Is online learning cost-effective?

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How can cost-effectiveness analysis help educators and policymakers take better informed action?

- Facilitate more efficient use of educational resources by
  - Allowing the *lowest cost* alternative to be chosen to achieve a target objective
  - Allowing the *most effective* alternative to be chosen given a fixed budget or resource allocation

There are two parts to the question…

- Compared with traditional face-to-face (f2f) classroom teaching:

1) Does online learning cost less, the same or more?
   - This is what most administrators and policymakers focus on
   - Existing published studies are usually based on self-reported data and do not tie into effectiveness or benefits

Part 2 of the cost-effectiveness question

2) Is online learning more, less or just as effective in promoting positive academic outcomes?

- This is what most people forget to consider thoroughly (or just assume parity of effectiveness) but what teachers and parents want to know
- Most published studies of effectiveness are at the higher ed. level

Online learning is not monolithic - the answers will depend on the model

Use and delivery of online learning varies dramatically:

- i) at one extreme some students learn full time online from home: *virtual schooling*
- ii) more commonly many students who attend school daily opt to take one or two pure online courses
- iii) a growing number of models incorporate aspects of both face-to-face and online learning in the same classroom: *blended learning*
- iv) at the other extreme students learn full time in face-to-face situations with limited online aspects to enhance the experience

Generalizing, the *apparent* costs per student increase from i) thru iv)

What are the cost numbers currently estimated for online learning?

- Cavanaugh surveyed 20 directors of virtual schools in 14 states – ave. cost of full time online students in 2008 was estimated at $4,310
- This is 42% of the ave. per pupil expenditure in 2007-08 of $10,297 (NCES)
- Compare this 42% with the general finding that the instructional program counts for about 60-65% of total education expenditures (Levin).
- The virtual school estimates exclude services such as
  - transportation, nutrition, counseling, nursing, college guidance, libraries, media specialists and resources, clubs, activities and professional development services.

To make a fair comparison between virtual and "brick and mortar" schools:

- We must consider
  - "costs" of losing these services or
  - costs of providing alternate access to them in the community
- Anderson *et al* (2006) estimated costs of virtual schooling to be about the same as regular brick and mortar schools when similar services are being provided, excluding transportation and capital costs

Some costs of online learning that are often not accounted for:

- Development costs of the delivery mechanism. Can be amortized over the expected lifetime use.
- Ongoing maintenance and adjustment of course content
- Professional development costs for f2f teachers incorporating online aspects or for pure online teachers/tutors
- Content costs – selection and purchase from outside vendor or development in-house; integration with current curriculum

How should we measure the effectiveness of online learning?

- Effectiveness can mean different things:
  - Higher standardized test scores
  - More content learned in a fixed time frame
  - Same amount of content learned faster (in some cases, speedier graduation)
  - Higher course completion/graduation rate than f2f (e.g. in credit recovery programs)

A few credible effectiveness studies exist – mostly for higher ed.

- U.S. DoE meta-analysis of online learning (2009) found 99 studies, comparing learning outcomes in online/blended learning with f2f
  - only 9 involved K-12 learners

- Conclusions of meta-analysis
  - Blended instruction is more effective than conventional f2f classes for older learners (undergrads and adults)
  - Pure online learning offers a "modest advantage" over conventional instruction for older learners
  - Treatment conditions often included additional learning time, materials and opportunities for collaboration
  - Based on a small sample of 5 studies, positive effects not found for K-12

CAI cost-effectiveness for math instruction

- Barrow, Markman & Rouse (2007)
  - Randomly assigned classrooms to computer labs vs. reg classrooms for algebra and pre-algebra instruction.
  - Concluded that students in CAI classes scored 0.17 of a s.d. higher on tests of algebra achievement than controls.
  - (Very rough and limited) estimate of lab cost is $1600 per student per year
- CE ratio = 1600/.17 = $9,411 per student to raise algebra test score 1 s.d.
- Need to compare with another intervention aiming to affect same outcome

Is CAI cost-effective?

Authors compared CAI costs and effects with Tennessee STAR class size reduction which, at $1850 per student per yr., resulted in 0.22 s.d. increase in test scores (CE ratio = $1850/.22 = $8,409)

Concluded that CAI may be a cost effective way to increase math test scores

Note, however, that the two interventions were not judged by the same test scores. Also STAR aimed to affect more than just math outcomes.

Some specific examples of online learning

- Blended learning for middle school math
  - School of One (So1), New York, NY
- Blended learning in the humanities
  - Roslyn High School, Roslyn, New York
- Online Credit recovery
  - Cross High School, New Haven, CT

School of One (So1)

http://www.schoolofone.org/

- So1 is a blended learning math program for 6th, 7th and 8th graders developed by the NYC DoE
- Serves 1500 students across 3 schools in NYC
- Students spend 70 minutes a day learning math
- Students learn in a variety of modalities both virtual and live
  - Learning with software
  - Independent
  - Small group instruction
  - Peer tutoring
  - Learning with remote tutors
  - Large group instruction
  - Small group collaboration
  - Integrated learning projects
- Each student's daily lesson plan or "playlist" is generated by a computer-based "Learning Algorithm"

Applying the “Ingredients” or “Resource Cost” method of cost analysis to School of One

- Costs can be separated into
  - Up front development costs
  - Adoption costs that would be experienced by sites adopting So1
    - Pre-requisites
    - New costs

Categories of ingredients

- Personnel (often accounts for about 75% of any educational intervention) including volunteers
  - Salaries, benefits (often approximated at 20% of salary)
- Facilities
  - rent, building costs
- Equipment and materials
  - Technology, books etc.
- Other program inputs
  - Insurance, electricity etc.
- Required client inputs
  - transport costs

Identifying the ingredients

- Review of program documents
- Interviewing personnel involved in development and delivery of intervention
- Direct observation of the intervention in a typical field situation

Assigning costs

- Once the quantity and quality of each ingredient is identified, costs are assigned to each
  - Market prices for salaries, equipment
  - Amortize facilities or equipment
  - Shadow prices for items where no market exists
  - Why we need to assign costs to volunteers or "free" resources
    - Replication elsewhere may not be able to depend on these
  - Concept of opportunity cost e.g. for high school mentors

Sensitivity analysis

- Costs may vary depending on scale and location
- Interventions with high fixed costs (as opposed to variable costs) will look cheaper as scale increases – up to a point
- Many educational interventions are added onto the existing program so that a marginal cost effectiveness analysis is appropriate

So1 Development costs – estimated at $7mm over 2 years

- Technology development costs to build a system that
  - houses 5000 math lessons that can be completed and assessed online
  - Learning Algorithm that tracks individual student progress, determines what skills (s)he has mastered and what still needs work
  - presents a daily "playlist" of math activities for each individual student
    - Currently outsourced to Wireless Generation

Estimated cost $4mm over 2 years

- Content: 5000 lessons purchased from 50 different vendors and adapted for So1 system

Estimated cost $0.5mm

- Panel of math experts to develop math skills map and review 25,000 possible lessons

Estimated cost $150,000

- Team of 12 education/technology professionals working with vendor to develop system and interfacing with schools

Estimated cost $1.2mm

Adoption cost assumptions

- Costs estimated based on
  - 480 middle school students
  - 4 fully certified teachers + 2 student teachers
  - 4 groups of 120 students each working with So1 for 70 mins/day, 5 days a week, 36 weeks a year

Pre-requisite resources at adoption sites: estimated costs per annum

- Math teachers – current model serves 4 math sections (25-33 students each) at once with 4 certified teachers plus 2 student teachers

Estimated cost $380,000
(expect to be lower outside of NYC)

- Wireless connectivity
  - $50,000 for entire school amortized over 5 years

Estimated cost $10,000

- E-mail access for entire school

Estimated cost $25,000

New per annum costs of adoption

- Construction costs of opening up suitable space in school building to accommodate 120 students at once

  Estimated cost $200,000 amortized over 5 years =$40,000

- Initial teacher professional development – 1 week in summer (provided by So1)

  *Estimated cost for 4 teachers *5 days = $8000*

- Full time in-house digital content manager to interface with So1 and provide tech support/professional development

  Estimated cost $80,000

- Approx. 100 individual PCs/laptops in classroom, two 48" LCD terminals displaying each student's daily playlist, 4 printers, 1 LCD projector

  Estimated cost $110,000 amortized over 3 years = $36,667

New per annum costs of adoption (cont.)

- Licensing charge from So1 for access to Learning Algorithm, all content and provision of daily playlists
  - *Estimated cost $150,000*
- Ongoing professional development – 2 hours weekly with So1 professional developer (assuming no extra pmt to teachers)
  - *Estimated cost of trainer $10,000*
- Virtual tutors (currently in the So1 model but due to high cost, shown here as an option)
  - *Estimated for 15 tutors, 4 hours/day, 180 days/yr at $30/hr = $324,000*

Estimated adoption cost summary

(assuming 6 teachers, pre-existing wireless connectivity and e-mail for all students)

* cost amortized over 5 years

** cost amortized over 3 years

	Cost per annum for school of 480	Cost per student
Construction*	$40,000	83
Initial p.d.	$8,000	17
Digital content manager/tech support	$80,000	167
Hardware**	$36,667	76
So1 licensing	$150,000	313
Ongoing p.d.	$10,000	21
TOTAL	$300,000	$677
Virtual tutor option	$324,000	$540
TOTAL with virtual tutors	$619,000	$1,217

Effectiveness data available for So1 http://www.schoolofone.org/research.html

- Summer '09 pilot 4hrs/day, 5 days /week for 5 weeks: rising 7th graders gained ave. of 28.2% from pre-test to post-test. (EDC/CCT evaluation)

  Issues to consider:

  - 10 adult educators and 3 HS interns for 80 students → very high teacher/student ratio
  - 100 hrs of math is equivalent to instruction for over 4/5 of an entire regular school year
  - Lack of comparison group prevents determination of how effective So1 is compared with traditional teaching or other models

Afterschool and in-school pilots of So1 (NYCDoE Research and Policy Support Group, 2010)

- Afterschool trial Feb-May 2010: 600 sixth graders across 3 schools
  - students opted in
  - Evaluation positive in only one of the 3 schools
  - only about half the students were included in the analysis
- Followed by in-school implementation May-June 2010 with all 6th graders in 1 of the schools.
  - No sig. impact on MAP scores vs. comparison group.

Another example: Roslyn High School iPad program

- Roslyn High School, NY serves 1100 students.
- Last June the supt. leased 275 iPads for 4 yrs
- Currently being used in 11th and 12th grade humanities classes in a 1-1 blended learning format
- Teacher uses class website to post articles, post assignments, hold online discussions.
- Paperless classroom and all homework exchanged/graded online.

Marginal costs of 1-1 iPad Program (beyond existing teacher and school costs)

* Note that in Roslyn the teachers volunteered their time and administrators provided the training

	Total cost per annum	Per student cost/yr
Wireless access	$78,000 for 1100 student building amortized over 5 years= $15,600	$14 (spreading cost over 1100 students)
Internet access	$50,000 for 5 schools (5400 students)	$9 (spreading cost over 5400 students)
Leasing 275 iPads	$180,000 over 4 years = $45,000	$170 (assuming 265 students use iPads)
Tech support	5% of total district tech support cost of $400,000 = $20,000	$73
Teacher training (10 teachers)*	$48,000 teacher payments $30,000 trainer fees = $78,000	$284
Additional iPad applications	$8800 (assuming 4 apps at $8 for 275 iPads)	$32
TOTAL	$217,400	$582

Effectiveness of Roslyn 1-1 iPad program?

- No formal evaluation conducted, program only 3 months old
- Early indications from teacher:
  - Higher homework completion rates
  - Easier for students to make up work during absences
  - Expanded learning time e.g. through after-school online review sessions before tests
  - Paperless classroom

Credit recovery programs e.g. Cross High school, New Haven CT

- 11th and 12th graders can "retrieve" credits through online courses taken at school or home. 22 current users
- Expenditures involved beyond existing costs of schooling:
  - Content licenses $375 per actual user
  - Computer room proctor/tutor 3 hrs a day estimated at $25,000 per annum
- If all students earn 2 credits a year, expenditures are around $755 per credit
- This can be crudely compared to the cost of a regular credit of approx. $2500
- Effectiveness?

Benefits of online credit recovery?

- The student may graduate rather than drop out or repeat the year
  - Lower costs for districts due to fewer repeating students
  - Higher tax revenues from greater earnings of graduates (but these accrue to Treasury, not schools directly)
  - If more HS graduates go to college, this will cost the state and while earnings of these college graduates will eventually be higher, they are deferred 2-4 years.
- However, is it realistic to learn in 30 hours online what might be learned in a semester long class (around 60 hours of instruction)?
- If remedial courses are required in college, these costs are just being deferred, not saved
  - Around ¾ of 17,500 freshmen at CUNY community colleges this year have needed remedial education (NYTimes 3/4/11)

Research on credit recovery effectiveness?

- There are currently no peer reviewed studies indicating effectiveness of credit recovery programs in terms of academic outcomes

Conclusions

- Significant cost savings are possible when online learning is used to replace f2f instruction, primarily due to
  - increasing student/teacher ratios
  - elimination of non-instructional services
- In some cases the costs are just being deferred elsewhere e.g. families, colleges.
- There is, as yet, little peer-reviewed documentation of the effectiveness of K-12 online learning wrt improving academic outcomes – we need to do more.

Online access to this presentation

- http://www.cbcse.org
  (Publications)

Effect size – a standardized measure for comparing interventions

- Effect size =

(mean score for Treatment group –

mean score of Control group) / pooled standard deviation for both groups

- Conventionally, effect size of 0.9 is considered large, 0.45 medium and 0.15 small

Calculating effect size (Cohen's d)

n = number of children in group
s = standard deviation
t = treatment group
c = control group

$$d = \frac{\bar{x}_t - \bar{x}_c}{\sqrt{\frac{(n_t - 1)s_t^{\,2} + (n_c - 1)s_c^{\,2}}{n_t + n_c}}}$$