The impact of ICT's on students' performance in Higher Education: Direct effects, Indirect effects and Organizational change[*]

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Abstract

The purpose of the present paper is to examine the relationship between the use of Information and Communication Technologies (ICT) and students' performance in Higher Education. Earlier economic research has failed to provide a clear consensus on the effect of ICTs' investments on student's achievement.

Our paper aims at summarizing the main findings of the literature and to give two complementary explanations.

The first one focuses on the indirect effects of ICT on standard explanatory factors. Since student's performance is mainly explained by student's characteristics, educational environment and teachers characteristics, ICT may impact those determinants and consequently the outcome of education. The differences observed in students' performances are thus more related to the differentiated impact of ICT on standard explanatory factors.

The second thesis advocates that ICT uses need a change in the organization of the Higher Education. While ICT equipment and uses rates are growing very fast in the European Union, the adoption of complementary organizational designs is very slow and differs from one institution to another. This may explain the observed differences in student's achievement.

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Introduction

During the last two decades the higher education institutions have invested heavily in Information and Communication Technologies (ICT). ICT have impacted the university context, organization and the teaching and learning methods.

One puzzling question is the effective impact of these technologies on student's achievement and on the returns of education. Plethoric academic researches have tried to answer this question at the theoretical and the empirical levels. They faced two main difficulties. On one hand, student's performance is hard to observe and there is still confusion about its definition. On the other hand, ICT are evolving technologies and their effects are difficult to isolate from their environment.

There's no standard definition for students' performance. Standard approach focuses on achievement and curricula. How students understand the courses and obtain their degrees or their marks. However, more extensive definition deals with competencies, skills and attitudes learned through the education experience. The narrow definition allows the observation of the outcomes of any change in higher education. The more extensive definition needs a more complex strategy of observation and a focus on the labour market. The outcomes of education are mainly validated in the labour market.

The relationship between the use of Information and Communication Technologies (ICT) and students' performance in Higher Education is not clear. The literature shows contradictory results. Earlier economic research has failed to provide a clear consensus concerning the effect on students' achievement.

Starting from this point, the aims of this paper are two-folds: first, we summarize the main findings of this extensive literature and second, we give two complementary explanations on the contradictory results. Our first explanation is that most of the literature has focused on direct effects of ICT while it's more appropriate to look at the indirect effects through the traditional channels. Since student's performance is mainly explained by student's characteristics, educational environment and teachers' characteristics, ICT may impact those determinants and consequently the outcome of education. The differences observed in the performances of students are thus more related to the differentiated impact of ICT on the standard determinants.

The second explanatory hypothesis is to suppose that ICT needs a shift in organization. While ICT equipment and uses rates are growing very fast in the European Union, the adoption of complementary organizational designs is very slow and differs from one institution to another. This may explain the observed differences in student's achievement.

Our paper is structured as follow: section one surveys the literature on students' performance and the use of ICT, section two explains the impacts of ICT on the traditional determinants of students' performance and finally, section three underlines the role of organizational change in education on the students' performance.

1. ICT and students' performance: No clear direct effects

The direct link between ICT use and students' performance was in the heart of an extensive literature during the last two decades. Several studies have tried to explain the role and the added value of those technologies on classrooms and on student's performances. The first body of the literature explored the impact of computers uses. Since the Internet revolution, there's a shift in the literature that focuses more on the impact of online activities: use of Internet, use of educative online platforms, digital devices, use of blogs and wikis…

This literature shows mixed results. On one hand, several researches demonstrate that there's no evidence of a key role for ICT in High Education (Angrist and Lavy (2002); Banerjee et al. (2004); Goolsbee and Guryan (2002); Kirkpatrick and Cuban (1998)). On the other hand some studies show a real impact of ICT on students' achievement (Kulik, 1999; Sosin et al. 2004; Fushs and Wossman, 2004; Talley, 2005; Coates et al. 2004).

(a) ICT does not play a role in students' achievement

Coates et al. (2004) surveyed three matched pairs of face-to-face and online principles of economics courses taught at three different institutions. The students' score in the Test of Understanding College Level Economics (TUCE) administered at the end of the semester is used as the measure of learning outcomes. After controlling for selection bias and differences in student characteristics, they report that the average TUCE scores is almost 15% higher for the face-to-face format than for the online format.

Anstine and Skidmore (2005) surveyed two matched pairs of on-campus and online courses, one in statistics, and the other in managerial economics. They report that after controlling for student characteristics and selection bias, students in the online format of the statistics class exam scored 14.1% less than in the traditional format, whereas, for the managerial economics class the test scores within both formats were not significantly different.

Navarro and Shoemaker (1999) surveyed a matched pair of on-campus and online sections of a class in principles of macroeconomics. The students self-selected the instruction format, each section was approximately 30 students, and there was no difference in the demographic composition of each section. They used a simple comparison of means of test scores and reported no-significant difference in academic performance between the two formats.

Terry, Lewer and Macy (2003) surveyed 240 students in a program offering courses in the three formats of online, on-campus, and hybrid. Using a standard regression model where final exam score is the dependent variable and student characteristics are the independent variables, they report that predicted exam scores for students in the online courses were significantly less than those of students in the on-campus and in the hybrid formats. However, the comparison of exam scores between students in the hybrid and students in the on-campus classes report no significant difference.

Brown and Liedholm (2002) surveyed students in a match pair of online and face-to-face principles of economics course taught by the same teacher. They reported that

exam scores, after controlling for differences in student characteristics, are approximately 6 percent higher for the on-campus format than for the online format. They attribute the relatively better performance in the on-campus classes to the benefit of in-person teacher-student interactions, and attribute the relatively poorer performance of the students in the online class to the lack of self-discipline necessary for successful independent learning in the online environment.

Leuven et al. (2004), conclude that there's no evidence relationship between increased educational use of ICT's and students' performance. In fact, they find a consistently negative and marginally significant relationship between ICT's use and some student achievement measures.

Students may use ICT to increase their leisure time and have less time to study. Online gaming, increased communications channels do not mean necessarily increased achievement. Many other explanations were advocated.

(b) ICT play a role in students' achievement

Kulik (1994) meta-analysis study revealed that on average, students who used ICT-based instruction scored higher than students without computers. The students also learn more in less time and they like their classes more when ICT-based instruction was included.

Sosin et *al*. (2004) construct a database of 67 sections of introductory economics, enrolling 3,986 students, taught by 30 instructors across 15 institutions in the United States of America during the spring and fall semesters of 2002. They found significant but small positive impact on students' performance due to ICT use. But they show that some ICT seem to be positively correlated to the performance while the others are not!

Fuchs and Woessman (2004), used international data from the Programme for International Student Assessment (PISA). They show that while the bivariate correlation between the availability of ICTs and students' performance is strongly and significantly positive, the correlation becomes small and insignificant when other student environment characteristics are taken into consideration.

The analysis of the effects of these methodological and technological innovations on students' attitude towards the learning process and on students' performance seems to be evolving towards a consensus according to which an appropriate use of digital technologies in higher education can have significant positive effects both on students' attitude and achievement.

Attwell and Battle (1999) examined the relationship between having a home computer and school performance, for a sample of approximately 64,300 students in the United States. Their findings suggest that students, who have access to a computer at home, for educational purposes, demonstrate improved scores in reading and math.

Coates et al (2004), show that students in on-campus courses used to score better than their online counterparts, but this difference is not significant here.

Li et al. (2003) pointed out: "*First, web-based instruction presents information in a non-linear style, allowing students to explore new information via browsing and cross-referencing activities. Second, web-based teaching supports active learning processes emphasized by constructivist theory. Third, web-based education is enhanced understanding through improved visualization and finally, the convenience, it could be used any time, at any place*".

(c) A need for a clarification and for more appropriate explanations

Fuchs and Woessman (2004) report two hypotheses explaining the mixed results shown in the literature. The first one run down to the point that everything else equal, ICT constitute an input in students' learning process that should help produce better learning output. ICT use can enhance learning by making education less dependent on differing teacher quality and by making education available at home throughout the day. Authors argue that the use of ICTs can positively infer knowledge to students. Furthermore, ICT use can help students exploit enormous information possibilities for schooling purposes and can increase learning through communication.

The second hypothesis combines arguments that:

Actually, everything else is not equal, ICT based instruction induces reallocations, substituting alternative, possibly more effective forms of instruction. Given a constant overall instruction time, this may decrease student performance. Also, given that budgets are not perfectly elastic, the introduction of ICT based instruction can result in a reallocation of funds in favour of ICTs, possibly substituting more effective instructional materials.

ICTs can distract learning. This may be particularly salient at home, where computers may be used mainly to play computer games and Internet access could be source of distraction because of chat rooms or online games, reducing the time spent in doing homework or learning. Thus, the impact of the availability of ICTs on student learning will strongly depend on their specific uses.

ICT-based instruction could restrict the creativity of learner. ICT tend to allow acting only in a predefined way with limited interactive possibilities. This might reduce students' abilities in terms of problem solving and creativity thinking in predetermined schemes but not coming up with independent creative solutions by their own.

For a better understanding of the link between student's performance and ICT usage, we suggest two alternative research strategies in the next sections. The first one consists in examining the impact of ICT on traditional explanatory variables of student's achievement. The students' performance depends on other explanatory factors and we may have a deep impact of ICT on these factors. Thus, differences in the observed performance depend on the nature and the intensity of these changes. The second explanation is given by the economic literature concerning of ICT's performances in economic sectors. In fact, education is a specific sector but can be considered as an economic sector and the literature of the "productivity paradox" suggest that organizational change is the key explanation of ICT performances (Sharpe, 2004).

2. Students' performances: Indirect effects

Students' performance is a puzzling question in education science and economics. The general approach followed by economics is to suppose a model of added value based on the educational production function. This methodology consists of evaluating the effect of the educational inputs (characteristics and attitudes of the teachers, physical resources committed in the universities, the teaching organization, the rate of students framing, etc.) on the students' performance by controlling other inputs (socio-economic origin, characteristics and attitudes of the students) (Hanusek, 1996, Jaag, 2006; Lazear, 2001; Krueger, 1999, etc). A large literature is dedicated to this subject and this section is not aiming to survey such research. However, the findings suggest consistent trends and evidence on the relationship between educational environment, students' characteristics, teachers' characteristics and performance of students and we propose to discuss them.

1.2. Students' characteristics

The first approach examines the effect of the students' socio-economic characteristics on their educational performances. Initial socio-economic differences are determinant of their achievement (age, gender, family structure, level of parents' education, geographical area…). A body of literature focuses on the relationship between the students' school results and the students' socio-economic characteristics.

Pozo and Stull (2006) highlight the importance of the initial provisions (secondary studies and competences in mathematics) in the university success. The secondary performances depend also on socio-economic variables. The students who come from underprivileged socio-economic milieu have worse school performances than the less underprivileged students (Conger et al., 1997; Haveman and Wolfe, 1995; Wilson, 1987). Bratti et al. (2007) show that the differences in students' performance can be explained by the differences between the areas in economic terms of structures, of devices of regional leisure, type of the institutions and the individual characteristics of the students (family and social characteristic).

Didia and Hasnat (1998) examined the determinants of student performance in an introductory finance course. They found that age, as a measure of maturity, had a significant influence on performance. Reid (1983) focused his study on an introductory university economics course and also found that age was a significant variable with older students performing better than younger ones.

Jaggia and Kelly-Hawke (1999) included variables concerning school inputs and student's family background in order to test whether these two kinds of variables influence student performance. They found that higher levels of spending did not have any consistent relationship with student performance. However, family background was clearly very important in explaining differences in achievement.

The link between the ICT revolution and the socio-economic variables seems very narrow. Family structure, Social environment and related variables are not sensitive to ICT; yet, ICT may act on secondary education and contribute to better achievement.

However, ICT may impact students' motivation. Becker (2000) found that ICT increases student engagement, which leads to increased amount of time students spend working outside class time.

2.1. Educational environment

The second body of economic literature aims to evaluate the impact of the educational inputs on students' performance using educational production functions (Hanusek, 2003; Glen, 2006; Glewwe et al., 2004, Glewwee and Kremer, 2006; Todd and Wolpin, 2003). Their starting point is the more the students' benefits from the physical environment of education the better is their achievement. Thus, increasing physical investment in education must lead to better results and performances.

One prominent variable catching the environment and physical investment is the class size. A better higher education environment is correlated with small classrooms. While the theoretical hypothesis seems evident, empirical research is more controversial. On one hand, Krueger, (1999); Angrist and Lavy (2004) provide a proof in favour of the positive and significant effect of the classes with small size. Arias and Walker (2004) conducted an experiment to test the relationship between class size and student performance. They controlled for variation in instruction, lecture material, and topic coverage by using the same instructors. They found statistically significant evidence that small class size had a positive impact on student performance. On the other hand, Hanusek (2003) had already shown that one cannot conclude in an unquestionable way that the reduction of the classes' size improves the students' performance. Hoxby (2000), by using data on the United States, does not succeed in finding an effect of the class size on the students' performances. This result was confirmed by other studies conducted by Dustmann, (2003); Mosteller, (1995) and Jaag (2006) that showed the existence from a significant and single effect of the class size on the students' performance.

The effect of the rate of students framing is also subject of controversies. In certain studies, one finds that, when it is weak, it can have a positive effect on the students' performance. Thus, starting from the results in mathematics in 148 school institutions in England, Raudenbush and Willms (1995) showed that a reduction in this ratio from 25 to 16 would increase the students' performance. On the other hand, by using data collected in England between 1992 and 1996, Bradley and Taylor (1998) found that the number of the students by teacher does not have an effect on the students' performance. However, they obtained a significant but weak impact when they studied the relationship between the variation of this number between 1992 and 1998 and the variation of the performances on the examinations during the same period.

Investing in ICT can be considered as physical investments that improve the educational environment. First, ICT may act as a mean by which HEI implement interactive learning based on reduced class size approach. The use of ICT in Higher Education is allowing a shift from a teacher-based approach to a student-based approach (Becker, 1997).

Second, since the usage of ICT leads to asynchronous learning the class size does not matter. By the usage of computers and Internet students have more time to interact with

the course. They are not constrained by the available time of face to face where their understanding and participation depend on the number of students. Third, concerning networks economics, the value of the network depends on the number of its users. Thus, the number of students may have a positive effect in online courses. This result depends on the teachers motivation and students characteristics

2.3. Teachers' characteristics

The third branch highlighted the effects of teachers' characteristics on students' performance. The influence of the teacher on students' performance had already been shown in the seventies by research of the type process-product of Rosenshine (1971) and those of Bloom (1979). These studies connected the behaviour of the teacher (process) with the training of the student (produced).

In recent empirical studies conducted in the United States, Rivkin et al. (2005) find that teachers in their first or second year of teaching are associated with lower students' performance in Texas, but teacher education and certification have no systematic relationship with performance. Jepsen and Rivkin (2002) obtain similar results using grade-level data from California. Preliminary results from Clotfelter et al. (2003) suggest positive impacts of teacher experience and teacher license test scores on student achievement in North Carolina. Betts et al. (2003) find mixed results for teacher characteristics using detailed individual-level data in the San Diego Unified School District.

The lack of significant effects for these teacher characteristics should not be interpreted as evidence that teachers have no impact on students' performance. Teacher quality, measured by teacher fixed effects, has an important impact on student's achievement in Rockoff (2004). In addition, Hanushek (1971) and Murnane (1975) find significant impacts of classroom fixed effects (i.e. combined impact of teachers and peers). Rivkin et al. (2005) find large effects for overall teacher effects measured at the grade level. In other words, teacher quality may be important, but it is not well captured by levels of teacher experience, certification, and education.

Recent research has pointed at the importance of transforming teaching in order to integrate ICT effectively. ICT is seeing as a catalyst of system, community, school or classroom reform because it provides opportunities to shift from teacher centred to student centred learning. In turn, ICT could also increase the pedagogical repertoire of teachers. This teacher effect is most likely to improve the outcomes of disadvantaged students because it attends to individual need and provides a variety of curriculum and assessment strategies to promote student capabilities across a range of learning outcomes. In that sense, good pedagogical practice in the use of ICT to enhance the learning of students who are disadvantaged is good pedagogical practice for all students. ICT may impact Teacher quality and characteristics and since then students' performances and achievement. Three complementary effects may be observed: First, teachers' acts may be completed by the use of learning object from Internet. The process of learning is not only based on teachers' materials. Second, teachers are acting as learners in the new setting of education. Teachers learn from peers and also from students. They are co-constructing the courses and are more sensitive to the students'

participation. ICT is transforming the classrooms and focusing the learning more on the process. Third and related to the two first points, while initial competencies and degrees of teachers' remain important, new skills are needed and students' performance seems dependant on the ability of teachers to develop these new competencies and skills. Extended training is needed in this subject in the European Union.

Basic Effects of ICT on The Teaching Process

- Has an edit effect in terms of quality of student work and practical examples through visualisation;
- Improves poor handwriting and languages skills through word processing;
- Equalises individual differences and particularly has dramatic effects for students with special needs;
- Facilitates self pacing with increased capacities to deal with individual learning styles as students can work at the pace and intensity suitable to their needs;
- Enables collaborative learning with little indication of the isolated learner;
- Encourages use of peer coaching and peer reviews;
- Develops communication skills and awareness of different audiences;
- Impacts on resource–based learning and access to real world information through the Web;
- Increases information's reliability and accuracy adding to authenticity of learning tasks, with realistic and up-to-date information;
- Increases student motivation through hands on activity, visual representations and improved modes of presentation;
- Encourages independent learning and individual preferences for process, layout, style and format;
- Gives students more control;
- Allows students to produce high quality multimedia products;
- Changes teacher practices, planning tools and assessment rubrics;
- Increases opportunities for classes to evolve and for student experiences to shape outcomes.
- Has motivated students to commit to learn and to participate in learning activities,
- Has improved students' quality of work and has given them the confidence to perform enhanced learning tasks,
- Has allowed students to learn independently, which has enabled more work to be completed, and
- Has enhanced achievement due to the reinforcement and practice that ICT has afforded.

3. ICT and students' performance: A lack in organizational change

Looking at the link between ICT and student's performances seems nowadays a misunderstanding of the role and the nature of these technologies. In fact, since ICTs are

General Purposes Technologies' (GPT's), they need to be specified in order to meet the needs expressed by students and to be adapted to their local context and constraints (Antonelli, 2003; Ben Youssef, 2008). A variety of models of usages can be identified leading to the same outcome. ICTs bring widened possibilities for the learning processes that are independent from place and space. ICTs also allow more flexible (asynchronous) and more personalized learning. They are offering new methods of delivering higher education. Taking advantage of these opportunities need a deep change in the organization of the higher education system (universities).

Economic literature has shown in the last decade that the technological change, by its own, does not lead to any change in the economic performance. Among the most popular explanations of this Paradox - huge investment in ICT without any economic performance - the complementarity thesis seems to be the most accepted nowadays (Greenan and Mairesse, 2004). Old methods need old educative technologies and new technologies need new organizational innovations. There's an agreement between researchers that the usage of ICT requires the usage of New Organizational Designs and a shift organization. Higher Education is not an exception and needs a huge organizational change.

Organization is defined as the way decision-making units are structured within an institution (here universities or Higher Education Institutions), the way the decision-making power and skills are distributed and the type of information and communication structures in place. Thus any change in the distribution of power, skills, and information or in the lines of communication constitutes an organizational change (Sah and Stiglitz, 1986). From an evolutionist perspective (Nelson and Winter, 1982) organizational change is a change in the routines that the universities operate. The Potential benefits, implications and challenges of introducing ICT into schools can be very different depending on the vision and the understanding of the nature of this change, as well as strategies for its management adopted by the leadership at the school level and beyond. (UNESCO, 2003)

Hargreaves (1997) and Meighan (1997) argue that merging ICT and education requires organizational changes at the level of the whole system: in the direction of allowing more distance-learning or even virtual schooling, thus changing the attitude towards time, place, curriculum and other connected attributes of the system.

ICTs have a deep impact on classrooms. They add a complexity to a non-linear system. This complexity needs a huge change in organization. Downes (2001) differentiates among four levels of use of ICT in the classroom:

Level 1: ICT skills are added into school program through a separate ICT subject, while teacher practices in subjects remain unchanged;

Level 2: ICT skills are integrated into teachers' daily work with some teachers' pedagogical practices and classroom behaviour remaining the same, while the practices of others change more radically;

Level 3: ICT is transformative at the classroom level as it changes content as well as pedagogy (what students learn as well as how they learn it);

Level 4: ICT is transformative at the system level leading to changes in the organizational and structural features of schooling.

Performance is then observed when the institutions reach the third or the fourth levels. Most of the universities are currently working at level one and two, especially universities with scarce and few resources. The usage of computers into classrooms is more often based on the vision of the teacher and his or her believes about the ICT. In some cases, when ICT are introduced without changes in organization this may lead to lower the performances of the students and the outcomes of the education.

From our perspective, organizational change related to ICT and its link to students' performance need to focus at least on four basic principles. First, ICT are collaborative technologies and need to be used according to this. Second ICT allows the personalization of education and personal services are a key element of ICT in education. Third, Universities must be viewed as learning organization. Fourth, the outcomes of education are changing by ICT and we need to focus more on competencies rather than curricula.

i. A shift to a more collaborative and less individualist model of learning

Few economic studies have tried to examine this dimension in the higher education sector. Fullan (1999) mentions that reforms failed due to the problem of changes in collaborative culture among students and between students and teachers. ICTs are mainly collaborative technologies and interactive ones. Improving the outcomes of the learning process needs a change in the way students interact. This is not a trivial dimension. Nowadays several technologies allow co-writing and sharing resources (Wikis, Blogs…). The collaborative and cooperative dimensions of the learning process are fundamental and an organizational change is needed in order to explore this dimension. Collaboration is also one of the most seeked skills in the job market. By enhancing the learning of this kind of skills, Higher Education provides the job market with better workers.

ii. ICT allows personalized learning and organization must follow this trend.

ICT are based on individual access, Personal mobile phone, Personal computer… besides, the personalization of the Web is the new trend. This fact implies that the needs and the competencies of students are quiet different and since ICT allows to have a one-by-one learning, a more personalized learning may constitutes the future trend of Higher Education. Better achievement of students is easier to obtain since the learning is personalized and customized. However, this implies a huge change in the format, in the organization of the classrooms and in the competencies and the availability of teachers. The differences observed in the impact of ICT on the performances of students may be explained by this fact. Wherever the introduction of ICT is associated with a personalized service for students, the performances increase.

iii. Universities as a learning organization

Hargreaves (1997) and Meighan (1997) argue that the potential impact of the implementation of ICTs in high education will not be observable without organizational changes at the level of the whole system. Universities must act as a learning organization. ICTs imply more interactions among all the actors. The institution is then developing a collective learning by changing its rules and routines. But the main change is that innovation becomes in the heart of the learning process. Teachers and Students are exploring the new possibilities given by these technologies and constructing capabilities concerning learning through ICT. Building absorptive capabilities concerning ICT usage in education becomes a discriminatory element among universities. The attitudes toward time, place, curriculum and other connected attributes of the system on a systemic level are changing.

iv. The outcomes of higher education are changing

The impact of ICT on the learning process seems to be more important and requires more than looking only to curricula. Improved student outcomes, with regard to: Motivation, enjoying learning; Self-esteem; ICT Skills; Collaborative skills; Subject-knowledge; Information handling skills; meta-cognitive skills… are observed.

In the European Higher Institutions, while students and teachers seem to be using more and more intensively the new available technologies, organizational designs are changing slowly. The lack of a strategy regarding organizational change, as several studies have showed, leads to a weak impact of the use of ICT on students' performance.

Flexibility of the trainings

The ICT are supposed to exploit the flexibility of the trainings. The rythm of study, the allocation of time and the availability of teachers can allow a better articulation between private life/professional life (studies) as well as a better allocation of time between the various uses. This allows a better students' performance in pecuniary terms of profits and achievement. Another channel would be the quality of the formation. The teaching supports, the availability of the resources and the variety of the training channels would change following the introduction of the ICT. This would make it possible to the students to acquire e-skills and to develop them in the labour market (OECD, 2006). Some go as far as claiming that the use of the innovating models of training permitted by the introduction of the ICT would make it possible to the students “to carry out a team work, to share knowledge and to decrease individualism in order to promote the authorized capital” (Lundin and Magnusson, 2003).

Conclusion

This article has tried to summarize the main findings in economic literature concerning ICT's usage and student’s achievement. ICT seems to have a deep impact on the process of learning in higher education by offering new possibilities for learners and teachers. These possibilities can have an impact on student performances and achievement. Empirical literature shows contradictory results in this field. Three different arguments

can be given in order to explain this lack of empirical evidence. First, since ICTs are GPTs and immature by nature. They need a long process of appropriation and exploration of their possibilities by the Higher Education Institutions before observing any significant change. This was the case in other economic sector and it's also true in higher education. Second, for us, we consider the lack of organizational change in high education the main explanation. While Universities have invested heavily in equipment and at the same time students and teachers are using more and more these technologies, there's little change on the organizational side. The adoption of complementary organizational innovations is the masterpiece of student's performances and achievement. Third, returns of education using ICT are changing. Students are acquiring new skills and new competencies – more collaboration, team building, project management – closer to the needs in the job market and perhaps less performance on curricula. Observing the performances of students needs to deal more with these topics and less with – knowledge of specific topic and curricula.

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