On Distant Education: Cost Issues

Lotfi Bouzaiane, Université Virtuelle de Tunis, Tunis, Tunisia, Lotfi.bouzaiane@uvt.rnu.tn

Abstract

This paper argues that the cost issue is only part of the story. First, it is a much more complicated matter than a simple accounting estimation. It involves technical choices for example between investment in authoring or expenses on tutoring. It is an important issue for emerging countries which are in need to set up a distant education strategy. They may invest large amounts in authoring sophisticated virtual courses without optimizing their use. Second, what should be expected from E-teaching is the better cost benefit balance. In many cases, for example, E-courses are more expensive than face to face class. But, E-courses may help achieving better internal efficiency of the system. Third, positive results from E-learning are helped by change in pedagogy, not only by communication technology. Finally, the analysis in the paper, based on real cases drawn from Tunisian teaching experience, points out critical institutional and actors behavior issues related to conducting innovation and technology changes in this field. The paper conclusion gives some crucial conditions which help optimizing distant education implementation in emerging countries.

1. Introduction

E-learning is of great attention for a growing number of education systems across the world. Share of on line courses in education was at some time expected to climb at as high as 20% or more. But, for most rich countries its average share is still above 5% [1]. While for developing countries, the move is attractive but still uncertain. Many factors are behind this delay. Technical, institutional and pedagogical obstacles are the most quoted ones. Cost is often classified as an encouraging one [2]. The argument is based on the fact that Web based courses lower the indirect cost of attendance, especially fare and time cost of transportation. It is for example the case for training which is very costly for firms in terms of time spending on education instead of work. A saving on time for transportation and flexibility of educational schedule activities help developing demand for on line courses. It is also an interesting option for students living in remote parts of large countries. Developing countries are attracted by lower cost promised by on line courses and by avoiding lack of teachers in some critical fields.

A growing literature is tackling cost issue of integration of Information and Communication Technology (ICT) in education system and more specifically Web based teaching. But, accounting approaches are developed to determine on line courses cost. They are based on a given mix between authoring and tutoring activities. Respective shares of authoring and tutoring are based on intuitive appraisal from pedagogical point of view. This paper suggests that there is a risk of sub optimality of such mixes if it is not based on economic analysis. The paper argues that as for any industrial process, it is necessary to deal with the both authoring and tutoring intensities as substitutable inputs of a production function. Quality of delivery is the yield of this function [3]. Optimality should be sought considering both technical aspects, in this case pedagogy, and budget constraint.

The paper is based on a theoretical scheme brought to distant education sector analysis from industrial economics. Main results are illustrated on base of simulations. But, we have in mind some specific realities such the case of Université Virtuelle de Tunis (UVT) [4], a pioneer experience of Web based distant education in developing countries. UVT has succeeded is offering as resources on line more than 400 courses. Pedagogical quality of these courses is very different. Some are simple enriched text and others more elaborated and interactive materials. Some of UVT on line resources are used for teaching and others not yet. UVT policy aims at setting new curricula using the on line resources. A frequent question facing this policy is how much should be tutoring along the use of on line resource? Strategically, a choice has to be set up about how much on line courses should be sophisticated. This paper suggests a way which might help a better understanding of the underneath optimizing quality and costs issues of such choices.

A first section of the paper is dedicated to introducing the analysis model inspired by what is used in micro economics for firms by economists. Second section deals with an example of optimizing quality under a budget constraint and the third section is about an example of reducing costs under quality constraint. Both examples are simulated with as realistic as possible parameters and figures from Tunisian cases. The conclusion points out the conditions which might help optimizing authoring-tutoring mix.

2. A model for E-teaching as an industrial process

This section suggests that as for any industrial product, E-course can be processed according a variety of alternative pedagogical techniques. Based on Cobb-Douglas production function [5], a simple model is elaborated to compare different techniques of E-course pedagogical delivery. In this model, distant education is considered as a process of production where two factors are involved: authoring and tutoring. As for any product where yield can be obtained from alternative combinations of Capital and Labor, in distant education a course can be taught with more or less authoring efforts or tutoring time. The model compares different technologies of production of the course by substitution between the two factors.

The yield in this model is the quality level of the course. Quality means the pedagogical pertinence of the course. That is what student could qualify usually as more or less quality of delivery of a course. It can be measured by the grade student can achieve in a neutral exam.

The inputs are quantity of efforts spent on authoring the course and quantity of tutoring.

A given level of course quality can be achieved by more or less quantity of authoring and a matching quantity of tutoring as described by the production function below:

$$Q = A\, C^{\alpha} T^{\beta} \qquad (1)$$

Where:

A: Units conversion coefficient.
C: Quantity of authoring (for example number of times an authored course can be spent within same year or during several years).
T: Quantity of tutoring (for example time spent by teacher to monitor student activities).
α, β: Parameters of the function measuring the elasticity of quality relatively to each of the two inputs, authoring and tutoring.

For any course, we will have a budget B to cover the costs of authoring and tutoring a given class. B is defined as following:

$$B = P_c\, C + P_t\, T \qquad (2)$$

Where:

P_c: Cost of a unit of authoring.
P_t: Cost of a unit of tutoring. We assume that tutoring a class is done according to a pedagogical standard which limits the number of students per teacher.

In order to simplify the analysis, let us assume $\alpha + \beta = 1$. This assumption means that we consider that returns on scale are constant. We assume then decreasing marginal productivity of authoring (and of tutoring). That is why at some point, more authoring, for example, as substitute to tutoring would lead to a decrease in delivery quality.

An optimal choice of an authoring-tutoring mix can be determined from the quality function (1) and the budget constraint (2). Figure 1 shows below how the model could help choose the optimal mix which minimize cost of a given quality of course or maximize level of quality for a given budget.

Sub optimal choices, as S1 or S2 on the figure, could happen. That are cases where a great accomplishment are done on authoring level but for institutional reasons, it is not possible to reduce tutoring expenses. That is the case also where not enough effort is done on authoring. Reducing cost (or improving quality) can be achieved by a better balance of authoring and tutoring activities. Such balance can be reached only if the education system is enough flexible and the skills for authoring are available.

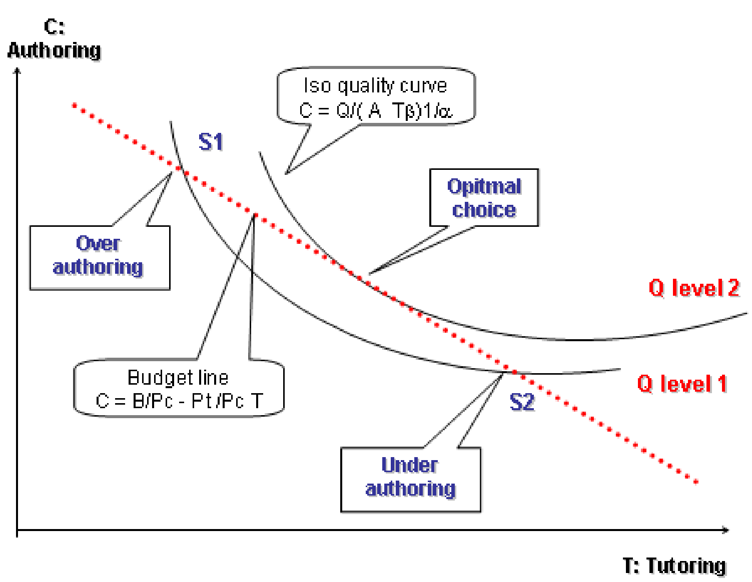

Fig. 1. Optimal and suboptimal authoring-tutoring mixes

Let us illustrate through two examples how suboptimal choices can happen in an educational system and how does that affect costs.

For any of these examples, four cases are computed. We consider two class sizes because of the change which is implied for cost per student. We cross these two cases with two assumptions about non optimized choice of authoring-tutoring mix. One is under authoring share and the other is a reverse case.

Same parameters are used for equations 1 and 2 in all the simulated cases [6].

Course quality of delivery (Q) is translated in terms of internal return level of the education system by the quotient of number of succeeding students per the number of enrolled students in a given course or class. This index is called hereafter effectiveness of delivery which determines an effective cost of E-teaching per (succeeding) learner.

3. Example 1: Optimizing quality of delivery under a budget constraint

An educational system may be tempted to introduce the use of ICT and especially putting on line some authored materials as a mean to improve quality of delivery in order to raise its effectiveness. But, this move is done under a budget constraint, because of, for example, state funding policy or fee limits. We will assume that a choice of authoring-tutoring mix is set intuitively or at random but with respect to a given total cost of teaching a course, let is say 45 US $ per student.

For small size class, let us assume two values of intuitive or random choices of C as C= 0,2 and C=0,5. Since we have a constraint on the total cost, we can derive form equation (2) T value respectively as T=37 and T=3.

For larger class, let us assume intuitive or random choices of C as C=0,1 and C=4 and derived T from the budget constraint at T=44 and T=5.

Even if these cases are hypothetical ones, they are in fact realistic. They reproduce tempting options for an educational system. The aim is to improve effectiveness of the system by raising quality of delivery without new burden on the total expenses.

In order to illustrate how random choices are not always the best options even if we control expenses, let us determine optimal solutions for a given total cost B. We can deduce from equations 3 and 4, the optimal solution as shown below:

$$C = \alpha\, B / P_c \qquad (3)$$

$$T = \beta\, B / P_t \qquad (4)$$

As a result of these two equations, for the given B budget, it is possible to have better delivery quality of teaching with C=0.22 and T=27 for small size classes (figure 2) and C=1.28 and T=27 for large size classes.

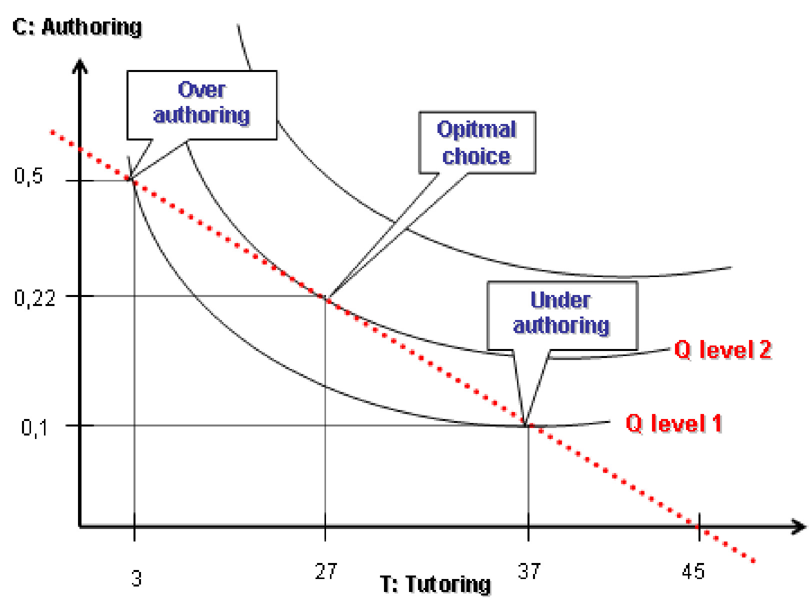

Fig. 2. Maximizing quality under a budget constraint (small class case)

For both cases, cost per student is constant for each class size as for the random mix but an important gain in quality of delivery is achieved and therefore a gain on effective cost per student (table 1).

The gain is for example as large as 16.9% for small classes relatively to the under authoring mix and more than 27% for large classes in respect compared to over authored mix.

For the chosen cases, on line based courses are more cost effective compared to face to face teaching, even with non optimal mix.

The simulations, under the chosen assumptions, show more general results which can help better choose authoring-tutoring mixes. The main general results are:

1. Adding an on line course decrease effective cost per student.
2. Effective cost saving is higher in the case of large classes.

For small classes it is better to not invest in authoring as much as for large classes

Table 1: Authoring-tutoring optimal mixes for a given cost

Cases and quality and cost impacts	Cost per student		Course effectiviness		Effective cost per student	
	US $	Index	Quality index	Internal return rate	US $	Index
Small class (60 students)						
Face to face class (C=0 ;T=45)	45	100,0	0,00	50%	90,0	100,0
Intuitive mix						
Over authored mix (C=0.5 ;T=3)	45	100,0	0,16	58%	77,9	86,5
Under authored mix (C=0.1 ;T=37)	45	100,0	0,35	67%	66,9	74,3
Optimal mix (C=0.22 ;T=27)	45	100,0	0,39	70%	64,7	71,9
Large class (500 students)						
Face to face class (C=0 ;T=45)	45	100,0	0,00	50%	90,0	100,0
Intuitive mix						
Over authored mix (C=4 ;T=5)	45	100,0	0,46	73%	61,8	68,6
Under authored mix (C=0.1 ;T=44)	45	100,0	0,39	69%	65,0	72,2
Optimal mix (C=1.8 ;T=27)	45	100,0	0,91	96%	47,0	52,2

4. Example 2: Minimizing cost under quality constraint

In some cases, educational system tries to reduce cost by providing on line some pieces of a course. A mix of authored course and tutoring are then available for students. Doing so, quality of delivery is raised while cost is lowered. But, the shift is not always optimal. Let us illustrate that from an example.

We assume that managers of the education system aim at lowering cost per student at a rate of 20%. Let us examine two choices where they order an on line course at a level of C= 0,1 and C=0,3 for a small class and C=0,1 and C=0,3 for a larger class. Given the target of 20% lower cost, if they don't care about equation (1), they will have to fix tutoring according only to equation (2) and they will choose for small class respectively T=28 and T=11 and for large class T=35 and T=16.

The cost lowering behavior leads in fact to a change in delivery quality between authoring-tutoring mix choices. This difference implies a difference at the effective cost per student. For example for small class, the mix C=0,1, T=28 corresponds to a quality delivery of Q=0,29 while the mix C=0,3, T=11 corresponds to Q=0,26

We can now illustrate how the intuitive or random choice of the authoring-tutoring mix can be sub optimal. To do so, one should remember that lowering cost led to raising quality of delivery. We can then search from equation (1) what are the C-T mixes which give the same new delivery quality. For given new Q, we will have the following relation:

$$C = (Q/AT^{\beta})^{1/\alpha} \qquad (5)$$

In order to optimize the mix C-T, we have to choose the one which minimize the total budget cost for a given class size. That means that we minimize equation (2) under the constraint of equation (5). We obtain then optimal value of T corresponding to the given Q and minimizing B as follows:

$$T=[(\beta/\alpha)(Pc/pt)]^{\alpha}(Q/A) \qquad (6)$$

The optimal value of C and T is unique and any other mix is suboptimal. That means, except an improbable chance, the random choice leads to a cost higher than the optimal one for a same delivery quality.

For our illustrating example, in the small class case optimal choice is C=0.16 and C=0.14 and corresponding value of T should be T=20 and T=18 which give an extra cost saving of 5.4% and 13.5%. For a large size class, C=0.66 and C=1.37 matching with T=10 and T=21 lead to an extra cost saving of 43.2% and 3.8%. More detailed results are shown in table 2.

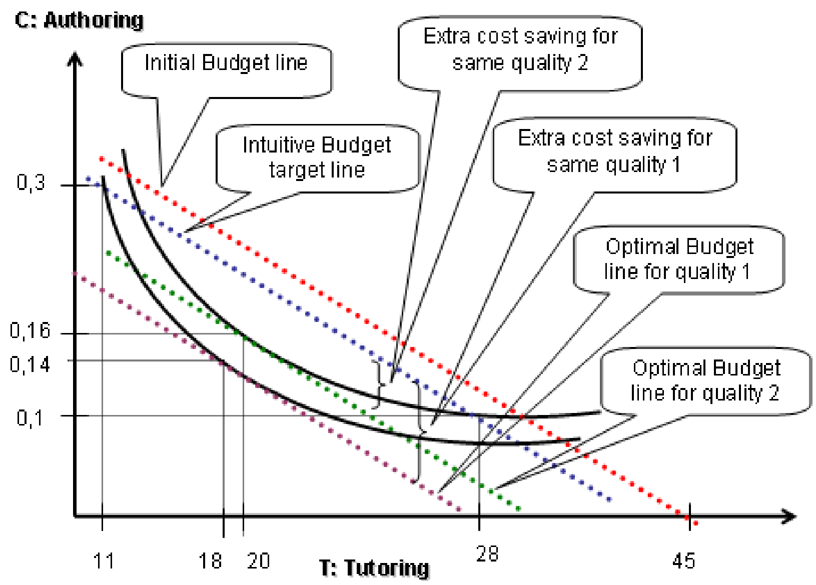

Fig. 3. Minimizing costs under quality constraint (small class case)

Table 2: Optimal authoring-tutoring mixes for a given quality

Cases and quality and cost impacts	Cost per student		Course effectiveness		Effective cost per student	
	US $	Index	Quality index	Internal return rate	US $	Index
Small class (60 students)						
Face to face class (C=0 ;T=45)	45,0	100,0	0,00	50%	90,0	100,0
Intuitive mix						
Over authored mix (C=0.3 ;T=11)	36,0	80,0	0,26	63%	57,1	63,5
Under authored mix (C=0.1 ;T=28)	36,0	80,0	0,29	65%	55,7	61,9
Optimal high authored mix case (C=0.14 ;T=18)	29,9	66,5	0,26	63%	47,5	52,8
Optimal low authored mix case (C=0.16 ;T=20)	33,6	74,6	0,29	65%	52,0	57,7
Large class (500 students)						
Face to face class (C=0 ;T=45)	45,0	100,0	0,00	50%	90,0	100,0
Intuitive mix						
Over authored mix (C=2 ;T=16)	36,0	80,0	0,70	85%	42,4	47,2
Under authored mix (C=0.1 ;T=35)	36,0	80,0	0,34	67%	53,9	59,9
Optimal high authored mix case (C=0.66 ;T=10)	34,3	76,2	0,70	85%	40,4	44,9
Optimal low authored mix case (C=1.37 ;T=21)	16,5	36,8	0,34	67%	24,8	40,4

A different way to find out an optimal choice is to stick to the aimed 20% lower cost and to determine the best mix authoring-tutoring which leads to the best delivery quality. This way is similar in fact to the one treated in example 1.
The main result brought by this second example simulation is the fact that lowering cost is not a best educational management system practice except if it is completed by targeting optimal delivery quality.

Other important result of the simulation is about optimal share of authoring. It appears that low authored mix may be better than an excessive authoring share even for large class course. This result is against general believing among educational manager who thinks that for large classes, a quasi total virtual class would be less cost than hybrid teaching. Actually this wrong thinking ignore to take in account increasing marginal cost of authoring which is related to its decreasing productivity.

5. Conclusion

Optimizing education costs by introducing ICT is a real challenge. This paper argued that it should be possible to lower education cost by optimizing authoring-tutoring mixes. The argument is based on several assumptions and conditions related to the innovation implementation at earlier stages which is worth to summarize in order to determine what could be help success in this way and avoid waste of resources.

A crucial assumption underneath all the argument is that adding an on line course yield better quality of delivery. That means that marginal productivity of on line course is positive. This assumption led to the fact that any mix of authoring tutoring is better than a totally face to face course. To make this assumption true, it is important to have skilled authors not only on the technical content of the course but also in the field of digital pedagogy. That is to say, that training teachers to make them able to write on line course must be a priority for ICT integration in education system.

A second important point in making educational management teams able to optimize cost is the knowledge of impact of ICT integration on the delivery quality. A lack of knowledge about the impact of using ICT in education (equation 1) is often a serious obstacle against optimizing managerial practice. Empirical studies in the field are rare. Economic analysis is not developed in this matter as it is in more traditional industries. So, a second priority in a strategy of ICT implementation is to attract researcher interest in this area.

A third condition is about institutional aspects. The shift from face to face or from a sub optimal authoring-tutoring mix to an optimal one may be seen by teachers as a threat to their interests. That is true especially if tutors cannot become authors. But, we should notice that improving cost quality balance of educative system can help expand its activities and create more employment opportunities. More enlightening studies of this point may help better understanding by teachers' community of real challenges and outcomes of the shift to E-learning.

Funding resources are an important issue also in capturing potential gains from ICT integration in education system. As it was shown above cost savings might lean in improving effectiveness of the system. In state funded education system, as in most of developing countries, budget authorities are more concerned by cost per student without considering enough the internal effectiveness of the system. New funding schemes in these cases would help setting the right share of on line courses in education systems.

6. References

[1] OECD: *E-learning in Tertiary Education: Where Do We Stand?*, OECD Publishing, 2005, pp. 7-10.

[2] Paul T. Walliker: "Cost Comparison: Instructor-Led Vs. E-Learning", June 2005, Retrieved May 25, 2008, from http://www.learningcircuits.org/2005/jun2005/walliker.htm

[3] In this paper, quality is related to effectiveness. For other quality notions: Ulf-Daniel Ehlers, Lutz Goertz, Barbara Hildebrandt, and Jan M. Pawlowski: *Quality in e-learning: Use and dissemination of quality approaches in European e-learning*, A study by the European Quality Observatory, Cedefop Panorama series, 116, Luxembourg: Office for Official Publications of the European Communities, 2005.

[4] UVT (www.uvt.rnu.tn) is a State funded university created in 2001 to provide other twelve Tunisian state universities with technical and pedagogical support and on line resources. UVT is also offering for its own web based curricula.

[5] Paul H. Douglas: The Cobb-Douglas Production Function Once Again: Its History, Its Testing, and Some New Empirical Values, *The Journal of Political Economy*, Vol. 84, No. 5 (Oct., 1976), pp. 903-915.

[6] We assume that $Q = 0.1\, C^{0.4}\, T^{0.6}$, $P_c = 5\,000$ US \$ and $P_t = 60$ US \$ per hour for a 60 student class and 500 US \$ for a 500 student class. Tutors are teaching 45 hours a class with 20 students per class at any size of the class. These assumptions translate some reality driven from UVT experience for the

costs and from industrial technology (substitution between inputs) for the quality function.