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On the Value of Pedagogical Assets[1]

Gabarro, Joaquim and Serna, Maria
Computer Science Department, Universitat Politècnica de Catalunya, Barcelona Tech, Spain.

Abstract

University education is facing new strategical changes that will lead to deep structural changes. Course organization is evolving and the organizational decisions have an economical impact. We propose a method to measure the present value of a pedagogical asset under a return rate. We apply the method to three courses in the Computer Science curricula taught at the Facultat d'Informatica de Barcelona of the Universitat Politècnica de Catalunya, Barcelona Tech. A large, compulsory, first year course (PRO1), a medium size undergraduate course (ALG) and a small specialized master course (AGT). Our results highlight that the present value gets higher values as a function of the size of the course and it goes in a negative relationship with respect to the level of computer support involved in their teaching.

Keywords: *Pedagogical assets; monetary value; present value; rate of return*

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1. Introduction

In the present Post Great Recession scenario money matters specially. This is of fundamental importance at Universities where higher education is considered (at least partially) a public good. There are many models of lecturing. In one extreme, lecturing may be based on small groups (and classrooms) and personalized attention to the students. On the other extreme, lecturing my have large groups, with strong multimedia and computer support and small or no so small groups for discussion. Both approaches are not disjoint and any mixture is possible. Some times the pedagogical objectives determine the teaching style. When more than one style allows to achieve the pedagogical objective, it is worth to know the expenses due to the different organizations. Roughly, we can associate to each pedagogical style a size and type of faculty staff. A model with small lecturing groups requires a big faculty staff. The different salary levels are a key determinat of the level of incurred expenses. In such environment academic managers working in public universities face an unavoidable dilemma: minimize expenses versus keeping a high quality education level. To quantify this dilemma in the context of computer supported education we propose a micro-economic model based on *pedagogical assets*. Recall that assets like stocks or bonds form the basic capital assets. G. Becker (1993), 1992 Nobel Prize in Economy, studied the human capital. There assets constitute the stock of knowledge, habits, social and personality attributes, including creativity, embodied in the ability to perform labor. Similarly, P. Bourdieu (1986) introduced the social capital and the related assets. Our proposed pedagogical assets are assets based in human and social capitals. They are multi-period assets that change trough time.

We argue that changes in the organizational aspects of lecturing, the ratio between live, computer supported and multimedia aspects, have an important economical impact. Courses with strong internet and computer supported content can become cheaper. Deep changes are coming form the USA. R. Sedgewick (2017) show us how live lectures in big auditoriums are becoming old fashioned. As he points out, he gave his last live lecture in September 2015. Live interactions between small groups of students and a lecturer can serve to discuss and enforce particular aspects of the video lecture trough practical work. This live interaction can also be used to motivate students and introduce more advanced material. There is a tiny equilibrium between online work and live presence of students and lecturers at the university. Live contacts are fundamental to develop a healthy society but the nature of these contacts need to be reshaped in the course planning. When a course is run for several years, time needs to be included to obtain the multi-year value of the whole course. T. Piketty (2014) relates money and time through the (annual) *rate of return* of the capital. The rate of return varies with the asset:, 7%–8% for long run stocks; 3%–4% for real state; even negative -0.25% – -0.1% for deposits. From the rate of return r, the value at year t of an initial inversion of $Q_0 = M$ euros can be computed using composite interest formula $Q_t = (1 + r)^t M$. From the point of view of year t, looking back in time, the *present value* of Q_t is $Q_t/(1 + r)^t$. We propose to use the sum of the present values of the flow of money expended (expenses minus incomes) Q along the years to measure the actual value of a pedagogical asset. In general, given a flow F of annual expenditures $Q_0,\ldots, Q_n$, with $n > 0$, and a rate of return r, the *net present value* of this flow is: $\mathrm{netPV}(F, r) = Q_0 + \frac{Q_1}{(1+r)} + \cdots + \frac{Q_n}{(1+r)^t}$. Observe that usually the rate of return is positive but in the last times this is changing and r can be negative. Observe that, when $-1 < r < 0$, benefits gives you extra money while loses are decreased.

When an entrepreneur buys a capital asset, for instance a loom or a truck, he expects to get some benefit using it, for instance a 5%. This idea was precised by I. Fisher (1930) in the *rate of return over cost*. J.M. Keynes (2007) inspired by it defined the *marginal efficiency*. Let P_S be the supply price defined as "the price which would induce a manufacturer to produce and additional unit of an asset". Consider the series of annuities $Q_1,\ldots,Q_n$, produced by the asset during its life. The *return* of this asset is the rate of discount r such that: $P_S = \frac{Q_1}{(1+r)} + \cdots + \frac{Q_n}{(1+r)^n}$. P_S is an initial investment, i.e., a negative yield $Q_0 = -P_S$. We can describe the asset by the series $F=(Q_0,\ldots,Q_n)$. Thus, the *internal rate of return* is the value r, if any, with $\mathrm{netPV}(F, r) = 0$. For a pedagogical asset, we take P_S as the initial investment in preparing the course. When possible we measure the efficiency of this asset by the internal rate of return.

In the remaining of the paper we precise the fundamental parameters that need to be quantified to perform the proposed analysis. We show how to calculate the present value and the internal rate of return of a pedagogical asset. Finally, we perform a monetary study of three pedagogical assets developed at the Informatics School, the Facultat d'Informàtica de Barcelona (FIB) in the Universitat Politècnica de Catalunya, Barcelona Tech (UPC). First, we use a massive first year course on programming (PRO1). Second, a medium size undergraduate course on algorithmics (ALG). Both courses are included in the curricula for the degree in Informatics Engineering. Finally, a small master course (AGT) in the curricula of the Master in Innovation and Research in Informatics. For those courses we provide the present value under different teaching organization and return rates. When possible, we also compute the internal rate of return. The obtained data shows, as expected, higher benefits as the size of the course increases and an opposite relation to the level of computer support involved in the teaching. On the other hand most of the studied scenarios lead to losses. In the scenarions with benefits the internal rate of return is quite high.

2. The Value of Pedagogical Assets

We develop here a model to estimate the monetary expenses and incomes of a pedagogical asset per year. From this flow, we compute the net present value under different return rates. We also compute, when possible, the internal rate of interest in order to compare the different assets. Lecturing in the EU is based in ECTS system. Each course in the curricula has an assigned number of ECTS, n_{ects}. On the other hand, students enrolling in a course have to pay a fix price per ECTS. So, we have two parameters n_{ects} and p_{ects}. These parameters are exogenous (or external) from the lecturers, they are fixed by UPC. The other parameter is the number of enrolled students *N*. Therefore, the monetary income at term *t*, assuming no variation on the exogenous parameters is $I_t(N_t, p_{ects}, n_{ects}) = N_t p_{ects} n_{ects}$. In UPC the p_{ects} varies with the degree. For the Bachelor's Degree, it is set to 39.53 and, for the Master's degree to 65.85.

An asset has associated expenses corresponding to the part of the salary of the lecturing staff running the course. We measure this part estimating on one side the number of working hours on the course of the teaching staff w_t and the average price of an hour of work p_h^t. Thus, the monetary expense at term t is $E_t = (w_t, p_h^t) = w_t p_h^t$. Estimating w_t requires to know the type of course, the teaching methodology, the division on groups, the teacher's experience, and the number of enrolled students. We provide later a separate analysis of w_t for each of the cases of study. For a given course and term, we have to estimate the price of one hour of work, p_h^t. This depends on the the teaching staff's size and composition. It is clear that the salary of a Full Professor (FP) is different from the salary of a Teaching Assistant (TA). We first estimate p_h^c , for each staff category c. Using those values, we estimate p_h^t as the average of the price per hour of the involved staff. In Table 1 we provide a summary of the considered categories and salaries.

Table 1. Teaching staff categories and wages (in euros).

	Annual	**P_{hour}**
Full Prof.	60498	43.21
Associate Prof.	45671	32.62
Teaching Ass.	7549	15.73

In computing those salaries (and p_h^c), we have taken into account the increases of salary due to years of work. We assume that a FP has over 15 years of experience, an Associated Professor (AP) around 10-12, and no experience for a TA. All positions are full time except TA which have a dedication of 480 hours per year. For full time positions, we estimate that, excluding holidays, an academic year has 40 weeks and that by law the work load is set to 35 hours per week. This gives a total of 1400 hours per year. Then, the price per hour is obtained dividing the annuity by the number of hours of work. The last column in Table 1 gives the obtained values of p_h^c. For a given University or Department it could be possible to get more precise estimations of p_h^c. However this seems unnecessary at this level of study as an "order of magnitude" is enough for our purposes.

Our final step is to analyze the net present value of a pedagogical asset *P*. We have to consider now that creating and a course has a price E_0. This price is determined by the work that the lecturers and administrative staff devote to the preparation. Once the course is running at year t, we asses the asset under interest r, in a period of n years, by $\mathrm{netPV}(P,r) = E_0 + \frac{E_1 - I_1}{(1+r)} + \cdots + \frac{E_n - I_n}{(1+r)^n}$. We say that P is making losses under interest r when $\mathrm{netPV}(P,r) > 0$, otherwise P is making benefits. When a pedagogical asset is making benefits, we can take it as an investment and we measure its efficiency of by the internal rate of return, i.e., the value r, if any, verifying $\mathrm{netPV}(P,r) = E_0 + \frac{E_1 - I_1}{(1+r)} + \cdots + \frac{E_n - I_n}{(1+r)^t} = 0$.

3. Analyzing some Pedagogical Assets

The Computer Science (CS) Department of the UPC, has been taking care of the first programming course, PRO1, delivered at the FIB along the years. From the beginning a structured approach to programming has been taken. Roughly, the course evolved, along the years, from a formal approach to a hands-on practical view. A big part of the current design is the use of computer support for practical programming. We use *Jutge*, an open educational online programming judge designed for students and instructors, featuring a repository of problems that is well organized by courses, topics and difficulty (Petit et al., 2012). The other two courses that we took in this study are also organized by the CS Department. The *Algorithmics* course (ALG) is a compulsory course for students having a major in Computing placed in the first semester of the third year. The *Algorithmic Game Theory* course (AGT) is an optional subject in a Master degree.

PRO1 has been assigned 7.5 ECTS while ALG and AGT have a load of 6 ECTS. PRO1 and ALG are offered the two semesters and AGT only in the first one. The students on the second semester of PRO1 are a subset of those in the second one, as there is no entrance in the second semester. Following, M. Blesa et al., (2016) we consider only data from the first semester. In contraposition, there is a very small overlap in the students ALG in the two terms, in this case we aggregate the data.

M. Blesa et al., (2016) provided an analysis of the pedagogical efficiency in PRO1 on a period of 5 years. We consider here the same period and take the fundamental parameters for our study w_t and N_t from there. We extract information from ALG and AGT to cover data in a similar period of 5 academic years and estimate the corresponding parameters by gathering information from the teaching staff in the corresponding period. The corresponding data is given in Table 2. As it can be seen from the data, the demand has grown along the years, for both ALG and AGT.

The splitting into groups of PRO1 has been almost uniform along the considered period involving a total of 20 teaching staff. The teaching of AGT involved just one group.

Table 2. Work load (in hours) and number of students.

	PRO1		ALG						AGT	
	Fall		Spring			Fall			Fall	
Period	N_t	W_t	g_t	N_t	W_t	g_t	N_t	W_t	N_t	W_t
t_0		196.00						190.00		250.00
t_1	493	4232.00	2	30	324.50	3	55	463.25	5	390.25
t_2	492	4177.00	3	44	428.6	3	60	479.00	7	394.75
t_3	465	4080.00	2	46	374.90	3	76	529.40	12	406.00
t_4	436	3851.00	3	59	475.85	4	78	595.70	16	415.00
t_5	448	4303.00								

In the case of ALG the subdivision in groups for practical lectures varies from 2 to 4 and this number (g_t) is given in Table 2. The number of involved teaching staff, for ALG, is $1 + g_t$. From those numbers, we can obtain estimations of p_h^t by setting the category pattern of the staff, (n_{FP}, n_{AP}, n_{TA}). We estimate p_h^t as the average price per hour of the selected composition. For PRO1, we consider three cases. **Case 1** (*1,1,18*) giving $p_h^t = 17.95$. **Case 2** (*1,2,17*) giving $p_h^t = 18.79$. **Case 3** (*3,17,0*) giving $p_h^t = 34.21$. For ALG, the value of p_h^t depends on the number of groups of the term. However, we consider three situations: **Case 1** (*1,0,g_t*), **Case 2** (*1,g_t/2, g_t/2*) and **Case 3** *(1, g_t,0)*. The values of p_h^t are in the range 21.23 to 24.89 (**Case 1),** 27.98 to 30.52 (**Case 2)** and 34.74 to 36.15 (**Case 3)**. For AGT we assume $p_h^t = 43.21$, i.e., a full professor.

Finally, we have to estimate the time needed to start up a course. This involves several tasks by the coordinator: meetings with the previous coordinators, first versions of lecturing materials, docs, slides, setting computer support systems ets. Even if we assume basic knowledge of the topic, the course preparation can involve in some cases, training of the future teachers, especially of the involved TAs. Our estimate for E_0 follows from an appretiation of the coordinators of the corresponding courses at the initial term of our studies. Those values are given in Table 3, together with the values of expenses and incomes, for the considered cases of teaching staff composition.

The net present values are given in Tables 4 and 5, for the different values of r. We take values for r from -0.250 to 0.1 to cover cases from moderate loses to moderate gains. Observe that in many cases the yields $I_t - E_t$ are always negative. So, no internal rate of return can be computed. We get positive yields for PRO1 (**Case 1** and **Case 2**) and ALG (**Case 1**).

Table 3. Values of I_t and E_t (in thousands of euros).

	PRO1				ALG				AGT	
		Case 1	Case 2	Case3		Case	Case	Case 3		Case 1
	I_t	E_t	E_t	E_t	I_t	E_t	E_t	E_t	I_t	E_t
t_0	0.000	3.517	4.945	6.705	0.000	4.729	5.798	6.868	0.000	10.802
t_1	146.162	75.948	106.788	144.779	20.160	18.546	23.307	28.068	0.329	16.862
t_2	145.865	74.960	105.401	142.898	23.480	20.511	26.260	32.008	0.460	17.057
t_3	137.860	73.220	102.953	139.579	24.666	21.295	26.759	32.223	0.790	17.543
t_4	129.263	69.110	97.174	131.745	25.141	23.398	30.437	37.475	1.053	17.932.
t_5	132.820	77.222	108.580	147.208						

Table 4. Values of netPV for PRO1 (in euros).

r	Case 1	Case 2	Case 3
-0.250	-275651.07	-150120.70	4511.92
-0.100	-281454.61	-149572.73	12883.90
-0.010	-313127.21	-163858.00	20016.92
0.000	-317993.35	-166127.90	20945.17
0.001	-323138.26	-168537.89	21904.15
0.100	-382560.86	-196771.14	32091.00

Table 5. Values of netPV for ALG and AGT (in euros).

	ALG			AGT
r	Case 1	Case 2	Case 3	Case 1
-0.250	-125.02	12281.04	24687.10	44946.13
-0.100	-2729.23	15882.73	34494.69	62412.52
-0.010	-4723.55	18756.31	42236.18	75905.50
0.000	-4967.56	19113.93	43195.42	77563.76
0.001	-5216.28	19479.71	44175.71	79255.65
0.100	-7676.99	23162.85	54002.70	96080.90

Cases 1 and 2 for PRO1, due to average low wage, provide a high benefit largely covering the supply price 3517.44. The corresponding internal rate of return is

18.96 and 7.97 respectively, which constitute and incredible internal rate of return. For Case 1 for ALG the internal rate of return is 0.34 which still can be considered high.

5. Conclusions and Open Problems

Universities need to be high quality, but budgets are being cut (or maintained). Nowadays computer supported education is a reality opening new opportunities and challenges. After introducing a computer supported concept, it is possible to practice it “unattended”, provided the adequate tools are created. The role of a lecturer in such topics is closer to “coaching” than to “teaching”. This fact can make university teaching cheaper. However, interaction with people continues to be fundamental in today’s higher education. The correct rate people versus multimedia content is an interesting open problem that depends on the topic.

In this paper we have performed a study of some courses in isolation. It would be of interest to have monetary valuations of Bachelor or Master degrees seen as a unique pedagogical asset. In this context it could be acceptable to make losses in a course if in other courses there are benefits. From our study it can be seen that quite usual teaching staff combinations are giving losses. While, other cases, with quite low wages, provide benefits and internal rates of return from 18.96 to 0.15. In a global view the combination of courses with benefits and looses might provide a more realistic estimation.

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