Editorial Column

Education: Our Most Important Service Sector

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Education is a service industry comprising 10 percent of the US GDP, second only to health care at 17 percent. In the U.S. and over much of the world, classroom education remains a labor-intensive craft profession, essentially unchanged since the 19th Century. A craft industry can be defined as a **"**Site of small scale industrial production often involving hand work and craft skills."[1] An example is New England shoe making in the 1830's:

> *"Shoes were usually completed in small shops, where each worker sat at a bench with his hammer, last, awls, pegs, string, wax, and bristles close at hand."*

In thinking of a teacher preparing for a class, consider this as a representative description:

> *Class lectures and exercises are usually completed at home in a den or small room, where each teacher sits at her desk with her pencil, pen, ruler, calculator, reference texts, laptop computer, and pads of paper close at hand.*

This describes a craft profession in the tradition of the 1800's but operating in the 21st Century[2].

The usual mode of educating students, whether k-12 or tertiary, is the teacher in front of the class lecturing and interacting with the class. Service delivery is labor intensive, repetitive, not scalable and highly dependent on the teacher's skills and knowledge. Each individual teacher crafts lessons plans, placing immense pressures on new teachers who have to plan and teach almost simultaneously, not unlike those cartoon images we may recall of a short train traversing the open desert, with workers laying new track 'just in time' out in front of the train as movement of the train has freed one section of track in the back. It's a struggle not to let the train slide forward ahead of the tracks, into the sand.

Education as a service industry is crying out for serious research. Smaller service segments of the economy, like retail, banking, supply chains and logistics, have received the attention of many researchers over the past half-century. Research in the health sector has been in the tens of billions of dollars, especially in inventing new medical treatments including pharmaceuticals, but nothing analogous has occurred in education. The research arm of the U.S. Department of Education (DOE), the Institute of Education Sciences, has an annual budget of about $160 million. There are about 56 million k-12 school children in the U.S. So, the DOE research devoted to education is less than three dollars per child per year. The picture at NSF is brighter, with an annual budget of its Directorate for Education and Human Resources of approximately $750 million, including tertiary as well as k-12 education. So, there is room for optimism going forward. Still, we would wager that education is at or near the bottom of the top ten U.S. service industries in research dollars spent per percentage unit of GDP. This may be due in part to the relatively smaller private sector in educational services as compared to other services.

Is there any more important service sector for our nation? Our world-leading prosperity in the 20th Century relied on creativeness, ingenuity, risk taking, and brainpower, leading to huge breakthroughs and new businesses. Other nations have seen this and are copying our model – investing in the minds of young people. Both Singapore and Israel are exemplars of nations investing in education, with Israel leading the world in patents per capita. And the Republic of Korea invests up to 22 percent of its GDP in education.

Our plea is to extend your interests in services beyond the traditional financial services, retail,

[1] http://sine.ncl.ac.uk/term_definitions.asp?thesaurus_code=ty&term_id=129
[2] This framing of craft industries is extracted from the paper, Larson, R. C. and M. E. Murray, "Open Educational Resources for Blended Learning in High Schools: Overcoming Impediments in Developing Countries," *Journal of Asynchronous Learning Networks,* V. 12, No. 1, Feb. 2008.

transportation/logistics, communications, etc., to include education. The fate of our nation, of every nation, is at stake.

How to proceed? A straightforward idea is to apply traditional industrial engineering and operations research (IE/OR) ideas to operations of educational institutions. This is a comfortable area for many of us, and problems such as classroom scheduling, space allocations and school bus routing could often benefit from a quantitative approach. *Comfortable, efficient, but not transformative.* Higher payoffs may be found from suggesting system redesigns, thinking outside of the box.

Example: Libraries. Traditional usage of library roaming stacks has plummeted, and their prime real estate can usually be recommitted to more productive uses. Where regional cooperation is possible, we suggest that universities and colleges partner with others in their area, creating a *library collaborative*. Under this system, all books whose copyrights have expired and are freely available over the Internet are no longer retained. Newer copyright-protected books are stored efficiently for robot picking in a nearby low-rent warehouse. Web-based book requests are sent immediately to the warehouse and picked with Amazon.com efficiency. Several times a day vans are dispatched from the warehouse to deliver ordered books to central locations at each respective participating institution. Individuals not needing books the same day would receive them the following day by campus mail.

The new system is likely to be better than the roaming stacks *status quo*. Often a person seeks a book, only to find that the nearest available copy is located elsewhere, to be acquired through an inter-library loan system. This takes days. But if most regional colleges and universities participate in the program, then all shared books would be just as available as those originally purchased by one's home institution. The warehouse would be one giant shared library! No more special activities for inter-library loans. There is still another advantage to the library collaborative. Newer books are often so popular that several copies must be purchased. If each individual library system must do this, then many books are purchased. But under the shared system, the law of large numbers suggests that the total number of such popular books that must be purchased to assure a given level of book availability is less, sometimes much less, than that in the each-institution-goes-it-alone system. OR's U.S. founder, Philip M. Morse won ORSA's coveted Lanchester Prize for his 1968 book, ***Library Effectiveness***, in which he demonstrated how tools of OR can lead to libraries becoming more efficient and effective. Now it's time to update his research in an institutional new structure that leverages all that has occurred since the 1960's. *Such work would be less comfortable, again efficient, and possibly transformative.*

But let's go further, into the heart of educational services. Isn't it time for service scientists and engineers to help develop ways to improve the teaching and learning function itself? In thinking of other services, what has been the dominant trend in services improvements over the past half-century? Answer: Adding technology to reduce labor content. A 19th Century craft industry certainly has considerable labor content. By leveraging IT technology in creative ways, we could help teachers strapped with crafting lesson plans simultaneously for several courses, to focus more on critical teaching and learning tasks and to liberate them from many routine tasks.

There is progress in these directions. Founded in 1994 by Dr. Frank Mayadas of the Alfred P. Sloan Foundation, the Sloan-C Consortium just celebrated its 15th birthday at a conference with over 1,400 participants. The Sloan-C professionals have led the way in bringing Internet-based "asynchronous learning networks" (ALN's) to tertiary education, initially to life-long learners who could not relocate to university campuses and now to university-based students as well. Online courses were once rare and are now ubiquitous, with well over 100,000 courses online. They facilitate the customer-orientation of successful services industries, in this case, ***"Learn anywhere, at any time."*** Mayadas estimates that 4,000,000 students took online courses in degree programs this past year. He says that this number is growing at approximately 20% per year. Done properly, significant teacher labor content can be removed from courses when they are placed online, yet the student may experience more communication with her teacher and tutors than in regular campus-based lecture style courses. The for-profit University of Phoenix is the country's largest private university, and the majority of its courses are taken online – at all degree levels including Ph.D. Students' educational attainment with online courses is often better than that of traditional campus-based courses.

The Hewlett Foundation founded a complementary and equally transformational online movement, namely the Open Educational Resources (OER) initiative. This started with a major grant to MIT in 2001, whereupon MIT eventually placed the materials of almost 2,000 of its campus-based courses online – available free for the World. Now other

colleges and universities worldwide are contributing their own OER content, for worldwide shared learning. These OER web sites are enjoying tens of millions of 'hits' monthly, from learners in virtually every nation. We see the important role of private foundations in supporting transformational efforts in education.

Placing courses and course materials online does not necessarily mean, "business as usual, but online." An example is CyberTutor, developed by MIT's Professor David Pritchard and colleagues. Quoting from one of Pritchard's papers,

> "CyberTutor is an interactive web-based program that functions as a personal tutor for the student, offering help with the problems when requested or in response to incorrect answers. CyberTutor collects extensive feedback which is processed to inform the teacher about current performance and lack of foundational skills of each student, to identify troublesome problems and concepts for the class..."[3]

In summary, CyberTutor is a homework problem grader, a real-time personal tutor and a collector of student data to inform the human instructor about the progress of each student. And, once its database is filled for homework problems of a physics, math or engineering course, it is all software with zero labor content. CyberTutor has been sold to a private commercial publishing company that now embeds it with college textbooks. The trends of other service industries are now becoming apparent in education!

Finally, what about k-12 education? The numbers are small, but growing rapidly – as many high school students are taking online courses for credit towards their high school degrees. Some are advanced placement courses that are not taught in the student's brick-and-mortar school, while others are remedial courses taken off calendar and still others are regular courses (say in a foreign language) that are not taught locally.

In our own research, we have found that high school teachers have complex attitudes towards use of technology in their teaching[4]. Ambivalence towards technology may be rooted in fear that their students are savvier with computers than they are; or that taking students out of the classroom into a computer lab diminishes the role of the teacher; or that lessons available online are not compatible with the pedagogical style of the teacher. We have started a pilot program to address these concerns, a program that may serve as a bridge from teaching as usual to teaching with more technology. This OER program is called BLOSSOMS, ***Blended Learning Open Source Science or Math Studies*** http://blossoms.mit.edu, funded by both the Hewlett and Sloan Foundations. Partnering with educators in Jordan and Pakistan, faculty members, graduate students and high school teachers are creating "BLOSSOMS interactive video learning modules." These video modules are not intended to replace existing curriculum content but rather to enhance development of critical thinking skills by the lively video presence of a gifted 'guest lecturer,' moving away from rote memorization and 'teaching to a test.' The BLOSSOMS modules are aimed at exciting young people toward STEM careers, where STEM = Science, Technology, Engineering and Math. Each video is designed for viewing in brief segments, allowing the in-class teacher time between segments to engage the class in active, goal-oriented exercises. Students in the classroom watch a segment of a BLOSSOMS video, no segment lasting longer than about 5 minutes. Then the in-class teacher guides the students through an active learning exercise building from the video segment. After the learning objective is accomplished, the video is turned on again for another short segment. This iterative process continues until the exercise is over, usually lasting a full class session. We call the BLOSSOMS pedagogical model a "Teaching Duet," with the in-class teacher and the video teacher being co-teachers to the class. If teachers adopt this model for some of their classes, we are hoping to steer the BLOSSOMS initiative towards "the World creating BLOSSOMS modules,' having a carefully moderated web site not unlike YouTube and welcoming contributions from people everywhere.

In summary, there are important stirrings in education, the World's most important service sector. These go far beyond the 'time and motion' improvements of typical IE/OR studies and can extend into the classroom and into the learning process in new and transformational ways. But there remains much to be done. We hope that you find time to join the effort!

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[3] http://www.americanprofessor.org/documentation/cybertutoraweb.pdf, **CyberTutor, A Socratic Electronic Homework Tutor at MIT,** David E. Pritchard, Elsa-Sofia Morote, and David Kokorowski.

[4] Larson, R. C. and M. E. Murray, "Open Educational Resources for Blended Learning in High Schools: Overcoming Impediments in Developing Countries," *Journal of Asynchronous Learning Networks,* V. 12, No. 1, Feb. 2008.