedness. This app should enable easy, frequent, and convenient monitoring of information pulled from a variety of digital sources. It should offer game and puzzle like incentives such as badges, achievements, and other status awards. Lastly it should offer concrete steps for students to follow to achieve desired outcomes.

Other options. There are a number of other areas in which pull mechanisms could "move the needle." For example, college and career readiness, student guidance, English language acquisition are three additional possibilities that are ripe for more exploration.

The follow-up paper that we will produce will explore the issue of outcomes more deeply and respond to the RFI questions: What information exists about the presence (currently available or potential given current trends or breakthroughs) or absence of effective interventions (technology-based, offline, or hybrid) to improve these learning outcomes?

Types of Prizes

Design Prizes

Small prizes could be used to incentivize innovative designs for new schools, new school facilities, or new systems of education. The NYC Schools Gap App Challenge focused on middle grade math. Winners received $50,000 in cash prizes, as well as $54,000 in Amazon Web Service Credits and became eligible to be considered for a pilot program in iZone schools supported by Amazon Web Services consulting services. The iZone schools are a collection of 250 innovative New York City public schools committed to personalizing learning for every student. An expert panel reviewed the applications.

There are a number of other possibilities for the ways in which prizes could be expanded to address broader issues:

- $100,000 prize purse for innovation school model and platform combination;
- $100,000 prize purse for innovative network design (see recent post on networks) with chance for follow on investment;
- $100,000 prize purse for design of a micro-credentialing (i.e., badge) system to manage matriculation of secondary students (and replace course and credits system).

Intervention Challenges

Intervention challenges would allow products, services, and strategies could be tested in comparable short cycle trials.

An interesting and rather complex challenge is the recently launched Robin Hood Prize: Creating College Success. This $5 million prize competition will reward the development of innovative technologies that increase academic achievement among community college students, particularly those in developmental education courses. Payouts will be made for hitting year 1, 2 and 3-year benchmarks.

Three examples of possible intervention challenges include:

- A prize purse of $1 million could be awarded to the best math interventions with a minimum threshold of one year gain (on average) during a six-week summer school.
- A prize purse of $10 million could be split among schools and vendors after a 12 month writing challenge incorporating innovation such as automated scoring, peer review, blogging, portfolio, grammar aid, and other writing supports.
- Short cycle trials (of perhaps a semester) could be added to a competition like the NYC Schools Gap App Challenge focused on middle grade math resulting in a prize of $100,000 and/or purchase commitment.

Data Competitions

Data competitions could engage data scientists globally to work on well-defined problems. A warehouse of data on each student will unleash the power of predictive analytics that will empower teachers to personalize learning in new and powerful ways. Prizes will accelerate innovation in analytics.

Example:

- Invite scientists to develop a useful predictive algorithm from the keystroke data of 1000 students collected over one or two years (could target a single subject or focus on other outcomes such as persistence).
- Facebook and the Bill & Melinda Gates Foundation have hosted several HackEd's which aim to bring together EdTech advocates, top-shelf technologists, and education experts to solve mission-critical problems in education systems around the world. Groups explore how to use fata and the Facebook platform to solve a number of challenges students face with navigating college applications, enrollment, and persistence.

Geo-Competitions

Geo-Competitions would invite districts, cities, or regions to compete on specific challenges over a specific period of time. Regional challenges may be useful when there are multiple pathways to better outcomes and broad mobilization is likely to be key.

Example:

- $10 million purse for the city with the biggest gain in literacy of five year olds (or English Language Learners or college-ready grads).
- Take a portion of the School Improvement Grant funding and use it to provide awards for those districts that could bring all students to third grade reading proficiency or achieve more than 1.5 years of gains for all students, or achieve a graduation rate of 100 percent.

It may even be possible to use prizes to promote the character development and career readiness skills. The key, as with every prize, would be a compelling goal statement, thoughtful metrics, and a well-developed assessment process.

Considerations

Market Development

The League of Innovative Schools, an initiative of Digital Promise, is a national coalition of 40 public school districts and education agencies in 24 states that collectively serve nearly 3 million students. The League "connects districts and schools with top universities and entrepreneurs, building a hotbed of innovation where we can demonstrate promising ideas, evaluate them rigorously and rapidly, and replicate what works – accelerating the pace of change in public education"

The League engages in three market development activities:

- Rapidly and rigorously evaluate what works.

- Break down silos and scale innovation.
- Transform the market by streamlining procurement, aligning supply and demand, and focusing the decisions of purchasers

Impact Bonds. There has been some recent innovation in social impact bonds, "a contract with the public sector in which a commitment is made to pay for improved social outcomes that result in public sector savings. This form of financing allows the government to partner with innovative and effective service providers and, if necessary, private foundations or other investors willing to cover the upfront costs and assume performance risk to expand promising programs, while assuring that taxpayers will not pay for the programs unless they demonstrate success in achieving the desired outcomes."

New York and Massachusetts have issued impact bonds investing in rehabilitating the incarcerated and aiming a savings from lower recidivism.

Impact bonds could be (and occasionally have been) used for any hypothesis leading to learning likely to result in increased wages or reduced costs

- Early childhood interventions/opportunities
- Dropout prevention/recovery
- Improve family support services
- Multi-dimensional treatment foster care
- Education of adjudicated youth

Policy

Question: What changes in public policy would facilitate experimentation with pull mechanisms at different levels of government?

One strategy used for years to help secure better pricing is cooperative purchasing, in which demand is aggregated and then bid out on behalf of the participants. Federal policy should incentivize aggregating demand in order to provide stronger business cases that would increase the number of providers, lower costs, and encourage faster deployment of services.

For example, The FCC's E-rate program currently has a number of elements that create an inadvertent bias against consortia, including average application wait periods that can exceed more than 290 days.[8] A coalition of Council of Chief State School Officers, The Foundation for Excellence In Education, the Alliance for Excellence in Education, the National Alliance for Public Charter Schools, The International Association for K-12 Online Learning (iNACOL), and the Clay Christensen Institute, the Knowledge Alliance, and Chiefs for Change have encouraged the FCC to eliminate existing disincentives to consortium participation by simplifying and streamlining consortium application processing, including prioritized review by dedicated review personnel. Going forward, the FCC should prioritize consortium funding and provide an additional 5 percent consortium-specific discount.[9] Incentivizing cooperative purchasing of broadband is one of the few proven ways to not only secure better pricing but also build the demand business case providers need in order to justify the upfront capital costs for building out new services.

It is also worth considering creating better metrics to gauge the efficiency and effectiveness of procurement processes or pull mechanisms. For example, using a version of the World Bank's Doing Business study, which presents an annual detailed analysis of costs, requirements, and procedures a specific type of private firm is subject to in 189 countries. A similar method could be used to gauge how "innovation friendly" state and district procurement and regulatory environments are to innovators. Asking providers (e.g. charter school CMOs, online course providers, publishers, education start-ups) questions about the number of steps and length of time for its charter school approval or procurement processes, the length of the average RFP, the cost of securing a contract or complying with regulations would do two things: First, it would provide more information to suppliers to help prioritize sales opportunities and allocate scarce resources. Second, it would provide new benchmarks for policymakers to improve upon, just as the World Bank found that countries launched reform strategies to reduce the steps and complexity of their business regulations.

Another good example is the Millennium Challenge Corporation (MCC) that has redefined the way foreign economic assistance is provided. The initiative uses a competitive selection process to demonstrate positive performance in three areas: ruling justly, investing in people, and fostering economic freedom. The competitive process rewards countries for past actions measured by objective performance indicators – essentially those countries that make the commitment and progress needed as a precondition to ensure foreign aid is maximized.

Lastly, the Federal government needs to create a level playing field for solution providers. There is a tremendous disconnect between the way Federal policy approaches social challenges. Federal policy has traditionally supported efforts to engage the private sector in solving some of the most challenging and intractable social challenges. Policymakers make use of a number of policy tools, including grants, loans, loan guarantees, and tax credits, to not only incentivize private sector engagement but also to stimulate consumer demand for new solutions and innovations. The underlying drive behind these policies is that there is a public good that results from attracting private sector entrepreneurs to tackle pressing public challenges.

However, Federal policy has the mirror opposite posture with respect to education. Instead of engaging the private sector, policymakers actually create policy and funding barriers that skew support to nonprofits and prevent for-profit entities from participating in programs aimed at improving teaching or learning. For example, the Investing in Innovation Fund (I3) shuts out private entities in a way entirely inconsistent with the innovation funding approaches at NASA, U.S. Department of Energy, and Health and Human Services. As a result, nonprofits could receive up to

$50 million in direct federal support from I3 but a for-profit entity was required to go through a lengthy procurement process with a school district or nonprofit entity or to operate as a subcontractor for typically modest sums only after a grant is awarded.

This uneven playing field creates disincentives for new approaches, innovators, and experts to engage on some of the most pressing education challenges facing our country. The same policy and competitions, that led to the U.S. government using SpaceX and pursing new energy innovations, should be brought to bear to education.

Stakeholder Involvement

Question: What role might different stakeholders (e.g. Federal agencies, state and local educational agencies, foundations, researchers, practitioners, companies, investors, or non-profit organizations) play in designing, funding, and implementing a pull mechanism for learning technology? What role would your organization be willing to play?

The respondents have extensive experience in constructing large-scale advocacy initiatives, designing and managing prizes; publishing policy reviews and recommendations; hosting meetings and conferences; and amplifying advocacy efforts with social media. The authors are current on education technology applications and deployment strategies having published more than 15 papers and 1,000 articles in the last 14 months.

The respondents are interested in and capable of providing the following services:

- Designing and managing sponsored prize competitions;
- Facilitating aggregated demand initiatives; and
- Promoting competitions to boost participation, investment and impact.

Conclusion

While mega-prizes have helped to break open targeted industries, including space exploration and other technical fields, they have not been common in education. As has been true in the fields of chemistry, material sciences and data analytics, a sequence of small, targeted prizes appears to be a promising strategy to produce focused innovations in education.

Prizes work best when the problem is well defined, metrics are quantifiable and not in dispute, and there is a market path to take the innovation to scale.

It is important to remember, “Inducement prizes and AMCs cannot substitute for robust research funding, protection of intellectual property, and development of a world-class workforce, but they can be a powerful complement to those efforts.”[10]

Endnotes

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[1] http://www.digitallearningnow.com/wp-content/uploads/2014/01/Procurement-Paper-Final-Version.pdf

[2] McKinsey & Company. "'And the winner is ...': Capturing the promise of philanthropic prizes." 2009. http://mckinseyonsociety.com/downloads/reports/SocialInnovation/And_the_winner_is.pdf

[3] Ibid.

[4] Sections from this case study adapted for use in this RFI. http://cdno3.gettingsmart.com/wp-content/uploads/2013/02/ASAP-Case-Study-FINAL.pdf

[5] http://cdno3.gettingsmart.com/wp-content/uploads/2013/02/ASAP-Case-Study-FINAL.pdf

[6] MIND Research Institute communication 2/27/14

[7] Personal communication 2/27/14

[8] Funds for Learning, Decision Times Vary by Priority, Applicant, and Amount. https://www.fundsforlearning.com/blog/2014/01/decisions-vary-by-priority-applicant-and-amount

[9] Coalition Reply Comments to the FCC, Nov 8, 2013 http://www.digitallearningnow.com/wp-content/uploads/2013/11/Education-Coalition-Reply-Comments-As-Filed2.pdf

[10] http://www.hamiltonproject.org/papers/prizes_for_technological_innovation/

Digital Promise
Accelerating Innovation in Education

Harnessing Pull Mechanisms for Advancing Learning Technologies

March 7, 2014

Digital Promise Response to White House Office of Science and Technology Policy Request for Information Published in the Federal Register

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Introduction

We must improve the opportunity to learn for people of all ages, ensuring quality and expanding access to unserved and underserved individuals and populations. As a capitalist democracy with a deep commitment to public education, we have an obligation to prepare all Americans to be successful workers and entrepreneurs in a highly competitive 21st Century economy, informed and engaged citizens in diverse communities tackling tough public problems, and lifelong learners in a world that is increasingly interconnected and fast-changing. While the challenge is daunting, now, more than ever before, the path forward is within our sights.

Digital learning – facilitated by excellent educators and powerful instructional technologies – promises to improve equity, increase engagement, and personalize learning. It can create new efficiencies and advance productivity, empowering learners and educators to use their time most effectively. Mathematics, language development and literacy, deeper learning competencies, and skills of all types can be supported with the smart use of technology.

While digital technologies have already improved learning opportunities for select classrooms and schools, they have failed to deliver the systemic and revolutionary impacts for students and teachers that we've seen in other sectors. Too often, technology in schools has been layered on top of or simply replicated existing instructional processes. And schools have struggled with lack of connectivity, expensive and hard-to-manage hardware and software, and a lack of high-quality digital content aligned to academic standards.

A confluence of factors is creating the potential for things to be different:

- Faster, more comprehensive broadband Internet access in and out of schools.
- Lower price points for new more powerful and easier-to-use mobile devices.
- A proliferation of lightweight, Web-based software applications.
- APIs to simplify account set-up and data integration from multiple sources.
- An explosion of digital content, tools, and resources in a $7.9 billion market[1] from open-source providers, start-ups, traditional publishers, and educators themselves.

These developments all create opportunities to rethink how students learn and teachers teach.

Traditionally, educational technology developers have taken an "if we build it, they will come" approach. Products are pushed into the market through various channels and sold using traditional contracts with an individual state, district, or school. Firms are paid to provide a product, not to demonstrate results.

Digital Promise is excited that the White House Office of Science and Technology Policy (OSTP) is requesting comments on pull mechanisms – policies and practices that can cultivate and leverage smart demand – to spur the development, evaluation, and adoption of advanced solutions to the nation's most pressing learning challenges, recognizing the role that technology can play.

Who We Are

Digital Promise is an independent nonprofit authorized by Congress in the Higher Education Opportunity Act (2008) and launched by President Obama in 2011, with the mission to spur innovation in education. Digital Promise works with educators, entrepreneurs and developers, researchers, and leading thinkers to support research and development to benefit lifelong learners.

A number of our initiatives are organized around understanding and improving the educational technology marketplace and point to opportunities for pull mechanisms. Our team at Digital Promise has been thinking about these issues for a number of years. We appreciate the opportunity to share our perspective with OSTP.

The Promise of Pull

Pull mechanisms are promising strategies for improving educational outcomes for children and adults, but can also be complex initiatives to structure and administer. The results achieved through pull mechanisms in other sectors (health, energy) included in OSTP's RFI are compelling. We recognize, however, that successfully educating students of all ages is different from vaccinating people against a disease.

An intervention that effectively empowers, engages, and educates one learner may be different from the type of intervention that will be successful for another learner – whether they're in the same classroom or across the country.

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[1] https://www.siia.net/blog/index.php/tag/education-technology-market/

It is also more difficult to isolate cause and effect in education. Because people learn offline, online, and in blended settings, attributing improvements in educational outcomes to specific inputs – an essential task for accurately selecting prize winners, advance market commitment recipients, and pay-for-success partners, for example – requires sophisticated program and evaluation design and data analysis.

Leveraging the kinds of pull mechanisms that require certainty of attributable success to identify "winners" in the market is most likely to be successful under conditions that make it possible to judge success objectively, including:

- Clear definitions of the problem to be addressed and the vision for success.
- Clear definition of the outcomes to be measured and availability of sound metrics to be used in measurement.
- Identification of appropriate test-beds for the innovation.
- Careful matching of the optimal pull mechanism to the challenge under consideration.
- Rigorous evaluation and monitoring to create confidence in results and award decisions.
- Development of independent expert groups to support and manage these processes.

And, perhaps most critically, we need to put a policy environment in place that not only permits, but also incentivizes the use of pull mechanisms.

For "pay-for-success" approaches as described in the RFI, there may also need to be a new class of social impact investors in the educational technology marketplace who cover program implementation costs and are repaid only after the provider achieves program objectives.

Those who seek to employ pull mechanisms to drive the development of new, game-changing solutions should begin with a focus on a small number of grand challenges with ambitious goals, as well as clear success metrics. This would advance well-known proof points associated with the viability of pull mechanisms in education.

Cooperative purchasing as a pull mechanism is different. The purpose of cooperative purchasing is not to drive the development and testing of new tools – it is to get the best possible price for an existing product by leveraging volume, and by doing so, bring the product to teachers and learners who might not have had access to it otherwise.

This is already happening regularly with basic goods that school districts acquire (i.e., pencils, paper, printers), and increasingly with computers and mobile devices (e.g., NJPA administers national contracts for computer hardware). We don't observe cooperative purchasing happening widely yet for the acquisition of instructional software. We agree that this seems like an area of opportunity, as long as educators can be as nimble as they need to be in acquiring software products that address specific learning needs for individual students.

One significant barrier to cooperative purchasing of instructional software at the elementary and secondary level – from digital books to fully adaptive learning and assessment programs – is the lack of a trusted online ecosystem with well-organized and continuously updated information including product descriptions, features, recommended usage, pricing, associated research, expert and user reviews and ratings, case studies, purchasing patterns, and more, for districts to identify appropriate and promising products.

If such an ecosystem were designed and deployed, purchasers could self-organize into groups for acquiring these products together. For example, school districts with similar characteristics and similar instructional needs looking for instructional software could connect with one another, collaboratively develop product preferences and purchasing procedures (RFPs, sole-source contracts, etc.), and leverage collective buying power.

As with other types of pull mechanisms, cooperative purchasing of instructional software cannot happen if state, municipal, or district policies get in the way.

Grand Challenges: Seeking Fresh Solutions

There are many critical educational needs that stand to benefit from cutting-edge, high-quality, and high-impact innovations. Digital Promise suggests particular educational needs in this brief list not to exclude others, but to illustrate the kinds of targeted learning outcomes that would be good candidates for the introduction of pull mechanisms because of the tremendous scale of need and the availability of concrete success metrics:

- Increasing access to and improving outcomes in adult education.
- Improving English language proficiency for English learners.
- Increasing passage rates for math placement tests and developmental math coursework at postsecondary institutions.

Adult Education

There is both a compelling need and untapped opportunity for using technology to increase access to learning opportunities for under-skilled adults, and to further personalize and accelerate learning for this population.

Last October, the Organisation for Economic Co-operation and Development (OECD) released the results of an international survey of adult skills that is part of the Program for International Assessment of Adult Competencies (PIAAC).[2] The findings shined a spotlight on a specific part of the U.S. population that has historically been overlooked and underserved by our education system: the large number of adults with low basic skills.

One in six American adults lack basic literacy skills – roughly 18% of the adult population, or 36 million people, according to the PIACC study. Nearly one in three have poor numeracy skills. Separate from PIAAC, we also know that there are approximately 37 million adults in the U.S. without a high school credential.

In a time of intense global economic competition and increasing income inequality at home, it is both a moral and economic imperative that we find innovative and cost-effective ways to help these adults gain the skills and credentials they need to participate fully in our economy and society.

According to *Time for the U.S. to Reskill? What The Survey Of Adult Skills Says*,[3] an OECD analysis of the U.S. PIAAC results commissioned by the U.S. Department of Education, those with the weakest literacy skills who did not participate in adult education – around 3 million people – said they would have liked to, which suggests a significant unmet demand for such services.

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[2] http://skills.oecd.org/Survey_of_Adult_Skills_US.pdf

[3] Ibid.

Currently, federal and state funding for adult education serves fewer than 2 million adults.[4]

Given that the adult education sector is historically under-resourced, and that a significant number of low-skilled adults are low-income, we believe pull mechanisms are needed to accelerate innovation in the development and adoption of effective learning technologies for low-skilled adult learners.

The Administration's proposal for reauthorization of the Workforce Investment Act[5] encourages the adoption of content standards and aligned assessments for adult education that reflect college and career readiness. Pull mechanisms, such as prize competitions for developing effective digital content aligned to these standards and targeted to the unique needs of adult learners, could enable more of those with low skills and lacking a high school diploma to move into postsecondary education and training.

While there are multiple subpopulations of adult learners currently underserved, we would recommend an initial focus on pull mechanisms for adult secondary education. Specifically, pull mechanisms that would accelerate the development of learning technologies to help those without high school credentials to earn them, and to quickly and efficiently transition to postsecondary education or training. This transition is something that more traditional programs and technology have struggled with.

Two programs are frequently cited by experts in adult education as showing great promise: Minnesota's FastTRAC (Training, Resources and Credentialing), which teaches basic reading and math skills intensively and in the context of specific career paths; and Washington state's Integrated Basic Education and Skills Training (I-BEST), where students work towards a high school credential while simultaneously earning college credits and/or workforce credentials.

These programs reflect two of the basic principles behind successful adult education: classes are intensive and concentrated, with clear goals and expectations, and the approach combines the teaching of basic skills with career-specific technical training. We believe new learning technology tools that support such models would lead to wider adoption – and to greater student success.

- **Outcomes to focus on:** Increasing the number of non-high school credentialed adults served by existing and new models of adult secondary education programs, and increasing the number of those who receive their credential and successfully transition to postsecondary education or training.
- **How they are measured and assessed:** The Department tracks the number of students enrolled in adult secondary education, the educational gain of students in the programs, the number of students who earn a high school degree or equivalent, the number who enter postsecondary education or training, and the cost per student learning gain or diploma/equivalent attainment.
- **Information on U.S. performance:** Despite increasing high school graduation rates, there are still millions of young people who lack even this basic credential and the number of job vacancies requiring some postsecondary education and training is projected to increase to 65% by 2020.[6] Sixty percent of adult education students who

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[4] Office of Vocational and Adult Education National Reporting System, 2012- 2013

[5] http://www2.ed.gov/about/overview/budget/budget15/justifications/o-ctae.pdf

[6] Georgetown University Center on Education and the Workforce: Recovery 2020.

identify high school graduation as a goal complete their diploma or equivalent, but slightly below 250,000 adults are enrolled in adult secondary education programs.[7]

- **Why a pull mechanism would accelerate innovation:** The current adult education system serves only a small fraction of adults who lack a high school credential and/or do not speak English well. Given the underserved population, limited funding available to providers, and unique needs of adult learners compared to K-12 and higher education markets, a prize competition would bring new solutions and entrants into the field. The publicity and attention of a prize competition should increase the number and quality of products and services available to states, local adult education service providers, and directly to students themselves.

English Language Proficiency

Increasing the English language proficiency of English language learners (ELLs) is another powerful opportunity to leverage pull mechanisms. The number of school age ELLs has more than quadrupled to approximately 4.7 million since 1980, according to census data, and much of the recent growth has occurred in states outside traditional immigrant gateways.[8] This growth in states that lacked the infrastructure and capacity to serve large numbers of ELLs presents a need and opportunity to develop and adopt learning technologies that can rapidly improve English language proficiency.

- **Outcomes to focus on:** The percentage of ELLs who are making progress in learning English, the percentage of ELL students who reach proficiency, the percentage of ELL students who score proficient on state reading assessments, and the percentage of former ELL students who score proficient on state reading assessments.
- **How they are measured and assessed:** Each state delivers assessments in English language proficiency to ELLs to monitor progress towards proficiency. A number of states are in the midst of creating next generation of assessments that include a summative assessment of English language proficiency, an on-demand screening assessment, classroom benchmark assessments, and aligned formative assessments.[9] These assessments could generate significant data to assess the effectiveness of the innovation.
- **Information on U.S. performance:** There has been modest progress for ELLs in recent years on the NAEP exam, but substantial gaps still exist, particularly in reading. Scores for ELLs in 4th grade reading increased 13 points over 15 years, but still lag non-ELLs by 39 points. That gap increases to 45 points for 8th grade reading.[10]
- **Why a pull mechanism would accelerate innovation:** The rapid growth of ELL student populations across the country makes it difficult for states and school districts to create the capacity to effectively serve these students through traditional means. Learning technologies could augment the services that bilingual or English as a second language teachers are able to provide for students. These technologies could also markedly increase the time on task that ELL students devote to learning English with content that is engaging, personalized, available anywhere, and contains embedded assessments to feed meaningful data back to their teachers and families. There are many types of pull mechanisms that could effectively serve this population including:

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[7] Data from ED FY 2014 Budget Justification for Adult Education.

[8] Data from ED FY 2014 Budget Justification for English Learner Education.

[9] ED Enhanced Assessment Grant to a consortium led by Wisconsin from FY 2010.

[10] NAEP data compares 2013 and 1998 taken from the Nation's Report Card.

  - *Prizes:* Prizes could be used to incentivize the development or adaption of existing products to demonstrate they are able to rapidly increase English language proficiency.
  - *Advance Market Commitments (AMCs):* Consortia of districts or states could commit to purchase access to digital content and/or tools that meets specified effectiveness and set-up/accessibility targets. Given the lengthy sales process with school districts, AMCs would allow new entrants to be confident that they could efficiently sell into school systems, provided they can prove the effectiveness of their learning technologies. Additionally, AMCs would enable new entrants to focus their resources on product development rather than building relationships with individual districts over sales cycles that can stretch to 18 months.
  - *Pay-for-Success:* These commitments could be for organizations that provide services and digital content to school districts with a commitment to increase English language proficiency at ambitious rates. Since they would only receive funding if the intervention serves the target populations effectively, this lowers the funding commitment for something unproven, while giving providers the opportunity to create verified proof points. Given the lack of trust many districts place in vendor-sponsored studies, this independent verification could be important to help high-impact learning technologies grow.

Developmental Math

Developmental math offers a third critical opportunity to leverage pull mechanisms to increase the development and adoption of learning technologies that advance important mathematics competencies. Spending on developmental courses for the 60% of community college students referred to them tops $7 billion annually, and only 20% of those students go on to complete credit bearing introductory math courses.[11] Developmental math presents a number of challenges where pull mechanisms offer the potential for improvement, including increasing the passage rates on placement tests, improving the accuracy of placement tests, and increasing passage rates of developmental math courses.

- **Outcomes to focus on:** There are no unified reporting requirements to enable tracking of national statistics, but research has been conducted on the following: placement percentages into developmental vs. introductory math, the accuracy of placements into developmental math, successful completion of developmental math, and successful completion of introductory credit-bearing math courses.
- **How they are measured and assessed:** Each of these outcomes is measured, but there is not a unified reporting mechanism in place to determine effectiveness and progress on improvement efforts.
- **Information on U.S. performance:** Many studies highlight the scale of the challenge to improve performance in developmental math. It is a steep funnel of students who are referred to developmental math (~60%), enroll in developmental courses (~60% enroll in either a math or English course), complete their developmental sequence (33% of those referred complete math sequence), and complete credit bearing courses (20% of those referred complete math).[12] These rates point to tremendous room for

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[11] Data from a variety of studies compiled by the Community College Research Center at Teachers College FAQ.

[12] Ibid.

improvement in the courses themselves, the referral (i.e., assignment) system for deciding which students take which courses[13], or both. It also points to a challenge ripe for innovation.

- **Why a pull mechanism would accelerate innovation:** There are significant efforts underway to develop technologies to improve competency in developmental mathematics, but the scale of this challenge will benefit from efforts to evaluate the effectiveness of new learning technologies and to scale technologies that can demonstrate effectiveness of a direct to learner approach, as well as across the many community colleges.[14] Pull mechanisms could include:
    - *Prizes:* These could include exemplar prizes for technologies that can increase passage rates, point solution prizes to improve placement testing accuracy, and network prizes to encourage collaborative efforts to create new solutions.
    - *Advance Market Commitments:* Consortia of community colleges – such as those receiving TAACCCT grants from the Department of Labor – could commit to purchasing innovative technologies that demonstrate effectiveness in improving developmental math outcomes in less time.
    - *Pay for Success:* Given the blended nature of course delivery, a pay for success challenge could give providers an opportunity to prove the effectiveness of their intervention and create a proof point to scale their technology.

Roles for the Federal Government, Digital Promise, and Others: Pull and Push

Because pull mechanisms are not yet prominent in the educational technology marketplace, and changing something as entrenched and complicated as the public procurement process is no small challenge, the federal government has an important role to play to make it more attractive and easier for states, school districts, educational institutions, and foundations to enter into these types of arrangements. Of tremendous value to the growth and acceptance of pull mechanisms is the ability of the federal government, and the White House in particular, to convene a diverse group of stakeholders and widely publicize new initiatives, prizewinners, and program successes.

Another group critical to the success of pull mechanisms will be independent organizations that can help organize, administer, and promote these initiatives. Digital Promise is strategically positioned to play a role in advancing pull mechanisms to accelerate the development and adoption of learning technologies focused on improving learning outcomes at multiple levels.

Current Activities

Digital Promise leads several relevant initiatives and partners with critical actors needed to drive these advances – innovative school districts, education technology companies, leading researchers and thinkers, and philanthropic foundations involved in the digital learning ecosystem. These efforts include:

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[13] "Improving the Targeting of Treatment: Evidence from College Remediation," Judith Scott-Clayton, Peter M. Crosta, Clive R. Belfield, NBER, October, 2012: http://www.nber.org/papers/w18457

[14] One example is the Carnegie Foundation for the Advancement of Teaching's Developmental Math Pathways initiative.

- The Digital Promise League of Innovative Schools, a consortium of 40 public school districts in 24 states that collectively serve nearly 3 million students. These districts are committed to demonstrating, evaluating, and scaling up innovations that deliver improved results for students, and are frequently called upon as leaders among their peers.
- The Digital Promise Content and Data Exchange (DOCENT), a content-agnostic, single sign-on platform developed in partnership with entrepreneurs where League districts can rapidly pilot and evaluate new digital tools, while providing a test bed for meaningful data to support research.
- Market research to improve educational technology procurement policies and practices, including earlier work with IDEO[15] and a current project with Johns Hopkins University and the Education Industry Association[16];
- The Teacher Wallets project, a decentralized procurement pilot program with individual educators as final decision-makers.
- An adult learning initiative to advance adult learning and support the closure of the skills gap through the use of digital learning technologies and facilitated partnerships.
- The development of micro-credentials (i.e., digital badges) for K-12 educators to support the recognition of advanced teaching competencies, including those that demonstrate the ability to engage students in deeper learning experiences, critical in the attainment of the Common Core Standards.
- The Digital Promise Prize Fellow who developed recommendations for how the organization can structure and administer prize competitions.

Our work at Digital Promise focuses on the intersection of educators, researchers, and educational technology entrepreneurs and developers. Through these projects and others, we are developing a deep understanding of the educational technology marketplace, strong relationships with key stakeholders, and a vision for how we can best contribute to spurring innovation to support learners of all ages. We view advancing pull mechanisms – to catalyze development of new products that solve grand challenges in education, and to leverage buying power of educators working together – as a critical part of that vision.

This year, our primary activities to support the expansion of pull mechanisms in the educational technology marketplace will be focused on connecting, convening, and communicating. We will gather and share insights about challenges and opportunities for pull mechanisms. Specifically, we will:

- Establish and coordinate a smart demand network in the League of Innovative Schools for leading superintendents and their designees to begin developing and disseminating strategies for:
    - Pull mechanisms that could improve acquisition of today's technology solutions; and
    - Pull mechanisms that could drive development of new solutions based on clear articulation of district needs and appropriate incentives for developers.
- Begin investigating state, municipal, and school district policies that stand in the way of adoption of pull mechanisms in the educational technology marketplace.

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[15] http://www.digitalpromise.org/ideo-digital-promise-release-evolving-ed-tech-procurement-in-school-districts/

[16] http://www.digitalpromise.org/join-us-in-improving-ed-tech-purchasing-practice/

- Identify specific challenges and opportunities for pull mechanisms, informed by our market study on educational technology procurement to be concluded in fall 2014.
- Conduct a pilot prize competition within identified school districts including within the League of Innovative Schools to promote the use of micro-credentials for teacher competencies to support the move to competency based education.
- Contribute to the national conversation about both pull and push mechanisms for developing a smarter demand and smarter supply in the educational technology marketplace through a strategic communications campaign.

Ideas for future work

Beyond this year, there are a number of things we could do to continue advancing pull mechanisms in the educational technology marketplace, including:

- Convening state, municipal, and school district policy officials to better understand and develop creative strategies for overcoming legal and regulatory hurdles that stand in the way of adoption of pull mechanisms in the educational technology marketplace, and developing strategies for overcoming them.
- Developing a Consumer Information Service focused on providing credible information and documentation of current and emerging products and services to facilitate innovative acquisition strategies such as cooperative purchasing agreements, teacher wallets, and advanced market commitments based on challenges and gaps. This would facilitate the ability to easily identify products, prices, pilot opportunities, and evidence for educational technology products in the marketplace, whether free or paid.
- Developing an online procurement platform for school districts to:
  - Communicate their key characteristics and instructional needs;
  - Connect and collaborate with other districts with similar characteristics or needs; and
  - Identify and acquire educational technology solutions that are a strong fit, either on their own or collaboratively with other districts.
- Empowering the League of Innovative Schools, adult learning consortia and other educators with tools and strategies to adopt and evaluate the use of pull mechanisms – first cooperative purchasing and prizes, and later advance market commitments and pay-for-success programs.
- Creating and administering pull mechanisms ourselves, including managing prize competitions at the national or even global level, or facilitating cooperative purchasing.
- Working with large and small school districts across the country to build capacity to design and manage prize competitions. For smaller districts, this may mean collaborating with one another to be sufficiently attractive to potential developers.
- Structuring evaluation and monitoring programs for the management of pull mechanisms, including pay-for-success programs.
- Identifying and promoting best practices in the use of pull mechanisms through our national network.

Push Mechanisms for Smart Supply

We can't talk about smart demand without also talking about smart supply. Investors, entrepreneurs, and developers need access to basic research on learning science, clear understanding of the instructional needs of educators, and credible product evaluation methodologies to ensure the products they develop are as likely as possible to solve critical challenges in learning and instruction. So push mechanisms are also important, and Digital Promise has a role to play there as well.

This year, we will establish and coordinate a smart supply network, in partnership with industry associations, regional startup hubs, and others, to develop and disseminate best practices for harnessing learning research and information about educators' instructional needs in the design of their products.

We will also leverage the DOCENT platform to provide product pilot feedback, including usage and outcomes data, as well as qualitative data from educators, to inform product design and development among participating instructional software providers.

Though known to most simply as Digital Promise, our name in the authorizing language from Congress is the National Center for Research in Advanced Information and Digital Technologies. Research is at the center of our mission and is the common thread that connects all of our work.

Shortly we will bring on a Director of Research who, in collaboration with our research partners at the UC Davis School of Education and Johns Hopkins University, among others, will lead our work on harnessing data, evaluation, and research findings to inform product design and development. These efforts will make it more likely that products in the marketplace address real needs, and do it well.

While Digital Promise can help cultivate a community of data-driven, evidence-based product developers and entrepreneurs, there remains a critical need for increased research and development funding to:

- Advance the state of basic learning science.
- Support the directed development of effective learning technologies focused on specific grand challenges.
- Understand the impacts learning technologies can have on development of deeper learning competencies (collaboration, communication, problem-solving, etc.) applied across contexts and on non-cognitive skills.

Changes in Public Policy to Support Experiments with Pull Mechanisms

Digital Promise will have more to say about the public policy context for pull mechanisms when we release draft findings from our market study on educational technology procurement at the beginning of the summer, and when findings are complete in the fall.

States and municipalities may have to enact changes to permit school districts and educational institutions to enter into novel agreements like pay-for-success bonds and advanced market commitments, and even to pursue cooperative purchasing arrangements.

States and municipalities may consider taking a gradual policy development approach by testing pull mechanisms in a contained setting before rolling them out to the entire jurisdiction. For example, the iZone, part of the New York City Department of Education – a member of the Digital Promise League of Innovative Schools – serves as a 300-school test bed among the nearly 1,800 public schools in the district. The iZone is innovating instructional approaches, as well as the ways in which the district interacts with the educational technology marketplace (i.e., including awarding over $100,000 in prize money as part of a "gap app challenge"). Other districts and education institutions could create an innovation incubator like the iZone as a venue for piloting pull mechanisms before deciding whether and how to scale them more broadly.

Conclusion

At Digital Promise, we bring together educators, researchers, and educational technology entrepreneurs and developers to spur innovation in education that will benefit all learners. It is clear to us that through smarter demand and smarter supply in the educational technology marketplace – including through the adoption of pull mechanisms – teachers and learners will be more likely to have access to learning technologies that will help them achieve their goals.

We are eager to discuss the ideas in this response with the White House Office of Science and Technology Policy, the U.S. Department of Education, and other potential partners across the country.

Jessica Lindl
General Manager

GlassLab

"Hi Cristin and Tom – here are our thoughts on a potential vision for a pull mechanism to create games around competencies that Were as effective as a personal tutor and as engaging as the best video game, and improved the more students used them.
All of the information and timeline and dollars donated are fiction to provide a feel for how we could execute.

GlassLab would provide the (1) Game Jams, (2) judges, (3) partnership opportunities in collaboration with you and (4) the assessment engine for continuous, real-time data from the winning games and the learning infrastructure to ensure successful adoptions of games in classrooms.

Thanks -

"

Jon Frederickson

Vice President, Government

Innocentive

"This is the InnoCentive response to OSTP's RFI.

Today, technologies exist that if applied, along with the fundamental principles of Open Innovation/Collaboration/Awards/Prizes, can "pull" students towards higher levels of learning across America. InnoCentive is one of the firms with the experience and technology to develop and expand the "pull" of competitions into the public school systems of America.

Concept – InnoCentive4EducationTM

STEM education funding is critical to improving and raising the skills and test scores of America's children. The American economy needs highly skilled and motivated students in STEM disciplines. American businesses of all sizes are faced with the fact that there are fewer student excelling in STEM disciplines when measured against foreign students abroad or those coming to the USA for advanced studies. For America to innovate and lead the world, STEM initiatives and incentives for students, instructors and schools are critical.

InnoCentive's belief is that with working with government in States and at the Federal level, the implementation of an Open Innovation tool such as InnoCentive@Work or the use of InnoCentive.com can "pull"" more students of all skill, ethic, socio-economic, gender status' into InnoCentive4STEMTM competitions. This capability can help teachers develop core and essential critical thinking skills in their STEM curriculum applied against real-world challenges when fully implemented.

How this would work –

Students and their STEM teachers would be invited to compete to solve real-world problems within the STEM disciplines. Students and teachers would use the challenges to enhance the classroom teaching in STEM by having individuals or teams of students register in a competition system to solve a problem. The challenges would be hosted on a web-accessible system where innovation challenges had been professionally written for students. The challenges themselves and the awards for solving the challenges could be localized and customized.

STEM challenges could be done in-State only or posted for students across many States to broaden competition. The platform would need to be hosted and open to all schools, hosted and open to select schools and students as options. The platform would need to have challenges segmented by STEM discipline and age appropriate complexity.

For example;

- Middle School or High School student Math or Science related challenges would be age and skill level appropriate (this could be determined against some State guideline of proficiency in the STEM areas)

- Teachers would introduce to the students the challenges that had been made available for solving. The teacher would decide on the solutions protocol as; done as a class, small groups or as individual students to be submitted through the competition technology.

- Teachers would evaluate submissions for in-class progress grading as a part of the learning plan for STEM

- Challenges – the challenges could be provided by large and small businesses in each State

o Businesses in States have a natural and direct interest in developing STEM students as potential workers for their enterprises in the future

o Business have real work challenges that for early learner STEM students would have to be simplified for a competition but would be easily reviewed for making awards to winners

o Businesses sharing challenges would be a part of evaluation teams judging student/classroom/or group solutions to make awards

o Businesses may be able to provide funding in dollars or in-kind merchandise to winners

 Winners can be schools as measured by school engagement in STEM challenges, % participation rate in challenges and % of winning solutions

 Winners can be teachers whose work in using this method produces winning submissions, # of winning solutions from teachers STEM students

 Winners can be students, teams, picked by judges

 Winners get;

 Cash – modest awards

 In-kind awards – i.e. If a computer manufacturer submits the challenge the school or classroom gets iPads/tablets

 Recognition – a letter or plaque from the governor/President in recognition of achievement

 Scholarships – State Colleges and Universities could make awards of scholarships to in-State institutions to Junior and Senior level students that excel during their high school STEM years. This strengthens the State higher educations systems by keeping in-State talent in State.

o The system is NOT LIMITED to STEM challenges only, challenges to improve trade or vocational skills for students not seeking higher education could be used in this system as easily as STEM challenges.

o Challenge formulation for this would be done by InnoCentive, the skills and our proven methodology could be taught as a discipline in schools so this would eventually be managed locally. We use Einsteins principle for the critical nature of challenges—the question.

 If I had an hour to solve a problem and my life depended on the solution, I would spend the first fifty-five minutes determining the proper question to ask, for once I know the proper question, I could solve the problem in less than five minutes. - Albert Einstein

Who Benefits?

- Students and Parents
  - Gets kids excited about STEM (makes STEM cool) based on a competition model with collaboration, rewards and recognition
  - Improves student critical thinking skills in the classroom to apply to the next levels of learning
  - Teaches the values of competition whether they win or not
  - Provides a sense of achievement by participating
  - Provides visibility for themselves to colleges, universities and business for future education and employment
- Federal Government
  - Potential improvement in STEM participation and national scoring
  - Validates investments in STEM programs by increased STEM scores and participation
  - Can be used to solve Federal government problems by its teachers, by students, or everyday citizens
  - Could be used for teacher evaluations on STEM effectiveness
- State
  - Improves State STEM scores on standardized tests
  - Becomes a selling point for employers to move to our stay in the State based on a highly educated population
  - Validates investments in STEM programs by increased scores and participation
  - Can be used by the State to reward and recognize teachers and students for outstanding achievement
  - Can be used to Solve State problems by its teachers, by students, or everyday citizens
  - Could be used for teacher evaluations on STEM effectiveness
- State Colleges and Universities
  - Creates a pipeline of STEM students that remain in State and attend their institutions
  - Creates a higher potential for better educated students being placed in businesses in State
  - Could create increased investments in State schools in STEM disciplines from the public and private sectors, endowments
  - Could attract out-State students in STEM to their institutions
- Local Schools
  - Recognition of School and Teacher achievements in STEM

 Potential increases in STEM funding based on achievement in competitions

 Student standardized testing scores increase

 In-kind gifts from businesses as winnings can supplement technology or other real classroom needs

o Teachers

 Personal recognition

 Personal satisfaction

 Demonstrable achievement as measured by learner success in testing scores

 Contribution to STEM improvements in the curriculum

 Monetary rewards – through cash awards from competitions or in merit increases

 Ongoing education support – State grants for STEM teachers for continuing education

o Business'

 STEM skilled students as employees that are highly skilled and trained in State

 Skilled employees create better products, services and innovation for their company which in ti=urn creates revenue

 With increased revenues and innovation, JOBS are created which benefits everyone

 Business recognition as a leader in STEM and student achievement

Systems and technology alone are not the solutions that drive change and STEM value increases. Those are important contributors, but it is the methodology that matters and the experienced guidance of experts that have run local, national or global challenges that make the difference. Very few organizations have that complete mix to drive change, its important that the government chooses wisely when looking at strategies and those that have the experience to execute using competitions.

This is InnoCentive’s view based on our expertise and experience, we hope to discuss next steps and potential funding to initiate a pilot program across States with Federal support and funding.

"

The Press Release:

Power Up to Level Up

Leveraging the transformative power of digital games to accelerate learning

President Obama Launches "Power Up to Level Up" National Learning Game Jam to Close the Engagement Gap and Accelerate Learning

Nationwide effort includes over $200 million in public-private investments to design and develop digital learning games to accelerate learning

President Obama today launched the “Power Up to Level Up” campaign, a nationwide grassroots effort to create digital learning games covering the most important learning standards that are just as compelling as the best video games in the market today.

In response to the President’s 2011 call to action “for investments in educational technology that will help create … educational software that’s as compelling as the best video game,” the nation’s prominent leaders and innovators in video games, education and technology have come together to host a series of national learning game jams that re-imagine game-based learning.

The Power Up to Level Up Game Jam is a national, year-long series of 48 hour game jams focusing on inventing the next generation of learning games. Everyone is invited - kids, families, small developers, large developers, teachers, school leaders - to “get in the game” by creating digital games tied tightly to critical learning standards. Partners will lend mentorship to the game creators in specific areas of expertise, and provide some commitments for helping winning games to get to the market. The Jam will not only create wildly successful learning games from the winners, but also a large, accessible set of prototypes that the community can riff fon for future games. There have been learning game jams in the past, but not with the breadth of partners, and not with the goal of letting the public actually create amazing learning experiences targeting the most important learning standards.

Speaking to key leaders of the education community and contestants of the “Power Up to Level Up” Game Jams, President Obama announced a series of high-powered partnerships involving industry, foundations, non-profits, and school districts dedicated to transform the way we teach and learn through digital games.

"Research demonstrates that students who use video games as part of their learning experience have over a 12% learning improvement than those who don't. Imagine game-based learning experiences that not only engage thinking and the imagination but that also provide constant feedback on the learning taking place," said President Obama. "This is what the leaders in digital gaming, education and technology have committed to create with the Power Up to Level Up National Game Jam."

Comment [1]: Cite SRI Research

The new game jam, with accompanying major commitments from philanthropic organizations and individuals, marks a dramatic first wave of responses to the President's call. Each of the commitments—valued together at over $200 million in financial and in-kind support—will apply new and creative methods based on video games to inspire deeper enthusiasm for learning.

Participants in the game jam include a diverse sampling of passionate learning game designers - from middle school students to professional game developers. Experienced learning, game and assessment designers will be available to participants.

Among the commitments announced by the President are:

- IP and game donations that can be modded for learning and assessment use from leading games like Project Spark, Minecraft, SimCity, The Sims, Skylanders, and Disney Infinity
- Over 20 corporate commitments from Activision, Electronic Arts, Microsoft, etc. to fund ongoing development of the winning game jam contestants. Each corporate sponsor is allocating $300,000 per winning game team to take their games to a commercial level of quality and ensure they have wide distribution into US homes and classrooms
- Foundation commitments from New Schools Venture Fund, MacArthur, and Gates Foundations to fund a common platform that provides standards aligned dashboards, a robust assessment engine and a learning management system to ensure actionable learning data is available at anytime, on any device
- Infrastructure commitments:
  - E-commerce from Google, Valve and Amazon to make purchasing simple and seamless for US K-12 institutions
  - Middleware from Unity, ?, etc. to make game designs come to life
  - Hosting commitments from Amazon and Google to ensure all learning data is actionable (available anytime / any device) and hosted in perpetuity for research purposes

Execution Details:

1. What:

The Power Up to Level Up Game Jam is a national, year-long series of game jams focusing on inventing the next generation of learning games. Kids, families, small developers, large developers, teachers, school leaders are invited to "get in the game" by creating digital games tied tightly to critical learning standards. We imagine partners would lend mentorship to the game creators in specific areas of expertise, and provide some commitments for helping winning games to get to the market. There have been game jams in the past, but not with the breadth of partners, and not with the goal of letting the public actually create amazing learning experiences targeting the most important learning standards.

2. Who we Target:

- Launch Partners: White House, World Wide Game Jam?, other?
- Funding Partners: Game developers and publishers, K12 publishers, Foundations
- Game Jam Contestants: Everyone - kids and teachers, families, game developers
- Sub-grantees (Potentially): Universities, Co.Lab (winners are incubates at Co.Lab?)

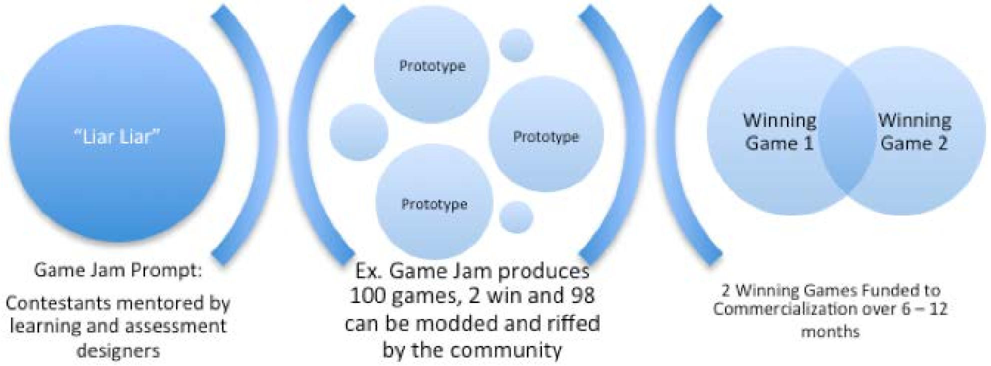
3. When:

- January: Finalize Concept with a planning document around resources, timeline and target goals
- February: Kick off founding committee to drive execution
- February - August: Fund-raising / Pitching for 6 months targeting public / private partners to make this idea come to life. Include fund-raising for media campaign for game jam.
- February - April: Design Game Jam; determine if we can have 2 - one in the spring and one in the fall? Spring is a "concept" game jam
- March - May: Announce Game Jam at GDC and SXSWEdu, announcement from the White House.
- May: Host Game Jam 1 as a concept / dry-run to get some games created
- May 22nd: Host event at the white house including:
    - Round 1 Game Jam winners
    - Playable games by high profile political members
    - Announcement of commitments to fund the winners to commercialization, announce Game Jam 2 in the fall with 2 x the level of commitment and

commitments to fund the infrastructure to ensure all games are commercially viable

- June: Kick off first winning cohort funding to commercialization (assume 6 - 12 month timeframe)
- October: Game Jam 2
- January - June 2015: Pilot Cohort 1 Game Jam games
- September - December 2015: Pilot Cohort 2 Game Jam games

4. How: Generate accessible, compelling, fun challenges to launch Game Jam, winners move to development stage (see below).



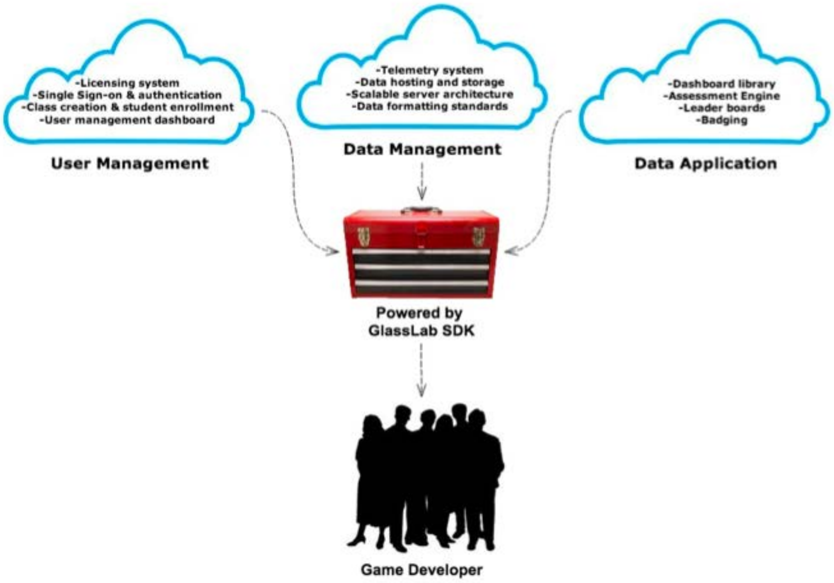
Partner with Game Jam organization to execute

- **Step 1 - Create Game Jam Prompts and Mentoring**: Make learning target focus fun, compelling and accessible: Game Jam focuses on difficult to teach and assess Common Core, 21st Century Skill and Next Generation Science standards delivered to contestants in an engaging manner. Contestants can choose their focus, we accept up to 10 (??) applicants for each standard, once we reach 20 they need to find a new standard:
    - Example game jam prompts (also generated by community):
        - "Persistence"
        - "Steep versus flat" (math, slope of a line)
        - "Liar, liar" (argumentation)
        - "Solid, liquid, gas" (science)
        - *etc.*
    - Game jams usually use only a single prompt. Five is too many, 2-3 may be OK.
    - Learning and assessment designer assigned to each standard who hosts

    office hours with contestants prior to game jam

- **Step 2 - Host Game Jams**
    - *Lots* of organization and promotion to drive participation
    - Game dev companies: Motivated to fund an area they have a vested interest in (for example: Disney can fund creativity)
        - blanket exemptions from non-competes
        - site hosting
        - “20% time” time off for employees
        - Donation of base IP such as game engines, IP (like Skylanders e.g.) or art assets
    - Cash prizes from contributing companies up to $300k to make the game commercially viable quality
    - Each contributing game development partner commits to funding at least one of the ideas, “shark tank” style.
- **Step 3 - Fund Commercial Development of Winners**
    - Winners are funded to bring their games to commercial quality over 6 - 12 months
    - Funding also integrates games onto the Powered by GlassLab Platform to ensure classroom access and robust assessment data capabilities

- **Funding Requirements:**
    - Marketing Launch and Game Jam Hosting: $500k ?
    - Top 50 winners funded to commercialization: $15,000,000 raised from institutions who commit to funding a winning idea and have the right of first refusal for licensing
    - Powered by GlassLab Infrastructure: $3,500,000 (see below)


-Licensing system
-Single Sign-on & authentication
-Class creation & student enrollment
-User management dashboard
User Management
-Telemetry system
-Data hosting and storage
-Scalable server architecture
-Data formatting standards
Data Management
-Dashboard library
-Assessment Engine
-Leader boards
-Badging
Data Application
Powered by
GlassLab SDK
Game Developer

Request for Information Response

Math & Science Academy

Date: March 7, 2014
To: Office of Science and Technology Policy
ATTN: Cristin Dorgelo
RFI: 79 FR 2201
Design and Implementation of "Pull Mechanisms" for Technologies that Significantly Improve a Given Learning Outcome
Issued: January 13, 2014

Executive Summary

The basic premise of any teacher professional development is carried by the following sentence: *The way we represent numbers not only carries the idea of numbers; it also determines what and how we think about numbers.* How we represent numbers also defines how we reason with numbers and how precisely we communicate our mathematically thinking. It is not only important for one to be able to use numbers and their operations to problem solve; it is just as important to move beyond the various mathematical procedures used to relate, move, and execute on numbers to a conceptual understanding of numbers and the properties that govern them. To this end, then, future teachers and practicing teachers' professional development program objective should be to assist teachers gain a profound understanding of the fundamentals of mathematics.

It is our vision that the **Multidimensional, Multicomponent Collaborative Working Space** will serve as the node around which private, state, and corporate entities and ideas will accrete and become something that begins to have influence on the way we prepare future teachers and continue to professionally develop our current corps of teachers. It is imperative that those in charge of teaching mathematics to our future mathematicians have the ability to think mathematically.

It is clear that the educational issues, specifically in mathematics education, facing our nation are comprehensive, varied, and complex. Accordingly, a broad-based, coordinated approach that brings many and varied entities together to collectively seek solutions is required. It is our vision that the **Multidimensional, Multicomponent Collaborative Working Space** will serve as the node around which private, state, and corporate entities, as well as experts in the fields of education, mathematics, cognitive psychology, and neuroscience will coalesce and become something that begins to have influence on the current state of our national educational continuum and the ideas that governs it. To this end, we accept the challenge of our nation's educational dilemma, and we also invite and embrace others' ideas and expertise in developing and growing a learning technology that effectively meets and transforms our educational conundrum.

It is important at the onset to state that Los Alamos National Laboratory (LANL) is seeking more than just an avenue to improve future-and-practicing teachers' content and practice. We are seeking a partnership(s) that goes beyond the numbers. It is our vision that a **Multidimensional, Multicomponent Collaborative Working Space** is the glue that binds us all and begins to look at our educational issues as a continuum instead of individual problems to be solved by isolated entities.

Math & Science Academy

Math and Science Academy (MSA) is a program for teacher professional development in Northern New Mexico created by Los Alamos National Laboratory in collaboration with New Mexico Council for Excellence in Education. The focus of MSA is providing rigorous, continuous and consistent professional development training in mathematics and science for K-12 Bureau of Indian Education (BIE) and Pueblo Community school teachers.

MSA offers professional development training through Summer Institutes, the Ir-Rational Number Institute, and coaching by master teachers. The Summer Institute is a three-week summer training where teachers receive intensive mathematics and science training and teaching strategies to use in their classrooms. The Ir-Rational Number Institute is a four-Saturday per semester sequence that builds upon the Summer Institute training and addresses areas of specific teacher needs. Additionally, MSA has four master teachers who visit MSA teacher classrooms to observe teaching practices and to support teachers in content areas self-identified by teachers.

Program Objectives

- Increase teachers' content knowledge of math and science.
- Increase teachers' use of research-based practices to conduct effective, inquiry-based math and science lessons in their classrooms.
- Increase school and district leadership capacity so schools can make continuous improvement in math and science.
- Ultimately improve student learning and achievement in math and science in northern New Mexico.

Professional Development

Continuous and personalized teacher professional development is something that is not prioritized in United States as is in other high achieving countries. Research shows that sustained and intensive professional development for teachers is related to student achievement gains. Effective professional development is intensive, ongoing, and connected to practice to build strong collaborations and interrelationships among school networks. In United States, 90% of teachers have participated in professional development, 57% received less than 16 hours per year, and 23% received less than 33 hours per year on the content of the subject they taught. In Singapore, teachers receive 100 hours of professional development each year in addition to 20 hours a week they have to work with other teachers and visit each other's classrooms to study teaching.

Response to RFI Questions

1. *What learning outcomes would be good candidates for the focus of a pull mechanism to catalyze the creation and use of new learning technology? These outcomes could be relevant to early childhood education, K–20, life-long learning, workforce readiness and skills, etc.*

   The teaching and learning of mathematics (K-12) is an excellent *candidate for the focus of a pull mechanism to catalyze the creation of a use of new learning technology* on many levels. Researchers struggle to identify the cognitive and numerical competencies that predict students' ways of thinking mathematically and mathematical success. Therefore, university professors are challenged with what and how to teach mathematics to pre-service teachers within a limited time-space, which then leads to in-service teachers being unprepared to deliver effective K-12 math instruction; this cycle repeats, underprepared secondary students then move on to educational baccalaureate programs to meet the challenge of becoming an effective teacher of K-12 mathematics

2. *How are these learning outcomes currently measured and assessed?*

Currently, there is no common form of measure of assessment for students at any level. Internationally, U.S. 4^{th}-and 8^{th}-grade students mathematical abilities (scores) are compared to other students using the Trends in International Mathematics and Science Study (TIMSS). The TIMSS is administered every four years, 2015 is the next assessment year. In addition, at the international level there is the Programme for International Student Assessment (PISA), which is administered every three years to 15-years-olds globally. Again, the latest U.S. students' scores were flat while their counterparts in other countries continued to rise.

Today there is a movement to compare American students' mathematical understanding of mathematical practices and abilities against a set of common core of standards in mathematics as measured by a common survey. In addition, there are various short-cycle assessments that measure student mathematical growth on a quarterly basis. Finally, there are many formal and informal formative assessment instruments and methods used by teachers to modify teaching and learning as they attempt to peer inside the math-mind of their respective students. The latter being the most effective as it provides immediate feedback for both the teacher and the student.

3. *What information exists about current U.S. performance relative to this learning outcome? What information exists about the presence (currently available or potential given current trends or breakthroughs) or absence of effective interventions (technology- based, offline, or hybrid) to improve this learning outcome?*

In 2011, 20,000 4^{th}-and 8^{th}-students in more than 1000 U.S. school participated in TIMSS. The United States grade 4 was "among the top 15 education systems . . . and scored higher, on average, than 42 education systems."

On the 2012 PISA, the United States performed below average in mathematics and is ranked 26 among the 34 Organisation for Economic Co-operation and Development (OECD) countries.

It is clear that the educational issues, specifically in mathematic education, facing the United States are comprehensive, varied, and complex. Accordingly, a broad-based, coordinated approach that brings many and varied entities together to collectively and creatively seek solutions is required.

It is LANL's vision that a collaborative learning and support environment for teachers that connects the ideas of arithmetic to algebra will serve as the node around which private, state, and corporate entities and ideas will accrete and become something that begins to have influence on the current state of our educational continuum. To this end, we submit that an online **Multidimensional, Multicomponent Collaborative Working Space** be developed as a high-impact learning technology that will attempt to bridge the arithmetic to algebra instructional gaps as well as connect the efforts of researcher of mathematics to university pre-service teacher baccalaureate programs, and district in-service programs. The purpose of the **Multidimensional, Multicomponent Collaborative Working Space** is to systematize the learning outcomes of pre-and in-service teachers and continue on to make seamless the professional development of K-12 teachers.

We foresee a **Multidimensional, Multicomponent Collaborative Working Space** that is an analogue to the multi-component theory of working memory (phonological loop, visual-sketchpad, episodic buffer, long-term memory, and executive function) as described by Repovs, G. and Baddeley, A. A space where mathematical concepts are translated into text and voice (phonological loop), mathematical models like tables, graphs, drawings, and video (visual-sketchpad) and search capabilities (episodic buffer) all come together on one screen that compels the students' attention and problem solving abilities (executive function). No more clicking around from one screen to another or moving from one web site to another.

We envision a digital space where all memory pathways (semantic, episodic, emotional, procedural, and automatic) are accessed. A place where a simple mathematic thought and act are coordinated to become two mathematical simple thoughts or acts, these becoming a system of smaller thoughts organized into a complex network of mathematical thought. A place where experts in mathematics (PhDs in mathematic, researchers, cognitive psychologist, neuroscientist, and university professors) come together with practitioners to creatively collaborate to provide the teacher with quality professional development materials and opportunities (anytime, anyplace, and on any tech-device) that will increase the students' potential for understanding and developing a profound understanding of fundamental mathematics. Teachers need a regular, predictable environment—a place where the can build mathematical intuition without fear of recriminations or wicked judgments.

4. *Why would a pull mechanism in this area accelerate innovation in learning technology?*

Challenge: Technologists and developers are always looking for the next challenge. Many products have been developed to increase fun and engagement in the classroom but most have failed mostly because they overcompensate one problem and ignore most others. Creativity, ideation, and synergetic thinking are crucial components in designing and developing effective learning technologies. The challenge is to develop a learning technology that meets these criteria:

Low production costs: Low R&D, deployment, maintenance and access costs while maintaining high quality and accessibility.

Ability to maintain high levels of "time on task": How can we engage both teachers and students in learning mathematics where the goal is for them to not only solve mathematical problems using algorithms but also engage in critical mathematical thinking, expressing their mathematical thinking through precise mathematical language, mathematical models, and mathematical concepts?

Continuous improvement: When the users are given an avenue to be part of the creators they maintain and continually improve content, design, and modes of engagement.

Learning anytime, anywhere: Product that is accessible via multiple devices with online/offline access capabilities.

Personalization by artificial intelligence: A product that can learn user behavior and respond to user with customized content based on learned previous trends.

Content creation: Content captured from one user is logged and used by other users.

Interactive simulations that enable "learning by doing": Simulations are a great way of emulating real world situations or environments.

Embedded assessments that measure incremental proficiency: Assessments that not only measure correct answers but also measure mathematical thinking and reasoning, critical thinking, language, modeling, and increased or decreased levels of proficiency.

Monitoring and evaluation: Monitoring and evaluation is a systematic collection of information from the product to determine whether the product meets the expected goal, ways of improving, accountability, and make informed decisions on future development efforts.

5. *What role might different stakeholders (e.g. Federal agencies, state and local educational agencies, foundations, researchers, practitioners, companies, investors, or non-profit organizations) play in designing, funding, and implementing a pull mechanism for learning technology? What role would your organization be willing to play?*

As mentioned above, our aim is that a collaborative learning and support environment for teachers will serve as a rallying point around which private, state, corporate entities and experts from education, mathematics, cognitive psychology, and neuroscience to come together to positively affect teacher practice, which will ultimately and positively affect student mathematics achievement and learning. In effect, the creation of an open online **Multidimensional, Multicomponent Collaborative Working Space** will require a team effort from a number of professional fields to redefine how we continue to grow pre-service teachers and continue to professionally develop in-service teachers through a newly conceived method of program delivery.

The first and foremost inducement for any individual interested in any technological advancement is to create a novelty. It is, in fact, a strong inducement to create a new technology or reconfigure a new technology that is not in existence but whose component are, in fact, in existence—in this case, to fashion a creative collaborative learning technologies prototype for teachers' life-long learning and professional development. To bring together at one point, in one space, on the same screen interactive instructional modules created through text, voice, video, sketchpad, modeling, and graphing components that will compel both teacher and student to use their inherent thinking tools to link previous knowledge structures with incoming information, content, and concepts. Creating, in the user, new memory networks and turning their full attention to learning and understanding mathematics at a profound level.

The second inducement is defined as a Point Solution Prize for creating a prototypical **Multidimensional, Multicomponent Collaborative Working Space** that in itself is a redefinition of the current status of learning technologies that stand alone or are in various locations on the Internet. A Point Solution Prize for redefining our current status of learning technologies would have a powerful effect on the field. Professionals and specialist would be intrigue and compelled at the thought of taking the currently accepted idea of learning technologies and look at it from a different perspective, and if it works—reap a handsome monetary prize. The outcome is nothing new, but now it is in a new place: a fresh perspective from which new ideas will spring.

What role would your organization be willing to play?

Fourteen years ago Los Alamos National Laboratory along with other business and foundation partners, initiated The Los Alamos National Laboratory Northern New Mexico Math and Science Academy (MSA) to begin professionally develop K-12 teachers in our seven-county impact area. We have had many successes preparing both future teachers and current inservice teachers, but as we continue to work with teachers and school leaders, we see a need for continuous, embedded teacher professional development in ways that transform our current model. Consequently, in the summer of 2013, our MSA staff of four master teachers brought together a small team of individuals with noteworthy expertise in the teaching of mathematics and information technology to create a novel teacher professional development initiative: The Math and Science Academy Arithmetic to Algebra Project (AtoAP). The AtoAP, through its Internet delivery system, will attempt to bridge the instructional gap created by time and distance between alternating coaching and classroom observation sessions and other MSA professional development program components, i.e., The MSA Summer Institute, and the MSA math weekends (The Ir-Rational Number Institute). The purpose of the AtoAP, then, is to continue and make seamless the professional development of our MSA teachers as MSA promotes the algebraization of the early elementary grades through teacher professional development.

This experience and our commitment to making the MSA Arithmetic to Algebra Project a reality compels us to dedicate resources to further advance the idea of a **Multidimensional, Multicomponent Collaborative Working Space** for professionally developing teachers.

6. *What changes in public policy would facilitate experimentation with pull mechanisms at different levels of government?*

Depending on the state, the public policy governing teacher professional development criteria vary with that state's political and philosophical bend on instruction and learning. In our state, current policy on teacher evaluation system requires teachers to continually improve their practice as part of a comprehensive teacher evaluation system. However, the current policy does not specify any particular curriculum or program of study. So, a teacher's personal program to improve her practice need not be a continuous, coherent program, but, alternatively, it can be a series of disconnected professional development opportunities that in many cases a teacher is responsible for financing.

More and more schools do not have opportunity or budgets to send teachers out for professional development, and with new requirements schools may find it difficult to support teachers in this domain. School districts and teachers may find it easier to seek out professional development opportunities when it is convenient and related directly to what they need.

It makes sense to provide quality, comprehensive teacher professional development that is contiguous, embedded, and available anytime, from any place, and on any device. It also makes sense that the professional development is open and free or at marginally low cost to the user. In addition, it makes sense that the professional development wrapped in the **Multidimensional, Multicomponent Collaborative Working Space** be compelling and provide the user with the opportunity to develop a profound understanding of the mathematics.

So what public policy changes need to occur at various levels of government to facilitate experimentation with pull mechanisms? **A public policy that completely transforms the preparation and selection of future teachers, and also transforms how we continue to professionally develop our current inservice teachers.** The focus has to be on teachers, what they know, and how we get them to know what they need to know. Research suggests that among school and other student achievement factors, the teacher is the number one factor in the classroom that determines student learning and achievement.

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LUMINARY
LABS

OFFICE OF SCIENCE AND TECHNOLOGY POLICY
REQUEST FOR INFORMATION

Introduction

Luminary Labs (GSA Contract GS-07F-015AA) is delighted to provide the Office of Science and Technology Policy with the following response to the RFI:

This Request for Information (RFI) response from Luminary Labs provides a point of view on how to effectively implement pull mechanisms for learning technologies that significantly improve outcomes.

We are addressing all questions in the RFI, and are primarily focusing on pull strategies and specific tactics such as incentive prizes and milestone payments.

Luminary Labs has a strong track record in helping to develop innovation challenge systems, as well as designing and executing individual challenges and competitions. We are particularly well known for our work with regulated industries, which share many attributes found in government agencies. These structures present unique risks and anticipated difficulties, such as determining intellectual property stance and ownership, protection against future claims, developing an authentic and attractive call-to-action aimed at the innovation community, and forging public/private partnerships.

We thank you for your consideration and look forward to hearing from the Office of Science and Technology Policy.

Company Name: Luminary Labs LLC

Company Contact: Sara Holoubek, CEO

Contact Information: 185 Franklin Street, 5th Floor, NYC, NY 10013, [redacted] [redacted]]

(1) What learning outcomes would be good candidates for the focus of a pull mechanism to catalyze the creation and use of new learning technology? These outcomes could be relevant to early childhood education, K-20, life-long learning, workforce readiness and skills, etc.

Before we identify specific outcomes, let's discuss the purpose of a pull *strategy*. Described in industries and sectors that have been fully transformed by the internet, handheld devices, social networks, sensors and other technologies, pull strategies help connect to the original purpose within each individual, our best intentions. A pull vs. push strategy acknowledges that top-down, hierarchical, supply-chain-centered industrial models of delivering services have reached the limits of effectiveness in a connected world.

A well-designed pull platform provides a process to attract the best minds, support the best teams, incentivize the best ideas, and provide a structured feedback loop to ensure the best outcomes are achieved, and that all stakeholders learn together[1].

A pull mechanism is a critical shift in how services and the efforts of individuals are financially rewarded: the best incentives delivered at the right points in the process to describe the challenge, to attract the best people and ideas, and to reward not just the best outcomes, but our collective understanding of which solutions deliver the best outcomes. In this RFI response, we will recommend a pull strategy, propose a pull platform design, and discuss specific pull mechanisms.

To define the best outcomes in education we recommend defining an overarching civic outcome defined in human terms: *to ensure that all investments in education result in employable, contributing citizens who are committed to a lifetime of continuous learning.*

One constant has impacted the lives of working Americans more than any other force: the rate of technological adoption in all sectors of the economy. From the radical shifts in media publishing, to the digitization of factories, to the adoption of algorithmic trading in finance, to the consumerization of information technology across the corporate sector, to the rise smartphones and sensors; the world outside of education is changing more rapidly than the practice inside our education sector.

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[1] *The Power of Pull: How Small Moves, Smartly Made, Can Set Big Things in Motion*, John Seeley Brown, John Hagel, Lang Davidson, Basic Books, 2010.

Yet technological change has resulted in marginalization for those that have not been equipped with the skills – not just discrete technology skills – but an agile, continuous approach to mastering the ability find one's purpose and contribute in a world of constant change.

The tasks of preparing ourselves for the constant of repeated rapid technological breakthroughs extends not just to the young generation, but also for all Americans who work. The commitment to stay meaningfully employed becomes not just a survival instinct but an investment in continuous learning, resulting in more meaningful work that generates not just productive taxpayers, but empowered citizens who find their identity in what they contribute.

Once we've committed to an overarching outcome, we can then break down specific metric in the context of how we want to measure the effectiveness of any one technologically driven solution. For Pre-K through university and higher education, all metrics should ladder up to an overall "KPI" or key performance metric – *how employable is the student upon graduation*. Literacy and math proficiency, comprehension of scientific principals, history, and philosophy – all of these abilities ultimately measure up to an ability to stay and be meaningfully employed. For lifelong learning and workforce development, another KPI is added – employability is critical, but so is *the level of citizen engagement in the process of lifelong learning*, not just to be employable, but to be good parents, healthy citizens, effective caregivers for parents and loved ones, and informed voters.

"*Education is the kindling of a flame, not the filling of a vessel*." – Socrates.

(2) How are these learning outcomes currently measured and assessed?

Current learning outcomes are more narrowly focused on educational attainment metrics.

Historically, assessment was determined and conducted through direct evidence and indirect evidence of student learning. Direct evidence includes assessments such as the number and completion rate of course and homework assignments, standardized tests, term papers and reports, observations of field work, research projects, portfolios, class discussions, classroom response, enrollment rates, drop out rates, presenteeism and absenteeism, and grades based on explicit learning criteria[2]: all measuring education in output, not efficacy.

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[2] *Middle States Commission on Higher Education, Student Learning Assessment: Options and Resources, 2nd ed.,* 2007, 38.

Indirect assessment measures are conducted to assess the overall education system: mid and end of semester course evaluations, course-level surveys, percent of class time spent in active learning, and department or program review data, for example.

In workforce and lifelong learning, similar metrics are utilized, but there is greater emphasis on employability, and job placement rates.

These outcomes are measured and assessed using a combination of paper documentation, and technology based document management, test delivery, and assessment analysis. While certain districts, states, and workforce education companies may employ state-of-the-art technologically enabled assessment technologies, many do not. There is uneven distribution of technology adoption, and therefore use of technological tools to administer tests, analyze data, and share insights and results.

What is missing in the current assessment practice is the ability to collect all data, store that data, and share across interstate boundaries. We not only lack a standard framework for testing, measuring, and learning, we lack a common vocabulary for how to test the intervention of technological solutions.

But most importantly, there is a dearth of creativity, human-centeredness, and iterative learning in the definition of these assessment metrics and frameworks. This explains why teachers and parents resist not just common core standards, but technological interventions of any sort, inclusive of digitally delivered assessments.

As part of the design of a pull platform for education, we recommend a stakeholder involvement process that engages all stakeholders not just in the evaluation of technology solutions, but also in the assessment of the actual assessment metrics developed. We only have strong hypotheses about which assessment measures will be the most effective at indicating that we are creating a citizenry of employed life-long learners. Using the best practices of effective technology companies, a well designed pilot/test design phase of a pull platform, assessment results are best if shared, discussed, and questioned in an iterative fashion- to determine if the assessment metric itself should be utilized going forward.

(3) What information exists about current U.S. performance relative to this learning outcome? What information exists about the presence (currently available or potential given current trends or breakthroughs) or absence of effective interventions (technology-based, offline, or hybrid) to improve this learning outcome?

We are falling behind, competitively, as a country, based on the evidence declines in learning outcomes across the U.S.

- College attainment rates in the US are stalled at just under 40% (vs. completion rates of 59%)[3]
- The World Economic Forum ranks the US just 49th out of 148 developed and developing nations in quality of math and science instruction.[4]
- NAEP Nation's Report Card samples more than 700,000 students across the country each year to provide a nationwide snapshot of math and reading performance of 4th and 8th grade students, finding most recently that only about 40% of students have attained proficiency at each grade level and in each discipline.[5]
- The Program for International Student Assessment, or PISA, compares test results across 65 countries to produce rankings every three years. The most recent results, in 2012, "show that U.S. students ranked below average in math among the world's most-developed countries. They were close to average in science and reading."[6]

Our early technology solution interventions have yet to find sufficient scale that both fills critical learning gaps, and levels the playing field.

- A lack of quality metrics to assess effectiveness and outcomes across the educational ecosystem leads to less scalability for digital learning platforms.
- Digital illiteracy and lack of incentives for professional development leads to learning gaps and a digital divide.
- Large-scale experiments and innovative approaches often fail to involve the teachers and faculty in their vision, and fail accordingly.
- Disagreement exists about the completion rate for MOOCs and other innovative online learning environments. Is 5-16% a sign of deep engagement for the self-directed, or sign of failure on the relative value curve. [7]
- Education concepts that captured the imagination of innovators such as edutainment failed to gain traction and find sustainable business models.[8]
- Venture funding for K-12 is starting to show signs of growth, but the sector has seen several large-scale failures with few profitable exits for early investors vs. social media and Internet technology, health tech, and other sectors.

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[3] US Department of Education, National Center for Education Statistics. *The Condition of Education 2013 (NCE 2013-037), Institutional Retention on Graduation Rates for Undergraduate Students*. 2013.

[4] The World Economic Forum. The Global Competitiveness Report. 2012-2013.

[5] National Assessment of Educational Progress. The Nation's Report Card: Reading 2011. Math 2011.

[6] OECD. *Strong Performers and Successful Reformers in Education - Lessons from PISA 2012 for the United States*. 2012.

[7] NMC Horizon Report. *2014 Higher Education Edition.* 2014.

[8] *What in the World Happened to Carmen Sandiego? The Edutainment Era: Debunking Myths and Sharing Lessons Learned*. Cary Shuler. October, 2012.

(4) Why would a pull mechanism in this area accelerate innovation in learning technology?

Government, the private sector, and philanthropic organizations have employed pull mechanisms to accelerate the formation and adoption of new technologies that drive measurable outcomes across many industries, yet this approach has been underutilized in the educational sector. One area of concern in the government sector is that early experiments in hackathons, open data jams, and single stage apps prizes yield non-sustainable, non-scalable solutions. Private sector prizes that are not aligned to a meaningful strategic goal, or do not inspire the best and brightest minds, fail to deliver lasting change to the system.

A pull mechanism, deployed in the education sector, on its own, will not necessarily result in positive outcome for the lives of students and citizens.

We believe that pull mechanisms need to be designed as part of a larger innovation system. Pull mechanisms in the form of innovation prizes have positive potential benefits when there is information asymmetry between funders and solution developers, and when it is difficult to identify the best path to achieve a desired outcome.[9] [10] Risk is mitigated and shared with the innovator – as only those solutions that demonstrate outcome are paid for their results.

The best technology companies can inspire us by applying their approach to utilizing pull strategies and pull platforms. Open sourced and agile methods of divining the highest impact solution embrace early failures that lead to longer-term successes.

For technology optimists, the convergence of several factors points to the potential for huge advances in educational technology to drive meaningful outcomes: advances in neuroscience, cognitive psychology, educational technology, big data, social media and social data, wearable technologies, connected devices, the internet of things – all point to a rich area of experimentation to solve entrenched problems that traditional methods have failed to accomplish.

Extrapolating the potential benefits of technology and software to education as a core strategic advantage means the chance to reap the benefits of low marginal cost, continuous, iterative improvement, anytime/anywhere availability, predictive analytics, and personalization.

The opportunity is tremendous. But the rate of technology adoption is mediated by the social cultural readiness to embrace technological change. We can temper the need to see

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[9] *Role Models for Radical Innovations in Times of Open Innovation*. Hans Georg Gemünden, Sören Salomo, Katharina Hölzle. Creativity and Innovation Management Volume 16, Issue 4, pages 408–421, December 2007.

[10] *Prizes for Technological Innovation*. Thomas Kalil. Brookings Institution. 2006.

the continued problems in education as an *engineering* problem to be solved, and reframe the approach to technology solutionism by adopting a stakeholder-centric model of innovation.

(5) What role might different stakeholders (e.g. Federal agencies, state and local educational agencies, foundations, researchers, practitioners, companies, investors, or non-profit organizations) play in designing, funding, and implementing a pull mechanism for learning technology? What role would your organization be willing to play?

Stakeholder involvement is a requirement to the effective use of pull strategies, and we recommend designing not just a pull platform, but also an overall innovation system.

We recommend an open-sourced, design-centered, stakeholder-driven approach to applying pull mechanisms for the widespread adoption of high impact learning technologies in the US educational sector. Constructed as a multi-stage innovation platform with prizes awarded to the leading solution developers, this approach is ideal for a sector that has been sometimes resistant to adopt new technologies, and by stakeholders who fear the negative implications of centralized, standardized approaches to assessment.

Recommended components to a pull platform for education include:

- Stakeholder definition and involvement at key phases.
- Need identification developed with a board of advisors representing key stakeholders.
- Public-private partnerships formed where government, private sector, and non-profit entities sign up to sponsor solution identification for the educational sector.
- Volume and variety in the form of multiple innovation prizes launched, each determining a discrete and framed call-to-action for innovator participants at the federal, state, and district level.
- Open innovation prizes that encourage entrants from multiple disciplines, and diverse entrepreneurial sectors.
- Application of the best practices of leading tech incubators that encourage active mentoring and iteration of the original concept into a scalable, high impact solution.
- Use of the best methods from design thinking and participatory design, creating an environment where educators, parents, students and entrepreneurs can engage in open dialogue in a safe space, and identify the deepest unmet needs.
- Public voting mechanisms to encourage continued citizen engagement.
- Qualified multi-disciplinary judging teams.
- Piloting phases with multi-stakeholder stewardship, with results that are publicly shared.

- Agile, iterative approach to outcomes and goal setting – the very purpose of the open innovation exercise can be to welcome technology not as a disruptor of human involvement, but as a tool to empower citizens.

Finally the pull mechanism itself: a no-strings-attached series of prizes to the innovators that best demonstrate outcomes defined, and who iterate and share their learning with the larger educational tech community. Intellectual property rests in the hands of the innovators taking the risk, but open to all types of entities (for profit, not-for-profit, benefit corporation, or individual inventor).

The role of different stakeholders becomes more clear when they see how and when to get involved:

Federal agencies: Based on provisions made available in the America Competes Act, the opportunity for substantial, large-scale public-private partnerships can extend the reach and geographic impact of these experiments at scale. Federal agencies should initiate multiple competitions and innovation prizes, and seek private sector partners to share in funding, definition of learning outcomes, mentorship, and other forms of support.

State and local educational agencies: The Federal government can provide an innovation system as a model for state and educational agencies, and incentivize a portion of funding to be delivered to administer these pull platforms, and matching prize awards for those technologies that deliver the greatest outcomes.

Foundations: The Gates Foundation, Robin Hood Foundation, and others have experimented with pull mechanisms in other sectors such as agriculture, and are focused on large-scale grants to generate better outcomes. By involving these or similar foundations in the design of the innovation system, and specific challenges, the foundations can support with grant funding, matching prize incentive awards, and can also provide meaningful insight and the ability to share outcomes and insights with all stakeholders.

Researchers: By developing an open sourced system, publically funded innovation exercises and their outcomes (shared through pilot/test phases) provide a rich resource for all researchers involved in education, and educational technology. Effectively designed pull mechanisms would also accelerate the technology transfer of intellectual property from academia to the field.

Practitioners: After the students themselves, teachers have the most to gain, but many fear they have the most to lose from the introduction of new technologies into the classroom. A majority of teachers say they aren't being listened to on matters of education policy at the state or national level. At the school level, 69 percent of teachers said their opinions carried weight.[11] A successful pull platform would involve teachers to help define goals as part of a

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[11] *Primary Sources: America's Teachers on America's Schools*. Scholastic Inc. and the Bill & Melinda Gates Foundation. 2014.

crowdsourcing exercise, and would involve teachers as mentors to the technology solution developers, providing meaningful input to the creation and deployment of these solutions in school. If pull mechanisms are well funded, we may encourage a new generation of teacher-innovators.

Companies: Companies have already expressed interest in funding education, and a pull platform will appeal to the performance culture of the private sector. The private sector is accelerating the rate companies deploy open innovation pull platforms to drive the development of technologies and attract the talent they need to compete. Companies have demonstrated a willingness to sponsor challenges outright, or provide matching incentive funds.

Investors: Investors in seed stage and growth stage companies are eager for the education sector to grow at the same speed as the health technology sector. The federal government's commitment to a shift in incentives for health outcomes has accelerated investment in all stages of health technology, and we are now witnessing an explosion of new ideas, and new approaches. Investors make for excellent mentors and judges in an innovation system, as they can provide business model advice and fund those technologies with the most sustainable, repeatable, highest outcome solutions.

Non-profit organizations: Not-profit organizations can be called upon to extend the participation of their participants in key components of an innovation system: to work with stakeholders across a variety of socio economic groups to identify need, to recommend specific communities for test pilots, and to provide mentorship and judging of winning technologies.

Innovators: Critically important to the system are the innovators themselves. Founders, innovators, and those with the scarce technology skills in the US are eager for more meaningful applications of their knowledge for the benefit of humankind. The first generation of internet-enabled technology has done a great deal to benefit humanity, within limits. Technology innovators are collaboratively connected through the tools they have created – through open source projects, tools like GitHub and knowledge sharing sites like StackOverflow. Technologists regularly volunteer their time to civic hackathons and serve as mentors and participants in innovation competitions. A pull platform is designed to appeal to the best and brightest innovators, and encourage them to create the technologies that will empower generations of lifelong learners, employed Americans, and engaged citizens.

What role our organization, Luminary Labs, would be willing to play: we are experts in designing systems for open innovation. We have worked with government and the private sector on pull platforms for innovation in health technology, primarily, and we would like to design the overall system, and program manage the platform for challenge design and development, execution, pilot management, and stakeholder involvement. Depending on the size of commitment by the Department of Education and other agencies, we would deign the overall system to involve other stakeholders to manage components of the system, but we have full capability for executing end-to-end innovation systems.

Luminary Labs has a strong track record executing sophisticated innovation challenges and competitions for the private and public sectors. We are particularly well known for our work with regulated industries, which share many attributes found in government agencies. These structures present unique considerations such as determining intellectual property stance and ownership, developing an authentic and attractive call-to-action aimed at securing the best submissions, and forging public/private partnerships.

In the last 30 months, Luminary Labs has been charged with producing 10 large-scale innovation challenges, awarding over $2,000,000 in non-dilutive cash prizes, as well as non-monetary awards, including:

- Sanofi US Data Design Diabetes Series: 2011, 2012 & 2013
- Janssen Connected Care Challenge to reduce hospital readmissions, 2012
- The Alzheimer's Challenge, 2012
- Ignite Ideas Challenge, 2013
- Collaborate | Activate Challenge, 2012
- Collaborate | Innovate Challenge, 2013
- Merck | Heritage Provider Network Innovation Challenge, 2013
- FDA Incentive Prize Competition for Improvement and Validation of Methods for the Detection of Microbial Foodborne Pathogens, launching in 2014

Luminary Labs is experienced in all aspects of challenge management, including challenge design and framework, front and backend innovation platform customization, communications, submission and judging workflows, virtual accelerator/testing environments, event management, and program management.

The Luminary Labs team includes both the products of public education and parents of children in public education, and we as a company are driven by our core value and purpose as lifelong learners, and educators. Many of us serve as professors in local NY academic institutions, and contribute to thought leadership in the field. We are eager to apply our expertise, and practical experience with education, to design a pull strategy for education in this country.

(6) What changes in public policy would facilitate experimentation with pull mechanisms at different levels of government?

Currently, pull mechanisms are available to each government agency through the America COMPETES Act, and experiments exist at the federal level for the Department of Education. Additional, a number of forward-thinking mayors have launched innovation challenges in major cities such as San Francisco, Washington DC, and New York City, proposing incentive prizes for apps that solve social and educational issues. To date, however, these pull mechanisms are seen as tactics, and participants in both federal and local challenges see these events as opportunities to earn press and reputation, but few have resulted in sustainable business models, let along educational performance outcomes. Apps challenges to date have been designed to incentives apps that solve for social gaps, rather than designing an overall pull platform to encourage the most effective solutions, with the highest learning outcomes, and the most sustainable business models.

Meanwhile, funding for education has remained static at the federal level and has declined in key state governments. Technology solutions in these constrained environments are then evaluated primarily for their ability to earn cost savings, rather than determining the positive or negative effects on learning outcomes. Further federal and state technology investments in advance of proven demonstrable educational outcome will only serve to ignite the criticism of weary taxpayers, and reluctant risk-averse practitioners.

We recommend a shift in policies that lead to technology spending from push to pull models, and adopt an agile approach to funding. Rather than mandate a large-scale technology systems model that focuses on the deployment of technology infrastructure and interoperability, we recommend modeling the best practices of the software sector. By quickly defining stakeholder requirements, and building solutions in agile pilots in specific local populations, and proving out efficacy before a larger commitment is made. The winners of an incentive prize then have the evidence and experience to accelerate the lengthy sales and implementation prizes, and further pull incentives for continuous iteration is awarded to those solutions that generate the biggest outcomes, fill the known gaps, and level the playing field for all. Rather than funding specific technology solutions, or assessment development efforts; the pull platform itself is set up as an open policy and solutions lab for the education sector.

"*Our freedom is the way in which we are able to let the world open before us, and ourselves stand open within it.*"[12]

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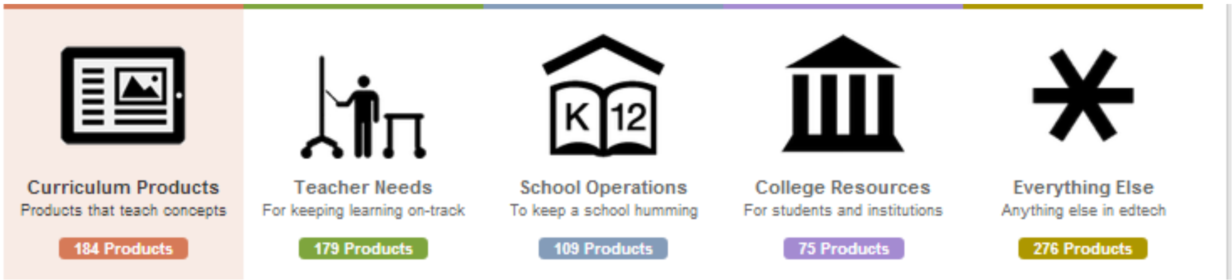
[12] *The Illusion of Technique: A Search for Meaning in a Technological Civilization.* William Barrett. Anchor Press. 1979.

Monitor **Deloitte.**

Office of Science and Technology Policy RFI on Pull Mechanisms in Education
Monitor Deloitte Response

March 7, 2014

Over the past couple of years, the field of education has seen hundreds of learning technologies appear that seek to address a wide range of learning outcomes. Whether it is curriculum products, teacher tools, school operations software, MOOCs, apps for parents, or digital textbooks, each of these technologies aim to directly or indirectly move the needle on student outcomes.



Source: The EdSurge Edtech Index

In theory, these technologies give the White House Office of Science and Technology Policy (OSTP) considerable latitude in choosing which learning outcome(s) to target. In practice, however, the choice is significantly circumscribed by the Government's desire to use a pull mechanism. In our experience, not every objective can be achieved via a pull mechanism. The target outcome(s), and the circumstances around it, have to be "pullable." If they are not, a pull mechanism simply will not work.

When Do Pull Mechanisms Work?

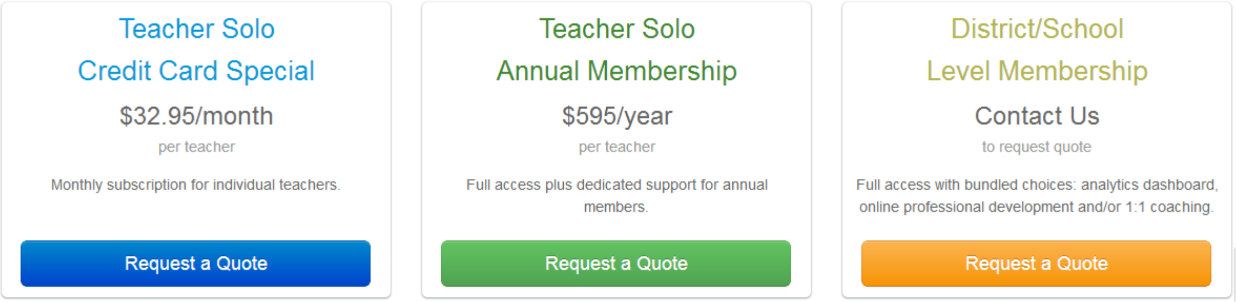
There are a number of factors and conditions we look for to determine pullability. An obvious one is **a clear and measurable indicator**. Eventually, we need to be able to declare a challenge winner. In order to do that, we need to know a certain outcome has been achieved. An outcome that aligns to the trend of 21st Century skills, like a "more entrepreneurial student," might be highly desirable, but it will be virtually impossible to measure whether one student is more entrepreneurial than another. An outcome like "ability to read at grade level by 3rd grade" is far more measurable, and hence more appropriate for a pull mechanism. There is also significant evidence that 3rd grade reading is highly predictive of educational outcomes later in life (i.e., high school graduation, college enrollment and completion). We acknowledge that this sort of outcome will lead directly into the "assessment wars," as it will require OSTP to choose a specific assessment measure to use. On the plus side, a challenge in this area could also change the incentives and expectations for ed tech entrepreneurs, who have been reluctant to date to hold themselves accountable for specific learning outcomes.

A second condition we look for is a **"Goldilocks" situation**. We are trying to crowd potential solvers into a particular space to achieve an outcome. If they deem that outcome too hard to achieve, they will not crowd in and we will not achieve our objective. If, in contrast, the outcome is relatively easy to achieve, we will crowd solvers into addressing a problem that would have been solved in any case; we will have wasted our prize money. The right outcome needs to be a stretch, even a major stretch, but an achievable one.

Third, we would ideally like to see some sort of **ongoing market demand for the prospective solution**. We want solvers to rush into a space, achieve the target objective, win the prize, and then continue to operate and innovate in that space well after the prize or challenge has concluded. In this way, the solution will be scaled-up and achieve the target outcome across a large number of pupils. We do not want solvers to win the prize and then stop offering the solution, because there is no ongoing market incentive. Ongoing, addressable market demand will help keep them in the game and help us achieve the scaled outcomes we want.

Finally, we look **to overcome the right type of barriers to achieve our target solution**. We are targeting a particular learning outcome because, despite our efforts, various barriers are preventing us from achieving that outcome. Some barriers are more amenable to a pull mechanism than others. For instance, if a solution is not being deployed for want of capital, then an after-the-fact prize will not help. In contrast, we have often seen a first mover disadvantage, whereby the first solver will incur a range of costs to identify the solution (e.g., figuring out the business model, marketing the solution to stimulate demand, etc.), and then follow-on solvers can quickly offer that same solution without incurring those costs. In this situation, a prize to reward the disadvantaged first mover can be very effective.

Another barrier is the way the education market currently operates. The market is not terribly “free,” with states and districts often being the main buyers for technology solutions. Selling to schools often takes many months, if not longer, as districts can require significant buy-in from major administrators and the community to move forward. Creating a prize that connects education technologies directly with consumers (e.g., teachers or students) may decrease the lead time to adoption and increase the scale of a solution. Successful examples already exist: in addition to targeting districts that will require a longer lead time, Goalbook, for example, directly targets teachers to decrease the lead time to adoption of their solution.



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Source: Goal Book app https://goalbookapp.com/teachers

Because various conditions and factors, such as the ones listed above, are important in determining the viability of a pull mechanism, our view is that it is quite difficult to identify an important problem that is also highly pullable. Indeed, OSTP would be wise to undertake sophisticated analysis of learning outcomes that will be good candidates for pull mechanisms.

What is the Proper Role for Various Stakeholders in a Pull Mechanism Process?

Also difficult, and yet critical, will be determining what roles different stakeholders should play in designing and implementing a pull mechanism. Doing this will be difficult, because determining the appropriate role of different stakeholders will depend largely upon the specific context in which they are operating. It depends upon the specific learning outcome that is targeted, and it also depends upon what geographic place a prospective solution is piloted.

Sorting out what the stakeholders ought to do will be critical, because overcoming the various barriers and realizing a targeted learning outcome probably cannot be accomplished via a single pull mechanism alone. We are interested in tackling important and persistent issues in education. These issues persist because there are multiple and complicated barriers to a solution (otherwise we would have solved them by now). It is likely that a pull mechanism on its own cannot solve the entire issue. Probably, we can only reach the targeted learning outcome through a mix of pull and push interventions, and these other push interventions will need to be carried out by the right set of stakeholders. Involving the stakeholders, getting them to understand the pull mechanism, and how their actions can enable and facilitate that mechanism will be very important for the project's success.

Conclusion

Pull mechanisms are a potentially powerful tool for surfacing innovative solutions to persistent problems and accelerating the uptake of these solutions. Pull mechanisms have worked well for organizations that are seeking breakthrough technology solutions that have market potential. In the last few years, prize designers are also attempting to apply pull mechanism to R&D challenges and agricultural market failures, where, frankly, market forces are less robust and stable. In these contexts, pull mechanisms are often paired with "push" techniques, such as grants, to engage the right solvers.

There is no reason to believe OSTP cannot use pull mechanisms to achieve significant impact in the field of education. But, success will depend in large part on doing some meaningful, upfront analysis to identify interesting and important learning outcomes that, above all else, are "pullable." Some will be; many will not. Success will also depend on involving a range of stakeholders in the solution process. This will add an additional layer of complexity to the work. But it will be necessary, since a pull mechanism is, by itself, unlikely to solve big, important, and heretofore intractable problems in education. It will be necessary to identify key stakeholders and recruit them to perform appropriate interventions that will support and enable greater pull mechanism impact.

This proposal or quotation includes data that shall not be disclosed outside of the Government and shall not be duplicated, used, or disclosed in whole or in part for any purpose other than to evaluate this proposal or quotation. If, however, a contract is awarded to this Offeror or Quoter as a result of or in connection with the submission of this data, the Government shall have the right to duplicate, use, or disclose he data to he extent provided in the resulting contract. This restriction does not limit the Government's right to use information contained in this data if it is obtained from other sources without restriction. The data subject to this restriction are contained in this entire proposal.

Rinat Sergeev

"Data Scientist and Senior Scientific Advisor

Expert on professional contests and crowdsourcing

Former winner of multiple Math and Physics Olympics

"NASA Tournament Lab, IQSS, Harvard University

"I. A Theory.

First of all, in order to run the competitions, you need to create the competitive environment. And if you want the competition to drive the education in the scale of a country - you need a corresponding scale of competition, and you need a corresponding recognition of the competition. We already have a regular and popular school competitions in sports that are driving forward a sport culture in America. We need a similar scale and popularity competitions in sciences.

The feeling of competitiveness, desire to outscore your peer, is a very strong force, and usually undervalued in a current education structure, when the most of the grades your peers receive, are hidden from you. It is understandable, why the competitive element has been nearly removed from day to day classes, as it may have some downturns on the relationships between the peers. But it can and should be restored in a separate, gaming-competitive environment, when on special events everyone can voluntarily test their skills against the peers through-over the country.

Generally, every competition is not decreasing, but increasing the gap between more and less successful students. But, by analogy with a ""free versus planned market economy"", it also drives the whole education standard up and exposes the flaws in educational system that can be treated specifically afterwards.

The benefits of such an environment include:

a) Self-selection.

You don't have to compete in everything. Instead, you have a choice, as you can compete only in the things you like, and you can avoid the participation in competitions at all if you don't feel up to. So, you have a real chance to select and test the areas you may have some talents for.

b) Satisfaction.

It is a win-win game, as even if you have not scored for award-winning positions, you have tried to compete. No one of your class peers will know how bad your actual performance was, so you are still - a participant. So, you are already better than those, who have not tried it at all.

c) Learning.

Competitions is a great opportunity to show the students how the toughest and coolest questions in the area look like. To get a taste of it is an important and inspirational learning.

d) People selection and evaluation.

You have the winners. You have also those, who advanced far enough. Those may be talented guys with interest and potential skills for the area. It is great if they are noticed earlier and offered advanced learning programs.

e) System evaluation.

You will know the students from which schools are advancing the most, and which schools are on periphery. It is one of the easiest ways to measure the objective strength of the school program in a given area. It may also push the schools to improve their programs if they are not performing well.

f) System standards.

You create a scoring. You create a ladder. You have ""good"", ""the better"", ""the best"", ""the best of the best""…, so you have selected the very best students who will have a desire for and need of an access to the most advanced learning resources. These people will drive the standard of education up. They will show what the kid can possibly learn at the age. It is like in science - you need a few Nobel Prize laureates for Master and PhD students to be more competitive.

g) Area promotion.

You need stars. You need superstars. You cannot drive forward the education when all the superstars are in baseball, basketball, and football. You need to create the kid-star-winners in the educational areas. And they need to be honored and praised. And they need to be an example for the kid of how to become famous by studying. You are interested in what the stars are interested - it is a basic human nature. Why there are regular competitions between the schools in sports and none of a comparable scale - in sciences?

h) Small competition promotion.

Having a large competition in place, automatically benefits all the smaller competitions that can be build around it. In today's IT world, the competition can be as simply served, as a Puzzle-series or a Trivia on iPhones. The most exciting part of the competition is not even infrastructure or the tasks themselves - it is the meaning. You need to know that what you are doing is not a waste of the time, but earning your real credentials and beating your real opponents in a something, you can become a star of. The steps in a ladder should look simple and easy, but the ladder itself should go very high, it is then when it becomes really attractive. You pull the ladder from the top and it spreads in the bottom. The best competition is like the best computer game - should keep the player in a sweet spot between boringly easy and frustratingly impossible, with a growing reward upon mastering the skills and improvement of the results.

i) Breaking inequality.

Yes, you may think that competitions are increasing the social gaps as allow for early separation of better educated from worse educated students. But they are just measuring and reflecting the real picture there, not driving it. At the same time, these competition may reveal social groups and geographic locations that are underperforming, and they may receive targeted help. The best cost/efficient help, to my knowledge, is to organize centers (may be even online?) for advance training in specific disciplines in those locations. These centers should not substitute schools, but instead, provide intense training opportunity in a single specific area the students have shown some talents for on the competitions. For example, in Math. Or in Physics. Or in Engineering. Or in Programming. Or even in Acting? Design? History? Politics? Advanced training will allow the students to improve their results in those competitions year after year. We know that currently the best way for a talented kid to get out of a problem neighborhood is to succeed in sports.

Why cannot we add other ways out of ill-being, as to succeed in Math or Algorithmic programming?

Good confirmations are coming from Africa and Asia: there are multiple examples of the countries with extremely poor general education that are currently very competitive in some narrow disciplines like Math/Statistics and Programming. If you cannot get everything - try to perfect early in a something, and that is the way out.

II. An Example.

A great and old example of such a special competitive environment is a system of Math Olympics that has driven the high-level math education in multiple countries, especially in Russia and China. Once a year, on a special day, every kid in a country can openly enter a multi-step country scale competition within his age group, starting with district, then city, the country levels, and if you succeed, you can end up as high as on international-level event. The Olympics are startIng as early as at fourth grade, and the kids who advanced in competitions are offered advanced evening courses in Math. Schools are usually not pushing the kids to participate in Olympics, but they are very proud when any of their students succeed.

The Russian Olympics system has been developed in early 80th, more than 30 years ago. With a current advancement in informational technologies, it can be completely reworked and renewed, with a lot of competing and educational components to be moved online. Some components of the Olympics may even be going non-stop, being served upon online requests.

But what has to stay is a scale and prestige of the competition itself.

No kid will compete in anything that cannot make him to be a star.

"

Chuck Hitchcock

Chief Officer, Policy and Technology Director

National AIM Center, CAST, Inc.

"This Request for Information (RFI) offers the opportunity for interested individuals and organizations to identify public and private actions that have the potential to accelerate the development, rigorous evaluation, and widespread adoption of high-impact learning technologies. The focus of this RFI is on the design and implementation of “pull mechanisms” for technologies that significantly improve a given learning outcome. Pull mechanisms increase the incentives to develop specific products or services by committing to reward success. Examples of pull mechanisms include incentive prizes, Advance Market Commitments, milestone payments, “pay for success” bonds, and purchasing consm1ia. The public input provided through this notice will inform the deliberations of the Office of Science and Technology Policy (OSTP).

Five suggested pull mechanisms:

1. Recognition for quality products and services

a. Develop robust guidelines for the development and provision of evidence-based, fully accessible, usable, flexible and supportive educational software, content and services. To the extent possible, align guidelines with existing industry standards provided by organizations such as the W3C WCAG (web and document accessibility), IDPF (accessible EPUB), IMS Global (APIP, Access for All, SIF, SCORM, etc.) , Schema.org (for LRMI Metadata), etc.

b. Establish a panel to develop a reasonable definition for “evidence-based” that will encourage innovation and provide support to developers and publishers who may desire to indicate that a product or service warrants recognition although expensive large scale controlled study results may not yet be available.

c. Establish rubrics related to compliance or alignment with all of the above-mentioned guidelines and provide support for an accurate response to be provided directly from the developer, publisher or distributor.

d. Trust but verify. Establish a voluntary expert product and services review panel to validate the rubric submissions to the extent possible.

e. Recognize exemplary products and services by providing product descriptions and rubrics available for download from a funded website. Posting such information would be initiated only with permission from the appropriate developer, publisher or distributor.

f. Develop a communications program to promote and support the completion, submission and use of the products and services rubrics.

2. In addition to providing deserved recognition, offer reasonable tax incentives for developers and publishers that are able to deliver exemplary products and services for the education markets. Specific criteria will need to be established.

3. Adopt and promote guidelines for the development of products and services that are fully accessible by all learners, including those with sensory, physical and cognitive disabilities. Fund a pool of experts who can be made available to developers during the planning and development phases of their work.

4. Support a program that will increase the demand for education technology products that are evidence-based, fully accessible and usable by all learners, flexible and supportive of varied learning preferences and abilities. For an example of a program designed to increase demand for accessible digital learning materials, please refer to the PALM Initiative at http://aim.cast.org/learn/practice/palm.

5. Fund the development of modest product and service exemplars and make them available to publishers and those who desire to learn more about what should be expected from the OER and commercial markets.

"

OPPORTUNITY NATION
THE SHARED PLAN TO RESTORE OPPORTUNITY

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www.opportunitynation.org

March 6, 2014

Ms. Cristin Dorgelo
Office of Science and Technology Policy
1650 Pennsylvania Avenue, NW
Washington, DC 20504

Dear Ms. Dorgelo:

Opportunity Nation, a bipartisan, cross-sector campaign driven by organizations and individuals committed to expanding opportunity and closing the opportunity gap in America, is pleased to submit comments on the Office of Science and Technology Policy's (OSTP) request for information to help inform policy development related to high-impact learning technologies.

Opportunity Nation is a collaboration of more than 250 non-profits, businesses, educational institutions, faith-based organizations, community organizations, and individuals whose partners support, engage, and reach more than 100 million across the country. We are committed to the notion that an individual's zip code need not determine his or her destiny and that targeted actions to provide greater opportunity for young Americans will pay off in long-term economic success for communities and the Nation.

We are encouraged that OSTP has requested information on the design and implementation of "pull mechanisms" for technologies that significantly improve a given learning outcome. Opportunity Nation supports "pay for performance" or "pay for success" models and/or contracting as a way to grow support for effective programs and activities with demonstrated results.

Historically, the federal government has supported programs regardless of whether the services delivered actually achieved results, as long as providers met federally-prescribed rules that generally focused on inputs. As a result, the federal government has funded programs that haven't necessarily worked, costing taxpayers and negatively impacting the very individuals that programs were intended to help.

Under pay for performance or pay for success models – such as those currently administered by the Department of Labor under the Workforce Innovation Fund – government dollars are paid out when providers achieve intended results for the people they serve. Under these models, programs enjoy flexibility from requirements that often accompany the design of federal initiatives and in return, receive federal support based on the extent to which they meet performance measures.

In order to improve opportunity for young Americans in our current fiscal environment, we have to change the way the government does business. We need to ensure that we are getting maximum results for our investments at the federal, state, and local levels. Accordingly, Opportunity Nation supports OSTP's interest in stimulating a conversation about how pull mechanisms – such as pay for performance and pay for success models – could be used to accelerate the development, evaluation, and adoption of learning technologies.

Thank you for you for the opportunity to comment. If you have any questions, or if I can provide any assistance, please do not hesitate to contact me.

Sincerely,

Mark Edwards
Executive Director

A Small Business Perspective

In response to the Office of Science and Technology Policy (OSTP) request for information (RFI) related to high-impact learning technologies and pull mechanisms, our small business in educational technology is providing the following information for your review and consideration.

Quantum Simulations, Inc. is a small woman-led business in Pennsylvania and, since 1998, has conducted rigorous research and development of adaptive learning and assessment technologies using state-of-the-art and new generation artificial intelligence (AI) methods through federal Small Business Innovation Research (SBIR) grants and contracts at the Department of Education, National Science Foundation and the National Institutes of Health. Through evidence-based research and third-party field studies and evaluations, we have obtained **three patents on new AI methods, are proven in numerous studies to have an immediate and significant impact on student learning outcomes, and are rated as the "most helpful" resource by students.**

Our technologies contain all of the initiatives listed in the OSTP RFI, as follows:

- Low Marginal Cost
- Maintain High Levels of Time on Task
- Continuous Improvement
- Learning Anytime, Anywhere
- Digital Tutors
- Personalization
- Learning by Doing
- Embedded Assessment

Quantum has either launched or achieved tested prototype stage in diverse subjects such as: Accounting, Chemistry, Developmental Mathematics for Adult Learning/College Remediation and Braille.

All of our technologies are 508 compliant and accessed through the cloud using computer, tablet and mobile devices. **We have developed the *only* intelligent, adaptive learning and embedded fine-grained assessment tools which use mastery learning techniques that are easily integrated with existing curricula, textbook publisher homework systems and learning management platforms.**

We have all of this available technology and over 100 person years of knowledge and expertise, most of which is described quite well in the OSTP RFI, but you most likely have never heard of us.

Over the past decade, we have attempted to employ a business-to-business model by converting potential competitors into customers and have partnered with the key channels to market: textbook publishers. Although book adoptions have been their key focus rather than full technology implementations that can make a real difference, they are beginning to change. However, the main technology they are currently implementing is **adaptive diagnostics rather than adaptive learning**, which is discussed in more detail below. Anytime Quantum received commercial dollars, immediate reinvestment was made to promote, press release and direct sell to schools, community colleges and universities to generate a grass-roots movement. Our Accounting product is currently in over 350 two- and four-year higher education institutions and we have successfully delivered more than 1.5 million on-line sessions. However, we have not been able obtain the necessary market share or capital to penetrate the market in order to sustain a business. **Quantum is caught in the chasm of converting from grant funding to complete product development/commercialization. Textbook publishers dominate markets with unnecessary, ineffective and expensive products** leaving little to no room for schools and institutions of higher education to afford additional tools and improvements. Publishers have been slow to change and only through market pressures have they reduced pricing and have finally begun to offer digital solutions. However they are risk adverse and lack research expertise so innovation is slow and conservative, matching competitors feature for feature in an attempt to protect market share. For Quantum, it is extremely difficult to figure out how to "fit in" and, as it stands, **we may not survive past 2014 and are actively seeking partnerships, investments (including PRIs from foundations) and federal/state procurement opportunities**, but continue to lack the necessary resources to compete with large business and academia or obtain the necessary contacts to secure federal procurements. I am sure we are not alone in this crisis and **small businesses need assistance to help bring proven innovations to the forefront in education markets and no longer be a whisper in a market dominated by big publisher marketing dollars within their longstanding network and deeply embedded faculty adoption behaviors.**

Below are comments regarding the OSTP's ideas for pull mechanisms:

On October 8, 2013, the New York Times published an article, *U.S. Adults Fare Poorly in a Study of Skills*, which summarizes the most recent study of adult mathematics, technology and literacy skills. The study conducted by OECD Skills Outlook, *Survey of Adult Skills (PIAAC)*, evaluated the skills of adults in 24 countries (http://skills.oecd.org/skillsoutlook.html#home). **This study reinforces the critical need for effective, measurable interventions in developmental mathematics for remediation in high school, college and adult learning.** The Office of Career, Technical and Adult Education (OCTAE) at the U.S. Department of Education led by Dr. Johan Uvin has widely disseminated this information to key stakeholders nationwide and is proactively working on policies and programs to develop solutions. We were introduced to Dr. Uvin and his teams by our SBIR program manager, Dr. Ed Metz, have been in contact with the OCTAE since 2011 regarding our intelligent learning and assessment technologies, in general, and **Quantum for Developmental Mathematics** in particular.

> **Comment:** What if federal procurement officers actively sought innovations from SBIR projects? Procurement officers would work directly with SBIR program managers to identify emerging and proven education products from small businesses. To open access for small business to procurement officers, a webinar hosted by the SBIR program manager would allow individual businesses to present their technologies directly. Procurement officers would then notify the SBA of their interest and small businesses would be SBA-assisted, funded and supported in the daunting bidding and procurement process. The result would be federal procurement of effective learning technologies produced by small business in weeks, not months.

Many federal agencies are already engaged in education technology innovation by providing SBIR funding through a rigorous and competitive proposal process in response to clearly defined solicitations. A key requirement is proof of efficacy in authentic education settings as part of the deliverables. However, the additional capital needed to leap from laboratory to market is not allowable (e.g. promotions, public relations, marketing and sales) through this funding mechanism. In this regard the National Science Foundation is the most progressive of the agencies we have worked with and recently offered a $3,500 SBIR supplement on a first-come-first-served basis for a group of small businesses to exhibit at the Florida Education Technology Conference (FETC) under the NSF umbrella at the end of January 2014. This was a small investment by NSF but had a tremendous impact on raising visibility and awareness for the participating small businesses. NSF also provides match-fund supplements that require the small business to receive cash funds from a potential customer or partner which are then 50% matched by NSF up $250,000 (or $500,000 if additional conditions are met). These funds must be used to conduct additional research. However, the research is not always what the partner or market wants. Quantum has had reasonable success in aligning prior grant research with commercial market opportunities. However partners want rapid development of specific products that further their competitive advantages and create either larger profit margins or greater market share. **This is where an opportunity exists for support by funding the bridge between research effectiveness and product commercialization and scalability.**

> **Comment:** For small businesses that have already proven efficacy through the SBIR-funded project, provide bridge funds for the small business to develop customer/partner specified products based on federally-funded technologies. Also permit funds to be used for promotions, public relations/social media/outreach, marketing and sales to attract customers/partners. Innovations would be more appealing and the small business would reach customers and partners more quickly to implement the solution. Customers/partners might include a direct-to-consumer model by engaging faculty at academic institutions (non-profit and for-profit) and/or a business-to-business model to reach corporations in all segments of learning and training such as degree/certification achievement and workforce development. The fund could be managed by the individual departments within the agency and program managers would internally determine which small businesses to fund based on market interest and quickly issue funds to the small business. This would accelerate commercialization and dissemination and stimulate job growth.

Adaptive “Learning” vs. Adaptive “Diagnostics”

As with any emerging industry, properly defining and clarifying functionality and purpose of technology is critical. A new generation of learners raised on the internet has emerged joined by an older generation of adult learners seeking new training. It is clear that traditional textbooks and a “one size fits all” approach of

Lecture →Read the Textbook → Complete Homework → Take the Test

is ineffective, especially for these diverse groups of learners. Publishers are transitioning from their textbook-based print model to digital assets delivered online via homework systems. These systems are built on legacy platforms that are inflexible and lack rigorous research to evaluate effectiveness.

Recently announced systems such as McGraw-Hill’s LearnSmart® and Pearson’s My Lab® (coupled with Knewton products) are able to diagnose student knowledge using “flash card” technology with sophisticated algorithms that introduce problem sets with varying levels of difficulty that increase or decrease based on student answers to identify learning concepts and skills where students need improvement. In order to quickly scale development across multiple disciplines, however, these tools and platforms **perform adaptive “diagnostics” rather than adaptive “learning”** and are not able to deliver essential content or meaningful pedagogical response to the learner. The result is little to no feedback beyond “right” or “wrong”, leaving students frustrated with the time required to be assessed and underserved by the lack of personal feedback and tutoring help. Although these adaptive diagnostic systems have value, they fall short in student intervention simply because they employ multiple-choice or fill-in-the-blank problems with no real intelligent analysis of student work, conceptual errors or conceptual thinking and simply refer students back to the same traditional materials for help (e.g. textbook, videos, study guides, etc.).

In order to create **intelligent adaptive learning** technology, expert content knowledge and pedagogy needs to be constructed and engineered. There are a few companies that began in the 1990s to address this by innovating technologies based on artificial intelligence (AI) techniques and methodologies:

- Carnegie Learning, Inc. created the excellent Cognitive Tutors® for mathematics using a self-contained system that provides individualized instruction from a database of fixed problems. Carnegie Learning was acquired by the Apollo Group, Inc. in 2011.
- ALEKS Corporation invented the first adaptive diagnostic system and was acquired by McGraw Hill in June 2013.
- **Quantum Simulations, Inc.** is a woman-run research and development small business innovating intelligent adaptive learning technology with a mission to prepare the next-generation workforce with core mathematics, business and science skills needed for employment and career advancement, creating a world of lifelong learners and independent thinkers. Quantum continues to conduct leading edge research in how students learn and has delivered more than 1.5 million sessions to students nationwide.

By continually engaging students, faculty, software developers and textbook publishers, Quantum realized early on that a closed, self-contained system such as Carnegie Learning was not optimal because it could not interact or integrate with existing content, curricula or platforms. Neither was a platform-wide solution that lacked meaningful content and personalized assessment such as publisher homework or learning management systems referenced above. As a result, Quantum developed a balanced, market-driven open architecture and is the only organization (for-profit or non-profit) offering publishers, distance learning, and curriculum and software developers the flexibility to deliver innovative products and intelligent technologies. Quantum:

- Directly supports partner content and problems
- Delivers real-time feedback and personalized content
- Offers adaptive learning and targeted practice tools
- Embeds fine-grained, on-demand assessments
- Integrates uniquely with products and platforms

In addition, **Quantum is 508 compliant** through funding from the National Institutes of Health. Finally, students, schools, colleges and universities can choose to use Quantum stand-alone through QuantumDirect™.

Criticism

Although AI-based solutions have been proven effective (*cf.* research summaries and references below), there has been recent criticism that development using AI is cost prohibitive, time consuming, and requires high level programming by AI scientists. In response, Quantum achieved breakthroughs in 2013 that address these valid concerns. Just like extracting expert knowledge from an author to place in any software, textbook or eBook, knowledge engineering needs to occur. Quantum now incorporates a proprietary **Automated Code Generator** which allows more efficient and accurate development of topics and subjects than traditional AI methods, significantly reducing production costs and time to market. For example, Quantum has reduced programming time for a topic (chapter in a book) with the Automated Code Generator **from two months to two weeks that can support any textbook or curriculum**. Once completed, new editions or versions are easily upgraded, significantly reducing maintenance costs. The result is **broader collaboration with subject matter experts and educators and lower marginal cost for development and deployment**.

Research Summaries and References

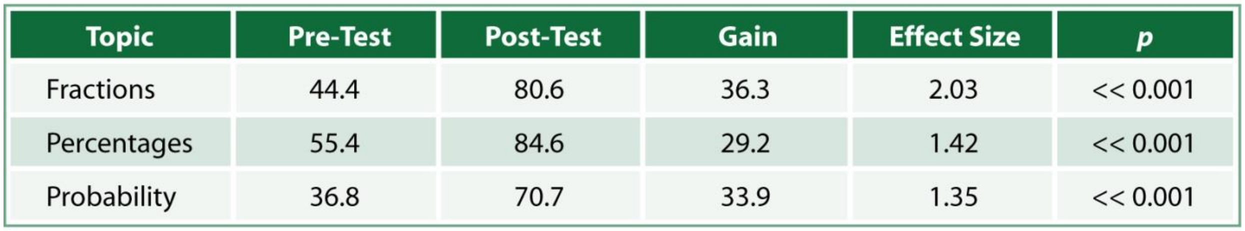
Quantum AI methodologies in general have origins in the ACT-R theory of Anderson and colleagues at Carnegie Mellon University [1-4]. Their Cognitive Tutors, primarily for mathematics, have in some cases been demonstrated to impact test scores significantly in authentic classroom settings, with effect sizes as high as one standard deviation reported [2-4].

Quantum has received more than thirty federal grants, contracts and subcontracts which require evaluation of efficacy and impact on student outcomes. The intelligent methodology which forms the foundation of content development work has been documented in small-scale empirical trials in several diverse subject areas, showing statistically significant increases in pre-/post-test gains relative to a control group by an average of over 50 percent. Below is a sample of summary data from field evaluations with students and faculty in authentic educational settings.

- In a study in chemistry, with a dosage of a single tutoring session of 50 minutes on a single homework assignment, an effect size of 0.70 standard deviations was obtained ($N = 51$, $p < 0.001$) [6]. Success rates in constructing complete and correct solutions were also examined; students who had used the ITS reached correct solutions twice as frequently as control group students on the most difficult problems [6].
- In a study on a different chemistry topic, an effect size of 0.54 was obtained ($N = 235$, $p \ll 0.001$) [10].
- Under similar experimental conditions, a study in accounting showed an effect size of 0.73 ($N = 55$, $p = 0.037$) [8].
- An accounting study used a treatment reversal design to address threats from differential maturation and found an effect size of 0.61 ($N = 139$, $p < 0.001$) [12].
- A recently completed project, *Developmental Mathematics Education for Adult Learners and College Remediation Using Artificial Intelligence, Phase II SBIR, U.S. Department of Education,* yielded the following preliminary results and the manuscript is in preparation for publication.

Table 1 gives mean pre- and post-test percentage scores for three developmental mathematics topics as well as effect sizes (as Cohen's d). Paired t-tests were used to assess statistical significance of the intervention's impact.

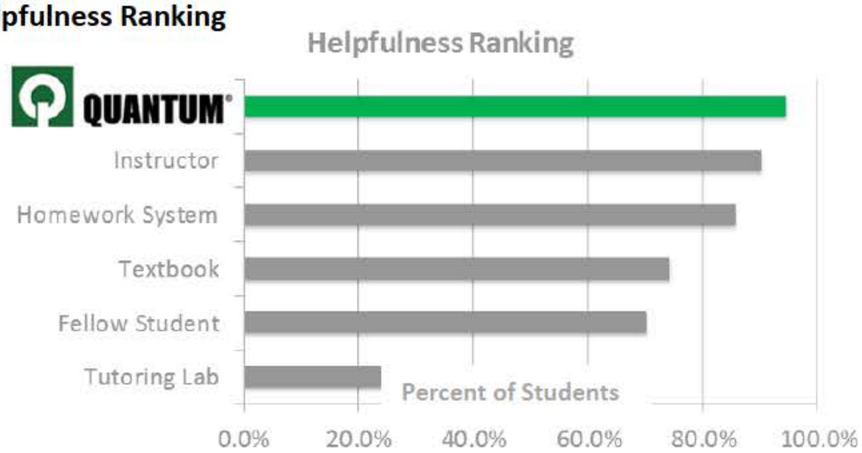
Table 1: Pre-Test and Post-Test Scores



Topic	Pre-Test	Post-Test	Gain	Effect Size	*p*
Fractions	44.4	80.6	36.3	2.03	<< 0.001
Percentages	55.4	84.6	29.2	1.42	<< 0.001
Probability	36.8	70.7	33.9	1.35	<< 0.001

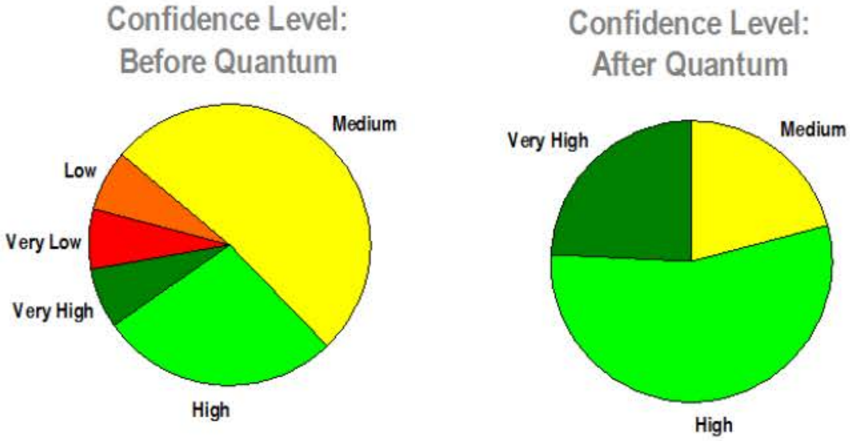
Understanding what students value most is critical to Quantum's software development methodology. Even though instructors require the material for a course in a classroom or online setting, knowing what students view as "most helpful" is equally important. Chart 1 and Chart 2 provide survey results indicating that Quantum is rated as the "most helpful resource" by learners when compared to traditional learning tools.

Chart 1: Helpfulness Ranking



Measuring learner self-efficacy is also important to evaluate and research has shown that Quantum improves learner confidence, motivation, and ultimately, effort towards mastery. Quantum achieves this through a series of "mini-wins" within the software as learners begin to rely less on the software as mastery increases and scaffolding is removed.

Chart 2: Confidence Level



View more research and published papers at: http://www.quantumhelps.com/research.html

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Summary

Conceptual teaching and learning is the cornerstone of Quantum's technology and problem-solving and critical-thinking skills are emphasized. Unlike the prevalent adaptive "diagnostic" systems discussed above or closed systems that use a fixed database of problems, Quantum's feedback is context specific and focuses on helping each student understand why their unique answers are right or wrong. Although Quantum can be used in the classroom, it is not a requirement and in particular, students may use the software stand-alone or integrated with specific curricula, textbook or digital content. Equally important, teachers and instructors do not need to change the way they teach in order to incorporate it. The technology reinforces instruction by giving students consistent, individual assistance, tutoring and homework help on demand.

By completing development and testing of the first AI software designed to supplement existing curricula and satisfy the unique learning needs of diverse populations, the outcome has been a greater number of individuals have achieved conceptual understanding and mastery of essential skills, allowing them to apply their knowledge effectively and efficiently. The outcomes for students include improved capability to:

- Exhibit accurate content knowledge
- Solve problems and apply skills using real-world examples
- Articulate procedural and conceptual reasoning when solving problems
- Accurately respond to questions
- Actively engage in their learning experience

Quantum delivers the finished solution as an entirely web-based application for use on demand during study at home, the library and in the classroom, strengthening the portfolio of a multi-resource learning environment, including distance education. The software contains seven distinct, complementary modes of usage designed to be practical and easy to use for all students. Although it is intended the software be beneficial to all students, it is specifically targeted to help those who have the greatest need, such as students of average or marginal performance and students from historically underserved groups.

1. **Anytime, Anywhere Learning:** Students navigate the software through a highly flexible and robust user interface (UI) that is easily enhanced or modified to partner specifications and dynamically and seamlessly adjusted to meet changes in platforms such as tablets and mobile devices. A backend web service permits maximum flexibility to interact with third party software (e.g., online grade books).
2. **Continuous Improvement:** Students receive automated instruction in real time on problems from their own curricula and assignments at times when the tutoring lab is closed or the instructor isn't available to help or answer questions. Problems are generated dynamically and feedback is personalized based on student work and errors. Practice is not limited to a static set of "canned" problems.
3. **Personalized Tutoring:** Students receive help on their own mistakes and ask questions about the concepts and processes being studied and how these relate to their problems.
4. **Stand-alone or Integrated:** Students use the software stand-alone or embedded directly in the student's own curriculum activities.
5. **Learn by Doing through High Levels of Engagement:** Students use **Targeted Practice**® developed through rigorous research in cognitive science, which reduces study time and improves learning by reducing cognitive load, a critical element in the learning process.
6. **Mastery Learning:** Students perform convenient self-checks by accessing **How Am I Doing?**®, an on-demand dashboard displaying progress, allowing a student to further customize their learning by topic, problem, concept or skill.
7. **Embedded Assessments:** Teachers and instructors access instant and detailed assessment reports with summary information or a drill-down to student-by-student at topic and concept level, using the tool for intervention and lesson planning. In addition, the automated system has the capability to provide comparison data and predictive analytics by student, instructor, school, state and nationally.

Development is iterative following tightly linked design-analysis-redesign cycles with practitioners in the field (e.g. teachers, instructors, subject matter experts). Evaluation of the impact on student learning and achievement (i.e. process-focused, interventionist, multi-leveled, utility-oriented) is conducted by independent evaluation firms.

Quantum is poised to scale and we welcome the opportunity to participate in national education initiatives. Not only can we develop new content efficiently and effectively, we can collaborate with academic institutions and industry on research and development and/or integrate with other curricula and software investments made by the federal government. **OCTAE, coordinated by Margaret Romer, is hosting a webinar** tentatively scheduled for **March 18 at 2:00 p.m.** where Quantum will be presenting and demonstrating its technologies and we hope you can attend.

We sincerely appreciate your time and consideration.

Best regards,

Rebecca Renshaw
Co-Founder and CEO

[redacted]
(C) [redacted]

Quantum Simulations, Inc.
Inspiring Students to Learn *Why*

The Office of Science and Technology Policy
Request for Information: Advancing Learning Technology through Pull Mechanisms

Strategies to Leverage Social Impact Bond (SIB) and Pay for Success (PFS) Financing Models to Accelerate the Adoption and Evaluation of High Impact Learning Technologies

FR Doc. 2014-00404; Document Citation: 79 FR 2201

March 7, 2014

Submitted by:
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SOCIAL
FINANCE

Executive Summary

Social Finance, Inc. is pleased to submit this response to the Office of Science and Technology Policy's Request for Information: Advancing Learning Technology through Pull Mechanisms. As an industry leader in Pay for Success and Social Impact Bond projects, Social Finance is uniquely positioned to assist the Office of Science and Technology Policy in understanding how best to accelerate the evaluation and adoption of high impact learning technologies through these mechanisms.

A Social Impact Bond and / or Pay for Success contract may play an important role in connecting the Office of Science and Technology, Department of Education, students, educators, state and local educational agencies, foundations, intermediaries, investors, and nonprofit and for-profit learning technology providers, to catalyze scale adoption of effective technologies. If applied strategically, a pull mechanism can:

1. Encourage innovation and entrepreneurship in the sector by providing a stable and predictable revenue stream for new technology.
2. Lower the risk associated with developing robust evidence base for a specific technology.
3. Promote demand-side collaboration and network adoption to reduce cost of implementing new technology.
4. Support student learning and achievement by focusing on learning outcomes, and scaling the implementation of effective technologies.
5. Emphasize government accountability by paying for outcomes, and only rewarding investors and innovators for solutions that work .

We are encouraged that the Office of Science and Technology Policy is invested in finding ways to scale effective learning technologies, and excited by the possibility of using Social Impact Bonds or Pay for Success to support this work. Ongoing experimentation with new applications for pull mechanisms represents a unique opportunity to support the adoption of effective learning technologies, while paying only for what works.

Please do not hesitate to contact us regarding information related to this response or any other matter. Thank you for your consideration.

Question 1: What learning outcomes would be good candidates for the focus of a pull mechanism to catalyze the creation and use of new learning technology? These outcomes could be relevant to early childhood education, K-20, life-long learning, workforce readiness and skills, etc.

The success of a pull mechanism—and a Social Impact Bond (SIB) in particular—relies on defined outcomes. To identify metrics for a SIB transaction, it is useful to understand the mechanics of the instrument. A SIB is the financing mechanism based on a performance based Pay for Success (PFS) contract, in which the contract holder commits to pay for improved social outcomes. On the basis of this contract, a working capital investment is raised from socially-motivated investors. This investment is used to pay for a range of interventions to improve social outcomes. If social outcomes improve, investors will receive payments from government. These repayments return the initial investment plus a financial return, depending on the degree to which outcomes improve. If social outcomes do not improve or deteriorate, investors lose their capital.

Given the aforementioned mechanics, program evaluators must be able to measure outcomes using data within a given application (e.g. learning technologies). *Metrics* can be either performance based or productivity based.

Performance metric. A performance metric is tied to achievement (improvement or decline). These measures could be associated with teacher performance (e.g. efficacy measures), administrator evaluation (e.g. overall school performance), or student learning (e.g. improved third grade reading level), and are measured with respect to performance over time.

Productivity metric. A productivity metric measures the change in utilization of a product or service as a result of a intervention. These metrics can be focused on utilization of specific services (e.g. hours out of the classroom), finite changes in concepts learned (e.g. vocabulary), or engagement measures (e.g. dropout rates). Productivity metrics should be selectively identified and employed to ensure that the pursuit of performance to outcomes does not compromise student learning.

Both performance and productivity metrics should be evaluated against a counterfactual—either by projecting historical data forward, or by establishing a control group—in order to attribute benefits to an intervention. Moreover, this comparative process will help to ensure that the right incentives are generated for the various stakeholders involved.[i]

While policy and educational experts are in the throes of devising the most appropriate tools to both evaluate learning and to support students and teachers, it may be difficult to devise financial instruments that are both outcomes focused and agreeable to all the stakeholders. The most important criteria for any metric is whether it encourages the provision of service that ultimately improves outcomes for those who use it. Thus, we suggest that any application of a pull mechanism in learning technologies focus on leveraging productivity outcome metrics.

Productivity metrics can be defined on two data sets that drive measurable and objective evaluation:

- **Binary Outcome Metric**: A binary outcome metric might be defined as an individual interaction with a given learning technology. While a clear metric, it is important to note that there is a risk that this measurement can lead to perverse incentives. For example, under a binary metric, a teacher might be faced with encouraging a student to interact with a technology, regardless of learning needs. While acknowledging the potential downsides of a binary approach, it is a model that is being applied and has the advantage of being simple to implement.

- **Frequency Outcome Metric**: The desired outcome could be a reduction in the hours of special education that a student might need. This approach encourages service providers to work with the entire target population. However frequency metrics are harder to measure because they are relative to a benchmark that must be defined. (e.g. What is the expected number of special education hours in the absence of the intervention?). [ii]

Social Finance, as a SIB and PFS expert, can provide recommendations for appropriate *application* of outcomes based programming to learning technologies, but recommends that the Office of Science and Technology Policy collaborate with intermediaries and leading operators in the space to fully survey the learning technology landscape. Early analysis indicates that productivity metrics (both binary and frequency measurements) directly impacted by learning technologies might include:

- **Learning productivity** (e.g. increased vocabulary) via tutorial learning technologies.

- **Special education reliance** (e.g. reduced hours in special education) via curriculum platforms, or early learner tools.

- **Industry skills certification** (e.g. increased number of vocational based certificates) via college readiness and application programs, or online certification applications.

- **English language learning for children or adults** (e.g. increased vocabulary) via tutorial learning technologies or completion of specific English language courses.

- **Drop-out prevention and recovery** (e.g. increased graduation rate) for over-age and under-credited students in grades 8 - 10 via engagement platforms such as social media networks and personalized learning.

Question 2: How are these learning outcomes currently measured and assessed?

Currently, performance metrics are measured through student and teacher assessments, and productivity metrics are measured through budget and statistics analysis. Analysis of evaluations performed on specific learning technologies is aggregated by the What Works Clearinghouse (WWC), managed by the Department of Education's Institute of Education Sciences (IES).

Performance Metrics

The Department of Education manages the National Center for Education Statistics (NCES), and supports the Nation's Report Card to "inform the public about the academic achievement of elementary and secondary students in the United States," using the National Assessment of Educational Progress (NAEP) exams.[iii] Locally, states and districts often leverage assessments that are mapped to state standards (e.g. the Massachusetts Comprehensive Assessment System (MCAS)).

Productivity Metrics

Nationally, productivity metrics are captured by the NCES. The national database captures dropout rates nationally and locally, as well as special education inclusion, teacher qualification, and participation in adult learning (including basic skills training, apprenticeships, work-related courses, personal interest courses, English as a Second Language classes, and part-time college or university degree programs). Moreover, the NCES manages the Schools and Staffing Survey that provides analysis of teacher utilization, compensation, hiring and retention, and student demographics information. Locally, schools are responsible for setting budgets based on productivity metrics managed by local education agencies (LEAs).

Challenges to Measurement

Three challenges arise from the current approach to outcomes measurement, which relies on performance assessment and statistics reporting:

1. **Reliance on historical baseline**, rather than randomized trial, makes isolating causation (rather than simply correlation) of impact difficult.
2. **Conflict on assessment methodology** makes consistent analysis of student, teacher, or administrator performance complicated. Tests vary in content coverage, mastery expectation and student demographics (including inclusion of English Language Learners or Special Education students), which makes comparison across districts and states difficult.
3. **Self reported data and internal analysis** often form the basis for outcomes evaluation in the for-profit space, and as a result, it is difficult to draw meaningful conclusions from these data

The ability to properly demonstrate causation and measure outcomes is foundational to effective implementation of a SIB or other pull mechanism. The most effective measurement tool to assess impact is not a baseline analysis, but a Randomized Control Trial (RCT) that measures either change in performance or productivity. There is, however, some tension between the most rigorous outcomes measurement instrument and time/money constraints. RCTs are expensive and time-consuming compared to other outcomes measurement techniques, as they add operational complexities and additional requirements with regard to population and control groups.

According to the Harvard Kennedy School SIB Lab, historical baselines determined through the use of administrative data are often necessary to determine value from improved outcomes. These baselines are essential for intermediaries to model public sector benefits resulting from scaled interventions. To date, SIB outcomes have been measured for a period of at least five years (and payments may be made on outcomes a decade or more beyond the contract's length), so accurate and comprehensive administrative data is essential even at the due diligence and contract negotiation stages. This data only becomes increasingly important as the parties develop an adequate evaluation methodology.

The Works Clearinghouse run by the Institute of Education Sciences is identifying "studies that provide credible and reliable evidence of the effectiveness of a given practice, program, or policy," and aggregating research (e.g. RCTs on a specific curriculum or platform) in the field—including a section dedicated to learning technologies. This work is a critical first step in developing a robust library for external study and validation of effective programs.

Question 3: What information exists about current U.S. performance relative to this learning outcome? What information exists about the presence (currently available or potential given current trends or breakthroughs) or absence of effective interventions (technology-based, offline, or hybrid) to improve this learning outcome?

Organizations across the learning technology landscape: funders (philanthropic and for-profit), corporations, educators, and policy makers, are anxious to fund and implement learning technologies that improve performance outcomes and productivity metrics. However, comparison data for U.S. education system relative to learning outcomes remains squarely focused on student assessment and performance.

Market Trends

Philanthropic, academic, and for-profit movement in the space indicates that there is a growing market and desire to spot-light the benefits of integrating technology into pedagogy, and to create an environment that is conducive to technological integration. An anecdotal survey of efforts is included below.

- **Philanthropy**: Major philanthropies, are working to create a friendly environment for learning technology adoption.
    - The Gates Foundation and the William and Flora Hewlett Foundation initiated the Next Generation Learning Challenge, managed by EDUCAUSE, a competitive process to "Catalyze Education Innovation with Urban Incubator Partnerships."[iv]

  - The Dell Foundation launched an Innovation portfolio cohort of investments in blended learning to "help to develop an evidence base that we (and others) need to better understand what works for students in blended learning models."[v]

  - The George Lucas Education Foundation funds Edutopia, a platform dedicated to improving the K-12 learning process through innovative, replicable, and evidence-based strategies that prepare students to thrive in their studies, careers, and adult lives.[vi]

- **Academia**: The University of Pennsylvania, Teachers College at Columbia University, Harvard University, Stanford University, University of Michigan, Northwestern University, and the University of Wisconsin-Madison have joined to form the consortium for Policy Research in Education (CPRE) to inform K-16 education policy and practice. These groups are making tremendous progress in furthering the adoption and expansion of learning technology in the classroom. For example, the Harvard Center for Education Policy Research alone is pursuing projects in understanding the role of technology in teacher efficacy, student performance, and data management

- **Market Innovators**: Education technology-focused incubators are working to pull innovators and entrepreneurs into the space (for-profit and non-profit), by providing opportunities for fledgling organizations to connect with potential funders, develop strong business plans, and increase access to markets; leaders in the space include: Socratic Labs, Startl, Tech stars, Imagine K12, 4.0 Schools, Startup Weekend, Learning Technologies, SIIA Innovation Incubator Program, Macmillan New Ventures, and Stanford Learning, Design and Technology. [vii]

- **Venture Capita**l: Venture capitalists are participating in the space, an indicator of market interest. Over $1 billion was invested in the space in 2012,[viii] and investors including Google Capital, Greylock Partners, GSV Capital, and Kleiner, Perkins, Caufield and Byers have participated in funding learning technology organizations.

Examples of Opportunities for Pull Mechanisms to Accelerate Learning Outcomes

It is clear that the learning technology market is ripe for increased impact and efficacy. Funding is flowing to the space, but robust evidence based analysis (e.g. RCTs, quasi-experimental analysis) of efficacy is not widespread. To scale the adoption of effective technologies, more organizations need to build an evidence base founded on analytical research to support adoption.

Some examples of interventions that have been validated by external research, and promoted by the What Works Clearinghouse include:

- "**Large-scale Randomized Controlled Trial with 4th Graders Using Intelligent Tutoring of the Structure Strategy to Improve Nonfiction Reading Comprehension**," which concluded that individualized tutoring for fourth-grade students in language arts—delivered via a web-based application—had a positive impact on reaching comprehension. The study was conducted via randomized control trial.[ix]

- "**Effectiveness of Reading and Mathematics Software Products: Findings for Two Student Cohorts**," which found that one of six reading products analyzed had a positive impact on student achievement, while no math programs had an impact on achievement. The study was conducted via randomized control, and was intended to examine specific platforms and their impact on achievement.[x]

Studies like these show that it is possible to measure learning technologies outcomes. If pull mechanism friendly metrics (e.g. objective productivity metrics) can be validated by academic analysis, the adoption of learning technologies that work will accelerate. SIBs are being used in early childhood education and dropout prevention for exactly this purpose, and are apt analogs for the like application of the mechanism.

- **Early Childhood Education***:* In August 2013, the Goldman Sachs Urban Investment Group (UIG) formed a partnership with the United Way of Salt Lake (the program intermediary) and the J.B. Pritzker Foundation to create the first PFS demonstration project designed to finance early childhood education. The Utah High Quality Preschool Program consists of a high impact and targeted curriculum focused on increasing school readiness and academic performance among at-risk 3 and 4 year olds. The education program uses a locally-designed, structured curriculum to better prepare children for kindergarten, close the achievement gap and help them remain on track through high school, while decreasing the use of special education and remedial services in elementary school. This results in cost savings for local communities, the school district and the State.

  Groundwork was laid for this project beginning in 2010, when Voices for Utah Children, Granite School District, and United Way of Salt Lake launched a multi-year study of academic results and cost savings related to early education for children at risk for needing special education. The evidence base derived from this study is convincing. About one-third of the children who enter the program score so low on a certain picture-based vocabulary test that they are likely to need special education and other costly interventions in elementary school, according to Bill Crim, senior vice president with United Way Salt Lake. After going through the United Way program, about 95% of those children catch up to their peers and do not need additional services.

  The demonstration project will scale the intervention, and provide current evidence on the economics of the program.

- **Dropout prevention**: In Michigan 14,000 high school students drop-out and 15,000 additional students fail to graduate on time each year. Consequently, when Michigan released a Request for Information for PFS financing in early September 2013, Social Finance and Communities In Schools (CIS) partnered as financial and program intermediaries, respectively, to frame a potential PFS contract. CIS pioneered the "Integrated Student Services" model, which provides wraparound community services within a school based on its specific needs (e.g. attendance problems, parent engagement). The program has been validated through three randomized control trials, a quasi-experimental study, and an implementation study that analyzed results from program sites.

When ascribing value and determining state payments, CIS and Social Finance believe that grade promotion and high school graduation rates are outcomes that would facilitate PFS financing, while others could be used to monitor program efficacy. A CIS SIB would help to expand the Integrated Student Services model, and provide analytical data for the economic viability of school based wraparound community services.

The aforementioned projects are indicative of a market exploring diverse areas of potential impact, and using pull mechanisms to fund evidence gathering to validate program efficacy.

Question 4: Why would a pull mechanism in this area accelerate innovation in learning technology?

The SIB is designed to facilitate the expansion of evidence-based programs delivered by effective intervention (social service intervention, technological intervention, or other). Current funding flows and outcomes show that the current 'push' strategy with regards to learning technologies, allocating funding based on process rather than outcomes, is sub-optimal. Despite increased investment, performance and outcomes have not systemically improved and effective technologies have not been adopted at scale. Building a scientific and robust evidence base of impact is costly for a fledgling technology organization, and securing capital to achieve these ends is made difficult by complex and fractured end-user markets. Pull mechanisms would encourage the spread of effective learning technologies in three ways:

1. **Ameliorating high start-up costs for evaluation, marketing, and implementation:** the barriers for an entrepreneur in education technology to both develop a robust evidence base and distribute the technology at scale is challenged by high growth capital needs. By providing an infusion of growth capital for promising organizations through private investment (or reimbursable government investment), and repaying these investors only if recipients are successful in proving efficacy, a pull mechanism will encourage activity in the space. SIBs allow a government to transfer the financial risk of prevention programs to private investors based on the expectation of future payment.

2. **Encouraging cross-silo collaboration**: a pull mechanism can encourage collaboration between government, education, business, and technology—leveraging the learning and expertise from each sector to develop effective technologies, and encouraging adoption at scale. Moreover, by encouraging districts to collaborate, scaled adoption of technologies can produce economies of scale in implementation and assessment.

3. **Facilitating outcomes based purchasing patterns**: SIBs encourage all stakeholders to operate to measurable outcomes, encouraging accountability—in innovation and in practice.

The power of SIBs lies in their ability to align all stakeholders' interests around achieving social outcomes for the benefit of poor and vulnerable populations. Stakeholders in SIBs—nonprofits, investors, government, and communities—would all benefit from successful SIB programs (see table 1). Innovative organizations with high impact learning technologies would have unprecedented access to growth capital to expand their operations. This stable and predictable revenue stream would allow them to spend less time fundraising and more time focusing on their core competencies: serving vulnerable populations in need. Participants would also benefit from increased coordination among organizations working on similar issues, raising their effectiveness. Investors would put capital to work that achieves both meaningful social impact and financial returns; they would also have the opportunity to participate in a new asset class with the benefits of portfolio diversification. Government would attain accountability for taxpayer funds and better results for its citizens at lower public expense, even after paying an appropriate financial return to investors. Most importantly, vulnerable individuals, families, and communities would benefit from wider availability of effective prevention services, breaking the cycle of reliance on crisis-driven interventions.

Table 1: Benefits to Stakeholders of Successful SIBs

Stakeholders	**Benefits**
Learning Technology Focused Organizations	• Access to growth capital to scale operations, and to build evidence base of efficacy • Access to stable and predictable revenue stream without labor-intensive fundraising • Facilitated coordination with organizations working on overlapping problems
Investors	• Achievement of financial returns and social impact • Participation in a new asset class with portfolio diversification benefits
Government	• Accountability for taxpayers funds • Reduction in the dispersion of process based (non-outcomes based) funding streams • Increased supply of effective services for citizens without financial risk
Districts, schools, students, and parents	• Access to an increased supply of effective learning technologies

Question 5: What role might different stakeholders (e.g. Federal agencies, state and local educational agencies, foundations, researchers, practitioners, companies, investors, or non-profit organizations) play in designing, funding, and implementing a pull mechanism for learning technology? What role would your organization be willing to play?

Each stakeholder in a SIB partnership plays a distinct and critical role.

Government, i.e. federal, state, and local educational agencies, is in a sense the linchpin of the process since government is the ultimate provider of funding and delivery for educational services. However, different levels and agencies of government have different roles to play. State and local educational agencies, as the direct adopters and procurers of educational products, are critically important in implementing a pull mechanism to encourage innovation, research, and development.

One possible avenue for **state and local procuring government agencies** is the Advance Market Commitment (AMC), which may be coupled with a SIB for maximum impact. An AMC is a binding commitment to purchase, or to subsidize purchase, of a certain volume of a product at a fixed price, if the product meets pre-defined performance characteristics. It is a binding contract that incentivizes research into developing new solutions to pressing problems, e.g. underperforming students.

The AMC concept has been applied to health services, but not yet to the broader arena of social services. One example is the pneumococcal AMC, in which donors commit funds to guarantee the price of vaccines once they have been developed. These financial commitments provide vaccine manufacturers with the incentive they need to invest in vaccine research and development, and to expand manufacturing capacity. In exchange, companies sign a legally binding contract to provide the vaccines at a price affordable to developing countries over the long term.

The AMC mechanism, in the above example, addresses the persistent market failure to develop and produce vaccines that are urgently needed in poor countries due to perceptions of insufficient demand or market uncertainty. In the educational technology case, the AMC would address the market failure of insufficient research and development, trial projects, and outcomes assessment related to high-impact learning technologies, due in part to the uncertainty of success and government adoption cycles. An AMC would guarantee a market for appropriate educational technology products and services, reducing uncertainty or volatility that can discourage investment, and increasing competition and innovation among companies and organizations. This could be coupled with a SIB to fund the research, development, and testing phase of the work.

The federal government is not directly involved in educational procurement processes, but stands to reap substantial rewards from a SIB project that succeeded in driving down federal spending on Title I and special education programs. Moreover, directing investor capital to turn around failing schools could also relieve pressure on federal spending. Thus, the federal government could and should play an important role in developing a SIB related to educational technology funding. The proposed $300 million US Treasury Incentives Fund could be used to incentivize state and local governments, investors, and service providers to participate actively in PFS based projects in this arena. A few examples of specific functions for the federal Fund and/or other federal monies in this regard are:

- *Motivate states to participate in PFS:* Early stage PFS project development suggests that most transactions need an avid and committed government champion to launch the project and keep it going. In states where this champion does not exist, federal monies could be used to incentivize participation by providing financial support. For example, funding could be used to cover a state's administration or evaluation costs in launching a PFS project.

- *Co-fund outcome payments:* Using federal funds as a supplemental payor of outcomes for PFS financings would help to catalyze the sector, facilitating transactions that may not otherwise get off the ground. Because the federal government would be a significant beneficiary of improved educational outcomes either directly or indirectly (e.g. federal Medicaid dollars, special education expenditures), there is a strong conceptual argument for including it as a payor. In fact, the federal government has already begun to implement this approach in other issue areas. In September 2013, the US Department of Labor awarded nearly $24 million in PFS grants to New York and Massachusetts, monies earmarked towards payments for employment and recidivism outcomes among formerly incarcerated individuals. Similar awards in the education space would be highly effective in supporting the use of PFS to develop high-impact learning technologies.

- *Guarantee investor principal:* One of the most efficacious uses of federal money may be in providing a guarantee for some portion of investor principal. This is not a new role for the federal government, which is already involved in providing similar types of financing support, if not in the PFS sphere. One Small Business Administration program guarantees up to 85% of commercial loans to small businesses. Additionally, Fannie Mae and Freddie Mac have been used to enhance access and reduce costs related to home ownership for low- and middle-class Americans. A federal guarantee of investor principal would encourage investor participation in the transaction and lower the cost of capital for the state. Moreover, the funds would recycle if the project is successful, remaining available to support future projects.

- *Insure investors against state appropriations risk:* Under this option, federal funds would be used to mitigate appropriations risk, rather than provide a blanket guarantee on investor principal. Because appropriations risk may be a binding constraint for many investors, this option would offer a relatively low-cost opportunity for the federal government to incentivize participation in PFS financings.

Foundations have engaged by:

- *Making grants* to support capacity building among key market participants, conduct research and encourage learning, develop proof-of-concept projects, provide credit enhancement, pay for outcomes and mitigate risk.

- *Investing* directly in SIB transactions through program-related investments, recoverable grants, and other forms of investment.

- *Fostering partnerships* among stakeholders by helping to bring together the various and diverse actors in this space, and helping to unite them around shared goals.

Intermediaries facilitate the structuring and negotiation of a PFS contract between other stakeholders in the transaction, such as the government, service providers, and investors. Intermediaries such as Social Finance have played an integral role in developing the US PFS market. Indeed, social impact financing is not easy because of the multiple stakeholders involved. Intermediaries can take on the tough and complicated work of creating a structure that will optimize incentives for service providers, offer a compelling investment opportunity that will draw in new pools of capital, and promote beneficial use of scarce resources for governments and taxpayers.

As the intermediary in a SIB designed to fund the development of high-impact learning technology, Social Finance may offer a variety of services, including:

- Identify and conduct due diligence on potential service providers and interventions
- Conduct financial modeling and structure the PFS program
- Establish outcome metrics and evaluation methodology with all partners
- Negotiate PFS contracts to align incentives among stakeholders
- Develop the financing vehicle and raise investor capital
- Manage performance and spearhead mid-course corrections as needed
- Work with independent evaluators to assess performance outcomes
- Educate the market and serve as a knowledge resource for others.

In addition, should an AMC become part of the educational technology initiative, the role of Social Finance would be analogous to the role of the World Bank in the AMC Pneumococcal Initiative. Social Finance would provide fiduciary support and coordinate legal, accounting, systems and reporting functions.

Investors may include high net worth individuals, foundations, and other institutions that are seeking social as well as financial returns on their funds. In the New York State SIB that was recently announced by Social Finance, there were more than 40 investors from these three categories.

High net worth investors are indicating growing interest in blended value, or triple bottom line, investment opportunities. In a 2013 survey, U.S. Trust found that nearly half (46%) of the wealthy individuals surveyed would be willing to accept lower returns from investments that create positive impact; 44% would be willing to take on higher risk.[xi]

In addition to giving traditional grants, foundations may invest in SIBs as program-related investments, or PRIs. PRIs are loans and equity investments that foundations provide at favorable rates to support activities that have a direct charitable purpose. In order to qualify as a PRI under the federal tax code, a PRI must meet specific requirements: It must be primarily intended for charitable purposes, must lack any significant investment purpose, and may not be used for electioneering or lobbying. PRIs that meet these qualifications may count towards a foundation's minimum payout. While barely 1 percent of US foundations make PRIs at present, there is substantial potential for growth in this sector.

Researchers and Practitioners are, in a way, the focus of the pull mechanism. Whether they work independently, at for-profit companies, or at nonprofit organizations, they are the individuals and groups that will be incentivized by the pull mechanism to develop high-impact learning technologies. Under a traditional SIB, the most promising research and service delivery organizations would receive up-front money to build capacity and launch demonstration projects.

Under an AMC, these organizations could be further incentivized by the promise of a binding contract to purchase these technologies at a fixed price and amount once they have been developed and proven.

Question 6: What changes in public policy would facilitate experimentation with pull mechanisms at different levels of government?

Historically, performance-based contracts with school districts have not gained widespread adoption, for two reasons. First, educational publishers and vendors do not control all levers of delivery (teacher quality, commitment, and training, for example). Second, educational assessment remains problematic. Accordingly, critical elements in a successful pull mechanism would include:

- Defining applications where providers have sufficient control over all levers of delivery, and
- Defining applications in which outcomes measurement is relatively clear-cut and monetizable.

For example, tech-based delivery mechanisms are less susceptible to variations in quality of delivery than mechanisms that are largely teacher-driven. Tech-based pedagogies with a demonstrable record of success exist and are readily scalable. Additionally, there are areas in which the measurement of improvements in productivity, such as reduced reliance on expensive specialists like school psychologists, speech therapists, and ESL instructors, is relatively straightforward and monetizable. Indeed, more funding has gone into educational technology research in the past two years than during the prior decade; private financing of educational technology companies is at an all-time high. The next step, then, is deploying a pull mechanism such as SIBs to scale up the use of these technologies and to add a rigorous component of outcomes measurement.

While there are many changes in public policy that would facilitate these mechanisms, such as favorable tax treatment for SIB investors who lose their principal, we focus below on specific steps that governments may realistically undertake in the near term.

Enable administrative data systems. Improving the ability of administrative data systems to actively integrate and communicate across agencies and levels of government would be a major step forward for PFS financing. Federal funds could support this improvement in various ways. For example, federal monies could target administrative data integration at the state level using a broad net. (This action would also have the advantage of positive spillover effects beyond PFS contracting.) Federal funds could also support initiatives within state and local governments to augment systems for data collection and analysis, to ensure that data is high quality, in a digitized format, and collected in a consistent manner. Alternatively, monies could be doled out to improve data collection and analysis specifically for individual transactions launching PFS transactions in this space, to ensure successful due diligence and evaluation for PFS projects in active development.

Scale demonstration projects. Core to the successful development of high-impact learning technologies is the implementation of on-the-ground demonstration projects to prove the efficacy of various technologies. Because the PFS approach represents a new way of doing business in the provision of social services, however, some governments may be reluctant to fund such projects on their own. The Utah project in early childhood education serves as an example of this phenomenon, as the Utah State Legislature narrowly missed passing the "Results-Based Early Education Act," which would have enabled the state to act as outcomes payor. Consequently, the United Way agreed to provide outcome payments of up to $1 million for the first year of the project. Federal funds have the potential to play a similar role, seeding the space with demonstration projects to help build a track record.

Encompass holistic public-sector benefits. At this point, states procuring PFS-based projects are inclined to structure outcome payments based on strict budgetary savings that accrue over a relatively short timeframe, which makes political sense. However, the federal government can and should take a broader view, accounting for value in addition to budgetary savings reaped through Medicaid, special education, and other programs. Education-based PFS projects may create social value over the longer term (e.g. better quality of life, lower crime rate) that does not accrue directly to state or federal budgets, as well as cost savings that materialize beyond the duration of the investment.

This suggests a role for the federal government in incentivizing state and local governments to take a broader view of social and public-sector benefits in adopting PFS-based programs. Federal funds could be used to supplement outcomes payments as described above, and to encourage federal and state agencies to work together across traditional silos when benefits accrue to multiple agencies and levels of government.

Moreover, because contracts are based on outcomes, government and service providers remain accountable for funding decisions and service provision.

Enact accommodative PFS policies. It is instructive in this regard to consider the UK, which has implemented a range of accommodative policies in addition to creating a Cabinet-level Centre for Social Impact Bonds. These policies include tax relief for investors in social enterprises and PFS contracts, and a "Red Tape Challenge" that aims to remove conflicting rules and exclusions in the current legal and regulatory structure for government PFS contracts. The ultimate goal is to update financial services regulations to ensure that PFS-relevant rules take into account the non-financial goals of a project, while also aiming to simplify understanding of fiduciary duties through a law commission review.

Similarly, the federal government could engage key actors: the IRS, SEC, and others to review regulations that apply to the PFS sector, and adapt them to provide a more accommodative regulatory structure. In particular, norms around fiduciary responsibility and tax obligations could be substantially overhauled to accommodate development of the PFS sector.

End Notes

[i] "Social Finance's Treasury PFS Incentive Fund Response—Strategies to Accelerate the Testing and Adoption of Pay for Success (PFS) Financing Models." Home. N.p., n.d. Web. 25 Feb. 2014.

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[ix] "WWC Review of the Report "Large-scale Randomized Controlled Trial with 4th Graders Using Intelligent Tutoring of the Structure Strategy to Improve Nonfiction Reading Comprehension"." *: What Works Clearinghouse*. N.p., n.d. Web. 05 Mar. 2014.

[x] "WWC Quick Review of the Report "Effectiveness of Reading and Mathematics Software Products: Findings for Two Student Cohorts"" *: What Works Clearinghouse*. N.p., n.d. Web. 05 Mar. 2014.

[xi] Full report available at: http://www.ustrust.com/publish/content/application/pdf/GWMOL/UST-Highlights-Brochures-Insights-on-Wealth-and-Worth-2013.pdf

"Pulling" Deeply Digital STEM Curricula

The Deeply Digital Coalition[1]

March 1, 2014

This paper is directed to the U.S. Office of Science and Technology Policy in response to the OSTP Request for Information concerning "pull" strategies for high-impact learning technologies. In the following, we describe technologies that can transform secondary STEM education followed by a recommended pull strategy that could make this happen quickly without massive Federal assistance. Rather than simply addressing the questions in the RFI, we have provided a narrative that places our answers within a larger context. A summary of our answers to questions in the RFI can be found at the end of this narrative.

The Problem

Many business leaders, educators, politicians, commentators, and, increasingly, the general public agree that it is vitally important to improve STEM education to better meet the needs of society. Failure to address this problem effectively will lead to serious consequences to individuals and nations. Student potential will be squandered, bad decisions will be made about national priorities, and businesses will fail or move.

STEM teaching is stuck in traditions and approaches of an earlier era that fail to prepare and inspire students for the future. The last wholesale innovations in the secondary STEM curriculum were made a half-century ago. In the two decades starting with the shock of Sputnik in 1957, the NSF funded teams of world-class scientists and educators to generate new texts, associated hands-on activities, films, and teacher resources. The first effort was centered at MIT and addressed secondary physics. This was followed quickly by revolutionary curricula for all grades in biology, chemistry, physical science, math, and engineering. Since that time, funding priorities have focused more on smaller innovations and research, which provide a solid foundation for another fundamental transformation of STEM curricula.

The increasing availability of information and computer technologies has generated many new educational resources, but these have had surprisingly little impact on curricula. Most technology-based STEM materials are enhanced texts of lectures and involve presenting material using multimedia and, sometimes, providing some tools like highlighters, glossaries, and a notebook to help students learn the materials. These are relatively easy to implement, but fail to take full advantage of the educational promise of technology. A much smaller group of applications is based on more active learning principles and is designed to engage the students in constructing knowledge through interactions and investigations. Materials in this category promise greater learning, but are harder to implement because they are often idiosyncratic.

This diversity of electronic materials is very difficult for educators to form into an effective curriculum. A teacher who tries to build a course from the best electronic materials faces uneven content coverage that often lacks coherence, makes inconsistent use of terms, has different assumptions about student prior knowledge, uses uneven assessments, and a mixes different user interfaces.

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[1] See page nine for a listing of members and endorsements.

A Transformative Curriculum

The OSTP has already identified this need and recommended effective responses in the 2010 report “Prepare and Inspire: K-12 Education In Science, Technology, Engineering, and Math (STEM) For America’s Future.” While the recommendations of this report for teacher professional development have led to concrete developments such as 100Kin10, no corresponding effort has been made in transforming the curriculum.

The PCAST report recommends a vastly increased, mission-driven effort to create "Deeply digital, whole-course instructional materials with several alternative versions for all major STEM courses. These materials should make optimal use of text, images, videos, interactive simulations, games, collaboration tools, embedded assessments, and adaptive problem engines.” (p. 82)

The ubiquitous availability of computers, tablets, and the Internet can make it possible to enhance education in ways not possible before now. But the technology must enhance learning and not simply bring old approaches in a new format. A central theme of the PCAST report’s curriculum recommendations was the need for “Deeply Digital” materials that take full advantage of the many ways in which technology has proven to improve teaching. An extensive research base provides clear guidance on which ways of using technology will be most effective for achieving deeper learning. The use of powerful technologies is what will make new, comprehensive STEM materials more effective than any previous STEM reform effort.

What We Know About Effective Curricula

In order to provide effective and accessible STEM education that meets the needs of all students, a curriculum needs to utilize three recent advances: the development of powerful instructional strategies, insights into the scientific basis of learning, and advances in educational technology. Over the past three decades, promising instructional materials have been developed that demonstrate the value of utilizing these advances. Most of these materials were developed for research and, as a result, there is a huge research literature that reports findings from these studies. Because of this research orientation, interesting innovations have been applied primarily to a few topics to test one or a few innovations. As a result, we know what features are needed, but there is no substantial curriculum that incorporates what we have learned.

We have distilled eight educational design features from this research. These features should be part of a deeply digital course. Each feature is backed by research that indicates student gains attributable to the feature. There is no research on a course that combines all eight features, but the results from such a course should be impressive. These design features are sketched below and in more detail in the attached supplementary materials.

1. **Coherence.** STEM instruction demands a sequential development of core ideas and practices that fit together in logical progressions so that students are always building on prior learning and using familiar tools.
2. **Student exploration.** STEM instruction must rely heavily on student learning that mirrors the practice of STEM professionals, using guided exploration and design challenges in real and simulated environments.
3. **Assessment.** Deeply digital materials should measure all the standards-based learning goals, taking full advantage of educational analytics built into student software and feeding results to teachers along with suggestions for addressing student needs.

4. **Collaboration.** Student collaborative activities should be used extensively, since they can boost learning and foster communication skills. Technology can enhance the value of collaboration and support course-based collaboration both in and outside school.
5. **Universal Design**. Universal Design for Learning principles should be built into courses to ensure that diverse students are engaged and supported by providing alternative ways of acquiring and assessing learning to meet the needs of individual students.
6. **Continuous Improvement.** Technology-based curricula should be designed to be flexible and easily authored, so that educators can modify and enhance course content in response to the needs of their students, improved technology, better techniques.
7. **Teacher Empowermen**t. The materials should take full advantage of the knowledge and experience of teachers by including tools for teachers to enhance communication with students and share ideas with colleagues, and providing opportunities for enhancing teacher pedagogical content knowledge.
8. **Parent and guardian engagement**. Technology can provide current information about student progress to parents and guardians and generate suggestions for family activities that support current classroom topics.

Another important design feature involves the scope of deeply digital materials. A single unified curriculum for an entire course would fail to take advantage of the flexibility of digital media and would be difficult to customize. A yearlong course that consisted of scores of tiny self-contained activities would lack coherence. The ideal size would be a unit that addresses a substantial part of a typical course, requiring six to eight weeks of class time. Such a unit would be large enough to be coherent and small enough to be easily modified or substituted with other treatments. If desired, units could be linked together to make a full year, coherent course. To simplify adoption, all the units making up a course would have a consistent level of treatment, the same delivery platform, and the same software tools.

There currently is no digital curriculum that includes all these design features. There are many studies of individual technology-enhanced strategies for improving STEM education, but the best of these have yet to be combined into a course.

The lack of even one course is a classic case of market failure. We know how to make deeply digital STEM courses, but there is simply too much risk in creating one of these courses, because it would be too expensive and too untried. Until now, publishers and federal funding have been the primary mechanisms for STEM curriculum development and dissemination. Both sources are becoming more risk adverse and less willing to invest in expensive technologies for several reasons. First, there is the perception that the Internet is brimming with good free curriculum materials. While it is true that many excellent materials exist, the task of combining them into coherent course is overwhelming because of the variability of treatment, technologies, and assessments. Another reason for market failure is that technologies are changing so quickly. An investment in a technology-based curriculum may be useless if the user devices, servers, or software used for development change during development, a problem that many developers have suffered through recently with the use of Java.

Development Costs of Deeply Digital Curricula

By implementing these eight design features and by exploiting technology to enhance the impact of each strategy, STEM education can be transformed. The problem, of course, is the cost of developing complete, technology-rich courses. A high quality, new science text can cost millions and while making only minimal use of technology. A more ambitious course that took full advantage of available technologies would cost several times as much.

We estimate that the first high quality, deeply digital, full-year STEM course using only proven technologies and designs would cost $15M to develop. This first course would be more expensive than subsequent ones because of the cost of technology; later ones could be developed more efficiently and at a lower cost. The total cost of a first course would include dissemination, professional development, technical support, and the maintenance of a decentralized revision and customization community. We envision that a publisher would be able to cover these costs from income generated by licensing and supporting the course.

The long-term goal of a complete transformation of the secondary STEM curriculum would involve approximately 16 courses.[2] Thus, the cost of transforming secondary STEM education is approximately one hundred million dollars.[3] This cost is modest in an economy where public funding of education is 5% of a 15 trillion dollar GDP or approximately $750 billion dollars. It is also modest relative to the hundreds of millions of dollars presently invested in building a new generation of educational tests for the Common Core. But it is also more than either federal grants or venture capital-backed startups can presently muster. To build the quality of STEM curriculum that today's students need and that is well within our reach as a society, we need an alternative funding strategy.

Since the 1960s, innovative STEM text-based curricula have come from educational publishers, almost always reducing their risk by building upon a federal investment in proof-of-concept draft materials backed by research and development. This is how the transformative curricula of the 1960s reached schools, and how individual innovations have continued to be distributed. However, the federal government currently has no programs to fund large-scale curriculum development. Most funding for technology-rich materials is for small pieces – instructional units needed for research that lasts for a few days or a week, not a year of instruction. Publishers, facing a major economic disruption and profit freefall, have very limited investment horizons as well. Venture capital funding could be an alternative, but venture capitalists are currently investing primarily in schemes where users provide the content, because this is less expensive than paying for content. A coherent curriculum will cost at least ten times typical venture capital funding levels and cannot be assembled from a hodgepodge of user-generated content. New funding alternatives are needed that spread the risk, overcome the problem of technological obsolesce, and provide examples for successful approaches that are both educationally sound and sustainable. A pull mechanism can provide that alternative.

Seeding Deeply Digital STEM Materials with an Exemplar

Any strategy to create a Deeply Digital STEM secondary curriculum would need to start with the market stimulation provided by an exemplary course that incorporates the design features that we know are effective. The actual topic of the course is of secondary importance, but it should

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[2] A complete STEM curriculum might include the following 16 courses: basic and advanced courses in biology, chemistry, physics, earth systems, and programming, and one course each in engineering, algebra I, algebra II, pre-calculus, calculus, and statistics.

[3] A sense of the approximate costs can be estimated by multiplying 16 courses each costing $10M and adding $10M for technology, giving $170M. A coordinated development of these courses could result in substantial savings. Technology could be shared, development could be streamlined, open source software could be used extensively, content could be leveraged from existing texts, and the basic and advanced versions of courses could share identical or similar units. These savings might result in a total development cost of $100M.

probably be one usually offered and considered to be both difficult and critically important, such as algebra I, modern biology, or physics. Solid research on the educational gains that the course provides would generate intense interest in generating additional STEM courses of the same design.

This course, when offered by well-prepared teachers, is likely to generate impressive gains in student performance. We anticipate that standards-based knowledge and skills gains by students will be significantly greater that current courses that cover the same content. It is impossible to know exactly how much better this course will prepare students, but do know that student exploration, formative feedback for teachers, student collaboration, and universal design, each independently reliably results in significant gains.

Given convincing data from this initial course, it will be far easier to finance additional courses from traditional sources such as grants, venture capital, and publishers as well as possibly "pull" sources such as buying collaboratives and advance market commitments. The most challenging step will be creating the first deeply digital course.

It is important that this initial course must be completed as quickly as possible because technology is changing so rapidly. It should be designed for technology that is available today with the expectation that the physical and software platforms will change. If this exemplar course is to stimulate the development of further courses within a reasonable time frame, it must start generating convincing research data on at least a portion of its curriculum as soon as possible. It should be possible to do this within the first two years of the development effort.

Pull Strategies for an Exemplar Course

We have considered a number of pull strategies for this first deeply digital STEM course; in the following we focus on one particularly promising strategy.

A binding school-based buying cooperative. The funding could be provided by 2,000 high schools each promising to pay $5,000 for perpetual access to a course that met agreed-upon features and performance. This has two problems: schools cannot make advance commitment to buy something that does not exist and will not exist for several years. Secondly, there would be a huge overhead cost in obtaining the commitments from so many school, even if schools could make them. Furthermore, work could not begin until a substantial number of commitments were made, perhaps delaying the project by two or more years.

A non-binding school buying cooperative. This alternative would be more acceptable to schools, but would require the course developer(s) to front the costs from investors. We believe that a school's non-binding statement of interest would not be valued by the investment community.

A buying cooperative based on States and Intermediate Units. This would require fewer entities, reducing the overhead of recruiting them, but whether binding or non-binding, would face the many of the same problems as the school cooperative. There would be a four to five year lag between commitment and delivery, during which time the political and financial landscape of these entities could change completely.

It appears that school funding, at the local, intermediate, or state level is not feasible given the costs and time constraints of a project to create an exemplar courses.

The most feasible approach would be a version of the "Pay for Success Bonds." A federal agency such as the National Science Foundation, would offer half of the $10M--$15M total cost of a course, requiring the grantee to come up with the matching funding through some combination of raising capital, obtaining grants, licensing, or making advance sales. The grant would be sufficient to develop the required technology and create some pilot units that could be studied. The results of pilot research should help pull the rest of the funding.

This strategy would involve substantial risks. A developer team might fail to meet their own goals. The technology developed as part of the initial funding may not be sufficiently powerful. For a number of reasons unrelated to the quality of the deeply digital idea, the pilot studies might not yield convincing results. Matching funding may not be forthcoming. For these reasons, to give this strategy a chance of succeeding, it would be wise to create three different projects that addressed different courses. In addition to providing redundancy and fostering competition between the groups, the developers would be able to pool their funds to develop a common overall design and approach to technology.

As a rough estimate, the total cost for three courses might be $10M for materials and research for each course, plus $6M for technology, for a total of $36M. Half of this, or $18M would be granted and the other half "pulled." Spread over three years, this would require $6M per year in grants and a comparable amount from investments.

Creating Deeply Digital Courses

Educational and research and development groups with experience with curriculum development are in the best position to undertake this work. There are a dozen or so such groups that are either stand-alone nonprofits or associated with universities or museums, that have provided the major innovations in STEM curricula for the last half-century. They are expert and managing large projects and have attracted professional groups of experienced and innovative educational developers and researchers. These R&D groups do not have financial reserves or access to investors that could provide the matching funding. They do, however, have a history of collaboration with other institutions, and could collaborate with for-profits that could raise capital against promising pilot results and market or license the resulting courses. Some of these R&D groups lack experience in creating educational technology and will need to pair up with organizations that are expert in developing technology-rich educational materials.

The National Science Foundation's Division of Research in Education is the ideal federal agency to administer this program. They have a dedicated team of program officers who administer over $800M in educational grants annually. They have funded and overseen numerous important educational projects at the $5M to $10M level. The NSF is responsible for many innovations in text-based precollege curricula starting with the PSCS physics curriculum that marked the first NSF educational funding in 1957. In the mid-1980s there was an NSF "Triad" program that was very similar to our proposed pull mechanism. This program funded the development of elementary science curricula. The grants were roughly $5M and nonprofit awardees had to collaborate with a publisher willing to match NSF funding dollar-for-dollar. Some of the collaborations floundered, but one, FOSS, is currently one of the best low-tech elementary curricula. Another, the NGS KidsNetwork, fostered the development of the student citizen science movement that continues to this day.[4]

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[4] The term "Triad" refers to the co-equal engagement of developers, publishers, and teachers in the projects. NSF commissioned a review of the Triad Projects by Arnold Stassenberg that could be invaluable in crafting the proposed "pull" project.

The NSF would have to make some minor adjustments to accommodate the proposed program. Currently, its programs are heavily oriented toward educational research—the deeply digital curriculum creation program would be far more applied than most current NSF programs. In addition, NSF current funding does not permit the level of technology development that would be needed to support deeply digital courses. Both weaknesses could be addressed by careful assignment of staff and reviewers. In addition, the NSF currently forbids matching funding, so an exception would need to be approved by the NSF's governing committee, the National Science Board, for this program.

If the NSF is unable or unwilling to provide the grant funding, it is possible that a private or company foundation, or venture philanthropies would step up to this challenge. The estimated costs for an exemplary course is less than many foundations give for education.

Answers to Questions

Our responses to the specific questions asked in the RFI are implicit in the narrative above and are summarized in the following for the convenience of readers.

(1) *What learning outcomes would be good candidates for the focus of a pull mechanism to catalyze the creation and use of new learning technology? These outcomes could be relevant to early childhood education, K-20, life-long learning, workforce readiness and skills, etc.*

When compared to student gains in typical courses, student gains in deeply digital courses would be significantly higher.

(2) *How are these learning outcomes currently measured and assessed?*

There are currently no ideal outcome measures; a new set of measurement instruments would need to be developed using a mix of assessment strategies based on current standards. Assessments to match the Common Core are currently being developed for mathematics. Many research and product groups are likely to engage in developing assessments for the Next Generation Science Standards, and existing funding mechanisms through IES and NSF may be sufficient to produce the necessary measures. This is also a concern of NCES with regard to NAEP, and it is possible that NAEP measures, which will align with modern standards, could serve as appropriate outcome instruments.

(3) *What information exists about current U.S. performance relative to this learning outcome? What information exists about the presence (currently available or potential given current trends or breakthroughs) or absence of effective interventions (technology-based, offline, or hybrid) to improve this learning outcome?*

Extensive research exists for student gains attributable to four of design features that we recommend incorporating in deeply digital secondary STEM courses. The authors can provide a summary of research reviews and key papers in each area. There is no research on courses that combine all of the recommended design features because no such course has been created.

(4) *Why would a pull mechanism in this area accelerate innovation in learning technology?*

The key challenge would be developing and testing at least one exemplary deeply digital course. Success with this one course is likely to stimulate the development of a full set of STEM courses. Because of the cost and possible risk in developing such a course, current grant policies and market mechanisms have failed to produce such a course, even though the know-how is available. A pull strategy similar to the "Pay-for-Success Bonds" strategy could spread the costs and risk between granting agencies and business investment.

(5) *What role might different stakeholders (e.g. Federal agencies, state and local educational agencies, foundations, researchers, practitioners, companies, investors, or non-profit organizations) play in designing, funding, and implementing a pull mechanism for learning technology? What role would your organization be willing to play?*

A possible mechanism for funding would involve the NSF EHR Division defining a program similar to its Triad Projects that were funded in the 1980s. The program would fund collaborations between awardees and companies to create deeply digital STEM courses. To ensure that at least one exemplar is successful and to spread the technology development costs, we recommend developing three different exemplary courses each incorporating the eight design principles and using the same software platform and tools. These courses would be carefully studied and compared to current practice, with the expectation that these exemplars would provide research and marketing data that would stimulate the development of additional courses without the need of federal funding. As in the Triad Program, the awardees would have to match grant funding with commitments from foundations, collaborators, and investors.

(6) *What changes in public policy would facilitate experimentation with pull mechanisms at different levels of government?*

The NSF educational funding is currently strongly committed to research and it would require a shift in priorities to add a significant effort for deeply digital course development. The long-term objective of educational research is to understand how best to make large-scale improvements in education. More than a decade of serious research has created a treasure trove of results that can and should be applied to transforming the STEM curriculum. There is sufficient funding for the NSF to continue a robust research educational program while also creating a new generation of curricula.

This program could be created by executive order; the NSF could easily divert to this program existing funds of approximately $6M per year over the course of four years to fund three courses without requiring new funding. The National Science Board would need to approve an exception for this grant category to the NSF policy that currently forbids matching funding.

If the NSF is unwilling or unable to alter its priorities to include large-scale curriculum development, another agency would be needed. The Department of Education's Institute for Educational Sciences would seem to be a logical place, but they are exclusively committed to educational research, have very few officers who are expert in STEM, technology, curriculum and technology development. Recognizing these problems, the PCAST report "Prepare and Inspire" recommended creating a new agency modeled after DARPA; a mission-oriented granting agency comfortable with innovation and technology and able to move quickly and take risks. A more practical alternative might be to undertake a concerted effort to convince private foundations or social venture funds to lead the development effort.

Supplementary Material

Authors

This paper was written by members of the Deeply Digital Coalition, and has been approved by the following members of this group (titles and institutions provided for information only and do not indicate institutional endorsement.)

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Deeply Digital Design Principles

The following is the beginning of a blueprint that describes the characteristics of the learning materials and teacher supports that are needed to power the kind of improvement we envision. There is convincing evidence for the ability of each of the following eight design principles to improve teaching and learning in STEM. Used together in supporting quality content, they are certain to improve learning. .

1. Coherence. STEM learning demands a sequential development of core ideas and practices that fit together in logical progressions so that students are always building on prior learning. Coherence is difficult to achieve and is often obliterated through the too-common practice of assembling a jumble of free materials from the Web.
2. Student exploration. Because the goal of STEM learning is for students to progress to being able to conduct independent inquiries, STEM instruction must include student learning through guided exploration based on hands-on investigations, interactive models, discussions and communication of findings, and self-reflection. Every course should allow students to experience research and design through engagement in investigations of their own choosing. Technology can greatly increase the range of possible explorations through the use of computational models, software and hardware for collecting data, data display and analysis tools, and visualization software.
3. Assessment. One of the barriers to improving curriculum and instruction is the use of testing that relies exclusively on easily measured facts, formulas, and vocabulary. Deeply digital materials should measure all the learning goals, including process and design skills, and the ability to communicate ideas and conclusions. These assessments can be ongoing and real-time, based on logging that is built into software, and fed immediately to teachers along with suggestions for addressing student weaknesses.
4. Collaboration. Deeper learning can be achieved when students work together in collaborative groups on well-designed challenges. Technology can be employed to foster this by facilitating assignment of students to groups, supporting student communication in school and at home, providing online resources that support collaboration in all aspects of learning, and tracking individual student contributions.
5. Universal Design. Universal Design for Learning principles ensure that diverse students are engaged and supported. UDL materials provide alternative ways of acquiring and assessing learning that teachers and students can tailor to individual strengths and needs. Good UDL design gives users control over the appearance of materials, provides tools such as vocalizers and glossaries, and supports alternative curriculum treatments. To reach the broadest range of students, the materials need to relate to student interests by using real-world questions to frame topics, presenting interesting design challenges, and making appropriate use of educational games and game-like challenges.
6. Continuous Improvement. The best learning materials should incorporate inputs from educators worldwide so that the learning resources improve over time. Curricula need to be adaptable to meet different requirements, educational strategies, and interests. The model of textbooks—one-size-fits-all tomes that are nearly permanent —needs to be replaced by a system that supports student activities generated by teachers, districts, and other sources. This flexibility needs to be balanced by the need for coherence, which can be ensured by providing a coherent core that is supplemented by optional materials. We envision an online community of educators who will develop, evaluate, and share supplemental materials that strengthen and extend a shared core of key ideas. The result

will not be a single deeply digital curriculum, but a cluster of curricula that are similar but adapted to the needs of schools and teachers. The technology used should facilitate this by simplifying authoring new activities and providing the review and publishing functions needed.

7. Teacher Empowerment. Teacher-led classrooms are essential and the curriculum must be designed to enhance the teacher's role and resources, and should never be viewed as replacing or sidelining teachers. The materials should take full advantage of the knowledge and experience of teachers by providing teachers with tools for communicating with students, holding class discussions, easily assigning and assessing individual as well as group work. Many teachers will need assistance in order to use the deeply digital materials effectively. A comprehensive approach is needed that includes pre-service courses, online resources, workshops, seminars, educative curricula, communities of practice, and just-in-time resources.
8. Parent and guardian engagement. Involving parents or guardians is a reliable way to boost learning. Parents can help if they receive accurate and timely assessments of their students' progress, are able to enjoy their children's performances, and are given suggestions for family activities that support current classroom topics. Technology linked to a curriculum can speed and simplify preparing and delivering relevant resources.

The core materials need to be consistent with, and exceed, applicable standards: NGSS for science and engineering, Common Core Math standards, or other accepted standards. This applies not only to the content standards, but also to standards that refer to the use of inquiry, exploration, design, and crosscutting themes. Engineering education is an essential part of STEM education and the NGSS standards. Since engineering is seldom an entire course, it needs to be integrated with science and, to a lesser extent, math content. This integration can be done in a way that enhances science and math learning.

RESPONSE TO OSTP REQUEST FOR INFORMATION ON PULL MECHANISMS

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General Comments

Several comments are offered that address general issues related to the RFI followed by several suggestions about the management of the enterprise of "pull-funding."

Personalization

One thought is the focus on personalization. Although heretical in the current environment, there are some legitimate reservations. It is possible to personalize everything, of course, from Christmas cards to adaptive game play. Underlying the notion of personalization is the concept of motivation, as it relates to goals, content, and process, as well as the belief that certain types of personalization are easier, cheaper, obvious to the learners, and effective. The question is the marginal gain for personalization in a learning setting, including the basis upon which it occurs, history, process data, stated preferences, and on-the-fly options.

Personalization may also be used for important issues, that is the goals and values of students, and for instructional attributes that do not matter too much, e.g., your favorite avatar, rather than asking students to select their preferred learning approach. There is probably a middle line where the main force of instruction and learning can be clean, engaging, and evidence-based, and smaller options for topic choices within, for example, a cluster of standards. In any case, personalization can vary in type, size, depth, interval, and so on, and has great currency in the development world with less clear supportive data. Lack of clear learning evidence may be attributed in part to the types of assessments actually used to determine effectiveness and their insensitivity to instructional features.

Person in the Loop: Teachers

The second question is about the person in the loop. Could many of the "prize" topics be directed to teachers-as-learners as well, especially to those in mathematics and science, where there is evidence of underprepared or low-confidence teachers in these fields? The argument is that the US needs to ramp up its performance in STEM. One approach is that teachers could be a focus of a prize effort, with similar prizes given for their acquisition, implementation, and effects on students (in a controlled setting). Another is to yoke both teacher and student learning elements. This proposition assumes a blended (people and technology) system in the near term.

Additional Possible Topics

The following topics are offered to augment the examples offered in the RFI documentation.

1. Accelerating learning in mathematics for poor-performing students, e.g., two years of algebra in six months meeting Common Core State Standards measured by the States plus a transfer test.

2. Building persistence to deal with "boring" or routine tasks, tasks that are necessary to move to higher achievement—an approach that contrasts with making all things fun. The suggestion implies that teachers or other mechanisms, including technology, could be used to support attention, persistence, resilience, and the resulting self-efficacy derived from successful effort, across a range of tasks. Underscoring that not everything is fun in life or job tasks, we could build capacity to succeed at both routine and interesting academic or real-world tasks needing focus and sufficient attention for learning.

3. In the assessment area, there are a number of important problems that should be developed. They may have less apparent value than some examples, but solving them would have long-term dramatic effects on the educational system.

    3.1. One such problem involves the creation of a standard that can be scaled across interventions and will permit the interpretation of findings from apples-and-oranges interventions. This would serve the purpose assigned in the past to "standardized" tests, which are no longer useful as an external metric because there are many of them, they narrow and transform instruction to drill and practice designed to meet criteria, and they have been subject to corruptions. Instead, if carefully designed assessments, a related computational model, and a revolving set of transfer or application tasks were created and not made available to users except through controlled technologically based assessments. These measures could be developed at key grade levels, for critical standards, and would begin to develop what education has long needed, a clean and clear standard scale against which different programs, schools, innovations, etc. could be measured. All would be done within a tight schedule, with good evidence involving various subgroups and enough students to be unassailable. This activity would go a long way to focus attention of learning and not just scores. Technology is there to solve the "apples and oranges" problem of different interventions.

4. Mapping in detail the learning goals, activities, and performances in domains such as math, literacy, and science, in a "learnome" approach, e.g., specific elements, sequences, or clusters of learning could be validated in transfer or new application tasks and in brain-mapping using fMRI technology. Accomplishment for a number of age ranges could lead to understanding better the reasons for the poor performance of American students. This work brings education into the Brain Initiative in an important rather than ancillary way and serves as infrastructure.

    4.1. Within the testing domain, the development of far greater transparency. This would be an innovation where test items or tasks within a particular domain are made available to students i*n advance* of their administration, without answers and in sufficient numbers such that memorization of individual items would not be an option. If the questions involve complex cognition, transfer, and generalization to new applications, and are drawn to represent common standards, they could incent learning, obviate the need for cheating, and reduce high security costs and the chilling environment they sometimes set for performance.

    4.2. Related and centrally important is the evidence base for giving performance for badges, tests scores, and so on. It is presently set in the hoary concept that one needs a different test for every assessment purpose, an idea that can be challenged easily through Big Data approaches, and the design and development of items at various levels of granularity. If we could use computational models that can simultaneously operate on tests for various purposes (e.g., summative, certification, formative, or diagnostic), overhead would be cleared out and results and reports would be made more comparable.

    4.3. More useful reporting options to show where individuals, subgroups, institutions, etc. (including training and readiness) are through linking both improved design (ontologies of domains and cognitive expectations, task models, analytical techniques, improved computational models) and visualization techniques from geographic, space, or biological mapping. The goal is to report multiple levels of findings, for different subjects and subgroups, against multiple criteria of excellence in an at-a-glance, intuitive way.

Potential Roles for CRESST

Given we know little about your start dates, operational periods, and so on, CRESST could help in the following ways.

CRESST or the evaluator could serve as a data repository and auditor and recommending certification for competitors. This role would mean specifying the data structures, the data flow during the project, and the evidence of performance validity offered, and might well include setting standards of performance and evidence for the competing teams. The work would require verification of sampling (e.g., a PISA problem historically), fidelity of interventions, other claims about participants, and process and outcome data including that generated by systems and that generated using external sources of evidence. The functions would include certifying the validity of measures if either a single cluster or a team-generated approach were used. Independent analysis would be conducted to verify claimed findings, and we would include nationally recognized leaders.

Assistance could come without having the actual data, to specify sampling requirements, assurances, and sources of evidence to be provided by teams. In considering time frames, sampling, attrition, and the usual threats to innovations, one would wish to avoid a halo effect, so one or more control groups would be needed and the scale of the experiment would need to be large enough to matter. That is, CRESST or the evaluator could support your effort by ensuring team specifications include technical characteristics to support validity and trustworthy findings.

White House Pull Mechanisms for Education

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We propose several pull mechanisms to incentivize school reform in the United States. One goal is to attain significant, sustained and widespread improved student outcome. Research has shown that success in school reform is not dependent upon current performance, wealth, system level, or school size.[2] It is only dependent upon consistent and long-term application of interventions, such as those listed below. We also recognize that each school's journey is different and does not have a set starting point. Towards this end, we suggest several entry points among possible interventions dependent on the reform stage of the school system. Schools will select from among interventions those needed for their stage.

1. Stages of School Reform

Entry Level (Early Reformer) School System:

Basic literacy and numeracy: Award prizes for the state (or district) that produces the greatest achievement in bringing all system schools up to minimum quality threshold, e.g., students achieve grade level in reading and mathematics at grades 1-3. Many learning technologies address reading (e.g., LISTEN) and mathematics (e.g., Wayang, ASSISTment, Cognitive Tutor).

Personalized Learning: Award prizes for the most innovative personalized software that provides deeper learning and services to produce real change in learning outcomes, graduation rates or workforce development, and especially in teaching 21st century skills (e.g., problem solving, dynamic thinking, collaboration and communication).

Scaffolding for low-skill teachers: Schools provide training for low-skilled teachers. Award prizes for productivity environments that enhance teacher collaboration and communication with other teachers, students and stakeholders.

Equality Prize. Schools run regional contests. If more privileged schools win, they have an opportunity to send the prize to less privileged schools in their district.

Forward Moving (Fair to Good) School System:

Production of high quality assessment data. Award a prize for new ways to measure student assessment. Also award a prize for schools that derive new insights from huge volumes of student transactional data.

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[1] Contact: Dr. Beverly Park Woolf, ([redacted] [redacted]

[2] Mourshed, M., Chijioke, C., & Barber, M. (2010). How the world's most improved school systems keep getting better. McKinsey.

Increased Engagement. Award a prize for improved student engagement through interactive digital pedagogy that includes graphics, simulations and visualizations. Digital natives learn best in context, in response to perceived requests or by solving real-world problems. They are accustomed to being involved in multitasking and "on the go" modes.

Formative Assesment. Award a prize to facilitate school systems that conduct *formative assessment*, real-time assessment (while students work online) to provide immediate feedback to students about how they can improve their own performance. Assessment should be *immediate, seamless, ubiquitous*[3] and *stealth* for learning, i.e., the ability to diagnose and intervene during a learning session based on detecting a particular student's learning needs in real time. Also award a prize for school systems that measure 21st Century skills such as problem-solving and critical thinking.

Deeper and more personalized learning: Award a prize for software that best meets children where they are and helps them develop their passion and commitment for a subject. Look for interactive feedback provided by intelligent tutors, classroom displays, and formative assessment systems.

Good to Great School System

Support teaching and school leadership. Typically teachers and school leaders are not allowed to stand back and evaluate their own systems. We need to tap the expertise of the best and brightest education leaders and support them to focus on how to improve the system. We suggest time off for "teacherpreneurs" who yet work to improve the system. The cost will be born by the school and teachers'union. Award prizes for the best ideas from education leaders who have taken off six months to innovate for schools.

Teacher Resources. Award a prize for tools that dramatically increase teacher productivity. For example, software that increase the availability of, and access to, effective content, for a given grade and topic, locating all within a single portal that provides interoperable standards and APIs for all modules. Such portals will support millions of students and adults and be designed to foster accelerated uptake of technology by students, teachers and parents as well as improved competence and expertise.

Great to Excellent School System:

Peer-based learning. Award a prize for paired master/new teacher programs. Measure the teacher training, especially in terms of new teacher resilience and grit.

System-wide interaction. Award a prize for development of Learning Kernels, or anytime, anywhere modules of knowledge, e.g., videos (Kahn Academy), problems, interactive books, exercises that enable students to access pockets of knowledge. Students receive badges of completion in areas of knowledge, e.g., Chinese Language, musical performance, theater.

Maker Projects. Award a prize for the best Maker Project. There are so many entry points for these activities outside of school, in school, on line, person to person, e.g., FabAcademy, Leggo First.

2. Metrics of Awards

This section suggests some metrics to evaluate the contestants. Learning technology produced by contestants will be assessed based on the product's ability to provide *access* (democratic entry, available to all), *excellence* (leading to learning gains) and *impact* (providing a social benefit).[4] Prizes will be awarded corresponding to the reform levels of the school for which it is intended (Entry Level, Moving Forward, Good to Great, and Great to Excellent).

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[3] Seamless refers to the removal of false boundaries between learning and assessment, and ubiquitous refers to the constant nature of assessment that feeds back results and implications into learning, anywhere and anytime.

[4] These values/missions are from Arizona State University.

3. Sources of Revenue

This section suggests several private and public mechanisms for funding education prizes.

Private Sources. The *Bill and Melinda Gates Foundation* has donated $2 billion for education since 2008.[5] Their goal is to support innovation that can improve U.S. K-12 public schools and ensure that students graduate from high school ready to succeed in college.[6] The *William and Flora Hewlett Foundation* focuses on deeper learning, to help schools nationwide prepare a new generation of students to respond to the ever-increasing demands of a rapidly changing world.[7] The *Joyce Foundation* works to improve teacher quality in schools that serve low-income and minority children, expanding early-childhood education, and promoting innovations such as charter schools.[8] The *Noyce Foundation* is dedicated to improving math, science, and reading instruction in public schools, promoting school leadership and education research, and expanding opportunities for informal, hands-on science learning for students.[9] The *Carnegie Corporation* is focused on generating systemic change across a K-16 continuum, to enable more students to achieve academic success and perform with the knowledge and skill needed to compete in a global economy.

Government Advance Commitment: This type of federal support takes the form of an Advance Market Commitment (AMC) meant to inflate the economic demand presented by low-performing schools and adult literacy advocates. It begins with binding agreements from donors/funders to make the market for educational software more profitable and predictable. The donor/funder commitment is also expected to have an impact on schools and adult literacy both through increased and accelerated supply of appropriate resources and increased demand. Ultimately, an AMC will identify schools and teachers that can commit to buying the curriculum in advance. Then the government will encourage acceleration and expansion of software development and increased investment in production capacity by developers. The primary goals for AMC are to (a) produce modules that meet school and adult needs; (b) guarantee the initial purchase prices; and (c) ensure continued module use through stable module pricing by participating companies.

Evaluation methodology. We recommend pursuit of a pipeline for an evaluation methodology to be used for learning technology similar to that which is currently practiced in the pharmaceutical industry. Specifically, new technologies would be evaluated initially with small pilot studies with students at a few sites, followed by larger-scale studies that compare new modules with currently pedagogies. As positive efficacy data are gathered, the number of users and sites is increased. Phase I and Phase II trials would vary from single centers to multicenter trials in multiple states. During these trials, researchers will recruit students, administer treatment(s), and collect data describing the observed benefits of the approaches. Due to the sizable cost that a full series of trials may incur, it is likely that the burden of paying for all the necessary people and services will be borne in part by sponsors including relevant federal agencies, publishers or software companies.

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[5] See http://www.edweek.org/ew/section/multimedia/gates-education-spending.html

[6] See http://www.gatesfoundation.org/What-We-Do/US-Program/College-Ready-Education.

[7] See http://www.hewlett.org/programs/education-program

[8] See http://www.joycefdn.org/programs/education/

[9] See http://www.noycefdn.org

Waterford Institute®
LEARNING WITH THE SPEED AND ENERGY OF LIGHT

March 7, 2014

Office of Science and Technology Policy
Attn: Cristin Dorgelo
1650 Pennsylvania Avenue, NW
Washington, DC 20504

Dear Ms. Dorgelo:

On behalf of the Waterford Institute, I am thankful for the opportunity to submit comments on the Office of Science and Technology Policy's (OSTP) request for information to help inform policy development related to high-impact learning technologies.

The Waterford Institute is a nonprofit research center founded in 1976. Waterford's mission is to provide every child with the finest education, through the development of high-quality educational models, programs, and software. An important concept at Waterford is combining technology and education to battle the achievement gap. Research over the past two decades has shown that without early intervention, an achievement gap develops between at-risk and average students, and the gap increases exponentially during the early years of education.

Waterford believes the solution to closing the achievement gap is early intervention with the right tools. Waterford early learning programs provide a solid foundation for preschool, kindergarten, and grade-school students early, before the obstacles to learning overwhelm them. Whereas traditional instruction can only target the approximate needs of the average student, computer-based courseware imparts a highly specified curricula that is thorough and rigorous but is also adapted to each student's learning needs. Waterford's programs ensure mastery of core concepts by individualizing instruction to meet the needs of each student. By intervening early, and using the combined strengths of technology, teachers, families and students all working together, Waterford is working to ensure that each student, regardless of primary language or beginning level of literacy, is prepared for success.

The Waterford Institute uses technology to promote the academic success of every child. Waterford uses technology to provide access to outstanding curriculum software designed to provide individualized, interactive instruction that ensures mastery of materials:

- Technology is Scalable – One great teacher can instruct only a handful of students every year; software can take that knowledge and teach almost a limitless number of students.

- Technology Provides Equity – All children, regardless of family means, should have access to the best education. Unlike standard schooling where schools and faculty can lack uniformity in terms of quality and talent, software makes it possible for the poorest children to have the same high-quality teaching available to them as the wealthiest children have.

- Technology Provides Individualized Instruction – Software adapts to a child's learning trajectory and ensures every activity is specifically chosen for that child's needs, challenges, and strengths.

- Technology is Artistically Engaging – Beautiful graphics, music, and interactive activities keep children focused on learning.

- Technology is Generationally Appropriate – Today's children are "digital natives" and adapt quickly and easily to software-based instruction.

- Technology Provides Instantaneous and On-Going Assessment – Testing can be seamlessly interwoven into the software curriculum and provide invaluable assessment and reporting functions.

- Technology is Cost-Effective – The scalability of software reduces per-hour instruction expenses to mere pennies.

- Technology Offers Accessibility – Children can receive instruction far beyond the 180 days of the traditional school year.

Unfortunately, in recent years many federal education programs geared toward supporting digital media and technology have had funding decreased or completely eliminated (i.e. Enhancing Education through Technology, Ready to Teach, etc.). However, given the new challenges faced by states, districts, and schools, we're seeing a renewed interest in supporting innovation in learning through the use of digital media and technology. Accordingly, Waterford supports policy approaches that utilize technology to transform teaching and learning and we are particularly pleased that OSTP is interested in actions that have the potential to accelerate the development, rigorous evaluation, and widespread adoption of high-impact learning technologies.

In order for learning technologies to be "high-impact" they must be successful. Accordingly, Waterford supports OSTP's focus on rigorous evaluation. Waterford programming has been formally assessed in a variety of schools and districts of varying size, location, and socio-economic status. The consistency of these research results, both within and between studies, has been impressive. In each of the studies, classrooms where Waterford programs were used outperformed comparison-group classes in most, if not all, the examined assessment measures.

Because of our constant focus on quality and evaluation, the Waterford Institute was recently announced as one of the highest-rated applicants for a Validation Grant under the latest round of Investing in Innovation (i3) funding at the Department of Education. The project will be a partnership between the Waterford Institute and Utah's geographically far-flung 18 rural school districts that is designed to expand and enhance Waterford's home-based technology solution for school preparedness in Utah – UPSTART (Utah Preparing Students Today for a Rewarding Tomorrow).

In addition, Waterford believes that OSTP should focus on evidence and results for any policies connected to high-impact learning technologies, including through "pay-for-performance" and related "pull mechanisms." Historically, the federal government has supported programs regardless of whether the services delivered actually achieved results, as long as providers met federally-prescribed rules that generally focused on inputs.

Waterford believes that grantees should be able to design evidence-based programs in a flexible manner that ultimately focus on early learning results, as opposed to federally-prescribed inputs. Too often, federal programs contain lengthy checklists of requirements, but pay-for-performance initiatives have the potential to change the status quo by ensuring that federal funding is actually linked to results and outcomes, not primarily on inputs and federal requirements.

Accordingly, Waterford is supportive of pay-for-performance and other related pull mechanisms that ensure government dollars are spent in an effective manner on programs that achieve the intended results for the people they serve. Waterford would encourage OSTP to develop high-impact learning technology policies in a way that both ensures providers are held accountable for results and also allows for adequate flexibility with regard to how a provider designs and implements the program.

Finally, to help ensure the success of any forthcoming policies related to high-impact learning technologies, Waterford would ask that OSTP consider developing policy options that include partnerships with effective external providers as part of the solution.

Waterford believes that schools and early learning programs cannot achieve the results that are demanded of them and that students deserve if they are working alone. College and career ready expectations require that our educational system provides additional, aligned services – such as more time for learning, early interventions, parent engagement, professional development for educators, tutoring, and related activities – and our current system does not have the capacity to do them all well.

Effective external partners can help to expand, deepen and accelerate learning – and external partners that have a track record of success and bring additional expertise and resources to the table can make a significant difference in the lives or our children. Accordingly, Waterford supports policies that encourage partnerships so that we can provide academic programs that allow students to receive a better array of supports and assistance needed to remove barriers to learning, improve our educational systems, and help the children that need it most.

Thank you again for the opportunity to comment on high-impact learning technologies. Please do not hesitate to contact me if you would like any additional information or if you have any questions regarding our recommendations.

Sincerely,

Dr. Benjamin Heuston
President
The Waterford Institute

XPRIZE Foundation Response to Office of Science and Technology Policy Regarding Advancing Learning Technology through Pull Mechanisms

- **Institution Name:** XPRIZE Foundation
- **Contact:** Chris Frangione; Program Director, Impact & Innovation
- **Mailing address:** 800 Corporate Pointe, Suite 350, Culver City, CA 90230
- **Phone:** [redacted]
- **Email:** [redacted]
- **Type of Organization:** 501(C)(3) nonprofit organization
- **Area of Expertise:** Prize development and administration

(1) What learning outcomes would be good candidates for the focus of a pull mechanism to catalyze the creation and use of new learning technology? These outcomes could be relevant to early childhood education, K-20, life-long learning, workforce readiness and skills, etc.

Learning outcomes that would be good candidates for the focus of a pull mechanism to catalyze the creation and use of new learning technology could address the following:

- English language needs of ESL/ELL learners with young children, to better prepare their children for success in school.
- Literacy, numeracy, and problem-solving skills of young adults who have dropped out of high school, enabling them to achieve high school diploma equivalency.
- Improvement of technological literacy of low-skilled workers, enabling them to advance in the workplace.
- Health literacy for improved health outcomes.
- Improvement of persistence, motivation, and time-on-task for adults in adult education programs, significantly increasing success rates.
- The challenge of children in early grades who fall behind in reading by creating technology as “mentor” in a way that allows even the poorest readers to enhance their chances of reading at grade level.
- Collaborative learning among children at the primary-school level using technology in a way that allows them the ability to teach themselves *and each other* the basics of reading and numeracy.

These learning outcomes could be effectively addressed through the pull mechanism of a prize competition because resulting solutions could be scalable, engaging, and tailored to a student’s pace of learning. Key elements that a prize competition for literacy would address are access, scalability, and “stickiness” of the solutions. In addition, a key element of a prize could be the requirement of an artificial intelligence (AI)-based component that serves as mentor to a child throughout her primary school life.

(2) How are these learning outcomes currently measured and assessed?

Learning outcomes are currently measured with outdated methods, such as school grades and annual standardized exams. Each of these current systems has a number of weaknesses that could be improved by the type of individualized learning tool that a prize could incentivize. With regard to grades, students often receive grades based on social promotion or submitted work that does not necessarily reflect mastery of a subject. On the other hand, standardized tests are often infrequent, not engaging and may not align with what a student has been taught.

A literacy prize could complement these assessments systems by providing tailored, entertaining instruction and instantaneous feedback to the learner. Additionally, a prize competition could incentivize the creation of new metrics that are more appropriate for the current educational landscape. For example, adults' mastery of "functional literacy" could replace standardized tests by measuring real-life tasks at which adults need and want to excel. By tying success to new, more meaningful metrics, prize competitions can address some of the key failings of the current adult education system, such as the lack of goal-oriented processes and outcomes that appeal to adults.

Testing is a convenient, or in some cases the only, means of extricating oneself from poor school systems (like those frequently found in U.S. inner cities or in rural areas in poor countries). Why has such a system prevailed? The answer is convenience of the testing and that the tests yield a rough approximation of comparative abilities, which is important when many people apply for a limited resource. However, these standardized tests would often be better replaced with project-based learning and individualized evaluation that take into account emotional intelligence, expressive arts, scientific abilities, artistic talent, and humor. This is particularly true in early learning, during which time children should learn learning but also to love learning. The development of technologies to measure this kind of learning would be a tremendous breakthrough.

(3) What information exists about current U.S. performance relative to this learning outcome? What information exists about the presence (currently available or potential given current trends or breakthroughs) or absence of effective interventions (technology-based, offline, or hybrid) to improve this learning outcome?

National and international organizations regularly provide information about adult literacy in the U.S. For example:

- Currently one out of six adults in the U.S. lacks basic literacy and numeracy skills.
- The U.S. workforce is ill prepared for the knowledge-based economy.
- This is the first time in U.S. history where the current generation is less well educated than the previous generation.

- Low literacy skills correlate strongly with poor health outcomes. Low-skilled adults are four times more likely to be in poor health.
- Shifting demographics in the U.S. require a focus on basic skills for new Americans, particularly if their children are to succeed in the education system.

Internationally, the U.S. ranks below average in both literacy and problem solving in technology-rich environments. The U.S. is also at the bottom of the pack in numeracy, among the 30 OECD countries. Additionally, socioeconomic background has a great effect on adult literacy skills in the U.S. than in other OECD countries, which speaks to literacy as a civil rights issue.

While innovations in technology have become popular among literacy programs for children, particularly the use of tablets for instructional games, there is very little data on the uses or benefits of technology innovations for adults. Adult education practitioners argue that low funding levels prevent them from having even basic technology, such as desktop computers, for their learners. This is a key area where low-cost technology innovations could significantly revolutionize the field of adult literacy.

In addition, we know that children who fall behind in reading rarely, if ever, catch up to their peers. While children can catch up in numeracy, reading has proven to be far more difficult. A prize could incentivize not only the use of artificial intelligence as mentor to children, but also the application of other competencies to enhance reading ability.

(4) Why would a pull mechanism in this area accelerate innovation in learning technology?

A pull mechanism in this area would draw attention to and create a scalable solution in an area where there are currently few solutions available despite the possibilities for real improvements.

For example, in adult literacy, key challenges faced by adult learners include access to technology and adult education programs, time required on task ("life gets in the way") and motivation. In addition to these challenges faced by individual learners, a larger public awareness problem exists in that most Americans do not know that 36 million American adults read at a basic or below basic level. With little public awareness and pressure comes little in the way of public resources or assistance for adult learners.

A prize competition would create public awareness around the issue in addition to incentivizing solutions that address the issues of access, time on task and motivation. Solutions would be required to demonstrate that they provide long-term, sustained results. Innovation in learning technologies will play a significant role in the development of contextualized, individualized and responsive technologies that take learning out of the classroom and into everyday life. By incentivizing the development of low-cost solutions, a prize competition could revolutionize the field of adult literacy, which currently lacks even the most basic technology resources.

(5) What role might different stakeholders (e.g. Federal agencies, state and local educational agencies, foundations, researchers, practitioners, companies, investors, or non-profit organizations) play in designing, funding, and implementing a pull mechanism for learning technology? What role would your organization be willing to play?

Various stakeholders could contribute to both the Global Literacy XPRIZE and the Adult Literacy XPRIZE by helping to design, operate, fund, judge, and promote these competitions. XPRIZE is currently developing the Global Literacy XPRIZE, which seeks to stimulate innovation in the area of technology-based learning to solve one of the world's greatest challenges: the lack of quality learning experiences for millions of the world's poorest children. The prize purse will be awarded to the team(s) whose technology can bring children in the poorest and most remote parts of the world from total illiteracy to a state of creative learning in the most autonomous fashion. The Global Literacy XPRIZE has the potential to empower children throughout the world to develop the necessary skills—reading, numeracy, and computer coding—to be critical and creative 21st century thinkers.

Because the Global Literacy XPRIZE will be operated in two developing countries, an experienced operational partner (e.g. global educational agency, NGO or nonprofit) and team of judges (e.g. researchers, practitioners) will be critical to the working success of the competition. These stakeholders will help to ensure that the competition is operated efficiently and fairly in each country, thus maintaining the integrity of the results. Another key stakeholder of the competition includes the hardware provider in which the teams' software technologies will be uploaded and disseminated to the test populations in each of the two countries. In addition to operational stakeholders, the Global Literacy XPRIZE will need promotional stakeholders to raise awareness of the competition. These stakeholders can include world-renowned education experts and thought leaders; CEOs; entrepreneurs; celebrities with a passion for education; global education agencies; NGOs; and nonprofits.

Within the field of adult literacy in the U.S., XPRIZE could collaborate with the U.S. Department of Education, state education departments, local municipalities and programs (e.g. library literacy programs), NGOs, and for-profit education companies to design and operate a robust adult literacy prize. XPRIZE is willing to develop and administer both the Global Literacy XPRIZE and the Adult Literacy XPRIZE in collaboration with stakeholders throughout education.

Another prize that could be developed is one that focuses on higher education and career preparedness. For the past 30 years, the cost of higher education has been on the rise in the U.S. As a result of a decrease in state funding, American families and students must assume the fiduciary responsibility to pay for collegiate and graduate education. The lack of state funding is exacerbated by the jump in average state tuition by 4.6 percent, more than twice the rate of inflation, in 2012 alone. In order for students to pay off their student loans in a timely manner and to adequately support themselves, they must land careers that offer financial independence and security. A prize that incentivizes collegiate and graduate programs to prepare students for these careers would provide the skills that are necessary to address the current skills gap and would ultimately offer students greater professional opportunities.

Another prize idea could focus on early childhood literacy. Exposure to a larger vocabulary at a young age is a meaningful indicator of lifelong success. Economically disadvantaged children and students suffer due to lack of exposure to larger vocabularies. A breakthrough in childhood literacy would level the playing field regardless of socio-economic status and provide these individuals with the tools necessary for greater opportunities and success.

(6) What changes in public policy would facilitate experimentation with pull mechanisms at different levels of government?

In addition to those mentioned in the Notice, there are numerous public policy changes at different levels of government that could facilitate greater experimentation with innovative instructional techniques. At the Federal level, Congressional reauthorization of the America Competes Act would allow agencies to utilize prize pull mechanisms as appropriate to foster innovation and allow government to partner with the private sector for these types of initiatives.

In addition to the reauthorization of the America Competes Act, additional Federal funding should be directed toward prizes both in education and in other areas. Well targeted prizes can draw attention to persistent problems and lead to the creation of innovative solutions and new markets. Various agencies in the Federal government should consider putting forth funding for prize competitions, both solely from their own budget and through public-private partnerships.

Additional Information

About the XPRIZE Foundation:

XPRIZE Foundation, a 501c(3) nonprofit organization, is the global leader in the creation of incentivized prize competitions. Our mission is to bring about radical breakthroughs for the benefit of humanity, thereby inspiring the formation of new industries and the revitalization of markets. XPRIZE works to accelerate the pace of innovation across sectors with prizes that are audacious, yet achievable. In developing these prizes, the XPRIZE Foundation has become expert in what works and what doesn’t work. We focus on developing competitions in areas where market failures have limited progress or resources have been exhausted.

Founded in 1995, the XPRIZE Foundation is the recognized world leader for creating and managing large-scale, global incentive prize competitions that stimulate investment in research and development worth far more than the prize itself. To date, XPRIZE has successfully awarded four prizes with combined purses of over $23 million. XPRIZE currently has three active prizes with combined purses of over $42 million and a prize group devoted specifically to developing prizes in education.

Service Innovation: Are We Creating Patchwork Quilts?
The Case of Education

Richard C. Larson, Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Imagine a complex socio-technical system that has evolved for over 1,000 years. Its current functioning can be viewed as a complex interwoven tapestry of finest legacy threads together with numerous patched weavings added in the 20th and 21st Centuries. The "System" is not quite working properly because the patches are not integrated into the whole. The design is no longer pleasing to the eye. "Experts" try to fix the problem by adding more patches and removing failed ones. The design only becomes more chaotic looking. The 'System" for which this is a metaphor becomes more dysfunctional as patches are tried, they fail, some are removed and others added. Have we created a randomized patchwork quilt?

This is the question we'd like to explore with regard to a most important service sector: ***Education***, especially k-12 education. Looking back over the past 200 years or so in the U.S., we see many attempts at "education reform" and an almost equal number of removals of such reforms. Today, with the Internet and computer technologies allowing us to do things futurists only dreamed of 50 years ago, many current reforms are technology-enabled. For the past 20 years or so, we have heard pundits offer lots of fixes for education. One suggests that invention of a $100 computer and then distributing them worldwide would solve the "education problem." Or we hear that smart-boards in every classroom will do the trick, or calculators for all students, or education via cell phones, or teaching grade-schoolers computer programming, etc., etc.

Our contention is that the socio-technical system of education is far too complex to think of reforms or improvements as add-ons or patches. For example, most teachers do not like their students sitting in front of computers because (1) the role of the teacher becomes ambiguous and (2) the students tend to know more about technology then they do, implying an unwelcomed role reversal. The national "patches" currently being implemented in k-12 education are Common Core Standards (CCS) for mathematics and Next Generation Science Standards (NGSS) for biology, chemistry and physics. Yet the history of American education, dating back to the 19th Century, suggests that these efforts will fail unless huge attention is devoted to teacher training, so-called "Professional Development." Idealized pedagogy coupled with deeper content sounds like a fine patch, but will not blend in with the whole unless attention is paid to the teacher – now forced to move away from scripted didactic lectures and towards a university-type exploratory style of teaching. For those teachers whose content knowledge is weak, there is no way that such classes will be successful.

Our message is broader than education. We hear buzz words like "Smart Systems," and that often implies adding technology to an existing but complex and centuries-in-the-making system. We need to think not of patches but of total integrated system redesign, recognizing that such efforts are difficult and come with discouraging time constants. But a beautifully intricate new embroidery awaits!

OFFICE OF SCIENCE AND TECHNOLOGY POLICY
Request for Information (RFI)
Society for Design and Process Science (SDPS)

“Learning is any change in a system that produces a
more or less permanent change in its capacity for
adapting to its environment.”

–Nobel Laureate, Herbert Simon

FOR SDPS NEXT GENERATION WITH HOPE FOR THE FUTURE, AUTHORS

For the Society for Design and Process Science (SDPS): Jim Brazell, VentureRamp.com and SDPS STEM Committee, Ravi Rao, Axelo, Inc., Darrell Woelk, Ph.D., Elastic Knowledge, Bob Allen, Ideas Orlando, Inc., Jason Robar Area 52 Games, Inc., Michael Parker, marketingeek, Rebecca Klemm, Ph.D., NumbersALIVE.org, Libby Livings-Eassa, National Career Pathway Network, Michael Bettersworth, Cliff Zintgraff, Davinci Minds, Inc. and SDPS STEM Committee, Jerry Higgs, Ph.D., AT&T and SDPS STEM Committee, Dr. John Carbone, Raytheon and SDPS STEM Committee, and Stan Gatchel, SDPS.

WITH PERSONAL SUPPORT FROM

Chittoor V. Ramamoorthy, Ph.D., Professor Emeritus, College of Engineering, Electrical Engineering and Computer Sciences, University of California Berkeley, Murat Tanik, Ph.D., University of Alabama Birmingham, Debra Mills, National Career Pathway Network, Bill Symonds, The Global Pathways Institute, Stan Leja, Del Mar College, Ray Rose, Todd Borghesani, Brett Hoffstadt, Ray Rose and Associates, Kelly Pounds, IDEAS/Teacher Studio, Ranjan Banerji, Slalom Consulting, Inc., Bill Carico, CEO from MeghaVault, and Garrett Ashmore, Stoneworth Financial.

BACKGROND

The Office of Science and Technology Policy requests comments to inform its policy development related to high-impact learning technologies. This Request for Information offers the opportunity for interested individuals and organizations to identify public and private actions that have the potential to accelerate the development, rigorous evaluation, and widespread adoption of high-impact learning technologies. The focus of this RFI is on the design and implementation of “pull mechanisms” for technologies that significantly improve a given learning outcome. Comments must be received by 11:59 p.m. on March 7, 2014, to be considered. In your comments, please reference the question to which you are responding.[1]

SOCIETY FOR DESIGN AND PROCESS SCIENCE (SDPS): SDPS was incorporated in the State of Texas on September 6, 1995. It holds non-profit status with both the IRS [IRS Code 501(c)(3)] and the State of Texas. SDPS is a professional society with international membership. It has been in continual operation since its founding. We promote science and education as stated in our articles of incorporation: The corporation is organized for educational and scientific purposes and shall be dedicated to the study,

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[1] https://www.federalregister.gov/articles/2014/01/13/2014-00404/notice-of-request-for-information-rfi

understanding and use of design and process science for the benefit of all people throughout the world.

SDPS Vision and Scope - It is the vision of this Society to be a catalyst for change, enabling the discovery of new approaches that lead to alternative solutions for the increasingly complex problems that face civilization.

SDPS Objectives

1. Promote the development of design and process science as applied to all traditional disciplines of engineering by sponsoring conferences and participation in other appropriate activities.
2. Encourage and foster research and development to advance the discipline of design and process science.
3. Provide leadership and resources to foster cooperation among organizations in establishing meaningful international standards. Distribute, promote, and encourage the use and application of these standards for universal improvement.
4. Encourage an interchange of ideas among engineers, scientists, managers, decision makers and organizations by:
    a. Disseminate information through publishing and other means.
    b. Organizing conferences and programs for presentations and demonstrations to advance the state of knowledge.
    c. Cooperating with other professional organizations and committees with respect to standards, interdisciplinary research, and technical meetings.
    d. Providing a liaison between the Society and Codes and Standards Committees.
    e. Providing an atmosphere of fellowship between members that recognizes those professional needs of society membership which can best be supplied by association with peers.
    f. Supporting continuing education activities; and g. developing international cooperation and understanding.
5. Recognize achievement in the field of design and process science.
6. Provide long-range planning activities to insure that the Society achieves its objectives and provides quality service to its members.
7. Develop and promote membership in the Society.
8. Support student activity.
9. Support other appropriate objectives.

SDPS CONTACT

Society for Design and Process Science and Software Engineering Society
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http://www.sdpsnet.org

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OSTP QUESTION #1 - What learning outcomes would be good candidates for the focus of a pull mechanism to catalyze the creation and use of new learning technology?

These outcomes could be relevant to early childhood education, K-20, life-long learning, workforce readiness and skills, etc. Learning outcomes that will catalyze pull mechanisms in the creation of new learning technologies include:

I. Concept of Operation, STEM Innovation, Research and Development and Commercialization (RD&C), High Level Learning Outcomes;
II. Intellectual Capital Grand Challenges, A Market Push and Pull Mechanism for Learning Technology, Human Performance, and Market Innovation; and,
III. STEM Innovation, Research, Development, and Commercialization (RD&C), Detailed Learning Outcomes.

1. **Concept of Operation, STEM Innovation, Research and Development and Commercialization (RD&C), High Level Learning Outcomes**. The National Science Teachers Association (NSTA) has recently fielded a definition of STEM that elucidates the importance of STEM to include knowledge integration, innovation practice, applied arts, contextual inquiry, contemporary tools and technologies, and facing complex problems with no apparent answer. Examples of complex unstructured problems include: leveling up education, human performance, health, poverty, environmental sustainability, leveling-up the workforce to market demand for skill innovation, catalyzing innovation in the economy, and peaceful collaboration.

   Below is a summary of the requirements of key pull mechanisms as articulated for K-12 STEM education by the National Science Teacher's Association (NSTA). According to NSTA, STEM is: An integration of disciplines that removes the traditional barriers between Science, Technology, Engineering, and Mathematics, and instead focuses on innovation and the applied process of addressing questions and designing solutions to complex contextual problems using current tools and technologies.[2]

   STEM practice in primary, secondary, and post secondary (community and technical college and university) is 100 degrees off from the NSTA definition. Additionally the definition lacks inclusion of Career and Technical Education, the vocations of science, technology, engineering, and mathematics (STEM), programs of study to

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[2] http://www.nsta.org/conferences/stem.aspx

reduce market friction and enhance the velocity of educational innovation relative to market externalities.

The Society for Design and Process Science (SDPS) has cultivated process and design thinking as a practice for turning out STEM innovators across industry sectors and educational disciplines since 1995. Process and design thinking is the science of change and transformation. This is the key learning outcome necessary to form an economy and market pull mechanism for next generation learning technologies (as well as improvements in human performance, sports, health, defense, privacy, security, global collaboration, the path to space 2.0, etc.).

Process and design thinking is the key learning outcome necessary to form a market pull mechanism achieving diffusion of next generation technologies, thinking, and innovation (where markets meet invention). Process and design thinking is not a discipline and therefore, market pull mechanisms are necessary to catalyze diffusion of this technique across disciplines. Teaching students process and design thinking (STEM RD&C) flips the educational system to achieve innovation from within. In practice, process and design thinking learning outcomes:

1.1. Places questions, scientific inquiry, and the scientific process at the locus of STEM learning, supported by mentorship;
1.2. Transforms STEM education through knowledge integration;
1.3. Focuses on innovation at the boundaries and spaces between, among, and beyond disciplines, social institutions, markets, industries, economies, technologies, etc;
1.4. Flips teaching by inviting inquiry (questions), design, construction, invention, innovation, and student leadership;
1.5. Integrates STEM knowledge and processes in theory and practice (praxis);
1.6. Requires collaboration across disciplines, public and sectors;
1.7. Integrates contemporary technology as a tool to further the disciplines and also a subject of inquiry among disciplines;
1.8. Provides a market and social research function necessary to understand the nature of challenges, opportunities, problems, and domains of inquiry;
1.9. Connects education, workforce, economic development to create wealth and solve complex unstructured problems in the context of community design and self-determination;
1.10. Invents but more importantly innovates, meeting a market demand, or human/social need.

(See below, Focusing on STEM RD&C pedagogy (Process and Design Thinking) Learning Outcomes)

2. **Intellectual Capital Grand Challenges, A Market Push and Pull Mechanism for Learning Technology, Human Performance, and Market Innovation.** By the time

grants are in the marketplace and technology intersects with public markets and schools in the next 18-36 months a complete paradigm shift is happening from the desk top and laptop and luggable legacy of the Personal Computer (PC) to a new world of mobile, wearable, and embedded computing (machine to machine computing, industrial control systems, embedded computing, cyber physical systems, etc.); therefore, SPDS proposes a demand pull market mechanism simply defined as issuing Intellectual Capital Grand Challenges (Global Architects) to students worldwide. Topics of Intellectual Capital Grand Challenges (Global Architects) may include education, human performance, health, poverty, job creation, economic innovation, environmental sustainability, entrepreneurship, etc.

2.1. The first grand challenge is a challenge to enhance global education and human performance in STEM innovation (Research, Development, and Commercialization) utilizing the intellectual property patents of Axelo, Inc., Austin, Texas.

2.2. Axelo patents represent the next generation of human-computer interaction and hold great potential to transform learning technology by moving online learning from the desktop to phones and wearable computers, and by liberating media from traditional devices to live in the space between cyberspace and the natural world (mixed reality, transmedia, augmented reality, cyber physical systems, etc.). The patents today are reflected in processes implemented in many consumer devices on the market today representing billions of dollars in intellectual property value.

2.3. The patents cover eyewear integrated with gesture computing, eye detection, voice communication, mapping the last 15 feet of the global positioning system from a user outward, and elimination of motion sickness (particularly in the context of 3-D media). The founders of Axelo are focusing their R&D on sports and human performance, while making these patents available to form market pull mechanisms for education using Intellectual Capital Grand Challenges (Global Architects) empowering students and inventors to use these patents to create new educational systems to improve student learning outcomes. Axelo, Inc. Patents include:

2.4. US 6,240,392 Communication 8/29/1996 Communication device and method for deaf CA 2, 214,243 Communication 8/29/1996 communication device and method for deaf

2.5. US 5,966,680 Motion sickness 2/15/1996 Motion Sickness/Vertigo prevention device and method CA 2, 197,588 Motion sickness 2/15/1996 Motion sickness/Vertigo prevention device and method

2.6. US 13/108,683 Spatial disorientation 5/14/2010 System and method for prevention and control effects of spatial disorientation CIP filed Spatial Disorientation 5/14/2010 Physiological biosensor system and method for controlling vehicle or powered equipment

- 2.7. US 7,683,883 MEMS 3D Inertial Sensing Technology 11/2/2004 3D mouse and game controller based on spherical coordinate system and system for use.
- 2.8. US 8,325,138 MEMS 3D Inertial Sensing Technology 11/2/2004 Wireless hand-held electronic device for manipulating an object on a display 13/573,945 MEMS 3D Inertial Sensing Technology Hand-held wireless electronic device with accelerometer for interacting with a display.

3. **STEM Innovation, Research, Development, and Commercialization (RD&C), Detailed Learning Outcomes.** Learning outcomes for high school-, community college-, and university- process and design thinking below the graduate level of education include:
   - 3.1. Apply, analyze, synthesize, evaluate, demonstrate, and create change by utilizing the fundamental concepts of:
     - 3.1.1. Process;
     - 3.1.2. Systems;
     - 3.1.3. Design; and,
     - 3.1.4. Metrics and measurement.
   - 3.2. Apply, analyze, synthesize, evaluate, demonstrate, and create satisfying and sufficient formulation of solutions and research designs for complex unstructured problems eschewing only optimal and perfect solutions and research design in light of human need, market demand, market timing, and market incentives:
   - 3.3. Formulate questions, design solutions, and use the scientific process in the context of unstructured complex problems and opportunities (known as “wicked problems” in the marketplace);
       - 3.3.1.1. Make progress and/or solve problems that have no apparent optimal or perfect answer;
       - 3.3.1.2. Create both quantitative and qualitative solutions to complex unstructured problems;
       - 3.3.1.3. Market and Social Research - Apply, analyze, synthesize, evaluate, demonstrate, and create understanding of human, social, environmental, and market need through research; and,
       - 3.3.1.4. Entrepreneurship - Connect new knowledge, processes, systems, and languages to market demand and need.
       - 3.3.1.5. Apply, analyze, synthesize, evaluate, demonstrate, and design satisfying and sufficient[3] cross-disciplinary approaches to complex problems.

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[3] Herbert Simon, Nobel Laureate

  3.3.2. For example, Herbert Simon, Nobel Laurate in Economics, was also a pioneer in the development of artificial intelligence and contributed novel ideas to other disciplines such as cognitive psychology, computer science, and political science.

  3.3.3. For example, applying encryption and cyber security measures and counter measures to problems associated with privacy, copyright and trademark licensing and content control, and/or cyber physical process control and monitoring.

3.4. Identify systems, processes, and metrics in a system, subsystem, or system of systems:

    3.4.1.1. Apply, analyze, synthesize, evaluate, and create change in natural and artificial[4] processes;

    3.4.1.2. Apply, analyze, synthesize, evaluate, and create change in market economies; Connect existing and emerging knowledge and technological innovation with market/human/social needs defined by micro and macro Intellectual Capital Grand Challenges (Global Architects).

    3.4.1.3. Apply, analyze, synthesize, evaluate, and create change in human learning, performance, and development systems;

    3.4.1.4. Apply, analyze, synthesize, evaluate, and create change in human and environmental health systems (entertainment, public media, education, water, poverty, pollution, etc.); and

    3.4.1.5. Apply, analyze, synthesize, evaluate, and create change in natural sciences, social sciences, formal sciences, and applied sciences with process and design thinking and knowledge integration techniques.

    3.4.1.6. Apply, analyze, synthesize, evaluate, and create new Intellectual Capital grand Challenges (Global Architects) and a sustainable platform for growth and innovation in global markets.

3.5. Apply, analyze, synthesize, evaluate, demonstrate, and create change using first principle reasoning as a foundation for formulating STEM research design, conducting experimental processes, and ultimately discovering satisfying and sufficient solutions to complex unstructured problems across domains (education subjects, educational disciplines, schools, markets, industries, and civil society):

  3.5.1. Apply, analyze, synthesize, evaluate, demonstrate, and create theorems from first principles;

    3.5.1.1. Reason from one or more general statements (premises) to reach a logically certain conclusion; and,

    3.5.1.2. Link premises and conclusions.

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[4] Herbert Simon, Nobel Laureate

3.5.2. Apply, analyze, synthesize, evaluate, demonstrate, and create processes utilizing principles and methods of *mathematical induction;*

3.5.2.1. Utilize a mathematical proof to establish a given statement for all natural numbers,

3.5.2.2. Apply, analyze, synthesize, evaluate, demonstrate, and create *a base case (*Prove the given statement for the first natural number),

3.5.2.3. Apply, analyze, synthesize, evaluate, demonstrate, and create an *inductive step* (prove that the given statement for any one natural number implies the given statement for the next natural number),

3.5.2.4. Infer that the given statement is established for all natural numbers,

3.5.2.5. Connect the result to applications that have meaning in the context of advancing human understanding, learning, and development,

3.5.2.6. Define educational implications across domains and promote research dissemination,

3.5.2.7. Connect to market research and entrepreneurship if applicable.

3.6. Knowledge of and ability to apply numeric and nonnumeric languages to the formulation, codification, computation, and ultimate resolution of solutions to unstructured and or unstructured complex problems.

3.6.1. Develop creative projects emphasizing what Nobel Laureate Philip A. Sharp calls “scientific convergence,” in this context, the integration of knowledge across disciplines with process and design thinking;

3.6.2. Demonstrate and create numeric and nonnumeric solutions, processes, designs, metrics, and symbolic languages

3.6.3. Apply, analyze, synthesize, evaluate, demonstrate, and create computational solutions leveraging human and machine cooperation through cognitive architectures and next generation big data algorithms;

3.7. Extend first principle reasoning and techniques of mathematical induction to more general domains through systems analysis (e.g. designing solutions to education, human performance and health, poverty, pollutions, etc.) using a grand challenge approach for complex and unstructured problems targeting high school, community college and university students, teachers, and stakeholders who are simply interested in numbers, puzzles, and challenges:

3.7.1. Apply, analyze, synthesize, evaluate, and change the world by designing solutions to human and market need (producing innovation);

3.7.2. Create a marketplace for Intellectual Capital Grand Challenges (Global Architects) utilizing game structures (story, simulation, visualization, character development, score, points, status, rewards);

3.7.3. Enable an exchange for rewards including micro loans, scholarships, job internships, work-study, jobs, mentorship, and apprenticeship;

    3.7.4. Connect Intellectual Capital Grand Challenges (Global Architects) defined by the full spectrum of stakeholders (top-down and bottom-up) to market incentives (score, points, status, rewards, micro loans, etc.)

3.8. Skill Mastery: Question, explicate, teach, lead, and mentor others in process and design thinking in online and offline environments (community of practice). Utilize the Socratic Method in mentoring and teaching peers. The Socratic Method shifts teacher and student communication to inquiry and dialogue, in a one-to-one mentor relationship where students learn to mirror expert thinking, and is especially relevant and important to STEM educational transformation in a K-12 setting.[5]

    3.8.1. Apply, analyze, synthesize, evaluate, demonstrate, and create change using first

    3.8.2. Apply, analyze, synthesize, evaluate, demonstrate, and create change using first

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[5] Coffee, Heather, LEARN NC, K-12 Teaching and Learning from the University of North Carolina, Socratic Method, last retrieved from http://www.learnnc.org/lp/pages/4994 on February 10, 2014.

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OSTP QUESTION #2 - How are these learning outcomes currently measured and assessed?

The traditional instructional design model is a linear, reliable and highly sequential approach to developing online and offline instruction and learning. The problem is that the prescriptive nature of the process can result in technically correct structures that spotlight content rather than interaction (Sims, 2002). To deal with the issue, the instructional strategies prompted by different learning theories can be concentrated along different points of a continuum, depending on the focus of the learning theory – the level of cognitive processing required (Ertmer, and Newby, 1993). Brazell and collaborators at the University of Texas Austin, Digital Media Collaboratory, call this type of adaptive instruction “Fluid Learning.”

Fluid learning[6] is the act of adapting learning theories to the audience and to the content being delivered to optimize learning outcomes. Rather than being based on dialing in the right media format or channel (audio, text, image, video), Fluid Learning adapts instruction to the learner and the environment in near real-time but focuses ultimately on matching the most appropriate learning theory to the knowledge and skill being taught and assessed.

Today, process and design thinking is taught in universities in a dynamic and highly personalized way by faculty in face-to-face setting; therefore, research is required to elucidate and make transparent methods of learning, teaching, and mentoring process and design thinking. Today learning outcomes are currently measured and accessed through the Ph.D. process at select universities worldwide across several different departments and disciplines ranging from electrical and computer engineering to social science. The state of instruction is outlined below:

1.1. Instruction is presented in three formats:
    1.1.1. Independent inquiry - reflective thinking and learning;
    1.1.2. Socratic teaching and mentorship - expert modeling of thought processes and design approaches by teachers, industry volunteers, and other mentors; and,
    1.1.3. Collaborative, constructionist, authentic, and situated learning.
1.2. Process and design science instruction is multi-modal, transcends any one discipline (or subject or market or industry).
    1.2.1. Process and design science instruction is highly adaptive instructionally (today it is generally only taught at the graduate level).

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[6] Adapted from Brazell, Jim, Mindy, Jackson, Darrell, Woelk, et.al., Task A: Leveraging Digital Distance Training Environments Project, Digital Warrior: Task A Report and Recommendations, May 24, 2004, University XXI. Please note, authors names were removed from the research led by this team.

1.2.2. Mentors and teachers adapt to the learner and the environment in real time based on feedback.

1.3. Process and design thinking (STEM R&D) pedagogy is fluid in nature, but relates three of the primary theories of learning: behaviorism, cognitivism, and constructivism.

1.3.1. The behavioral instructional model focuses on what the learner should be able to do when the instruction is concluded (writing performance objectives), which makes the subsequent planning and implementation steps clear and effective. In addition, instruction is specifically targeted to the skills and knowledge to be taught, and offer the appropriate conditions for the learning outcomes to occur. A criticism is that behavioral instruction lacks flexibility in meeting the varying needs of learners. This implies that the models may be most appropriate when teaching procedural knowledge, with an emphasis on the acquisition of basic skills.

1.3.2. The cognitivist instructional model emphasizes that the instruction must shift focus from the presentation of material and concern for overt behaviors, to the generation of cognitive structures. In addition to teaching content, instructors should design instruction, which can teach learners effective learning strategies. Moreover, the models focus on the learner and the activities the learner can be engaged in to improve learning. The instructor's role is a strategy coach and facilitator who trains and encourages learners to use cognitive strategies and develop self-regulation skills. A criticism is that cognitivist techniques do not initiate learners to do learning, and learners depend on the instructor's "cues" for functioning.

1.3.3. There is no constructivist instructional design model. Constructivism is not a "systems builder" in the grand traditions of Newton, Hegel, Skinner, or Freud. Instead, it tends to see knowledge as connected to practice and as context-dependent (Wilson, 1995). Constructivism proposes that knowledge is individually constructed and socially co- constructed by learners based on their interpretations of experiences in the world (Jonassen, 1999).

1.3.4. In the Fluid Learning Approach to instructional design, instructional designers adapt learning theories to the learner and the environment to achieve the best result. Mergel, 1998, validates this approach. Learning theories such as behaviorism, cognitivist and constructivism have been widely used and explored to provide guidance for instructional practice (Mishra, 2002). Assessment therefore will include formative and summative assessment with a lot of human to human and human to system interactions forming a unique basis of assessing knowledge and skill in the context of process and design thinking and STEM RD&C.

1.3.5. Instruction will zoom from basic and formative knowledge in mathematics, engineering, and science, to advanced topics in theory, metrology, and complex problems. Constructivism can be supported by dynamic delivery of behaviorist and cognitivist learning models facilitated by learners, human trainers and AI-based systems such as Artificial Cognitive Architectures.

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OSTP QUESTION #3 – (b.) What information exists about current U.S. performance relative to this learning outcome? (a.) What information exists about the presence (currently available or potential given current trends or breakthroughs) or absence of effective interventions (technology-based, offline, or hybrid) to improve this learning outcome?

(b.) What information exists about the presence (currently available or potential given current trends or breakthroughs) or absence of effective interventions (technology-based, offline, or hybrid) to improve this learning outcome? Thales of Miletos (c. 580 BC) first developed deductive reasoning as far as we know. Deductive reasoning is the root of process and design thinking—"thinking for living" (Tanik, 2014). Deductive reasoning and process and design thinking are fundamental to STEM RD&C globally today. The techniques and methods of this approach are not fundamental to education below the graduate level of education. The Society for Design and Process Science is an international, multicultural, cross-disciplinary professional society dedicated to transformative research and education through transdisciplinary means, including process and design thinking.

Thales was the first thinker in the West to provide a rational explanation of things. By claiming that everything can be explained in terms of water, he proposes that there is a way to make sense of our experience of changes in the world. Behind the appearance of change, he suggests, is something constant (a one behind the many) in terms of which everything is to be understood. This turn from myth to reason is significant in three ways: it focuses on a natural rather than a supernatural explanation, it suggests that reality is different from appearances, and it describes not only the fundamental nature of reality (as water) but also how things in nature change (as a result of internal forces).[7]

1. **RESEARCH - ALGORHYTHMS FOR LEARNING: D. Woelk, Ph.D.**
    1.1. White, A., S. O'Hare, J. Stawasz, R. Jenevein, D. Fussell and D. Woelk, "Digital Warrior: Blending Pedagogy and Game Technology", Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC), 2005.
    1.2. Woelk, D. "E-Learning Technology for Improving Business Performance and Lifelong Learning" in The Practical Handbook of Internet Computing, edited by Munindar Singh, CRC Press, 2004.
    1.3. Woelk, D. and P. Lefrere. "Technology for Performance-Based Lifelong Learning", Proceedings of the ICCE World Conference on Computers in Education, Auckland, New Zealand, December, 2002.
    1.4. Woelk, D. and S. Agarwal. "Integration of e-Learning and Knowledge Management", Proceedings of E-Learn 2002 World Conference on e-Learning in Corporate, Government, Healthcare & Higher Education, October, 2002.

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[7] http://philosophy.tamu.edu/~sdaniel/Notes/01class2.html

1.5. Woelk, D. “E-Learning, Semantic Web Services and Competency Ontologies”, Proceedings of ED-MEDIA World Conference on Educational Multimedia, Hypermedia and Telecommunications, June 2002.

2. RESEARCH - ALGORHYTHMS FOR LEARNING - COGNITIVE ARCHITECTURES J. Carbone, Ph.D. and Crowder, Ph.D.

2.1. Crowder, James A., John N. Carbone, and Shelli A. Friess. Artificial Cognition Architectures. Springer, 2013.
2.2. Crowder, J.A., Friess, S., “Artificial Neural Diagnostics and Prognostics: Self-Soothing in Cognitive Systems.” International Conference on Artificial Intelligence, ICAI’10 (July 2010).
2.3. Crowder, J. A., Friess, S., “Artificial Neural Emotions and Emotional Memory.” International Conference on Artificial Intelligence, ICAI’10 (July 2010).
2.4. Crowder, J. A., “Flexible Object Architectures for Hybrid Neural Processing Systems.” International Conference on Artificial Intelligence, ICAI’10 (July 2010).
2.5. Crowder, J. A., Carbone, J, “The Great Migration: Information to Knowledge using Cognition-Based Frameworks.” Springer Science, New York (2011).
2.6. Crowder, J. A., “The Artificial Prefrontal Cortex: Artificial Consciousness.” International Conference on Artificial Intelligence, ICAI’11 (July 2011).
2.7. Crowder, J. A., “Metacognition and Metamemory Concepts for AI Systems.” International Conference on Artificial Intelligence, ICAI’11 (July 2011).

3. DETAIL ARTIFICIAL COGNITIVE ARCHITECTURES.

Recently current trends are increasingly focused upon autonomy. Hence, significant recent research exists in autonomous operations along with explosive growth in robotics, which is driving the need for these systems to think for themselves. This is most necessary for those systems which must operate in deep space, the ocean floor and even microscopically and autonomously within human subjects. These environments are austere complex environments and thus require degrees of autonomy using what is known as Artificial Cognition Architectures. These architectures fit under the umbrella but differ slightly from traditional artificial intelligence because they focus on development of true humanistic brain architectures within systems to improve the dynamic nature of the system, employ learning algorithms of various types per function, and to more effectively develop systems to improve the human experience and the ability to learn from a system more like themselves. Hence, a new field is also evolving known as Artificial Psychology. This is a field that focuses on the development of systems to develop models of comprehensive psychological characteristics into software systems and then experiment with them algorithmically to try and solve problems other than the use of a couch and trial and error.

From these technologies what has been proposed is a Cognitive Interactive Training Environment (CITE). The architecture for this is found within citation 1 below. The CITE environment using the technologies described above learns and improves through the use of a Human Operator acting as a Mentor for the software, until the software is capable of performing the desired operations autonomously and with improvements (see Figure 9-19). CITE provides for Human Interaction Learning (HIL); as the human operator's role changes from manager to mentor to monitor while a SELF evolves from learner to performer. A CITE system, Prefrontal Cortex Model, based on CITE interactions provides effective feedback mechanisms to allow humans to influence the systems and vice versa. The heart of CITE is a Cognitive Architectures Polymorphic, Evolving, Neural Learning and Processing Environment PENLPE learning management system which tracks changes in the cognitive framework. Utilizing PENLPE's monitoring and metric generating capabilities for collaborating with humans, humans can influence PENLPE in a positive way and CITE allows Cognitrons (information enabled with emotional memory) to learn and improve. The human has the ability to review a artificial system choices, based upon PENLPE's suggestions and then provide feedback as to why a given choice or set of choices was effective or not.

The PENLPE management framework then provides feedback to the human to give the human an understanding of the processes a SELF utilized to make inferences and decisions. This process of feedback and human-SELF interactions and collaborations provides humans insight to develop trust and hence, we believe based upon years of research in human to human learning when experiences are positive, significantly facilitates human educational development over time and will help to increase the effectiveness and efficiency not only of the artificial cognitive system, but also provides a significantly more effective evolving Human to Inanimate system interface. Lastly, CITE is designed to gather and assess metacognitive indicators like:

1. Problem solving skills (analytical proficiency)
2. HRI Collaborative skills
3. Cognitive self-awareness
4. Cognitive self-regulation
5. Emotional self-regulation (a artificial Limbic system)

Lastly, one of the main divisions of human memory is “Procedural Memory.” Procedural memory is a form of implicit memory that includes classical conditioning and the acquisition of skills. Procedural memory creation contains central pattern generators that form as a result of teaching or practice and are formed independently of conscious or declarative memory. In his work on Procedural Memory and contextual Representation, Kahana showed that retrieval of implicit procedural memories is a cue-dependent process that contains both semantic and temporal components (Kahana, Howard, and Plyn 2008)]. Creation of Procedural Memories is tied to not only repetition of tasks, but also to the richness of the semantic association structure (Landauer and Dumais 1997). In order to provide cognitive resilience, the CITE system provides interactive training that allows humans to create procedural memories, or “scripts” that have emotional, social, and psychological triggers and provide the skills required at the time for cognitive self-evaluation, self-awareness, and self-regulation to present or reduce psychological disorders, or problems, caused by trauma, either physical, psychological, or environmental [Crowder and Friess 2011a].

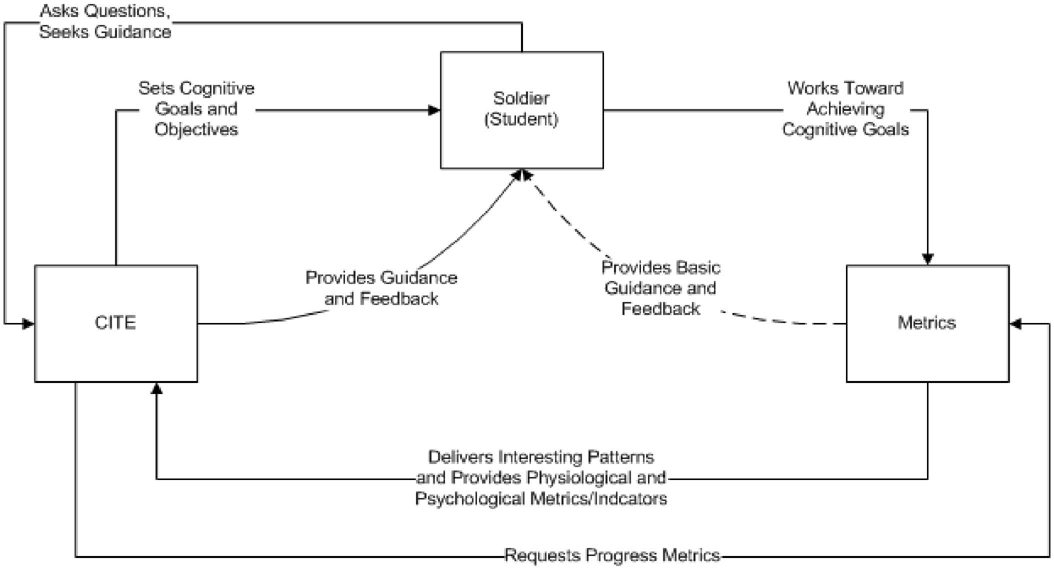
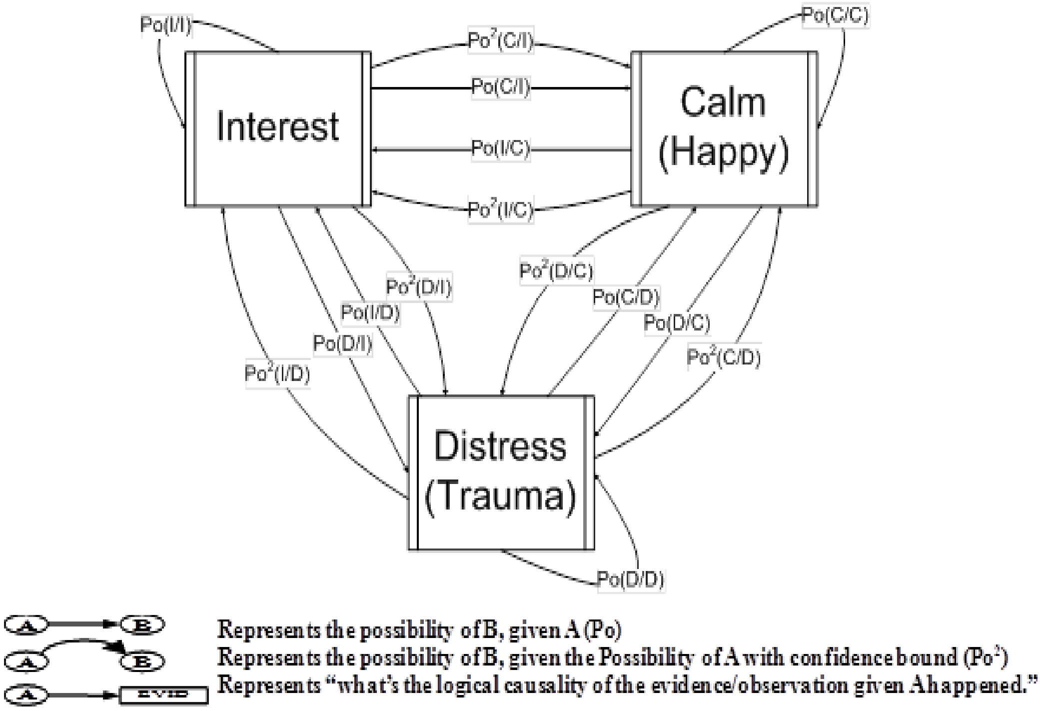


Figure 1, CITE Block Diagram

Thus, as mentioned before when the CITE interactive training cognitive system learns from humans, developing strategies and training scenarios specific to a given person, it allows humans to develop procedural memory strategies, i.e., implicit procedural memories, that will “kick in” under specific emotional memory queues, based on physical, emotional, psychological, for environmental events that the human encounters.

CITE develops a model, or picture, of the humans prefrontal cortex, based on the continuous cognitive interactions with the system. This prefrontal cortex, or mediator, model (see Figure 2) allows CITE to understand the humans particular cognitive processes and what drives changes between emotional and cognitive states and therefore an artificially cognitive architecture for developing qualitative reasoning and learning.



Represents the possibility of B, given A (Po)
Represents the possibility of B, given the Possibility of A with confidence bound (Po^2)
Represents "what's the logical causality of the evidence/observation given A happened."

Figure 2- CITE pre-frontal cortex model based upon interactions

(a) What information exists about current U.S. performance relative to this learning outcome? Information about current STEM performance exists in the form of international educational benchmarks we are all to familiar with today; however, the definition of STEM varies in practice and theory nationally and worldwide. STEM has many different representations in practice including a general trend toward multi-disciplinary faculty and classroom teaming designed to increase student retention, interest, and performance. Various types of interdisciplinary STEM teaching include: STEM and arts, STEM and Career and Technical Education, STEM and liberal arts, STEM and entrepreneurship, STEM and research, STEM and medicine, STEM and games, STEM and history, STEM and social studies, and STEM and civics. STEM initiatives have appeared in the literature and in practice since 2005, however, STEM is widely varied in theory and practice across primary, secondary, and post secondary education, across the nation and world.

In the context of primary school education, the President's Council of Advisors on Science and Technology (PCAST), convened from across the National Academic of Science, suggests an approach to STEM that balances conceptual understanding, factual recall, and procedural fluency: …a growing body of research has illuminated how children learn about STEM, making it possible to devise more effective instructional materials and teaching strategies. The National Research Council and other organizations have summarized this research in a number of influential reports and have drawn on it to make recommendations concerning the teaching of mathematics and science. These reports transcend tired debates about conceptual understanding versus factual recall versus procedural fluency. They emphasize that students learning science and mathematics need to acquire all of these capabilities, because they support each other.[8]

1. In schools, especially K-12 education, emerging and new STEM practice generally reflects a process-level change in educational pedagogy. This pedagogical shift is one that embraces applied practice in addition to traditional academic concepts of learning, teaching, and knowledge. Examples include:
2. In P-20 education, Programs of Study (POS) dovetailing secondary education and two- and 4-year pathways use the Career and Technical Education (CTE) framework pioneered over the past 27 years by the now defunct, Tech Prep;
3. Unification of computer science, engineering, mathematics, and physics to fuel research and development across the disciplines, and innovation in STEM subjects (especially in university R&D (Convergence Science or STEM Convergence, but also emerging in K-12 STEM education);

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[8] REPORT TO THE PRESIDENT PREPARE AND INSPIRE: K-12 EDUCATION IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH (STEM) FOR AMERICA'S FUTURE, Executive Office of the President, President's Council of Advisors on Science and Technology, SEPTEMBER 2010 PREPUBLICATION VERSION, last retrieved online February 11, 2014.

4. Trending toward unification of knowledge- and skill- based instructional practice and learning. In academia, theory and practical arts are unified by process in the escalation of computer science and/or computational thinking into the academic domain of science and the core curricula. In the CTE world, academic-CTE integration is the alignment of theory and applied arts in secondary and post secondary career and college preparation. The movement to integrate the arts and STEM (or, vice versa) and to mainstream engineering in K-12 education practice also represent this convergence, or unification, of academics and applied arts; and,
5. Orientation of learning and education to design and innovation that unifies classical and contemporary knowledge and tools. STEM is about innovation, how we work together to adapt to the world in which we live, and how we approach learning and education of the next generation.

THE VOCATION & AVOCATION OF STEM - STEM, A HISTORICAL PRECEDENT FOR CONNECTING ACADEMIC THEORY & APPLIED PRACTICE & THALES' DEDUCTIVE REASONING

A similar shift was undertaken by US education in an effort to expand the country's STEM intellectual capital following the launch of Sputnik. The publication and widespread adoption of the textbook titled "Physics" for high schools served as the transformational force in education at the start of the Space Race—a STEM talent and innovation race.

MIT's Physical Science Study Committee developed the book and its approach to teaching physics. The text was groundbreaking in that it was created to stimulate students' interest in the subject of physics, to teach students and teachers to think like physicists, and to enable students to approach physics through observation and experimentation.[9]

The MIT Institute Archives Special Collection web site has more information: Teaching materials created by the PSSC were designed to emphasize fundamental principles in physics, encouraging engagement and understanding as opposed to memorization, making the subject more attractive to students. The first edition of the high school textbook Physics appeared in 1960, followed by many subsequent editions.

At the time, this textbook represented a shift in pedagogy from inductive to deductive learning strategies in high school physics education. The Physics textbook from MIT states: "Rather than simply teaching the essentials, facts and theories are… embedded within questions, experiments, challenges, and games." Using this approach, academic standards are embedded into thematic physics units for instruction through applied practice."

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[9] Physical Science Study Committee, 1956, MIT Institute Archives and Special Collections, last retrieved from on February 7, 2014.

The important meaning of STEM in this larger historic context is derived from the pedagogical changes that it engenders for the whole of education. Emerging K-12 STEM practice in U.S. schools underscores a fundamental process-level change in educational pedagogy. This pedagogical shift is one that embraces applied practice in addition to traditional academic concepts of learning, teaching, and knowledge in an effort to open learning and knowledge to a broader base of students.

Considerations of STEM in the broader context of history, sociology, philosophy of science:

1. STEM is transformation by design. STEM is transformation of social, human, and environmental systems by human design and the unintended consequences of our actions.
2. STEM is a technological force changing society and social institutions. STEM is changing the structure, flow, and composition of social institutions and personal identity: family, education, work, economy, law, government, etc. From an identity perspective technology and more broadly STEM effects our worldview, our concepts of: self-efficacy, subjectivity, objectivity, privacy, time, space (place), geography, cosmology, individuality, identity, values, beliefs and culture.
3. STEM is a process of collaboration connecting institutional silos (education, government, industry, and civil society) to form self-organizing innovation networks to invent innovate, and export technological solutions to market and human/social needs. STEM is confronting the local challenges in your community and school through the process of inquiry, design, and innovation. STEM is turning a community inward on itself to form learning communities and laboratories designed to effect local and global opportunities and challenges through collaboration and cooperation.
4. STEM is a moral imperative to prepare all students for their future, rather than our past. STEM educational practices, ideally, today open access and opportunity in education through a balanced approach to learning that retains the important fundamentals of classical education while integrating contemporary knowledge, processes, and tools.

PREVAILING DEFINITIONS OF STEM JOBS: ONLY 5.5% of the WORKFORCE, REALLY?

The U.S. Department of Commerce, Economics and Statistics Administration July 2011 Issue Brief, “STEM: Good Jobs Now and For the Future,” lists fifty specific occupation codes totaling 7.6 million STEM workers, or 5.5 percent of the workforce in 2010. The occupational codes are divided into four categories: computer and math, engineering and surveying, physical and life sciences, and STEM managerial occupations. The Department of Commerce offers the following definition of STEM along with the rationale for discounting other science- and technology-based disciplines: The acronym STEM is fairly specific in nature—referring to science, technology, engineering, and math—however, there is no standard definition for what constitutes a STEM job. Science, technology, engineering, and math positions consistently make the lists of STEM occupations, but there are fewer consensuses about whether to include other positions such as educators, managers, technicians, health-care professionals or social scientists. In this report, we define STEM jobs to include professional and technical support occupations in the fields of computer science and mathematics, engineering, and life and physical sciences. Three management occupations are also included because of their clear ties to STEM. Because of data limitations, education jobs are not included. Further, we elected not to include social scientists.[10]

The largest group of STEM jobs lies within the computer and math fields, accounting for forty-six percent of all STEM employment. Second are engineering and surveying occupations with one-third of STEM employment. Thirteen percent of STEM jobs are in the physical and life sciences, and nine percent of STEM jobs are management occupations. The Brief defines STEM employment to include not just scientists and engineers, but also science and engineering technicians and drafters, while computer occupations range from computer support specialists to computer software engineers. (Langdon, et al, 2011)

Understanding job supply and demand is difficult; however the Georgetown Center for Education and the Workforce (CEW) defines STEM, differently than the Department of Commerce, Bureau of Labor Statistics, to include 6.8% of U.S. jobs today, growing to 8 million jobs by 2018[11]:

1. Job openings. STEM occupations will provide 2.4 million job openings through 2018, including 1.1 net new jobs and 1.3 replacement jobs due to retirement.
2. Postsecondary education. 92% of STEM jobs will be for those with at least some postsecondary education and training.
3. Equity. Diversion of women and minorities is compounded by other factors. For women and minorities, STEM is the best equal opportunity employer. Although pay gaps exist between minorities and Whites/Asians and women and men in STEM, they are smaller than in other occupations.
4. Shortages. We face a chronic shortage in STEM competencies as the demand for STEM talents grows outside traditional STEM jobs.

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[10] David Langdon, George McKittrick, David Beede, Beethika Khan, and Mark Doms, "STEM: Good Jobs Now and for the Future." US Department of Commerce, Economics and Statistics Administration last accessed online October 28, 2012

[11] Smith, Nicole. Projections of education demand for the STEM future workforce, The Georgetown University Center on Education and the Workforce, December 8, 2011, last accessed January 27, 2014.

5. Further adding complexity to STEM employment and workforce analysis, STEM has a systemic effect on labor supply and demand including the increasing demands of technology for:
6. Knowledge and skill innovation—changes in work procedures and practice due to technological and adaptation across low-middle-high skill job categories;
7. Increasing tendency toward multi-disciplinary, multi-skill, and transdisciplinary work and research and development;
8. Increasing complexity and operational tempo (speed) of work;
9. Structural changes in work due to automation and optimization of processes for efficiency and productivity; and,
10. De facto standardization and/or adoption of cyberspace as a mass medium of communication, collaboration, and process control effecting virtually all segments of society—and academic disciplines.

STEM JOBS: A LOOK BEHIND THE WIZARDS CURTAIN.

While there is no compelling evidence of STEM labor market shortages for the nation as a whole, we face a chronic shortage in STEM competencies as the demand for STEM talents grows outside of traditional STEM jobs.[12] STEM intensive Metropolitan Service Areas; however, have structural labor market deficiencies in fulfilling some middle- and high-skill STEM jobs (Broookings, 2013)[13]: As of 2011, 26 million U.S. jobs—20 percent of all jobs—require a high level of knowledge in any one STEM field. STEM jobs have doubled as a share of all jobs since the Industrial Revolution, from less than 10 percent in 1850 to 20 percent in 2010.

Half of all STEM jobs are available to workers without a four-year college degree, and these jobs pay $53,000 on average—a wage 10 percent higher than jobs with similar educational requirements. Half of all STEM jobs are in manufacturing, health care, or construction industries. Installation, maintenance, and repair occupations constitute 12 percent of all STEM jobs, one of the largest occupational categories. Other blue-collar or technical jobs in fields such as construction and production also frequently demand STEM knowledge.

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[12] Anthony P. Carnevale, Nicole Smith, and Michelle Melton, "Science, Technology, Engineering & Mathematics", Georgetown University, Center on Education and the Workforce, October 20, 2012 last accessed October 28, 2012.

[13] Jonathan Rothwell, The Hidden STEM Economy, Brookings, June 10, 2013, last accessed online January 27, 2014 at http://WWW.brookings.edu/research/reports/2013/06/10-stem-economy-rothwell

STEM jobs that require at least a bachelor's degree are highly clustered in certain metropolitan areas, while sub-bachelor's STEM jobs are prevalent in every large metropolitan area. Of large metro areas, San Jose, CA, and Washington, D.C., have the most STEM-based economies, but Baton Rouge, LA, Birmingham, AL, and Wichita, KS, have among the largest share of STEM jobs in fields that do not require four-year college degrees. These sub-bachelor's STEM jobs pay relatively high wages in every large metropolitan area.

BEYOND STEM: EDUCATIONAL ATTAINMENT, WAGES, & THE WORKFORCE.

In 1973, the Center on Education and the Workforce (CEW) reported that nearly a third of the nation's 91 million workers were high-school dropouts, while another 40% had not progressed beyond a high school degree. In effect, a high school diploma was a passport to the American Dream for millions of Americans 30 years ago. By 2007, this picture had changed beyond recognition with 63% of jobs requiring at least some college, an Associate's Degree, or industry licensure/credentials.

According to CEW's 2008-2018 workforce projections that factor in educational attainment included in the Pathways to Prosperity report from the Harvard Graduate School of Education: In 2018, 36% of jobs are forecast to require a high school degree or less, 30% of jobs require at least two years of post secondary education, and 33% of jobs are expected to be held by people with a Bachelor's degree or higher.[14] According to Bill Symonds, the primary author of the Pathways Report, "This means that almost all good jobs require education beyond high school. At the same time, however, we must recognize that many jobs do not require a four-year college degree."[15]

According to the report, Help Wanted: Projections of Jobs and Education Requirements through 2018, the United States is on course to fall short by three million college-educated workers. According to the report's authors: By 2018, we will need 22 million new workers with college degrees—but will fall short of that number by at least 3 million post secondary degrees . . . At a time when every job is precious, this shortfall will mean lost economic opportunity for millions of American workers. Post secondary education provides access to occupations across the economy, while workers with a high school diploma or less are largely limited to three occupational clusters that are either declining or pay low wages.[16]

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[14] Bill Symonds, email interview, February 16, 2014.

[15] Email Interview, May 4, 2011, Bill Symonds, Harvard Graduate School of Education.

[16] Help Wanted: Projections of Jobs and Education Requirements through 2018, last retrieved on February 10, 2014

Post secondary education provides access to occupations across the economy, while workers with a high school diploma, or less, are largely limited to three occupational clusters that are either declining, or pay low wages.[17] Bill Symonds notes:"…the Pathways Report found, today's workers with an Associate degree earn 73% more than those who have not completed high school…"

Research from the Educational Testing Service in 2003[18], illustrates what few people realize about the correlation between formal education and work salaries (March 1998):

- 80% of workers with associate degrees earn less than $44,000, compared with 62% of workers with bachelor's degrees
- 38% of workers with bachelor's degrees earn more than $44,000, compared with 20% of workers with associate degrees.

CEW has done more to elucidate the value of two-year degrees and workforce credentials, in the past five years, than any other institution the facilitator is aware of today. CEW found 27% of people with postsecondary licenses or certificates—credentials short of an Associate's degree—earn more than the average Bachelor's degree recipient.[19]

CONCLUSION

Problems in the theoretical underpinnings of dominate U.S. education and workforce definitions of STEM, present a major barrier for policy to overcome if innovation is the goal—collaboration is a must. Today, exigent labor market requirements are for STEM-based skills across many jobs not typically classified as STEM.

The net effect of the adoption and diffusion of technology is transformation of social institutions—including family, work, school, law, the economy, and national defense.

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[17] March CPS data, various years; Center for Education and the Workforce forecast of educational demand to 2011 in Carnevale, Smith and Strohl, June 2010.

[18] Carnevale, Anthony P. and Desrocher, Donna M. Standards for What? The Economic Roots of K-16 Reform, EDUCATIONAL TESTING SERVICE LEADERSHIP 2003 SERIES, 2003 last retrieved online February 10, 2014.

[19] The Center on Education is hardly alone in concluding that "middle skill" jobs will offer well-paying opportunities for those with less than a B.A. Economists Harry Holzer and Robert Lerman have made this case in several recent papers. And in a July 2009 report—"Preparing the Workers of Today for the Jobs of Tomorrow"—the Council of Economic Advisors concluded that the fastest job growth is likely to come "among occupations that require an Associate's degree or a post secondary vocational award." (Pathways to Prosperity, 2011)

It is therefore important to define STEM in a way that elucidates how these institutions are changing as well as what skills give rise to economic innovation and sustainability of democratic ideals.

While many career and education practitioners generally understand STEM as a transformational system of technologies and a process of innovation, the dominant workforce and education definitions of STEM are functionally specialized, missing the systemic and transformative nature of STEM and the wisdom of practitioners (crowds), something important for U.S. public policy:

STEM is the tools, knowledge, and processes necessary to transform existing situations into preferred situations, and STEM is a force acting on the individual, society, and the natural world. STEM is an ends means question that should be answered in the context of human survival and resilience—especially now, as the unfolding technology revolution ushers in a new era of abundant economic innovation, jobs, and opportunities for human relationships, collaboration, and development.

Unprecedented in force and magnitude, the emerging paradigms of cyber physical systems (4th generation computing), "Convergence Science," Artificial Psychology (AI, etc), and transmedia (particularly, the 5th world, the space between cyberspace and everything else: augmented reality, mixed reality, and perceptual computing). In short, living in 2014 is like living in science fiction from Star Trek's initial concept design of a platform like the I-Pad to the dystopian concerns of Sky Net, much of the science fiction imagination of the past 100 years, is approaching reality and every day experience for people in the next decade.

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OSTP QUESTION #5 - Why would a pull mechanism in this area accelerate innovation in learning technology?

GLOBAL ARCHITECTS - AN INTELLECTUAL CAPITAL CHALLENGE SYSTEM for HIGH SCHOOL, COMMUNITY AND TECHNICAL COLLEGE, UNIVERSITY, AND HOBBYISTS CREATING A DEMAND PULL MECHANISM AND COMMERCVIAL EXCHANGE CROSS SUBSIDIZING EDUCATION & HUMAN PERFORMANCE. GLOBAL ARCHITECTS.

CHALLENGE I – EXAMPLE – N QUEENS CHALLENGE STEM RD&C, LEARNING AND HOBBYISTS WORLDWIDE. An online programming, math, visualization, and big data environment for running grand and complex challenges and competitions. See question #1-#5 above for requirements of grand challenge system, pull market mechanisms, and learning design.

> **N QUEENS SYSTEM COCNEPT:** a system for fielding Intellectual Capital Grand Challenges (Global Architects) (and complex challenges) for the next generation; to enjoy and learn about the unique characteristics of complex unstructured problems, big data analytics, and process and design thinking.
>
> **A COMMUNITY OF PRACTICE:** The system is an ecology that support principles of extensibility from software engineering while simultaneously underpinning a market economy of virtual and real monetary rewards for accomplishment and demonstrated learning.

The N QUEENS[20] will be the first of many math and language challenges used to teach and prepare students to face an increasingly complex world inside of the envelope of the actual solution to the problem being revealed as a closed form solution in the next five (5) years. If the RD&C team working this problem fails, the thinking and learning will be passed onto the next generation.

To understand the mechanics of the N QUEENS problem, it is helpful to understand case 8, where there is a standard chessboard, 8x8 squares, and 8 queens. A standard chessboard has 8 rows and 8 columns (8x8=64). The standard 8 by 8 Queen's problem

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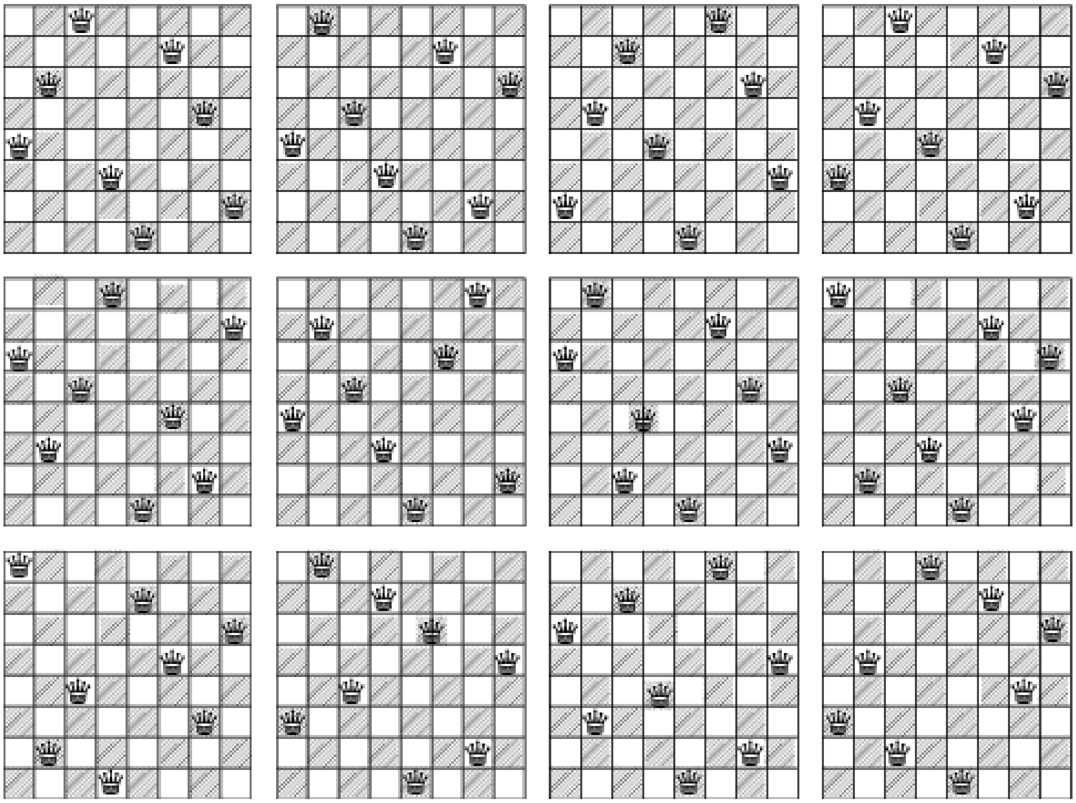
[20] The N-Queens problem is a commonly used example in computer science. There are numerous approaches proposed to solve the problem. We introduce several definitions of the problem, and review some of the algorithms. Cengiz Erbas, Seyed Sarkeshik, and Murat M. Tanik, Different Perspectives of the N Queens Problem, Proceedings of the 1992 ACM annual conference on Communications Pages 99-108, Association for Computing Machinery (ACM), ACM Digital Library, last retrieved from http://dl.acm.org/citation.cfm?id=131227 on February 12, 2014.

asks: How does one place eight (8) queens on an ordinary chess board so that no one Queen takes another. For example, solutions to N=8 for N QUEENS:



(Source: Wolfram)

N QUEENS is a great rally point for students and teachers because it is simple to grasp, but ultimately a challenging problem to solve mathematically. In fact, there is no closed form mathematical solution to N QUEENS today, or knowledge of whether one exists.

The N QUEENS is commonly used to teach the programming technique of backtrack search, and other concepts such as isomorphism, transformation groups or generators, and equivalence classes.[21] The problem is classified by the Association of Computing Machinery (ACM) as a problem generally relating to that of algorithms, backtracking, measurement, non-numerical algorithms, problems, and theory. The ACM Computing Classification System classifies the N Queens problem in relation to Dr. Tanik's research

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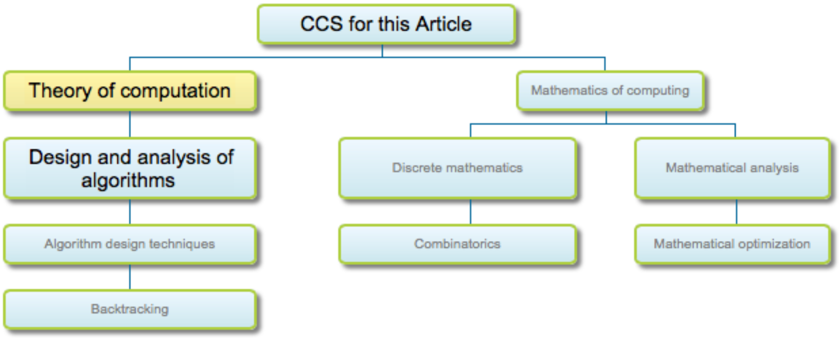
[21] (Isomorphism and the N QUEENS Problem, Last retrieved from February 10, 2014.)

in the following taxonomy of scientific knowledge (CCS rev.1998).[22]

FIGURE: The ACM Computing Classification System (CCS rev.1998)



CHALLENGE II – EXAMPLE – WHAT's NEXT in ED TECH, SPORTS, HEALTH, ENTERTAINMENT, HUMAN PERFORMANCE, & THE ENVIRONMENT?

AXELO, Inc. will seed its patents to the grand challenge program for learning technologies and media/entertainment. challenge is a challenge to enhance global education and human performance in STEM innovation (Research, Development, and Commercialization) utilizing the intellectual property patents of Axelo, Inc., Austin, and Texas. Axelo patents represent the next generation of human-computer interaction and hold great potential to transform learning technology by moving online learning from the desktop to phones and wearable computers, and by liberating media from traditional devices to live in the space between cyberspace and the natural world (mixed reality, transmedia, augmented reality, cyber physical systems, etc.). The patents today are reflected in processes implemented in many consumer devices on the market today representing billions of dollars in intellectual property value.

The patents cover eyewear integrated with gesture computing, eye detection, voice communication, mapping the last 15 feet of the global positioning system from a user outward, and elimination of motion sickness (particularly in the context of 3-D media). The founders of Axelo are focusing their R&D on sports and human performance, while making these patents available to form market pull mechanisms for education using Intellectual Capital Grand Challenges (Global Architects) empowering students and inventors to use these patents to create new educational systems to improve student learning outcomes. Axelo, Inc. Patents include:

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[22] Ibid.

1. US 6,240,392 Communication 8/29/1996 Communication device and method for deaf CA 2, 214,243 Communication 8/29/1996 communication device and method for deaf
2. US 5,966,680 Motion sickness 2/15/1996 Motion Sickness/Vertigo prevention device and method CA 2, 197,588 Motion sickness 2/15/1996 Motion sickness/Vertigo prevention device and method
3. US 13/108,683 Spatial disorientation 5/14/2010 System and method for prevention and control effects of spatial disorientation CIP filed Spatial Disorientation 5/14/2010 Physiological biosensor system and method for controlling vehicle or powered equipment
4. US 7,683,883 MEMS 3D Inertial Sensing Technology 11/2/2004 3D mouse and game controller based on spherical coordinates system and system for use.
5. US 8,325,138 MEMS 3D Inertial Sensing Technology 11/2/2004 Wireless hand-held electronic device for manipulating an object on a display 13/573,945 MEMS Inertial Sensing Technology Hand-held wireless electronic device with accelerometer for interacting with a display.

Technology not only exists at a net net zero cost relative to price performance, it is transforming from stationary information appliances to mobile, wearable, and embedded. Computing is shifting from from luggable an stationary information appliances to computers embedded in everything from clothing to glasses to eyes. By the time OSTP, NSF, and/or U.S. government grants are in the marketplace in the next 18-36 months a complete paradigm shift is happening from laptops, tablets, and desktops to embedded computing (machine to machine computing, industrial control systems, embedded computing, cyber physical systems, etc.); therefore, SPDS proposes a demand pull market mechanism simply defined as issuing Intellectual Capital Grand Challenges (Global Architects) to students worldwide. Topics of Intellectual Capital Grand Challenges (Global Architects) may include education, human performance, health, poverty, job creation, economic innovation, environmental sustainability, and entrepreneurship.

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OSTP QUESTION #5 - What role might different stakeholders (e.g. Federal agencies, state and local educational agencies, foundations, researchers, practitioners, companies, investors, or non-profit organizations) play in designing, funding, and implementing a pull mechanism for learning technology? What role would your organization be willing to play?

OPEN MARKET FREE ENTERPRISE PLATFORM – INTELLECTUAL CAPITAL GRAND CHALLENGES FOR ANYONE WHO RIASES THEIR HAND AND SAYS I WANT TO LEARN AND I WANT TO INNOVATE. The cost of educational and business technology today compared to 1985 is net net zero. Grand challenges will shift thinking about STEM and technology to understand that STEM and innovation are human processes—derived from the Greek "techne" and "logos"– art, craft, and logic. SDPS will act as a guide and advisor in developing programs, curricula, infrastructure, and evaluation of learning related to intellectual capital Intellectual Capital Grand Challenges (Global Architects) and process and design thinking. Our team name, "Global Architects" was created in January 2014 by student of George W. Carver High School and Girls, Inc, Alabama during the LIGHTSPEEDGEN workshop led by the Continuous, Collaborative, Science, Technology, Engineering and Mathematics Innovation initiative of the department of Electrical and Computer Engineering, "Innovation by Design."

LIGHTSPEEDGEN

Being the Change, Doing Science

SOCIETY FOR DESIGN AND PROCESS SCIENCE

S D P S

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OSTP QUERSTION #6 - What changes in public policy would facilitate experimentation with pull mechanisms at different levels of government?

Today U.S. foundations, corporations, and federal agencies (such as NSF) are focused on identifying and/or scaling exciting educational practice, rather than doing educational invention and related new break-the- mold innovation. Because many of the needs, goals, and presuppositions of U.S. STEM needs are complex in nature, funding for invention and experimentation is necessary. Recommendations to this need to fund real invention, innovation, experimentation and to align market mechanisms in the context of the questions 1-5 answered above include:

1. Create a market-based platform that enables markets with need and STEM RD&C talent with something to prove to meet in the middle:
    1.1. Create a Virtual Incentive System - Use score, badges, skill/competency, status, levels, story, simulation, and performance aiding similar to decision support and/or games;
    1.2. Create a market based platform with tools for transformation, learning and creating communities of practice including connecting crowd funding, public financial markets, the second market (pre-IPO), and risk capital for seed and investment funding across the entire spectrum of financial support needed to conceptualize, create, bring to market, and license intellectual property and manage related processes in relation to US PTO and other agencies to capture and enhance patent holder rights, incentives, and processes enabling less friction in collecting payment for patent violation, arbitrage, and non repudiation of IP related matters in the high technology domain across industries. And, especially in relation to US government use of market based intellectual property;
    1.3. Enable open source and copyright-based market solutions including buyer and seller side markets utilizing auctions and reverse auctions and similar market-based exchanges; and,
    1.4. Create a constructionist platform whereby the online infrastructure is extensible by members of the community.
2. There is no effective documented effort today among the National Academies of Science, the National Science Foundation, the Department of Labor, or the Office of Science and Technology Policy to create a vocation of STEM, support the career and technology education (CTE) community in STEM programs of study, managing transcript credit across intuitions with particular focus on course transfer, dual credit, and/or credit articulation.
    2.1. Create integrated learning outcomes, pedagogy, and systems and technologies that support the vocation and avocation of STEM RD&C practice spanning online, offline, and blended learning tools and techniques with a special emphasis to managing CTE/STEM RD&C-based Programs of Study across university, community and technical college, and high schools.

2.2. **Reduce Friction in the Educational Ecology and Economy By Standardizing Programs of Study, Course Sequences, and Transfer Agreements for Transcript Credit Among K-12, Community and Technical College, and University Levels.** Applied STEM programs, especially STEM RD&C, Transcript credit and particularly course articulation and transfer is a major source of friction in the economy of education that can be remedied by focusing first on parity and congruity among applied community college courses and degrees and applied university courses and degrees (for example digital media design, nursing, physical therapy, engineering, information technology, law, accounting, and/or medicine).

2.3. Create an online system for managing programs of study for applied STEM programs spanning K-12, community college, and university programs (8th grade to Ph.D.). See Joint Letter for Career Pathways for more recommendations and explanation of programs of study:

http://cte.ed.gov/docs/RPOS_2012/Joint_Letter_Career_Pathways.pdf. A full description of the Program of Study (POS) design framework can be downloaded from the Perkins Collaborative Resource Network (PCRN).

2.4. Create a STEM RD&C Rigorous Program of Study with seamless transfer of transcript credit across institutional levels of education:

  2.4.1. Incorporate and align secondary and postsecondary education components;
  2.4.2. Include academic and CTE/STEM content in a coordinated, non-duplicative progression of courses;
  2.4.3. Offer the opportunity, where appropriate, for secondary students to acquire postsecondary credits;
  2.4.4. Grant industry-recognized credential for STEM RD&C;
  2.4.5. Implement high-quality, comprehensive STEM academic and career pathways;
  2.4.6. Provide quality assurance markers for national, state, regional, and local measures of success for schools with particular attention to rewarding high school and community colleges for producing students who complete college course credits, workforce licenses and certificates (For example community college students that complete 3 to 60 credit hours but do not get an associate's degree are not recognized or rewarded for students who move on to university, rather they are penalized in the form of not counting a student that goes onto higher education as a success measure);
  2.4.7. Support states in developing STEM RD&C College and Career Pathways, programs of study, course sequences, and course transcript articulation, transfer in such a way as to reduce friction in the educational exchange and transport of credit.

2.4.8. **THE ELEPHANT IN THE ROOM (THEORY AND PRACTICE) -** Shift policy and pedagogy to investigate competency and skill-based assessment and particularly systems that illustrate the market gaps between required jobs in the market and educational credentials related to workforce and industry licensure and certification in applied STEM courses and degrees across high school, community college and university.

2.4.9. **Increase the Velocity of Education, Increase the Velocity of Education, Increase the Velocity of Education! Offer rigorous, sequential, connected, and efficient STEM RD&C curricula that "bridges" academic and applied educational domains and cultures—** especially with an eye toward a model similar to Germany's Siemen's where 2 year and 4 year degree candidates complete the exact same first two years, while those advancing 4 years gain a Bachelor's degree and those advancing 2 years gain a workforce credential or equivalent of an Associate's Degree.

2.4.10. Facilitate secondary and postsecondary industry recognized credentials, sector specific employment, and advancement over time in education and employment within a sector with an eye toward life long learning support using cognitive architectures as a performance aid.

2.4.11. Manage STEM RD&C programs of study and college and career pathways through collaborative partnership among workforce, education, human service agencies, business, and other community stakeholder participants by establishing consortia similar to old school tech prep; however, get K-12, community college, and university on the same "transcript page" using programs of study and rewards for reducing friction and increasing the velocity of education by removing parries to course transfer, articulation and dual credit in K-12, community college and university applied STEM fields, especially STEM RD&C.

3. **Moving Beyond Provincial Notions of STEM—STEM is GLOBAL! In considering how a region's STEM activities can be aligned with its economic development priorities,** a recommended strategy that builds on work from the U.S. Department of Education's Office of Vocational and Adult Education (2010) is based on the Program of Study (POS). At the core of a POS is a core curriculum sequence, but a POS also provides a framework compatible with the many challenges of aligning a region's STEM education activities from secondary education, into higher education, and on to STEM-based jobs that correspond to local economic development priorities.

   3.1. Programs of Study are a framework for a region to engage a student early; educate students, parents, and educators regarding important coursework; highlight specific local pathways; minimize remediation and maximize early credit; and move students efficiently through college-level coursework (Zintgraff, Green, & Carbone, 2013).

3.2. **We recommend the development of a Programs of Study platform that will support development around existing assets in a region, enable their integration, and encourage coordination of efforts, resources and strategy among secondary educators, college-level educators, industry, government and community advocacy groups.** Such a platform should:

3.2.1. identify available Programs of Study in a region;
3.2.2. highlight related career opportunities, in support of outreach functions to students, parents and educators;
3.2.3. identify required coursework from middle school through advanced degrees;
3.2.4. show the alignment and various pathways through which a student can arrive at STEM-based credentials and jobs;
3.2.5. identify student counseling resources (Conley, 2007);
3.2.6. show extracurricular supporting activities (camps, competitions, etc.);
3.2.7. be a clearinghouse for scholarship opportunities;
3.2.8. be a clearinghouse for internships at the high-school and college level; and
3.2.9. connect finally to local employers and career opportunities. Systemically, a defined Program of Study is an object around which a community can gather.

4. To the extent that coordination among all the players in a regional economic development system sets apart the competitiveness of a region (Gibson & Butler, 2013), a Program of Study is a powerful mechanism for collective community action.23, 24,25

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[23] Conley. D. T. (2007). Redefining college readiness. Eugene, OR: Educational Policy Improvement Center.

[24] Gibson, D., & Butler, J. (2013). Sustaining the Technopolis: The case of Austin, Texas. *World Technopolis Review*, *2*(2-6), 64-80. U.S. Department of Education Office of Vocation and Adult Education. (2010). Career and technical programs of study: A design framework. Retrieved 10/14/2012 from http://cte.ed.gov/file/POS_Framework_Unpacking_1-20-10.pdf.

[25] Zintgraff, C., Green, C. W., & Carbone, J. N. (2013). A regional and transdisciplinary approach to educating secondary and college students in cyber-physical systems. In Suh, S. C., Tanik, U. J., Carbone, J. N., & Eroglu, A. (Eds.), *Applied Cyber Physical Systems*. New York: Springer.

WealthyLife

Company Overview

The Wealth Factory, Inc. is the developer of WealthyLife©, an adaptive learning platform that teaches people how to make better financial decisions through online virtual reality games in 20 comprehensive lessons that walks users from birth to retirement, gathering real-time performance analytics. WealthyLife greatly improves financial literacy by 30% after three game plays and is structured according to the Common Core Standards of the Business and Finance Technology Personal Finance Education Frameworks to include decision making, reporting income, budgeting, saving, investing, transactions, banking, financial institutions, credit and risk protection.

Product

The mission of The Wealth Factory is to raise financial literacy standards across the world by providing access to all. We are developing new technology that supports students' financial literacy development to foster their long-term financial health. Learners will be motivated to use WealthyLife both in school and in their own time as they are making financial decisions. It will promote the practical application of financial topics in everyday life situations. Over the next 5 years this technology will advance DMV education technology standards, boost America's financial understanding, and reduce debt. Eventually, anyone age 5-95 will play WealthyLife to learn financial literacy.

Value Proposition

WealthyLife is the only financial literacy education technology curriculum product. We're inventing a game that will be customized to every individual's lifestyle and learning needs. As a start-up company with a new concept – teaching comprehensive financial concepts through education technology with virtual gamification – this social enterprise is of utmost importance. Our courseware puts the full power of a financial company, academic classroom and video arcade into a single application that can run on your desktop, tablet or smartphone.

Market

Conservatively, WealthyLife will capture at least 3-5% of two emerging markets – digital courseware and gamification. Digital Courseware has been leading the growth in the PreK-12 industry and will continue to do so at a growth rate of 8.8% through 2015; currently, digital holds 30.5% of the media used in classroom instruction. Gamification is a $100 million market that should grow to $2.8 billion by 2016, according to M2 Research. In America, there are over $13k school districts and $4k universities, producing over 55M students. The average US school spends over $12k per pupil, $597B in total – $316B specifically for instruction. Maryland is #1 in educational spending.

Sales Strategy

Our ideal customer archetype are cornerstone universities with strong academic influence. Initially, our courseware will be designed at the AP level for college freshmen/HS seniors and sold directly to the universities/school districts. Registration fees will range from $1,500 to $15,000 depending on pupil size along $100 per student, per year. These schools will be motivated by the necessity to fulfill financial literacy requirements, use allotted budgets for programming and effectively educate students on financial literacy. Moving forward, we will build sponsored financial literacy ministries/workshops in churches, prisons, shelters, VFWs, etc. to grow wealth in older populations.

Validation

We have agreements with U of MD, Hampton U, High School Inc., and the National Baptist Convention. We were a finalist for GWU's Dolphin Tank, leading to acquisition interest from Capital One Labs. IBM Partner World recognizes us as a Global Entrepreneur, we were accepted into the UM Technology Enterprise Institute (MTECH), completed Start-Up Weekend Next under Bob Dorf and have been invited to Wharton's Innovation Summit by the President of Wharton DC.. Socratic Labs, 1776 and Tech Cocktail recognizes us as one of top ten hottest education startups. We are developing strategic partnerships with Pearson Education and YWCA.

Competition

Top Competitors: Current Curriculums (traditional formative assessment and procedural instruction); Everfi (financial literacy start up curriculum product for high schools); MoneyThink (financial literacy start up after school program); Practice Money Skills (basic educational gaming with light traction); Rich Dad Poor Dad (board games and procedural instruction with high notoriety); and Junior Achievement (corporate sponsored in-class mentor program)

Competitive Advantage: WealthyLife is the only financial literacy resource that spans *all* financial topics in a comprehensive format. It is the only financial literacy courseware system with a virtual reality full-life game and the only marketing platform with custom data analytics extracted from game behavior patterns.

Management Team

Angel Rich, *Founder and Chief Executive Officer*
Prev. Global Market Research Analyst & Comm. Outreach Advisor, Prudential; BS in Marketing, Hampton U.
Courtney Keen, *Co-Founder and Chief Operations Officer*
Contract Specialist, US Air Force; BS in Accounting, MBA, Hampton U.
Gene Reese, *Co-Founder and Chief Technology Officer*
Tech Entrepreneur; BS in Finance, MBA, Vanderbilt U.
Shyaam Srinivasan, *Chief Information Officer*
Chief Information Officer, Votimo; MS in Infosec, GWU U.; M.A. in Intelligence, Candidate, AMU
Rachel Spivey, *Chief Marketing Officer*
People Program Coordinator, Google; BS in Marketing, Hampton U.
Jared Ursani, *Business Development Officer*
Director, Financial Regulatory Agency, BS in Finance, MBA, U. of Maryland
Dr. Tammy Clegg, *Principal Investigator*
Prof., iSchool, Dep of Teaching and Learning, UM; PHD CS, S. of Interactive Computing, GA Institute of Tech.
Dr. Mona Leigh Guha, *Assistant Investigator*
Research Assoc., C. of Info. Studies, UM, PHD, Human Development, University of Maryland
Jeff Schell, *Project Manager,* IBM Global Entrepreneur Program
Akbar Dawood, *Advisor,* Director, Maryland Technology Enterprise Institute (MTECH)

Information about ***Paradigmatic Mismatch***
Offered to OSTP in response to ***Request for Information: Advancing Learning Through Pull Mechanisms***

March 7, 2014

Drs Paul Stephen Prueitt and Arthur Murray

Do education reform efforts consistently miss the mark? Our answer suggests that policy makers frame questions in a way that limits our insight. We continue the paradigm that is responsible for an expensive system that is highly dysfunction for most young Americans. We consistently see policy that frames questions as dialectic. Push education must be wrong, and thus pull education must be right.

The problem is more than mere semantics. There are also related assumptions that intelligence must be model based. What does this mean? In humans, where does this model reside. Are models different from one person to another? Does the model physically process symbols? Is intelligence a physical symbol processor? The assumption is asserted as if clear truth, and yet where is the evidence?

Many scholars, for example Paul Churchland, point out that social belief drives advances in science. If social belief has specific types of flaws then our science is likely to reinforce these flaws. Perhaps science about learning and mythology share a lot in common. Having a root in the past is not unusual. The thesis advanced by Thomas Kuhn is that Newtonian mechanics agrees with common "folk psychology" and is thus consistently re-emerging in various forms even as evidence accumulates regarding complexity; e.g., a non Newtonian reality.

Many scholars feel that learning is complex. Learning involves not just pushes and pulls by social, economic or psychological phenomenon. And yet policy statements persistently treat learning and education in overly simplistic terms. Funds flow and end up reinforcing paradigms that no one would accept if it were not for the funding.

Deep learning is a paradigm in machine learning and in the neuroscience of memory, awareness and anticipation. Experience is internalized and then expressed though the engagement of goal-directed attentional orientation. Awareness is a composition of parts of memory and is shaped by parts of anticipatory mechanism. This is an alternative theory.

Educational theory is behavioral in the sense of Skinner, and in this way reflects a non-complex reactive paradigm. So we have a structural problem. Educational processes, like so much of our economic and social realities, do not account for individuality or for the nature of self-directed inquiry. Because of educational practice we learn to understand what is expected of us, and then either reject this expectation or accommodate it. Individuality and self-directed inquiry are joined at the hip. If one suffers the other does also.

A revolution in data analytics and distributed computing has the potential to transform education, not only in K-12 but also in higher education, life-long learning, and workforce development. We have a means to meet the Vice President's inquiries about just in time, right size training for existing and near term emerging employment. But we are held back because of common perceptions about the nature of learning. For example, we make tacit assumptions that only a few really need to know math, and that only a few are capable of seeing into the foundations of higher mathematics. A similar assumption is made about average capacity to read with high comprehension and write in a lucid and expressive manner. Minority communities experience the blunt of under expectation.

We are calling for a Manhattan-type Project that builds a 3D based social media designed for the generation, representation, and transfer of human knowledge. We propose a federal project to design, fund, and implement *complex mechanisms for learning support* within an avatar environment (see www.secondschool.net).

Natural complexity exists, in the sense defined by scholar Robert Rosen, when there are separate endophysical dynamics and separate exophysical dynamics. This means, to those in the complexity community, there is a deep structure to behavioral expressions, to memory and to anticipation. The measurement of deep learning should be consistent with measures of pull and push forces, but should also be consistent with the notion that internalization of knowledge is creative and self-fulfilling without the need for external rewards or validation.

Our point is that traditional notions of reward are absent a well-qualified theory of private intention. Educational practice based on traditional notions may in fact inhibit the capacity to direct inquiry because the individual is assumed very similar to every other individual. The point is relevant. Not requiring self-directed motivation systemically may result in the observed nature of student performance in middle school, high school and college.

The social media design we have developed might create fifty state Education Bridges, between high school and college. A topic map based representation of all core college curriculums might serve as the basis for adaptive assessment (similar but better than the ALEX software). Data analytics might be used to create detailed models of a great variety of different pathways through the same college curriculum.

Business Intelligence (BI) methods might be used to guide inquiry driven by a four-step method. The four-steps are: topic enumeration, first illustration by the student of a single topic, the creation or finding of two or more illustrations of the same topic – in which these illustrations are as different as possible, and composition of a handwritten narrative about a self selected small set of topics[1].

More on our approach is provided at www.secondSchool.net. We are appreciate of the opportunity to express these views.

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[1] See description at: www.educationworlds.com/principles/10.html

Don Fitch

Founder and Executive Director

Center for Career Freedom

"Submission #1: Hello, the Center for Career Freedom is an NGO,NYSED Lic. Business school preparing youth w mental (ASD,SPMI,IDD) & physical disabilities (CP) to pass their online Certification exam for Microsoft Office (word, excel!PowerPoint) &/or Qkbks.. Students learn in about 1/3rd the time that our traditional, Instructor-led classroom model required. We developed a multimedia,highly visual, minimalist, employer-aligned curriculum in a 1:1 flipped setting. We're 100% govt. funded; NYSED/ACCES-VR, NYSOMH , opwdd/CSS, dol/OneStop. An important part of our vocational prgm is that Graduates are hired by the Center to apply their new skills; data entry, Google research, peer instruction, mailings, business cards, flyers,etc, pro bono, to other NGOs to strengthen their resume. We also train to the job. In 2014, we're piloting a Skype prgm for youth diagnosed w CP that have aged out of the school system. Staff are unique in that we all have business backgrounds. www.cybility.org contains research evidence, curriculum, advisory panel, publication,Tutorials,etc our challenges are 1) working around the SSI gross earnings cap (1/2 of everything over $85./mo) 2) imbuing a work ethic in our students 3) convincing govt. admins & educators that these populations can learn 21st century job skills, they don't have to collect carts at Safeway, etc.

Submission #2: Hello, The Center for Career Freedom is a 15 yr old NGO,NYSED Lic.business school teaching computer job skills (Microsoft Office, Qkbks, Keyboarding,Internet,etc)to over 100 youth & adults diagnosed w Autism, IDD & Psychiatric disabilities (SSI/SSDI). We're 100% govt. funded(ACCES-VR ,NYSOMH,NYS Opwdd,DOL OneStop). We've developed a highly visual, minimalist, multimedia curriculum administered one on one in a flipped classroom setting. Evidence; five office tasks; a letter in Word, a spreadsheet in Excel,a business card & labels in Publisher, payroll checks in Qkbks were administered in four settings; traditional Instructor-led classroom, 1:1 , Skype & alone, using our comic book style Cybility Tutorials & short,fun YouTube videos. the Cybility Tutorials reduced instruction time & error rates to about 1/3rd of Traditional classroom mode. (go to www.cybility.org for the raw data) Why the Cybility model works; it's visual (no lectures, minimum of text), it empowers the student ; the student is in control of their learning, the Instructors role is a facilitator, guide, it's tangible; the student gets the task, they understand the goal,what there expected to do, their progress is quantitative; every task is measured by two metrics;elapsed time & errors. Students compete against themselves, they have physical evidence of their achievements; results are downloaded for the student to show their friends, family, caregivers reinforcing their accomplishment & building their self-esteem,it's respectful; instructors spend a minimum time orienting the task & if there are no questions, they step back at least five ft. (This is a critical element, especially for ASD students) instructors don't engage unless asked(this is a problem for the majority of teachers, they can't stop talking/ micro managing) Once the student passes their online exam, their given $8/hr to do real world work from fellow NGOs; labels, Google research, mailings, business cards, etc. we also started an in-house Employment Agency. to scale the program, we built a Skype Broadcast Studio to replicate the Cybility model at two sites; an NGO for youth w CP & an after school prgm for a 12th grade Special Ed class. Challenges include navigating the SSI income cap (1/2 of gross earnings over $85.00/mo) inculcating the work ethic (children of immigrants have more motivated parents) and convincing our state & local govt. officials that our populations can do a lot more than bag/collect carts at Safeway. "

Christine Shock

Technology Coordinator

Eagle Ridge Academy

"I don't know how our school would function without Google Apps for Education. It has reduced my need for servers, storage and shares by moving the majority of our student and faculty work to the cloud!!! And it has saved our school thousands of dollars in equipment costs for servers, storage and backup services. Money that we can put to better use, money to save art, to add additional technology like wireless and to improve the student experience by adding additional digital projectors. Email is handled efficiently, and without the service disruptions we experienced with Microsoft Exchange. The longest time Gmail has been down is 15 minutes in 3 years...good luck with Microsoft Exchange having the same low fault rate. And unlike Microsoft 365 I do not have to build and support a SharePoint Server. (Thousands of dollars I don't have to spend with Google Apps for Education). Students and faculty can share files up to 20 MB and store up to 30 GB of files without ever touching my servers and I have no need to set up shares or shared drives or VPN connections as students and faculty can collaborate with each other in the cloud. Faculty, students and staff regularly do Google Hangouts for assignments and hybrid days where students perform 50 minutes of classwork at home once a month to get ready for online classes in college. And Google gives us great tools in Docs, Sheets and Slides to keep students accountable like File revision history, comments and document histories so that we can see if all students participated in an activity and for how long. Google Forms gives us the ability to create self grading and self emailing assessments for formative and summative assessments throughout the year. Without Google Apps for Education, our whole school would be lost... Best of all...the majority of the services (all but Vault) are free...and Vault is only $10.00 per Staff/Faculty per year. Students are covered by Vault for free... No better deal in education! Thanks Google...I can't imagine running a school without Google Apps for Education.

"

Walt Carlson

Technology Chairman

Fairfax County Council of PTAs

"Thank you for seeking input on how to address one of the most important challenges facing our K12 schools. Your effort is needed and long overdue.

The question addressed by this proposal:

""What changes in public policy would facilitate experimentation with pull mechanisms at different levels of government?""

As is stated in the RFI:

“Currently, there is a large gap between the relatively modest impact that technology has had on education, particularly in K-12, and the transformative impact that it has had in many aspects of our economic and social life……”

“Education, particularly K-12 education, remains relatively untouched by advances in our understanding of how people learn, how to design instruction that incorporates those insights, and the explosion in information technologies such as low-cost smartphones and tablets, cloud computing, broadband networks, speech recognition and speech synthesis, predictive analytics, data mining, machine learning, intelligent tutors, simulations, games, computer-supported collaborative work, and many other technologies……”

Technology in education has not had a major impact on K12 education -- on student learning. That is the case in spite of over twenty years of trying to integrate it into American education, in spite of dedicating more and more of educational resources to technology, in spite of there being more and more technology in our schools. Hopefully the OSTP’s well intentioned RFI results in major “Pull Mechanisms” that help address this failure. It is also hoped that the RFI results in a decision to pause and identify the real reasons WHY technology in K12 schools has been less that consequential.. It may be worthwhile to understand why so many efforts and resources have not resulted in significant improvements in student learning. Knowing why a problem exists allows for directed strategies to solve the problem.

A first attempt in obtaining that understanding may be to identify the policies that govern the use of technology in American education.

POLICIES DETERMINE COSTS, POLICIES DETERMINE EFFECTIVENESS.

It is essential that educators in our schools understand the policies that govern their technology programs. It is essential that educators know how effective those policies have been implemented.

EXAMPLE: Teachers are to integrate technology into their curriculums.

This has been the over-riding mantra of educational technology. Has it worked? Is this policy responsible for the failure of educational technology to make a difference? What changes to this policy are needed?

SUGGESTED “PULL MECHANISM”:

Conduct a nationwide study to:

- determine why technology has not made a difference.
- identify the best policies that might be used to govern educational technology.
- Identify tools to help school systems monitor the effectiveness of their policies.

The study might include:

- regional conferences.
- Blogs.
- A commission to evaluate studies conduct by schools of education across the nation that address the question of “Why Isn’t Technology in Our Schools Helping”.
- ??

There needs to be a nationwide, high-profile discussion of the problem and the policies and causes of the problem. The Fairfax County Council of PTAs (FCCPTA) has developed a blog in the attempt to conduct such a discussion concerning the use of instructional technology in Fairfax County public schools.. You can see it at http://www.fccptatech.org. While the FCCPTA blog may be asking the wrong questions it provides some ideas for the kind of questions that need to be asked.

Thank you for the opportunity to comment on this important issue and challenge. Hopefully your consideration of the proposed ""Pull Mechanism"" serves some value to you.

"

Kevin Chen

Co-Founder

italki.com

"I'm curious to ask:

* Should foreign language acquisition be another area that should be included in the document? (Particularly for technologies that enhance second language acquisition.)

I believe helping students learn foreign languages and connect with the outside world is a key skill in a globalized economy.

Outside of the US, learning other languages is an important requirement for graduation. US graduates tend to only have a marginal ability with a second language. This gives US graduates a weakness when looking for international job opportunities. Of course, there are many other benefits to learning other languages, from broadening perspectives to brain health.

New Technologies and Policies

* Pull based policies could involve a monetary rewards for students that acquire mastery of language skills. This can give students a defined and achievable goal. Language skills could be measured by a standard similar to the State Department's system that exists for diplomats. Policies that reward these achievements would also function as a signal to potential employers that the student has achieved a certain level of language competency.

* Many technologies exist to help students acquire language proficiency, and have not yet been adopted by schools. ***Particularly in foreign language learning, there are unique benefits for international collaboration, both from a learning efficiency perspective, as well as a cost perspective.***

* As sources of education become increasingly decentralized, incentivising the results of skill mastery, can give students the freedom to find alternative paths to achieving the same goals. In this case, help students to experiment with new technologies to learn a foreign language. The final goal is the same, but allows for different methodologies tailored to the student's learning style.

My background

I am an American entrepreneur that is working on italki.com, a language learning startup that connects students with teachers around the world for 1-on-1 language tutoring. We have over 1.5 million users, ~2000 teachers, tens of thousands of paying students, taking hundreds of thousands of lessons per year. 20% of our students are from the US, with roughly 35% from Europe, 25% from East Asia.

http://www.italki.com

"

Bill Landis

Director of Campus Technology, Technology Support

Lubbock, TX Independent School District

"(1) Learning outcomes that can be demonstrated by using the technology that is common place in the current world of work. Providing the devices and the skills to use them successfully to solve tomorrows problems. Example might be we learn to read in the early grades and then we read to learn. All of us realize that being able to read accelerates the learning process from third grade on – or hampers the learning process if the level of reading comprehension is low. What technology skills would accelerate the learning of children as they go through school. These skills can level the educational accomplishments of children or if they are not possessed they can widen the gap between the haves and the have nots. Technology skills SHOULD NOT be evaluated by current standardized test – these test in no way measure the methodology of using technology they are focused on acquired knowledge. If these skills are not provided for children in the early grades then we set them up to fall further and further behind. Current use of technology for tier two and tier three interventions has no relevance to technology skills – it is dependent on teaching the same objects in the same ways (just on an electronic device) Compare a book that is in PDF format to the national geographic magazine available online and you will see the difference between the 1950s and the 21st century. BTW many libraries carry digital versions of magazines like national geographic free for all patrons – great resource unless you do not have access to the tablet – download in schools and read at home.

(2) Currently the skills in using technology are not measured or assessed. Some would say we have self assessment – ask children, parents, teachers, school districts do they think they have the appropriate skills – why not ask a 14 year old “Do you have the skills needed to drive a car?” How would one know what one does not know? There are some industry certifications that students and adults can take but these are much to narrow for them to be useful on a wide scale. Are you MicroSoft certified in word? This tells me that at some time you knew a specific program on a specific platform – it does not tell me you know how to use technology.

(3) The only information we currently have is access to technology. Do you have a certain ratio of devices to students. I know of no information focused on how you use this information or even what the best use of this information would be – ISTE is probably the best source of national trends. The current trend is schools chasing level one changes to produce marginal gains while technology is producing level two changes in all industries. Unfortunately the factory model is alive and kicking in education while factories no longer have the need for low level, physical skills on repetitive task. Ask employers “How many of you would consider hiring based on a multiple choice assessment?” Those that I have talked with over the past decade (in relation to CTE programs) have told me: What I need is an individual who (1) comes to work (2) works as a team member (3) solves problems that come up on the job (4) communicates effectively in print and directly (5) Is adaptable – learns what is needed and applies it as they need it. IF the tool for learning was flexible, available when I need it, available in different formats – print- video- audio – and yes face to face and not based on time we would see unbelievable results. Similar to the way you get your news, entertainment or how you learn new skils.

(4) Rather than a preoccupation on remediation and acceleration we would be focused on actual learning. We would look at students demonstrating their understanding not trying to cookie stamp

students. What tools does the military use to train our troops. Do they have multiple choice test for their skills? (well yes at the beginning level) BUT they quickly move to application of the skill and that is where we want our students to be focused. – Go to Fort Bragg NC and ask the trainers there why individuals are willing to put themselves through the rigor of Special Forces and it will become apparent most individuals want to learn and achieve but in the real world. Why am I going on and on -- BECAUSE technology can put our students in real life situations without the baggage of physically creating the environment. Why are students drawn to technology (1) real world (2) immediate feedback (3) available when and where I want it. Why is education not like this? Our funding is determined by keeping each child in a seat 5 hours a day, 180 days a year for 12 years. The incentive in education is to go at a steady, continuous pace. Nothing in the world of technology is like this. What would happen if technology increased the rate of learning so that a student could finish in 100 days – problem school would have a drop out because there is nothing left for the student to do for the rest of the year. A pull mechanism in this area would have students moving through math in 8 years and moving on to college and graduate level math prior to what would have been their high school graduation date. Those are the students that are going to be moving innovation forward in massive ways.

(5) Roles each might play

a. Federal agencies – reward the systems that allow for movement through education at the child's pace – Tax breaks for organizations that allow for this to happen – Use your school system (DODEA as a proving ground) - I worked in that system for 10 years and the potential for a world beater of a system is right on your door steps – AND it is your system – no state problems – no local problems – pick up the pace lead the pack

b. State agencies – reward the innovation and flexibility – forget the states that are self-absorbed in politics – you cannot win when the focus is not on students

c. LEA – get behind a futuristic thinker and let them show the results and the methodology

d. Foundations – joint or matching funds to encourage innovation

e. Researcher – Show me what the results of this kind of instruction is 10 years after schooling – Did this instruction really make a difference in the individuals life

f. Practitioners – Bring in the teachers that are on the front line

g. Companies and investors – The killer system will make everyone richer but competition must be level

h. Non-profit – other than LEAs this group is most able to be flexible and use these new systems

(6) Reverse the current methods used by the federal and state government. THIS IS VERY UNPOPULAR. Please do not mistake this comment as a naïve person who just came to the party (42 years in education) How do you determine where to spend your money? Federal? State? Local? The school that has bad test scores or results gets MORE MONEY. The game is to do poorly but not too poorly and get shut down. We look for students that are not doing well and give the system more – has this worked? In business does Walmart spend more money on the stores that do well or do they send extra money for the stores that are doing poorly? You will get the results you encourage. If you want poor results give more money to districts and schools that have poor results. If you want students accelerated do not fund schools based on seat time but on results! We currently know how to teach all students at

whatever level we want. The fact that we do not tells me that we (1) do not have an ethical imperative or (2) do not have a financial imperative.   In either case the only change that can be made by governmental agencies is number 2.

"

Danielle O'Bannon

Associate Analyst

M Powered Strategies, Inc.

1. Who is the target audience? More specifically, which government agencies or government offices, are trying to get to implement these “pull mechanism” programs?

2. In what programmatic context (planning, operational, or budgeting) do we want to apply pull mechanisms?

3. The example of a pull mechanism was related to prison recidivism, is the goal of this effort to apply similar approaches, to educate individuals on the benefits of pull mechanisms, or to persuade stakeholders of its potential benefits?

4. What is the opposition to this effort? E.g. lack of understanding and awareness, limited budget, momentum against change, etc.

"

Hugh Ching
Founder and President
Post Science Institute

"Dear White House Office of Science and Technology Policy:

The White House Office of Science and Technology Policy should focus research and education is areas of relevance, which are directly related to Post-Science Knowledge Declaration mainly for solving current financial crises and future complex crises:

Ò Non-violable laws of nature regulate all material and human behaviors.

Ò The laws in science are exact and based on empirical verification.

Ò The laws in social science are fuzzy and are accepted based on mathematical rigor.

Ò Uncertainty requires fuzzification to expand the range of tolerance to cover all possibilities.

Ò All valid decisions are part of an Infinite Spreadsheet within the range of tolerance.

Ò The range of tolerance of the non-violable laws in social science gives the illusion of freedom.

Ò Fuzzification or diversification causes complexity.

Ò Complete automation solves unlimited complexity.

"

William Weil

Co-Founder and CEO

Tales2Go

"Happy to further discuss... something I wrote for an ed tech journal that will be published soon.

Listening is a neglected language art. That's about to change, as more and more schools adopt the Common Core State Standards (CCSS). Literacy experts have long understood that children need to be good listeners in order to become good readers. Effectively, there is a link between listening, vocabulary and proficient reading, famously spelled out in the 1995 Betty Hart and Todd R. Risley 'word gap' study that showed children from low-income homes entered kindergarten having heard 32 million fewer words than children from professional homes, the latter benefitting from a quantity of spoken, sophisticated vocabulary in the form of conversation, being read to, etc. This vocabulary deficit explained an achievement gap for low-income students that extended throughout elementary school, and still does.

The CCSS lays out very specific listening requirements by grade, as part of a dedicated section on speaking and listening standards, and even goes so far to make the point that listening comprehension outpaces reading comprehension until late middle school. In other words, listening remains the most effective way for a student to onboard vocabulary, fluency and general understanding of a text up until 8th grade. Think of granting a fourth grader access to complex text (another CCSS requirement) by removing the burden of decoding advanced words; in fact, students can listen to and comprehend an audio book two full grade levels above their current reading level. And for those tempted to just pair audio with visual text, that approach is valid with emerging readers, but not what the standards intend. Listening, on its own, is considered a desired skill for a 21st Century college and career ready student, e.g., ""Recount or describe key ideas or details from a text read aloud or information presented orally or through other media.""

Standards aside, adding a listening component to reading instruction has been shown to raise student achievement and scores. Teachers who blend a combination of independent reading, guided reading, listening to fluent reading and phonics work have seen success in their classrooms. They also see their students' general excitement about reading, or a favorite character and series take hold. There's something about sparking a child's imagination thru listening (i.e. the mental pictures) that provides a catalyst for growth and learning. Audio books are not ""cheating,"" or only good for struggling readers, despite all too common misconceptions. It's why established reading methods such as The Daily 5 use audio books as part of their program, for all students in primary grade levels. For something that many adults love to do on their commute, and benefit from, it's interesting that audio books have been so narrowly defined in terms of their use in schools up until now.

So what's the big deal? Teachers and parents regularly read to their students and children. Right? Well, many do, but most don't do it enough, some not at all, and others are unable to read in English. It's not really a matter of audio books replacing reading to children - we hope not - it's using audio books to increase the amount of fluent words that children hear, whether as part of a literacy rotation in a classroom, quiet time for a child at home or a necessary aid to a non English speaking parent in a Head Start home. Further, in a world of personalized learning, not all students will be inspired by the same book. Schools and caregivers need flexibility, both in the classroom and at home. One thing's for sure, children still love listening to a great story, well told.

For those so inclined, feel free to explore the new delivery options for audio books. There are some exciting new technologies. CDs, cassettes and Playaways are being replaced with digital download and streaming options that give users instant, unlimited and simultaneous access to thousands of titles at a time; for the first time ever, a teacher can now assign the same audio book to an entire class or grade to listen to at the same time. The point being there are new ways to access audio books which leverage your school or district's investment in mobile technology, whether 1:1 laptops, tablets or BYOD, both in school and from home. And with an estimated 73% of teachers using cellphones for classroom activities, the technology is there.

It's time to make audio books a core component of reading instruction in early childhood and primary school education. Listening both in the classroom and at home; the more the better. The new standards require it, research supports the efficacy of it and it's never been easier thanks to advanced mobile technology. With just 33% of fourth grade students reading proficiently in the U.S. (and just 17% of low-income students), educators and caregivers need every tool at their disposal.

"

Adam Thackeray

Founder and CEO

TeachIt, Inc.

"We are writing you today to provide our comments in response to OSTP's request for information as it pertains to widespread adoption of high-impact technologies in education.

Below are responses to the questions included in the RFI. We look forward to continued dialogue with OSTP on the value of technology in education.

(1) What learning outcomes would be good candidates for the focus of a pull mechanism to catalyze the creation and use of new learning technology? These outcomes could be relevant to early childhood education, K–20, life-long learning, workforce readiness and skills, etc.

The area of focus for new learning technologies should be lifelong learning. Lifelong learning is an extension of the classroom across all subjects areas. It accounts for over 70% of the learning we experience. The new technologies will break down the walls of traditional classrooms, mobilize lessons and provide teachers with unparalleled flexbility for instructing their students.

(2) How are these learning outcomes currently measured and assessed?

These learning outcomes are measured by an existing, well-adopted specification that can track and correlate data from both offline and online learning.

(3) What information exists about current U.S. performance relative to this learning outcome? What information exists about the presence (currently available or potential given current trends or breakthroughs) or absence of effective interventions (technology-based, offline, or hybrid) to improve this learning outcome?

Informal learning accounts for 70% of learning over our lifetime. Education today focuses too heavily on teaching and learning with an instructor in front of a classroom. This reliance ignores the power and reach of informal learning.

(4) Why would a pull mechanism in this area accelerate innovation in learning technology?

Funding for startups continues to be a significant challenge. Developing technologies to support lifelong learning have costs associated with them that are not trivial in nature for a startup company. Funding allows innovators and startups to have 100% focus and dedication to advancing education.

(5) What role might different stakeholders (e.g. Federal agencies, state and local educational agencies, foundations, researchers, practitioners, companies, investors, or non-profit organizations) play in designing, funding, and implementing a pull mechanism for learning technology? What role would your organization be willing to play?

Federal agencies - Show nationwide support through campaigns and support in Washington for the use of informal learning to extend our learning beyond the classroom..

State and local educational agencies - These stakeholders would be responsible for promoting the use of informal learning, financial backing for the advancement and use of the technologies.

Foundations, researchers, companies and NPOs - They would provide instructors and content to grow the lesson base to support informal learning.

Our company, TeachIt Inc. - We provide the technology. TeachIt Inc has created TeachIt Community, the evolution of lifelong learning - We connect instructors with students through lifelong learning. TeachIt Community is a simple and powerful mobile community designed to share informal educational content on demand.

(6) What changes in public policy would facilitate experimentation with pull mechanisms at different levels of government?

Public policy has to breakdown the barriers that still promote the problem that exists with learning today - Education today focuses too heavily on teaching and learning with an instructor in front of a classroom. This reliance ignores the power and reach of informal learning.

Thank you for your time. We look forward to your response.

"

Tom Zurinkas

President

Truespel, Inc.

"I'm Tom Zurinskas, creator of truespel phonetics, the one and only English-based phonetic notation making it easy to ""write"" as well as read phonetics for all ages, even kids. Now there is a "phonetics" requirement in the US Common Core Educational curriculum for K-1 students. Present phonetics is too complicated for children but it's perfect for truespel phonetics.

The big problem for US literacy is that the IPA and dictionary guides are not good for showing English pronunciation. They use special symbols. Thus, writing with phonetics is not taught in US grade schools, nor is it used in US media or government publications. Basically, academic phonetics is mostly useless outside academia. To overcome this, truespel phonetics is designed to use only the letters of the alphabet to enable "writing" as well as reading phonetically. This is new – and brings forward a huge number of academic possibilities, such as phonetic awareness assessment and ELT phoneme display.

The best part is that truespel is easy to learn and free. See the truespel phonetics youtube tutorials listed at http://justpaste.it/useit. For ESL, when the 40 sounds are mastered, learners can speak US English without a problem. They can read US English phonetically with minimal accent by pasting paragraphs into the converter at http://truespel.com/en. The two-way converter displays phonetics next to traditional text to show pronunciation, where words can be clicked to show definitions. (Note the spelling is based on US English, and the pronunciation model is from the spoken words of US ""talking"" dictionaries. The vast majority (57%-Wikipedia) of native English speakers are from North America.)

I'd like the US to work toward developing and applying truespel phonetics in the future. Literacy is fractionated. Truespel is finally the answer for integrating reading texts with dictionaries, translation guides, ESL, phonemic aptitude assessment, and analytic methodologies. Results of ongoing trials in Korea show that high school students vastly prefer truespel phonetics to IPA or dictionary notations that use special symbols. It's learnable in 15 minutes they say, and in a short time they were actually "writing" notes in phonetics to show pronunciation.

I've recently co-authored a paper on the upgrading of the Korea language based on truespel phonetics. The paper is ""The Romanizaton of Korean using TrueKor,"" presented at The International Conference for the Korean Association for Corpus Linguistics (KACL 2012) on December 10, 2012, by Hyung J. Martin, UNIversal Language Institute and Thomas E. Zurinskas, Truespel Inc.

The four truespel books are at http://tinyurl.com/3v2ekzn . They consist of a VOA dictionary with a truespel pronunciation guide (where none was present at all) and two books of phoneme frequency analyses. All English teachers should be familiar with the data in these books. A free course on truespel phonetics is at http://justpaste.it/course2.

This is actually a revolution. Phonetics should be simple, not hard. For a quick demo of truespel for US English, see http://tinyurl.com/40numfox ESL learners need only know how to say each of the sounds in this demo to speak correctly any word in US English. The latest truespel initiative is ""One phonetic spelling for all languages."" This is achievable with truespel phonetics.

Previoius work in k-1 with phonetics was successful. See http://bit.ly/17frEJc Truespel has modernized this technique for the internet age. I hope I can work with you on developing truespel phonetics.

"

Gary Kitmacher PhD EdD

University of Houston TX

"Dear OSTP;

I am responding to your RFI for learning technologies.

I recently completed my dissertation studying the use of technologies and media specifically in the area of space science. The NSF next generation science standards call for Earth and space science to be taught in all schools and the Texas state requirements have had this in the program since 2010. Science teachers have faced major hurdles in providing adequate education to their students.

This study reached out to 1300 school districts and collected information in surveys, classroom visitations and at conferences. I am providing the text of the dissertation, including the abstract, attached to this email. The appendices include the survey, parametric data and regression analyses that identify the specific factors, including specific technology and media requirements that affect the teachers' ability to teach. Please let me know if you wish me to send the appendices as they use considerably more computer memory.

My findings were that a relatively small percentage of teachers or students have access to computers or the internet in their classrooms. The number is currently less than 40% for all grade levels though the numbers are growing. Specific details of why such access is required is included in the dissertation. NASA internet resources are by far the most used resources for this subject area. Other resources are available, usually at a cost, which limits their use. The NASA resources are generally not well organized and are not established for classroom 'lessons'. Specific requirements for classroom use are detailed in the dissertation. The curriculum for this subject area is not well established and there is little continuity in the subject area from one grade to the next.

My specific recommendations, detailed in the dissertation:

(1) establish the specific topics to be covered by each grade level. This could be done through a Delphi panel of subject matter experts and education experts and I am now working to begin that process;

(2) for each of the topics, for each grade level, develop curriculum resource ""study units"". These would be consistent with national and state education standards. They would promote critical thinking, problem solving, teamwork and communications; they would incorporate real and current scientific data and imagery. The units would be developed by subject matter experts working with education experts;

(3) each unit would be field tested prior to deployment;

(4) units could use both internet and paper distribution; in time internet would be more prevalent but currently, based on my research, fewer than 40% of teachers or students have regular internet access in the classroom;

(5) training programs would be established for teachers; the emphasis for much of the training would be internet based, since funding, travel and time for in-situ training are major issues.

"

Mike Beutner

"Instructional Technology Associate Professor, Instructional Technology Graduate Program (100% Online) Department of Curriculum, Instruction, and Leadership, College of Education and Human Development

" University of Louisiana at Monroe LA

"Thanks for the opportunity for me to make a comment during the RFI regarding the encouragement and acceleration of the adoption of high-impact learning technologies.

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""This Request for Information (RFI) offers the opportunity for interested individuals and organizations to identify public and private actions that have the potential to accelerate the development, rigorous evaluation, and widespread adoption of high-impact learning technologies.""

""OSTP is interested in identifying policies and serving as a catalyst for public-private partnerships that have the potential to accelerate the development, rigorous evaluation, and widespread adoption of high-impact learning technologies.""

""Education, particularly K-12 education, remains relatively untouched by advances...""

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As an experienced educator (Associate Professor, tenured, Director of a graduate program in Instructional Technology) who has taught thousands of educators ways to apply technology in learning, I came to the conclusion that a key factor for technology adoption in K-12 schools often comes from high school students and their parents. With that in mind, I was involved in establishing some years ago what may very well be the first state-wide online technology competition among high schools in the USA. It's called the Louisiana High School Technology Challenge. (http://ulm.edu/techchallenge/) Since 2006, thousands of high school students have competed with very favorable evaluations. In its 8th consecutive year, this online event has been positive in many ways, at very little cost. In my opinion, this strategy for establishing a state-wide competition can be copied and applied across the USA to encourage the adoption of a culture of acknowledgement; this would encourage technology adoption that can be directly supported by business sponsorship.

This Model Can Be Scaled

- The model has been used successfully since 2006.
- It's all done online, including the judging.

- Every state could establish an online competition for high school student teams.

- Teachers are recognized in getting students involved in team-based projects... and, students really like it.

- The dynamics of competition in representing a team in a state-wide event... elevates the social status of ""technologically-gifted individuals"" in high schools. Is this important? Yes. This is VERY important to young people.

- Only the scores of the top 5 high school teams are announced. All other teams receive a relative ranking. Why? The event is a competition for excellence, not a comparison among schools. So, the event positively reinforces the best features of competition. We want to encourage poor performing schools to compete.... without penalty.

- The cost of running a state-wide online competition is relatively low when the online event is hosted by a university on its LMS network, like Moodle... as we do.

- A corporate sponsor, like CenturyLink, in our case, can cover the basic costs of the competition.

- So, the components of this involve involve a university, a plan, a sponsor, some promotion, volunteer judges, some publicity, and some effort. It works!

- The winners shine.

Benefits

- The act of encouraging students to compete in a challenging academic competition changes the nature of learning in a subtle and positive way.

- The act of students working together as a team cannot be underestimated. This process builds valuable interpersonal skills.

- The social organization of working together as a team encourages acceptance of technology integration in a school environment.

- Teachers who are active use this event as the means to elevate their status as positive agents of change and acceptance of technology.

Potential

- If a matching mechanism were put in place across the USA at the state level to match corporate contributions with government incentives, the winning teams could earn scholarships that impact a positive future in the integration of ""high-impact technologies""... from the students' perspective in an authentic learning environment.

- If adoption can take place in high school environments, they can occur anywhere.

- In this model, incentives work: Principals are happy; parents are happy; teachers are happy, students are happy. And, companies want to support education in a meaningful and tangible partnership with high visibility.

Conclusion

A low cost approach, like this established model, based on online competition (a theme that resonates with young people and organizations), this ""movement"" can provide the means to enhance a culture of acceptance to new learning technologies. It's a workable partnership because distinct roles are involved, each in concert with others. And, students love it.

If there is any way that I can be of assistance in the future, please let me know. I'm active in my field. Here's my CV: [redacted]

Regards,

Mike Beutner

"

Trish Portnoy

College Freshman Seminar Instructor

West Islip NY High School

"Dear Learning/Technology Staff,

How are you? I am a high school teacher who helps students select and apply to college during their senior year.

I work with large groups students during the ""process"" of applying to college...but I am not a guidance counselor...I lead the students through exercises, assignments and analysis that culminate in ""applying to college"".

I was even able to get a book published on the topic... College Apps: Selecting, Applying to, and Paying for the Right School for You. It is for sale at Barnes & Noble and on the Internet.

So, over the years, I figured out that students don't necessarily need access to more data...they need to understand how to use the data that's out there already, especially on the Internet!

At West Islip High School, I teach a class that walks students through the steps and analysis of applying to college...we do it in ""real time"", fall of senior year, in a high-speed Internet computer lab.

I would love the opportunity to share my insights and experiences with those on President Obama's team.

Thank you."

Marie Demery

[NO CONTENT]

Brian Hawkins

"The book Project RED provides guidance for how to move forward with digital technologies.

I recommend reading the book Every Child, Every Day by Mark Edwards. Development of a district strategic plan that expressly calls out the need for digital conversion with specific deliverables moves the process forward with its impact on conversation within the district and on budget decisions. Another important component is the state level strategic plan that is in process in Oregon."

Richard Maxfield

"With a Ph.D. in learning, I and partners have developed new technology to match the research on learning. I figured out a way to structure curriculum and imbed it with software that can monitor the learning process as well as learning activities. The ability to learn about the student as they are learning the subject provides the data to continuously improve both. Doing that requires structuring content for learning rather than teaching and then inserting logic software to handle the necessary branching. The technology also requires a delivery platform that can capture and interpret data on the fly. We had to build a special analytics engine to do that. If you are interested in this technology, my contact information is below. Once content is properly prepared, it is ready for implementation.

The best to your efforts in tapping better technology for education."

Nora Sabelli

"My comment relates to the fact that learning technologies, even the best designed and tested, are only as good as their implementation in classrooms, museums, homes, and places of work, including schools.

To achieve the desired results, as much or more effort needs to be placed on creating the transformative systemic (human, organizational and technological) conditions for their adoption that in creating excellent products and processes, of which a plethora exists. How to make their use routine and system-wide is where the rubber meets the road. This is as true in education as it is in health, were there is a new and much needed emphasis on implementation research.

The NSF commissioned a couple of years ago a Task Force on Cyberlearning and Workforce Development, among others Task Forces and reports relevant to learning technologies. The CLWD TF considered the learning needs of a cyber-infused society, focusing on issues of learning, research, and human and institutional barriers. the Task Force report can be found in http://www.nsf.gov/cise/aci/taskforces/TaskForceReport_Learning.pdf.

I copy here some of the more relevant passages in support of the need to consider integrative approaches that include not only cognition but creating the conditions for transformational use. Lack of simultaneous approaches to learning, implementation, and organization have delayed the full impact of technologies in education. The emphasis added is mine.

""We note two possible approaches to addressing the challenge of this transformation: revolutionary (paradigmatic shifts and systemic structural reform) and evolutionary (such as adding data mining courses to computational science education or simply transferring textbook organized content into digital textbooks). Both can be pursued simultaneously but we posit that the nature of the challenge we face demands an emphasis on the revolutionary approaches, to stimulate systemic change in educational institutions that will make them capable of responding to rapidly changing technology skills and knowledge at a pace necessary for a competitive workforce.""

""We recommend the promotion and sustained support of a new cross-disciplinary community that will perform not only the transformative research called for in recent reports, but also the work of translating the research for use by increasingly varied research, development, and implementation communities, with particular attention to the needs of women, minorities, and persons with disabilities.""

""We recommend involvement of research, education, and industry in a functional, robust, and sustained process for addressing two critical challenges of systemic change: (1) developing models for educational system organization and processes that can respond quickly and appropriately to rapidly changing technologies; and (2) defining the skills and knowledge essential to support a strong national and internationally connected economy and workforce.""

""We recommend the development of a comprehensive, cogent, and accessible CI architecture to support cyberlearning and workforce development nationwide, and the incorporation and repurposing of CI-enabled STEM research tools and resources for educational purposes."""