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A New Theory of Economic Stimulus: The Example of a Rapid Learning Education System

By Lloyd S. Etheredge[1] [2]

Proposal: As a stimulus investment: Design and activate a national rapid learning system for K-12 education that meets three requirements (digitization, discovery, and implementation). Incorporate ideas and cross-sector conversations from the first national rapid learning system (for health): [3]

1. **Digitization**. An immediate step: Transition to a full (digitally-supported) national rapid learning education system. Near 0-% loans will enable state and local school systems, K-12, to make additional infrastructure investments to equip each classroom and student with suitable individual tablets/computers for daily instructional and home use.[4] Participating school systems will create privacy-guaranteed, digital educational records for each student that contain a core of basic data and meet software compatibility standards for data sharing to support agreed-upon learning projects.
2. **Discovery Functions**. Participating teachers, schools, and school districts can elect to be part of leadership networks (created by the federal government and including foundations, academic researchers and other stakeholders) to establish the learning priorities and methods for specific subjects, technologies, grade levels, and students. (These might include more efficient testing and grading; experiments to explore comparative effectiveness of teaching materials, methods, and software; creative R&D partnerships with the private sector to develop and explore new ideas; the swift testing and improvement of personalized learning software for all students and especially disadvantaged minorities and learning-challenged and handicapped students, etc.)
3. **Implementation Functions**. Change does not occur quickly if discoveries only are published in academic journals or produce successful demonstration projects. Implementation needs to be managed - a local task that requires leadership and motivation, multi-year persistence, a system-level perspective, adaptation to local needs and circumstances, and its own learning process. The federal government will work with stakeholders to create learning and training programs for (local) implementation science to support interested schools and school systems. [5]

> → The goal of the rapid learning education system is to create the best educational experiences for each student as quickly as these can be invented.

Discussion:

- **Digital Capacities and Learning**. The digitally-supported national education system can eliminate much of the classroom time now devoted to testing, including standardized testing. By drawing items for homework and classwork from new, national, standardized databases, student learning can be assessed routinely from achievement in their daily work.[6] By the same shift, all comparative effectiveness research for software and other research priorities [perhaps especially for Common Core-related learning] can – for the first time! - be conducted quickly and efficiently with random assignment and a large N of students in participating schools and districts with rapid answers for teachers.[7]

- **The Time is Right**. We still are in an era of experimentation and discovery. However, a full investment in digitization probably is justified for access to digital content and software-based improvements. There already are areas (and there will be more) where new technology probably can assist teachers and students, across subjects, to use time more efficiently and get superior results. [8]

  - MOOC creators like Coursera and edX and innovators like Khan Academy have conducted more randomized experiments to test and improve educational methods than were published in all scientific journals prior to this decade. For example: An Active Mastery design presents new material for 15-20 minutes (about the limit of full classroom attention). Then software kicks-in and begins to challenge students to shift the new material from short-term memory into active problem solving. The software continues to present problems, and make diagnoses and offer coaching, until the student masters the new concept or wants to stop. (Later, the personalized software can resume and also will recommend optimum review schedules.) The Active Mastery improvements contrast with traditional methods in which a teacher might present a 45- to 50-minute lecture (with fading attention) and then problem sets are assigned for homework – when they are done that night . . . or before the next class . . . or the night before the exam . . . if ever! Active Mastery is more efficient, a steadier process, apparently raises mean scores, and reduces failure – in fact, it is very difficult for a persevering student to fail, since both students and teachers know very quickly whether each concept is being mastered.[9] Rather than "cram" studying the night before an exam and guessing that they have learned the material – and then discovering reality when they receive their graded exam (and the class moves-on to the next subject) – students know whether they have achieved mastery.

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  - Another discovery by the Khan Academy, Gates Foundation, and others is the unique psychological contribution of online software with a distinct coaching and cheerleading spirit that explicitly enrolls students to an "Anybody Can Learn Anything" mindset. (This includes a discussion of the "grit" and "perseverance" that, with good teaching and coaching, achieves mastery.) The discovery contrasts with traditional "Bell curve" ideas that can be reinforced in the mindsets of students who fall behind and decide that school subjects are too hard, or that they are dumber students and not smart enough to learn the material.[10]

- **Costs.** About $2.5 billion for hardware and $1.5 billion/year to $1.8 billion/year for other costs over the next decade. Estimates will require further work but here is the basis for the hardware numbers. (Estimates of other costs are discussed in the attachment.)

    - One basis for an estimate is that there are about 55 million K-12 students in the US (including 4.9 million attending private schools) and 99%+ of schools already have Internet connections of growing capacity. [11] [12] [13] Schools report about one computer for every five students, although probably half of the school systems recently have been acquiring tablets for Common Core and mandated standardized testing.[14] (Concerning home availability: about 70% of American households have at least one computer or tablet.)[15] The newest Kindle Fire tablet sells for $49 (although more capability probably is desirable for schools). If we assume the purchase of 25 million devices that students can take home if needed, and an average price of $100/device, the digitization infrastructure investment will be about $2.5 billion.[16] [However, a national cost might be lower: a potential competitor for providing these 25 million devices (Apple) has $215+ billion in unspent reserves. Apple could develop a bold hardware and software strategy that expands its current position and uses about 1% of its reserve to take ownership of the entire educational market in the US for rapid learning. Next, it could use rapid learning capabilities to produce a Golden Age of online resources, worldwide.[17]]

- **Global Competitiveness**. With these US investments the global education industry becomes a potential market for rapid growth via digital technologies and improvements pioneered here.[18] Before the new capability for efficient, independent, scientific testing, startup companies struggled with marketing costs. Innovation was slow and giant print publishers and their sales forces dominated the new software market. Now, the equations change. Innovators with scientifically demonstrated improvements (e.g., for foreign language instruction) can render obsolete the US and world's entire stock of textbooks overnight. Open Courseware also can improve quickly: there are huge global shortfalls in the availability of high quality K-12 education for which extraordinary online resources will be essential contributions to realize human potential.

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- **A New Theory for Economic Stimulus and Growth**. For economic science and higher growth rates, the new theory and strategic idea is to identify what is missing, by sector, and to create a rapid learning system (including an inspiring, imagination-capturing, psychological component) to solve the problem.[19] The requisite chemistry likely will involve organizing and managing (with self-reflective learning) three dimensions: 1.) Full digitization (designed for data-sharing and data-mining), 2.) Discovery functions (including curated, pre-populated, large N, Everything Included data systems and analysis capabilities in the public domain and shaped by networks of users), and 3.) Implementation functions that support rapid learning cycles for an entire sector and concomitant growth.

- The theory of rapid learning systems still is evolving, but I think that it is going to work. We do not yet know how quickly the sectoral growth and American global leadership, and full human benefits empowered by the new rapid learning health system, will occur. However, billions of dollars of new capital are pouring into health- and cancer-related startups at a rate matching the early investment for Silicon Valley.[20] [21] And this is just the beginning.

Attachment: Lynn M. Etheredge, "A Rapid Learning Education System: Lessons from a Rapid-Learning Health System. Prospectus" (Working paper, April, 2016).

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Notes

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[1] Lloyd Etheredge is Project Director for the Government Learning/Rapid Learning Economics Project at the Policy Sciences Center, Inc., a public foundation incorporated in New Haven, CT. Comments welcome. URL: www.policyscience.net; lloyd.etheredge@policyscience.net; 301-365-5241. My thanks to Lynn Etheredge for many discussions of these ideas. His contributions to the (first) rapid learning system for health, and to the evolving design for education and science of learning systems, are reflected in the attached paper.

[2] This paper continues a series of ideas from the Rapid Learning Economics Project, suggesting how creative social science – e.g., the new science of learning systems - can accelerate economic recovery.

[3] Lynn M. Etheredge, "A Rapid Learning Education System: Lessons from a Rapid-Learning Health System. Prospectus" (Working paper, April, 2016). Attached.

[4] The national stimulus loans can purchase (for physical loan to parents) suitable devices for home use.

[5] For the evolving state of implementation science in K-12 public education see the example of the Baldrige Award process (Montgomery County, Maryland) described by Michael Perich, https://www.youtube.com/watch?v=Eu2SKd8D2hg .

[6] National standardized testing at the end of 4th and 8th grades could still be justified during the school day. See Harold Kwalwasser, "Standardized Tests Don't Help Us Evaluate Teachers," Los Angeles Times, September 10 2015. Online http://www.latimes.com/opinion/op-ed/la-oe-0910-kwalwasser-standardized-testing-problems-20150910-story.html.

[7] See I. Glenn Cohen *et al*., "The Legal and Ethical Concerns That Arise From Using Complex Predictive Analytics in Health Care." Health Affairs, 33:7 (2014), pp. 1139-1147. Routinely investigating the comparative effectiveness of treatment alternatives that are reasonably believed to be beneficial, and without prior knowledge of which is superior, is one of the issues that has been addressed in developing the rapid and routine experimentation capabilities in healthcare.

[8] Although research is greatly aided by Common Core, there already is sufficient agreement about school subjects that the fast discovery infrastructure for comparative effectiveness research created by the new system can generate useful information. For example, for $3 billion/year purchase decisions for digital content and specific assessment of the best options for the characteristics of any single school or school district.

[9] Andrew Ng, "Education for Everyone" https://www.wolframdatasummit.org/2013/attendee/presentations/ .

[10] See the implementation of these discoveries in the design of LearnStorm Challenge 2016: http://www.learnstorm2016.org/ .

[11] Benjamin Herold, "Technology in Education: An Overview" Education Week, February 5, 2016. Online: http://www.edweek.org/ew/issues/technology-in-education/

[12] Terrance F. Ross, "When Students Can't Go Online," The Atlantic, March 13, 2015. http://www.theatlantic.com/education/archive/2015/03/the-schools-where-kids-cant-go-online/387589/ . Internet connectivity is good enough to begin, although improvements may be needed. "Full Internet" for all students throughout the day may not be the right answer. We do not yet know whether a blend of electronic and paper-and-pencil methods and human face-to-face interactions (e.g., teaching a new concept to somebody else) might help the brain to create new pathways more quickly.

[13] Home Internet connectivity will be valuable, but it may not be necessary, especially for lower grades if software and problem sets are available on smartphones. Internet connectivity can be provided by smartphones if there is a waiver of connection and data transfer charges when using agreed-upon education sites.

[14] "Schools purchased more than 23 million devices for classroom use in 2013 and 2014 alone." And "The biggest development on this front has been states' adoption of online exams aligned with the Common Core State Standards. During the 2014-15 school year, 10 states (plus the District of Columbia) used exams from the Partnership for Assessment of Readiness for College and Careers (PARCC), and 18 states used exams from the Smarter Balanced Assessment Consortium, all of which were delivered primarily online. Many of the other states also used online assessments

"The 2015-16 school year will be the first in which more state-required summative assessments in U.S. middle and elementary schools will be delivered via technology rather than paper and pencil, according to a recent analysis by EdTech Strategies, an educational technology consulting firm." Herold, *op. cit.*

[15] Monica Anderson, Technology Device Ownership, 2015. Pew Research Center. http://www.pewinternet.org/2015/10/29/technology-device-ownership-2015/

[16] Smartphones already are used by many secondary school students for homework and they provide alternative connectivity. A policy under discussion in UDCs is to provide free connection time and unlimited data transfer for users connecting to educational and health information Websites.

[17] Jeremy C. Owens, "Apple Isn't Really Sitting on $216 Billion in Cash," Market Watch, January 27, 2016. http://www.marketwatch.com/story/apple-isnt-really-sitting-on-216-billion-in-cash-2016-01-26 . Mr. Owens' point is that the money is invested, mostly overseas (to avoid US tax liabilities), and is not technically cash. There might need to be a limited tax negotiation for Apple to use 1 % of its wealth to complete the infrastructure investment for the new rapid learning system. It has focused on educational software since the days of the Apple II but has not yet had the rapid learning capabilities and potential Everything Included data and real-time, fast, and affordable large N experiments of the new system.

[18] We do not yet know how cultural and other differences affect the best approach to learning. It would be timely for governments, researchers, and the private sector to build global standards for data-sharing and research. The equivalent global project for genetics-based medicine came together quickly (https://genomicsandhealth.org/).

[19] See an extended argument in this direction: Bruce Greenwald and Joseph Stiglitz, Creating a Learning Society: A New Approach to Growth, Development, and Social Progress (NY: Columbia University Press, 2014).

[20] Ariana Eunjung Cha, "There's a New Sheriff in Town in Silicon Valley – the FDA." Washington Post. April 28, 2016. ttps://www.washingtonpost.com/news/to-your-health/wp/2016/04/28/theres-a-new-sheriff-in-town-in-silicon-valley-the-fda/ . About $10.1 billion in startup funding (US only) was invested in 783 deals in 2015, close to the level of the dot-com bubble. More broadly: Carey Murphy et al., Global Healthcare Private Equity Report, 2015, http://www.bain.com/publications/articles/global-healthcare-private-equity-report-2015.aspx .

[21] By way of illustration: Other sectors that may be ready for similar organizing and investment in rapid learning systems include such diverse fields as: 1.) Economics (for which the "Everything Included" cross-disciplinary data systems are one of the missing ingredients; 2.) Genetics-based agriculture; 3.) Rapid learning for equal justice under law; 4.) Rapid growth of comparative national security/intelligence agency studies where repeated and predictable cycles of misperception and misjudgment (sometimes reflecting *hubris* by American leaders, but also by foreign leaders and enemies about the US, and about each other) cause prolonged, expensive, sometimes unnecessary, and often unwinnable, wars. [For world politics, the growth of professional graduate training for international relations creates a new potential for implementation of discoveries and for a much wider set of investigations extending beyond the study of US mistakes.]; 5.) Popular music, for which virtually all songs, performers and performances are digitized and sales and other measures of listener responsiveness could be linked. The learning functions are not yet organized to identify the active ingredients that produce superior effects (by different definitions and measures) for sub-groups of listeners. A rapid learning system might improve the quality of the world's popular music (and sales), perhaps eventually with integration of neuroscience variables.

A Rapid-Learning Education System –

Lessons From A Rapid-Learning Health System

Prospectus

By

Lynn M. Etheredge *

Working Paper

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Summary

The US is making large national investments to develop a rapid-learning health system. There is increasing evidence that this strategy works well. This paper suggests that the rapid-learning health system could be a useful model for developing a rapid-learning education system. Using this collaborative, voluntary model, national education strategy would include: (1) a national digital infrastructure for education; (2) a national technology assessment system for educational products and practices; and (3) a national infrastructure of rapid-learning schools, school systems and networks. Estimated federal budget costs are $1.5 billion to $1.8 billion annually over ten years.

I. Toward A Rapid-Learning Health System

How much faster can the US accelerate our discovery and use of new knowledge and better practices – our rate of progress?

After nearly a decade of investments in a "rapid learning health system", the health sector is starting to realize revolutionary new answers to this question. For example,

--A recent review of epidemiology research finds that study costs were 11 cents per participant for accessing new electronic health records databases (for 138,514 patients over eight years) generated from patient care, compared to traditional research registries costs of $2,732, $11,800 and $17,750 per participant; [1]

--A multi-year clinical trial (TASTE) in an established research program with an electronic data registry cost $300,000 ($50 per randomized patient), compared to $10 million (or much more) for conducting the trial in a traditional program that required creating new collaborations and data systems; [2]

--Population medical studies that needed 2-3 years of hand coding from paper records will be doable in 2-3 weeks using automated research tools and computerized national database networks with tens of millions of patient records. [3] A recent briefing on NIH's Collaboratory Distributed Research Network (DRN) reports that it now offers rapid response from quality-checked and formatted electronic databases; it accesses more than 90 million lives and 300 million person-years of observation. [4]

Such metrics show revolutionary acceleration in the potential pace of scientific discovery. For the same budget levels, the amount of new knowledge that is discoverable each year can be multiplied by factors of 10:1, 20:1 and much, much more.

To fully appreciate this learning revolution, acceleration in discovery speed must be multiplied by vastly increased scale of electronic databases that can include much more clinically rich detail per person (e.g. genetics) as well as multi-national research with hundreds of millions of patients. Many more patient experiences can be studied, many more variables included, many more questions addressed, many more researchers can use (and re-use) data, biomedicine can become a digital science, the usable evidence base and discoveries can grow exponentially, more targeted, effective prevention and therapies can be developed, personalized medicine will be possible. Such vastly increased "big data" resources include the NIH Precision Medicine initiative with a 1 million person database with genetics and much more data, and three national cancer "cloud pilots" that will soon offer more than an exabyte of comprehensive cancer data (and growing rapidly) for open science (one exabyte = 1,000 petabytes). Similar investments are revolutionizing discovery science in the UK and European health systems. [5] **The potentials of artificial intelligence, e.g. IBM's Watson, Google's AlphaGo, other new computer and cyber-social learning software, and data science advances (e.g. predictive models) will also accelerate the pace and dimensions of learning.** [6]

Healthcare delivery systems have needed upgrades to translate such explosive growth of new knowledge into better care for every patient, as quickly as possible. Recent news shows that rapid-learning strategies are starting to have payoffs.

--Electronic health records now provide a national digital infrastructure for healthcare delivery and improved performance. In 2014, 76% of non-Federal acute care hospitals had adopted at least a basic EHR system, compared to 9% in 2008. [7] In 2013, 71% of physicians had adopted an EHR; the uptake was particularly rapid in larger physician group practices (92% in 11+ physician practices). [8] A national center offers electronic clinical quality improvement (eCQI) resources for EHR users. [9]

--A comprehensive review of progress in "implementation science" reports that high performing health systems now do far better than traditional methods that publish studies in academic journals and have 14% innovation uptake over 17 years. Health systems that develop expert implementation teams now achieve 80% success within three years.[10]

--Project ECHO uses weekly peer-to-peer video conferences to share specialists' expertise and new knowledge with primary care practitioners in rural and underserved areas. It can make rapid learning a reality for physicians, nurses and patients who aren't in academic medical centers and urban areas. Using a "hub and spoke" model it is now being implemented nationwide (e.g. community health centers, Veterans Health Administration). It is also expanding internationally with a goal of reaching 1 billion persons in underserved and rural areas worldwide. [11]

-**The American Society of Clinical Oncology has launched a rapid learning cancer system, CancerLinQ, so that all oncologists and their patients can share computerized patient data and have on-line access to the latest research and best practices.** The ASCO initiative will collaborate with the new NIH cancer initiative so that the US has the world's fastest and best cancer research – *and* can deliver the best care to every cancer patient. [12]

--**Thirty percent of Medicare enrollees (10 million persons, $117 billion of annual payments) are now in arrangements that gear payment to learning and achieving quality goals. HHS reports, for example, there was a 17% reduction in hospital-acquired infections from 2010 to 2014, saving 87,000 lives and $20 billion.**

With $10 billion funds for an innovation center, CMS is now supporting hundreds of projects for implementing better care. [13]

II. Toward a Science of Learning Systems and a Rapid Learning Society.

Nearly every week brings new evidence that the "rapid learning health system" ideas are making revolutionary progress. They are starting to shape the future of our world-leading biomedical science agencies (NIH, FDA), our largest healthcare financing programs (Medicare and Medicaid, with 100 million enrollees), and the US health system (18% of GDP, $3 trillion of annual spending, 320 million persons served).

What is being implemented in healthcare can offer useful models to accelerate scientific evidence and widespread use of new knowledge in many areas. The NSF has supported workshops for a new "science of learning systems" that expand cross-sector conversations among my colleagues and scientists, social scientists and experts from many disciplines. [14]

III. Toward A Rapid Learning Education System.

This paper focuses on how lessons from the rapid-learning health system work may be useful for a rapid-learning education system. I have been engaged in such "cross sector" learning discussions since 2010. The US education system now has visionary leaders and the foundation for a national rapid-learning education system using three strategies that are discussed below.

Indeed, there are several reasons why a RL strategy could work even better in the education system than in the health sector.

-- First, the education system already has organized delivery systems (schools and school districts).

-- Second, education already has a culture of assessment and (now) a Common Core curriculum that can be a focus for computable data, methods assessments, and national rapid learning;

--Third, several million children are taking Algebra I every year (and many other subjects), so there are many learning opportunities;

-- Fourth, well designed education technology can make education better, easier, and more fun – and be very popular with teachers and students. For example it can lessen much of classroom time assigned to formal quizzes and testing – and steeply reduce teachers' homework time of grading tests. [15]

While this discussion focuses on K-12 education, rapid-learning initiatives may also be useful for medical and health professions education, pre-school education (e.g. the critical first three years), community college, college and university education, professional education, and life-long learning for all workers. [16]

<u>Strategy #1. A National Digital Infrastructure for Education</u>

In healthcare, major IT investments have included:

--National investments to assure that all Americans and healthcare providers have electronic health records that capture computable, comparable data that can be used for research, quality improvement, and personalized care. ($32 billion of Medicare and Medicaid incentive payments to 479,000 healthcare providers from January 2011 thru February 2016). [17]

-- A vast expansion of pre-designed, pre-populated, quality-checked ("research-ready") and computerized databases and networks, with automated on-line tools, so that, in the foreseeable future, it will be possible to do "rapid learning" on almost every topic for almost every patient group. [18]

-- More than 17,000 Apps that allow patients and physicians to use or share health-related data. [19]

Following this model, national education strategy would:

A. Invest in a national IT system for every student – using a personal electronic health records model. The Education IT system will capture standardized, individual student data from class work, homework, use of digital textbooks and videos, quizzes and tests. It will support personalized education, quality upgrades, and research. The Common Core standards, now adopted in 43 states, provide a foundation for this kind of national investment strategy. [20]

Schools and school districts will be able to make these investments knowing they will be part of a national collaborative system for accelerating educational progress.

Developers of digital textbooks, MOOCs, Khan Academy-like instructional videos, and others will see a national market for new, better products that work with such IT systems.

B. Encourage and use first-rate learning software, digital textbooks, websites, videos, on-line courses, and Apps and other digital technologies, covering all subjects and grade levels, that work with the IT infrastructure.

The Department of Education recently published a **2016 National Education Technology Plan** with many recommendations and resource information. [21] The standards for federally supported Education IT should include interoperability and open software (APIs). This strategy will expand the resources available for teachers, students, and families. Research studies from the IT system can help to assess the value of these materials and methods.

C. Use these data to provide the best education for each student, to support Total Quality Management initiatives (identifying problems, planning and implementing change, and assessing results) and rapid-learning cycles, and to accelerate educational science.

My local public schools (Montgomery County, Maryland) combined a student-level education IT system with APQC's Process and Performance Management methods to win the Baldridge Award as best national school system (2010). [22] MOOC developers and others are discovering that online courses offer low-cost ways to do many rapid randomized and sequential trials, formative assessments, and data analyses that can quickly improve products and educational science. [23]

D. Use Education IT – with privacy-protected data - to develop a vibrant, interconnected 21st century education system -- with learning communities and networks. [24]

The following table illustrates the high return for a national learning strategy that uses data sharing compared to traditional methods where every school or school district learns on its own.

Figure 1

Economics of Data Sharing

- If 10 institutions each share 100 cases
  - Database = 1,000 cases
  - *Every* institution gets 900 added cases for a contribution of 100 = 9:1
- If 100 institutions each share 1,000 cases
  - Database = 100,000 cases
  - *Every* institution gets 99,000 added cases for a contribution of 1,000 = 99:1
- **Data sharing is a high pay-off strategy. More data sharing multiplies benefits.**

There are many possibilities for schools, students, teachers, school districts, and others to create learning networks on common issues, e.g. (1) STEM education and computer-based mathematics, (2) assisting each child in reading to grade level by the end of third grade, (3) dramatically improving pre-college preparatory mathematics, (4) blended classroom education/MOOC experiments, (5) personalized learning R&D and software development, (6) networks organized by subject matter (English, history, social studies, sciences, foreign language instruction), (6) networks organized by skill development, such as writing topic sentences, paragraphs, and compositions or using humanities to develop empathy, (7) networks organized by student characteristics (special needs students, gifted students, students who have a primary language other than English), (8) networks organized by student and teacher interests (math clubs, chess clubs, creative and performing arts, student government and leadership development, journalism and media, computer programming, robotics, video-game and Apps development, bio-engineering, 4-H clubs, entrepreneurship, (9) networks organized for teachers and principals (Project ECHO model peer-to-peer learning, early career development and mentoring), (10) networks to assess educational Apps and digital technologies. And much more. Leading schools and school districts could augment IT systems with specialized data modules for such areas of interests. New Education IT capabilities enable many collaborative learning possibilities.

It is important to design, pre-position, and pre-populate new "big data" investments in the context of learning systems and networks that create communities, institutions, and processes that can collaborate in identifying questions, designing and building databases, and generating, testing, and rolling-out useful knowledge and innovations on an organized national scale. Public and private sector health examples that might be useful for the education sector include: the Health Care Systems (HCS) Research Network,[25] the FDA Sentinel Network, [26] NIH's

Collaboratory Distributed Research Network, [27] PCORI's PCORnet, [28] patient sponsored networks (cystic fibrosis, chordoma), [29] hub-and-spoke systems (Project ECHO), and many more.

It is also important to design effective research and data coordination mechanisms to support rapid learning research. NIH, FDA, PCORI, the HCS Research Network and others have selected **the Harvard Pilgrim Health Care Institute and its PopMedNet; the Institute's leadership role and competency have been vital to progress in building a national RL health system** [30] Another model is **NIH's "Commons"** to assure that data from NIH-supported studies will be available in data "clouds" for open science [31]. A recently announced $250 million grant to facilitate collaboration and coordination among six leading cancer centers offers a model **for philanthropy-led initiatives**. [32] These are critical investments to establish data standards, define core data sets, developed automated tools, assure quality checks and rapid response capabilities, and coordinate rapid research projects.

Strategy #2: A National Technology Assessment System for Educational Products and Practices

With a flood of new ideas, knowledge, products and devices, and methods, it is important to make comparative assessments about what they offer for potential users. **In the health sector, a key initiative has been federal legislation to create the Patient Centered Outcomes Research Institute (PCORI), with $600 million annual funding.** [33] Its major initiative has been to create 29 learning networks to conduct studies on topics of interest to patients and physicians. It also supports assessment studies directly. NIH has been re-organizing cancer clinical trials for simultaneous, parallel testing of many therapies, with comprehensive, standardized data collection, and matching of patients to therapies predicted to give each person the best outcome. [34] This framework produces useful comparative assessment of new therapies for personalized medicine.

In education, a key initiative has been federal legislation to create Digital Promise (the National Center for Research in Advanced Information and Digital Technologies) to accelerate innovation. [35] Its activities include the League of Innovative Schools, 73 school districts that collaborate on exploring the best use of new digital technologies. In 2014, it had $14 million in public and private support. As noted earlier, the Education Department is launching discussions about a national strategy for new educational technologies.

A. Create rapid-learning research and testing networks.

It is now very difficult and confusing for school districts, schools, teachers and students to sort out the hype from the valid results about new digital products and software. [36] What Digital Promise has started needs to be done on a larger scale. A national system for comparative testing could help better products reach a large national market faster and also assist teachers, students, schools and school districts in making choices about best uses of new digital technologies. The new Education IT infrastructure could enable such initiatives, e.g. through organized research networks, registries and studies; the PCORI and comparative cancer trials models may be useful.

B. Support widespread, rapid dissemination of useful research about comparative assessments.

From PCORI's budget, about $100 million per year is transferred to HHS's Agency for Healthcare Research and Quality (AHRQ) to support dissemination of results. A RL education system needs a dissemination strategy and budget.

Strategy #3. A National Infrastructure Of Rapid-Learning Schools, School Systems And Networks.

To use all of this new knowledge rapidly and effectively will require building new management capabilities, including HIT and "improvement science" methods and discipline for performance improvement into school systems.

One of the major reasons for the health sector's quality, safety, cost and other performance problems is that it was built without modern performance improvement capabilities and management training. [37] **In top US companies, process and performance management are core competencies and central to their success.** There are now many such "improvement science" technologies and success stories, such as APQC's Process and Performance Management, Toyota Production System, Lean, Six Sigma, Total Quality Management, and Continuous Quality Improvement.

The new IT infrastructure of electronic health records gives health institutions, executives and physicians the ability to learn from their own data and

manage quality and costs, and new possibilities to improve performance through collective learning. In healthcare, the Institute for Healthcare Improvement has been a leader in wider adoption of these new methods. [38] Other leaders in transforming the health sector through such methods include Kaiser Permanente, [39] Denver Health, [40] Cincinnati Children's, [41] Geisinger, [42] and the Pittsburgh area. [43]

A key health initiative to accelerate learning and adoption of best practices was the creation of a $10 billion Innovation Center at the Center for Medicare and Medicaid Services (CMS). The Innovation Center adds billions of dollars of "demand pull" for faster adoption of new practices that will improve quality and save money. The Medicare and Medicaid programs cover more than 100 million enrollees and pay for more than $1 trillion of services annually, so they have a lot of potential leverage – and high stakes in improved performance. CMS has prioritized national initiatives where there are large gaps between best practices vs typical care, e.g. for patient safety, heart attack and stroke deaths, and reducing premature delivery. CMS gains leverage by using strategies that combine purchasing power of public programs and third-party payers. Its initiatives include a Learning and Action Network with more than 5,000 collaborators in the public and private sector to speed national progress. [44] Several hundred projects are supported. For parallel capabilities:

A. <u>Develop and integrate top-level commitment, high potential innovations, professional implementation teams, and "improvement science" into schools</u>.

Our educational system, like the health system, was built without modern performance improvement capabilities. Carnegie Foundation for the Advancement

of Teaching is now one of the leaders in transporting these methods into the education system. [45] Its work draws on the process and performance management technologies used by the Institute for Healthcare Improvement, leading health systems, and high performance US companies. Carnegie has embarked on creating a national education system that uses these methods and "networked improvement communities (NICs)". [46] **APQC Education has extended APQC's work with 750 of the global 1000 companies and 40 years of experience into work with leading educational systems.** [47] **Harold Kwalwasser's study of 40 of the nation's leading schools reports: "Nearly all of the districts and several of the charters I saw had adopted a form of TQM (Total Quality Management) or at least a disciplined version of continuous improvement." These methods offer proven capabilities for achieving top performance.**[48] **Leading schools and school districts are achieving national recognition for how well they are using performance upgrade strategies; a rapid-learning education system can "go to scale" by fostering similar initiatives everywhere.** [49]

B. Create A National Implementation Plan for RL Education initiatives.

In health care, the rapid-learning leaders have often included visionary organizations that have a mission to improve health science and healthcare. **A comparable strategy would be to start with national investments in a collaborative, voluntary leadership group of enthusiastic school districts and schools as flagships for a national RL education strategy, e.g. the League of Innovative Schools that has 3.2 million children in 33 states and 73 districts, APQC Education (125 members of its North Star community), Carnegie's Networked Improvement Communities (NICs) and collaborators**[50]**, and the Gates Foundation's LEAP Innovations**

Network.[51] NIH leadership has been critical to creating new scientific research capabilities; US Education Department support, in collaboration with philanthropies, could have a similar role for education science.

IV. Implementation and Funding

A rough estimate for new federal investments over the first ten years for rollout of the "rapid learning health system" strategy is about $90 billion, to benefit more than 320 million Americans per year. The $90 billion includes about $65 billion for electronic health records subsidies, $10 billion for the CMS Innovation Center, $10 billion for NIH and FDA research investments and initiatives, and $5 billion for PCORI comparative effectiveness research. **An overall accounting, however, should also include the benefits that are coming on line. HHS reports that per capita Medicare health spending was reduced by $350 billion between 2009 and 2013, compared to 2000-2008 rates, and patients are receiving better care. [52]**

Rough guesses at comparable education sector investments are $15-$18 billion over a decade.[53] These estimates need much further refinement with detailed proposals, as well as judgments about how quickly successful voluntary initiatives would spread. Nevertheless, these annual costs ($1.5B to $1.8 B) would be affordable in a federal budget now spending $4 trillion per year (2016) – 1.5/4,000 = .04% – and recognizing the great importance of upgrading US school performance. Moreover, we can learn important savings and implementation lessons from the health sector experience. The largest expense, $65 billion (over 70% of the total) for national EHR systems, could be sharply reduced by using "cloud" computing and centralized servers, e.g. at a school district level, rather than purchasing and maintaining stand-alone systems for each school; there are approximately 13,500 school districts (2013) compared to 129,000 K-12 schools (2012). [54] The education sector will gain economies by being able to focus on schools and school districts; while the US has about 4,900 community hospitals, federal EHR subsidies go to 479,000 providers to connect physicians' offices and other locations to the healthcare system. Another important implementation lesson is to develop "Apps" and a rich universe of compatible modules for all users early, and to require subsidized Education IT systems to meet standards to work with them (APIs). The successes of smart phones, compared to basic cell phones, is largely due to the fact that one can do so much more (and so much more of interest) with them. In contrast, the HIT strategy emphasized purchase of basic EHRs with limited capabilities and ability to work with 3rd party Apps, resulting in slower adoption and less value.

Physicians have concerns about the amount of time they must spend in EHR data entry. **In contrast, well-designed education software should be a great time saver for teachers (and students), as electronic data can be captured from classwork and teacher grading time sharply reduced.** Since the education sector is much smaller than the health sector, system wide progress may be faster. Based on its experience in all industries and dozens of school systems, APQC Education has proposed a national initiative for K-12 schools development of process and performance management, using a hub-and-spoke teaching strategy, for a cost of $44 million over five years. [55]

V. Conclusion

There is growing evidence that a "rapid learning health system" – enabled by vision, leadership, investments, and much hard work – is accelerating a knowledge and performance revolution for health and healthcare. This experience offers lessons for a collaborative "rapid learning education system" that will deliver best-in-the-world education to every U.S. student.

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* Director, Rapid Learning Project, Chevy Chase MD. Thanks for comments on a draft of this prospectus to: Lloyd Etheredge, Stanley Jones, Harold Kwalwasser, Judith Moore, and David Smith

[1] The registries also had many fewer participants (Framingham 5,209, ARIC 16,000, MESA 6,800). Joan Casey, Brian Schwartz, Walter Stewart, Nancy Adler "Using Electronic Health Records For Population Health Research: A Review of Methods and Applications" in Annual Review of Public Health 2016 37:61-81. Their review references six summary articles on a wide range of research uses of electronic health records (pg. 65). For an introduction to RL health system initiatives, see Lynn Etheredge "Rapid-Learning: A Breakthrough Agenda" *Health Affairs* July 2014 and Rapid Learning Project material at https://www.researchgate.net/profile/Lynn_Etheredge

[2] Michael Lauer, Ralph D'Agostino "The Randomized Registry Trial – The Next Disruptive Technology in Clinical Research?" *New England Journal of Medicine* October 24, 2013, 36:1579-81; interview with Dr. Lauer at: http://www.nhlbi.nih.gov/news/spotlight/fact-sheet/dr-michael-lauer-co-publishes-perspective-piece-on-randomized-registry-trials.html. October 28, 2013

[3] Jeffrey Brown, Lesley Curtis, Richard Platt "Using the NIH Collaboratory's and PCORnet's Distributed Data Networks for Clinical Trials and Observational Research: A

Preview" Nov 14, 2014 at https://www.nihcollaboratory.org/Pages/Grand-Rounds-Hub.aspx

[4] Jeffrey Brown "Use of the NIH Collaboratory Distributed Research Network" March 11, 2016, at https://www.nihcollaboratory.org/Pages/Grand-Rounds-Hub.aspx

[5] The UK databases have 65 million electronic health records, a national biobank, and a national cancer database. http://www.farrinstitute.org

[6] National Research Council Frontiers In Massive Data Analysis, National Academies Press; 2013; David Donoho "50 Years of Data Science" Sept 18, 2015 (Version 1.00) (section 6), available at: http://courses.csail.mit.edu/18.337/2015/docs/50YearsDataScience.pdf

[7] https://www.healthit.gov/sites/default/files/data-brief/2014HospitalAdoptionDataBrief.pdf ONC Data Brief #23, April 2015

[8] ONC Data Brief #21, December 2014

[9] https://ecqi.healthit.gov. https://www.cms.gov/eHealth/eHealthUniversity.html

[10] Dean Fixsen, "Scaling and Implementation Science" December 2, 2015, presentation available at https://www.nasi.org/civicrm/event/info?reset=1&id=201. The author thanks Robert Gibbons, Arnold Milstein and participants in the "Bright Spots" workshop at the Center for Advanced Studies in the Behavioral Sciences, Stanford University for discussion of these issues, October 22-23, 2015.

[11] http://echo.unm.edu

[12] http://cancerlinq.org

[13] https://www.cms.gov/Newsroom/MediaReleaseDatabase/Fact-sheets/2016-Fact-sheets-items/2016-03-03-2.html

[14] Charles Friedman, Joshua Rubin, 10 co-authors "Toward A Science of Learning Systems: a research agenda for the high-functioning Learning Health System" *Journal of the American Medical Informatics Association* October 24, 2014 http://jamia.bmj.com/content/early/2014/10/23/amiajnl-2014-002977.full.pdf+html . Lynn Etheredge "11Models For A Science of Rapid-Learning Systems" August 2015, working paper at https://www.researchgate.net/profile/Lynn_Etheredge

[15] I am grateful to Harold Kwalwasser for pointing this out to me. Student math performance, for example, can be continuously evaluated by drawing problem sets from national pools. Learning software, e.g. using "formative assessments", can not only help to grade but also diagnose reasons for errors and suggest supplemental material

[16] My thanks to Rebecca Chopp for suggesting a professionals education initiative, to George Halvorson (Three Key Years, InterGroup Press 2015), and to Lloyd Etheredge for suggestions on MOOCs, global education, and life-long learning.

[17] https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/DataAndReports.html

[18] Examples include: the NIH and PCORI distributed research networks, FDA's Sentinel network, NIH's cancer cloud pilots and the 1 million person Precision Medicine Initiative, NIH's Big Data To Knowledge initiatives, NIH's national reference databases (http://www.ncbi.nlm.nih.gov/guide/all/), and more.

[19] http://research2guidance.com/2010/11/10/500m-people-will-be-using-healthcare-mobile-applications-in-2015-2/, imedicalapps.com

[20] http://www.corestandards.org, http://www.ed.gov/essa?src=policy. Current standardized data systems and tests are typically designed for state, district, school and teacher assessment, rather than to personalize education and provide real-time feedback and student assistance.

[21] Department of Education Future Ready Learning: Reimagining the Role of Technology in Education 2016, downloadable at http://tech.ed.gov

[22] https://www.youtube.com/watch?v=Eu2SKd8D2hg For a software example: http://www.hmhco.com/hmh-assessments/data-and-learning-management/edusoft. Kevin Carey, Robert Manwaring "Growth Models and Accountability: A Recipe for Remaking ESEA" 2011 (downloaded from www.educationsector.org)

[23] Andrew Ng "The Online Revolution: Education for Everyone" (Coursera) Wolfram Data Summit 2013, at: http://www.wolframdatasummit.org/2013/attendee/presentations/, Bror Saxberg (Kaplan), Education Sector panel on The Next Decade of Educational Data, December 7, 2010

[24] Privacy of student-identifiable data must be guaranteed; the health records federal patient privacy statute (HIPAA) may be a useful model for education; in distributed database networks research is typically done with de-identified data and procedures to assure confidentiality.

[25] http://www.hcsrn.org/en/

[26] http://www.fda.gov/Safety/FDAsSentinelInitiative/default.htm

[27] https://www.nihcollaboratory.org/Pages/distributed-research-network.aspx

[28] http://www.pcornet.org

[29] https://www.cff.org, http://www.chordomafoundation.org

[30] http://www.popmednet.org/?page_id=41, Richard Platt, Jeffrey Brown and their colleagues deserve much recognition for what they are accomplishing

[31] https://datascience.nih.gov/commons

[32] http://wpo.st/-ceU1, Ariana Cha "$250 million, 300 scientists and 40 labs" *Washington Post* April 13, 2016. The grant is from Sean Parker.

[33] http://www.pcori.org

[34] http://dctd.cancer.gov/MajorInitiatives/NCI-sponsored_trials_in_precision_medicine.htm

[35] http://digitalpromise.org

[36] Frederick Hesse, Bror Saxberg Breakthrough Leadership in the Digital Age: Using Learning Science to Reboot Schools Corwin 2013. Textbook publishers and others are now moving to digital products, e.g. http://www.pearsoned.com/prek-12-education/, https://www.khanacademy.org, https://www.knewton.com (adaptive learning),

[37] See the PCAST report *Better Health and Lower Costs: Accelerating Improvement Through System Engineering* http://www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/pcast_systems_engineering_in_healthcare_-_may_2014.pdf

[38] http://www.ihi.org/about/Pages/default.aspx

[39] Lisa Schilling, A. Chase, et.al, "Kaiser Permanente's performance improvement system" *Joint Commission Journal on Quality and Patient Safety* 2010 Nov; 36(11) 484-98

[40] Patricia Gabow, Philip Goodman The Lean Prescription CRC Press, 2015.
[41] http://www.cincinnatichildrens.org/service/j/anderson-center/learning-networks/default/
[42] http://www.geisinger.org/sites/provencare/pages/provencare-services.html
[43] Naida Grunden The Pittsburgh Way to Efficient Healthcare: Improving Patient Care Using Toyota Based Methods Productivity Press 2007
[44] https://innovation.cms.gov/initiatives/Health-Care-Payment-Learning-and-Action-Network/
[45] Anthony Bryk, et. al. Learning To Improve Harvard 2015; Anthony Bryk "Accelerating How We Learn To Improve" *Educational Researcher* Vol 44 No. 9, 467-477 December 2015; http://www.carnegiefoundation.org
[46] http://www.carnegiefoundation.org/get-involved/events/summit-improvement-education/2016-summit-program/
[47] http://www.apqceducation.org
[48] Harold Kwalwasser Renewal: Remaking America's Schools for the Twenty-First Century R&L Education 2012, pg 6. I thank Hal for many discussions about implementing these ideas throughout the health system
[49] Baldridge prize winners (http://patapsco.nist.gov/Award_Recipients/), Broad prize winners (www.broadprize.org), Kwalwasser op.cit. (pg xi)
[50] http://digitalpromise.org/initiative/league-of-innovative-schools/; http://apqceducation.org/images/pdf/conf2015/15Bentsen-Moving-Forward.pdf;
[51] http://www.leapinnovations.org/images/PN_C1_Research_Brief_FINAL_red.pdf
[52] endnote #13
[53] The lower estimate pro-rates spending by number of beneficiaries, e.g. there are about 56 million children enrolled (K-12) compared to 320 million persons in the health system. 56/320 = 17%, 17%x90 B = $15 billion (2014). Using spending, US health spending was $3.0 trillion (2014) while national elementary and secondary school education spending was $621 billion (2011-2012); 621/3,000 = 21%, 21%x90B = $18 B.
[54] https://www.edreform.com/2012/04/k-12-facts/
[55] Jack Grayson *Using Process and Performance Management (PPM) to Transform Education* APQC 2014