MEASURING COMPETENCE IN COMPUTER SKILLS

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1. INTRODUCTION

The aim of this paper is to suggest and to test a strategy for measuring and analysing personal, practical knowledge of core computer skills. These skills are crucial for success in the labour market and in nearly every field of human activity (Zang and Espinoza, 1997). The motivation for undertaking this research derives from the evident and increasing importance that ICT has in a knowledge-based economy. This in turn highlights the need for suitable statistical information on its development and diffusion (Romer, 1990; Foray and Lundvall, 1996; Colombo and Grilli, 2004). In spite of this clear need, official national and international statistics have not provided adequate information for in-depth study about the diffusion, the characteristics of knowledge and skills in the new economy and some other important correlated aspects such as ICT skills shortage, gaps or mismatches (European Commission, 2004). Furthermore, the lack of data does not concern computer spread and other electronic and communication devices but rather systematic and repeatable information about demand and supply of skilled workers, changes in capabilities, knowledge diffusion and utilisation, production process organization changes, foreign direct investments property links, etc.

Eurostat started a working group on statistics connected to the ICT society in 2001 to face the need of harmonized information on ICT usage in households/individuals and enterprises. In Italy, in the field of business statistics, ISTAT carries out a survey on firms with more then 10 employees that includes some questions suggested by Eurostat on computer and related technology usage, internet access and e-commerce (Demunter, 2004). The National Association of Chambers of Commerce performs another important survey on the demand for new employees and their skills in many activities including computers. In order to gather information at the household level, Eurostat designed a questionnaire to be added by most EU member States to their national household surveys every

year (Demunter, 2004). In Italy this questionnaire, which includes some questions on computer and internet use, has been introduced since 2002 in the annual multipurpose survey on "Aspects of daily life". Moreover computer and internet usage by individuals was analysed by ISTAT for the first time in 2000 within the five years survey "Citizens and their leisure time" (Morrone and Zanella, 2004), which collected information on the reasons, the places and the time spent using the computer. However, all the cited surveys do not provide detailed information on individual practical capabilities and skills and above all they do not satisfy the need to measure them adequately.

Because the lack of suitable statistics on individual competence we decided to identify and to evaluate actual individual skills in the use of core computer applications, and to test an approach for collecting data on those capabilities through a fairly simple, cheap and repeatable survey. The aim of this analysis is to devise and suggest an instrument to measure computer skills that could eventually be integrated into current labour force surveys. Such an instrument could accordingly be used to improve current statistics on human capital and on the labour force. Data on personal knowledge and skills could be particularly useful for the estimation of economic models, such as earnings functions, where those characteristics are typically introduced as independent variables in order to predict workers' wage. Because of the lack of information on these variables, they are often simulated or treated as latent (Farber and Gibbon, 1996; Chiappori *et al.*, 1999; Altonji and Pierret, 2001).

This paper also focuses on the need to provide data for local analysis where lack of data is well known. Analysis of the economic performance of regions is increasingly important and this is particularly true in Italy where the economic landscape is characterised by some important economic areas (industrial districts: Sforzi, 1997). Many small business which are highly specialized and interconnected are concentrated in industrial districts. Thus studying their competition and capacity to employ skilled workers seems very useful.

Checking the population's practical skills in crucial fields for economic competition means that in practice one can monitor the performance of individuals in managing such knowledge. This is a not simple problem to solve from a statistical point of view. According to the literature in fact, international research on measuring human capabilities has been carried out above all by international agencies. These agencies have used three main approaches: 1) aptitude and psychological testing, aiming at evaluating capabilities by cognitive tests proposed by psychologists (OECD, 2002; Gallina, 2005); 2) statistical surveys which ask individuals directly if they have specific capabilities and skills for certain tasks (Moss and Tilly, 1996; EUROSTAT, 2004); 3) self-evaluations of one's own capabilities and skills, often used together with one of the previous strategies (UNESCO, 2003). The first solution allows a detailed investigation of very basic capabilities, like "prose" or "document literacy", "numeracy" and "problem solving". This approach is useful if it permits us to identify specific personal characteristics, which can be used as proxies for the skills being researched. An important survey based on this approach is carried out by OECD - the Programme for International Student As-

sessment (PISA). The survey's aim is to assess the skills of students who are finishing their compulsory education. It seeks to measure if they have acquired knowledge and skills useful for participating in the labour market. Tests are administered to a sample of students ranging between 4,500 and 10,000 in each of the 43 countries involved. The domains of reading, mathematical and scientific literacy are covered in terms of the knowledge and skills needed in adult life (O-ECD, 2002). Hence skills investigated are very general and are not appropriate to the task of measuring practical capabilities like those required for computer applications, even if some evidence has been found regarding the correlation between adult literacy and human skills in general (Gallina, 2005).

The first approach is time consuming, expensive and difficult to repeat, therefore it is clearly useful for investigating a specific population at one specific points in time, while it is not suitable for meeting the objectives of statisticians asking for timely and repeated data on large populations.

The latter two strategies also have drawbacks, since they are based on respondents' self-evaluations of their own capabilities. Both strategies are prone to a "subjective" bias. Even though self-evaluation on computer knowledge has been used in many studies on students, some authors who utilized self-evaluation methodologies (Duvel and Pate, 2004), admit there is concern about the reliability of self-reported information. Thus the question is how to check practical knowledge, if we cannot use an aptitude test. Our aim is to look for a strategy able to produce "objective" observation avoiding the risks of "subjective" bias. In our view this task can be achieved by using a statistical survey able to test respondent's capabilities in a specific field. In the case of computer applications, our basic idea was to administer a questionnaire based on questions similar to those asked to people seeking the European and Computer Driving Licence (ECDL). This is an internationally recognised qualification which enables people to demonstrate their practical competence in computer skills, which is adopted as standard by governments in many countries (Matei, 2003). In this approach the candidate's skills in using computers in a wide range of applications is tested by asking specific technical questions and making the respondent choose the correct answer from a set of different possible answers.

The approach described above has been implemented in 2004 in a sample survey focused on individuals' knowledge of computer applications. In particular we were interested in investigating skills related to some widely used software and not to the knowledge of hardware. Further, we decided to focus especially on the most commonly used operating system, Windows, as does the test for the European and Computer Driving Licence. Hence we collected information on the capabilities acquired in core applications and programs used in the Windows environment, because computer literacy has evolved beyond basic word processing and file management, to desktop publishing, spreadsheets and internet management (Lawson and de Matos, 2000).

If the strategy proposed works successfully it could be applied to other topics, becoming a very useful instrument to obtain statistical evidence on human capital skills.

In our experiment we also asked for a self-evaluation of skills considered. Comparing self-evaluations with replies given in the test-questionnaire will make it possible to check the reliability of self-evaluation of computer skills and to verify whether or not our assumption that self-evaluation of these skills is unreliable is a too pessimistic view.

The outline of the paper is as follows. Section 2 gives a description of the sample survey (target population, sampling design, questionnaire, etc.). Section 3 provides the analysis of main results which allows us to compare the effectiveness of the survey strategies described and to study the relationship between the interviewees' level of competence and other characteristics like their employment status, their educational level and the district where they live. Some concluding remarks and possible further developments are offered in section 4.

2. THE SURVEY

The target-population is constituted by young people (from 20 to 35 years old) living in the 22 industrial districts of the Emilia-Romagna Region. Districts considered are "Local System for Work" (LSW), that are groups of municipalities defined according to the number of workers commuting towards a municipality, which are defined as "industrial districts" if the business are mainly small or medium and if their output is mainly in the same sector. Districts contain about 45% of both municipalities and population of the Region and are specialized, according to the National Statistical Institute, in four economic sectors: "food industry"; "mechanics"; "furniture"; "textiles and clothing" (ISTAT, 1997). Our study's restriction to one region was due to budget constraints. However, the region selected is one of the most developed areas in Italy, having one of the highest levels of income in the country, as well as an integrated and extended network of competitive firms. Therefore it provides a very interesting observation point from which to study the Italian economy's ability to face the challenges of the new economy[1].

The choice of the target-population depends on the assumptions that these people are those that most need informatics skills and that the knowledge economy' capacity to grow depends upon them.

As we said our questionnaire is based on the approach used for obtaining the European and Computer Driving Licence (ECDL). On this basis we selected six basic computer applications which cover knowledge of different programmes generally used to solve many different problems: 1. "managing files"; 2. "word processing"; 3. "spreadsheets"; 4. "access database"; 5. "information and communication: basic web search task"; 6. "information and communication: web pages construction".

Since one of our objectives is to check the reliability of self–evaluation, the

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[1] The interest of Emilia-Romagna Region on topics related to our purpose is shown by another sample survey on households, "The Spread of Internet among Emilia-Romagna Citizens", carried out in 2003 in order to collect information on the use of internet and e-Governance.

discrepancies between self-evaluations and actual knowledge demonstrated in the test are evaluated for each of those six sections.

Moreover the questionnaire includes questions on several characteristics of the respondents and on their computer use (frequency, places and reasons for using the computer, how they learnt to use it, training courses, etc.). The particular knowledge of the different programmes listed above and the general knowledge of computer use is measured by both the self-valuation, given in a scale from 1 to 10, and the result of the test, that is the number of correct answers given to each section/application and on the whole test.

The sample is a stratified and the planned size is 1,200 units. Strata have been defined by the already mentioned four district typologies. The sample size allows to obtain reliable results for each strata[2]. The allocation of interviews per district within each stratum keeps constant the district estimates' standard error within the stratum. The same condition is valid for the municipality estimates' standard error within each district. That choice implies an equal number of interviews in each municipality of the same district and an equal number of interviews in each district of the same stratum.

The CATI (Computer Assisted Telephone Interview) technique was used. The questionnaire was previously tested on a pilot sample of 20 units in order to check the comprehension of the questions and answers asked by telephone and no difficulties arose from the test.

Since a complete list of persons within the range of age of interest is obviously not available, households have been selected randomly from telephone directories and then eligible household's members have been interviewed.

On the whole 9974 telephone numbers have been called to obtain 1,157 completed interviews (a sample size slightly lower than planned). No person in the range of age of interest was found in two out three (6,696) calls. Telephone numbers were incorrect in 236 cases, for 1,313 numbers no one was found at home after four attempts and 524 contacted households having an eligible component refused to participate. Finally, we had no interruption of the interviews due to problems of understanding or inconvenience resulting from the specific type of interview-test administered.

For a survey with ineligible units, the response rate may be simply calculated as the ratio between the number of interviewed cases (*I*) and the sum of the interviewed and the refused interview cases (*R*). This ratio is in our case equal to 0.7. Conversely, the response rate may be obtained by adding at the denominator also the estimated number of cases that would be eligible among the non contacted sample units (not found at home after four attempts). If we let *e* be the proportion of households contacted in the study with eligible persons (0.2 in our survey), the number of cases that would be eligible among the non contacted sample units may be estimated as the product between *e* and the non contacted sample

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[2] The strata sample dimension has been chosen so as to obtain estimates of a proportion per stratum with a sampling error which overcomes 6% with a probability equal to 0.05. This involved the execution of about 300 interviews for each of the four strata (Cochran, 1977).

units[3] (McMillen *et al.*, 2001). The response rate calculated in this way results in our case equal to 0.6. Such rates are similar or lower than those obtained by other Italian surveys carried out by using a CATI technique, such as a recent survey on "the listening on the radio" carried out by the Tuscany Region (2005).

A first important result arises from this last piece of evidence. In spite of our doubts about people's willingness to participate in such a survey, the approach proposed was basically accepted by people contacted. Some usual problems of CATI interview stems from our experiment essentially because we were looking at particular classes of ages, but the important finding was that it is possible to ask these particular types of questions through a telephone interview. It should be noted that refusals arose at the moment of the contact and not because of the questions. Interviewees generally understood the questions and showed interest in testing their skills. From this point of view it seems possible to say that the experiment has been successful given the response rate, the cooperation shown and the respondents' good understanding of the questions asked.

However, to reduce possible bias effects on estimates induced by refusals and coverage errors in telephone directories, sample weights have been adjusted according to the last Census results, which date from 2001. Coverage errors in telephone directories may be due to the increasing diffusion of mobile phones which is leading to a gradually substitution with the home phones. However the percentage of households having only mobile phones in Emilia-Romagna in 2002 was only 10% (ISTAT, 2003).

Hence, the sample structure was adjusted according to gender and quinquennial ranges of age within each district (the only two data available at the time of the survey for the district level). In each of the post-stratum so defined, weights have been calculated as the ratio between the number of persons in the population and the number of persons in the sample, taking into account of the three years difference between the results coming from the two sources.

A comparison between the structures of the sample and of the population with respect to other characteristics such as the education level or the employment status is not straightforward, since that information is available from the last Census only at regional and provincial level. However, the comparison between sample results and the Census in Emilia-Romagna shows that our sample has an higher percentage of persons with a upper secondary education (63%) to the detriment of the lower secondary education (22%) than the regional population where those percentages are 53% and 32% respectively. Furthermore, our sample is found to have a smaller percentage of the labour force (75%) than the regional population, where this percentage is 82%. Differences observed could be due to the territorial concentration of highly educated persons and students in districts which are often secondary school and university poles.

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[3] $RR = \dfrac{I}{I + R + eU}$

3. RESEARCH FINDINGS REGARDING COMPUTER SKILLS

In this section some main findings are presented, according to the following outline. First of all computer use is analysed: frequency of use, where and why computers are used, skills achieved, participation in training courses on PC use, etc. (par. 3.1). Then, a comparison between results obtained by the two measurement strategies employed is carried out (par. 3.2). A more accurate analysis of the individual characteristics in connection with those results is outlined in paragraph 3.3. Finally, paragraph 3.4 provides a picture of different patterns of competence that persons demonstrate having in the six questionnaire sections.

3.1. *PC usage*

The population considered seems split among three different groups: about 2/3 (60%) uses computers daily, 20% use it only from time to time and the remaining 20% never use it. Windows is found to be the most frequently used operative system: 99% of the population use it[4]. There is no prevailing reason for using computers and most people use PCs for more than one task: 87% of them use the computer for leisure, and 86% of the workers use it for work reasons. Students using PC at school are a smaller fraction (67%).

The first results show that a very large portion of the population considered uses PCs (80%, 927 persons). It is possible to compare this last percentage with that obtained by ISTAT from the Multipurpose Survey on "Citizens and their leisure" which is, for the whole country in 2000, about 64% for persons aged from 20 to 24 years old and 54% for persons aged from 25 to 34 years old (ISTAT, 2004). Considering that ISTAT data refer to two years before and to the whole country, and that Emilia-Romagna is one of the most economically and socially advanced Italian regions , it becomes clear that our findings do not indicate that the Region occupies a leading position regarding population skills in the core computer applications. Further, our study found no evidence that the Region's economic system favours the diffusion of qualified computer skills.

Skills considered are not acquired through a systematic training but rather based on self-training. Most of persons had not attended training courses and one or more training courses providing a certificate have been taken by only 22% of them. On the other hand, it is to be noted that such training was becoming increasingly important in the more recent years, where a higher concentrations of course attendance have been found: 2000 (12%), 2002 (17%) and 2003 (13%).

"Self-learning" is considered the most important way of getting and/or improving computer competence, followed by the "on-the-job training" for workers and by "training at school" for students (Table 1)[5]. If the analysis of the contribu-

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[4] They are the only interviewees that respond to the rest of the questions on the knowledge of informatics.

[5] The percentage contribution to one's own computer skills derived from: training at school, training at work, other courses attended on one's own initiative and self-learning have been investigated. This analysis has been carried out for "employed and unemployed persons" and for "stu-

tion assigned to "other courses" is restricted to persons stating that they have taken training courses providing a certificate, the average of percentages increases to 21% for employees and unemployed persons and to 28% for students and persons looking for the first job, but the most frequent learning strategy remains "self-learning".

TABLE 1

Different ways of learning for one's own knowledge (average of percentage)

	Employees and unemployed persons	Students and persons looking for the first job
On-the-job training	34	-
Training at school	14	33
Other courses	7	7
Self-learning	45	60

3.2. *Computer capabilities: evidence from the strategy suggested and analysis of the reliability of self-evaluation*[6]

Respondents were asked to assign an evaluation of their knowledge choosing a score in a scale from 1 to 10. The aspects to be evaluated were: *i*) general computer knowledge; *ii*) competence regarding "managing files", "word processing", "spreadsheets", "access database", "basic web search tasks" and "web page construction", which constitute the six sections of the questionnaire. Each section also includes five specific questions chosen to provide an objective evaluation of the respondents' knowledge in each topic, in order to evaluate the specific competence mentioned above by using the number of correct answers given to each section (from 0 to 5) and the number of correct answers given in the whole (from 0 to 30).

Since our test was designed to measure a specific field of knowledge, we wanted to evaluate if the selected multiple-choice questions covered this field adequately that is, if the test is likely to produce consistent scores. To this purpose we calculated the "Kunder-Richardson formula 20 statistic"[7] (Kunder and Richardson, 1937) providing a unique reliability coefficient which depends on the inter-correlation among the items-questions and which may vary between 0 and 1. High values mean that the questions are measuring the same underlying construct while low values mean that data have a multidimensional structure. The high value reached by that coefficient in our case, 0.85, confirmed the reliability or internal consistency of the test performed.

Looking at the general knowledge of computer applications and referring to

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dents and persons looking for the first job" separately, since the last ones had obviously given a zero percentage to on-the-job training.

[6] Persons interviewed who declared no computer use were excluded from this analysis.

[7] $\rho_{KR20} = \dfrac{k}{k-1} \cdot \left(1 - \dfrac{\sum pq}{\sigma^2}\right)$, where p is the proportion of respondents passing a given item, q

is its complementary, k is the number of items and σ^2 is the variance of total score obtained by respondents.

self-evaluation, the mean score is 6.4 and its standard deviations is 1.7. Thus our population seems to have sufficient competence of core computer applications. The next question is to check if our test confirms that self-evaluation. The comparison is not straightforward since the two variables have different ranges of variation[8]. For this reason the results of the test have been grouped by three (in order to have it also expressed in a scale from 1 to 10) and a kernel non parametric density (Silverman, 1986) has been estimated on the so rescaled domain for the test and on the original domain for the self-evaluation (Figure 1a, 1b). From the comparison between the two distributions it arises that the one concerning self-evaluation has an evident negative asymmetry, while the opposite is observed for the test distribution. Self-evaluation results in individuals to heaping their answers around some values. This result was expected, but the difference observed is very high. The mean score calculated on the rescaled tests results is 3.9 and the standard deviation is 1.7. Therefore, while persons tend to value their knowledge sufficient on average, their performance in the test on average is not sufficient and the variability is higher. Therefore, self-evaluation seems affected by a systematic positive bias when compared to the results of the test, that would lead to a more optimistic image of reality. We can state that self-evaluation appears less reliable than a specific check.

The low scores in the test confirm findings of other studies concerning Italy (Gallina, 2005) where lower scores in comparison to other countries and also more inequality have been observed.
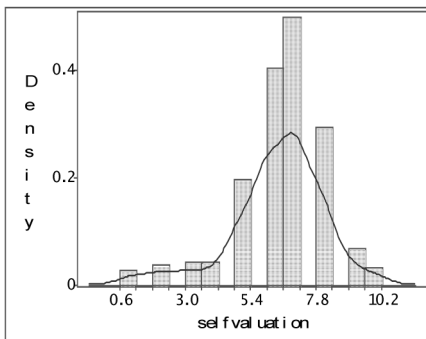

Figure 1a – Kernel density estimation for the self-valuation*
* Mean = 6.4, Median = 7, Mode = 7, Standard deviation = 1.7, Coefficient of variation = 26%
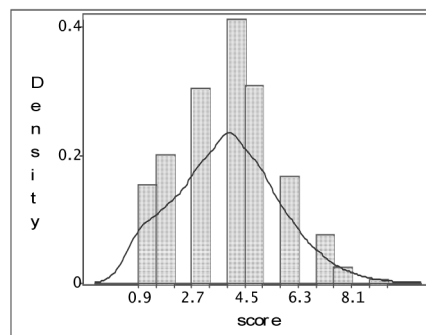
Figure 1b – Kernel density estimation for the score**
** Mean = 3.9, Median = 4, Mode = 4, Standard deviation = 1.7, Coefficient of variation = 43%

We also considered the extent of concordance between the results obtained from the two evaluation strategies for each individual. This task has been per-

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[8] The presence of two different score systems is due to the choice of using a scale from 0 to 10 for the self-evaluation, reminiscent of scores used at Italian primary and secondary schools, but has a maxim which differs from the number of questions introduced for the test.

formed by using the following scatter-plot (Figure 2). Here respondents are represented according to both self-evaluation and the test. The coefficient of correlation (ρ) between these variable is only 0.54. Most discrepancies derived from respondents who evaluate their knowledge more positively than their performance in the test. The percentage of persons whose self-evaluation is higher than their (rescaled) result in the test is 89. Percentage of cases where the contrary happens is 3.
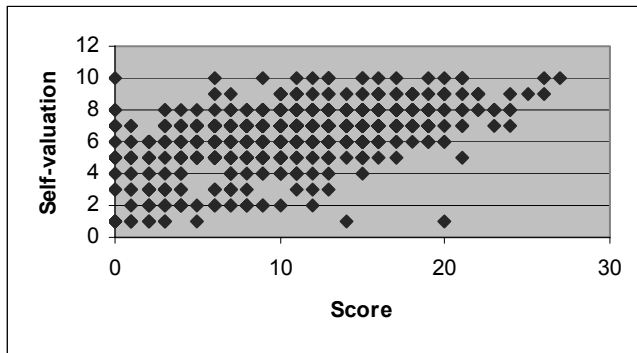

Figure 2 – Scatter-plot for self-evaluation against score.

The comparison between the two evaluation strategies is further developed on the basis of results obtained from the six specific sections of the questionnaire, which are given in Table 2[9].

Not all the 915 interviewees who state using a computer answered all sections (the number of respondents to each section is reported beside each section name). Clearly missing answers concern the sections where respondents gave as an answer to the first question of the section (do you have some skills about the issue asked?): "no knowledge at all". It is to be noted that the respondents to the last two sections "access database" and "web page construction" are very few compared to the other sections, showing that these two specific capabilities are quite rare in our population.

When each application is considered, differences between scores in the two approaches are less evident probably because of the different variability of individual scores. We evaluated also the actual relevance of differences by the correlation between individual self-valuations and tests in each section. Correlation is high (ϱ: 0.86 and 0.89) for "access database" and "web page construction". These tools are quite sophisticated and less spread applications so that respondents seem more aware of difficulties and of their real skills. On the contrary, correlation is slightly lower for "managing files" (0.58), "word processing" (0.62) and "basic web search" (0.61).

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[9] Also in this case, the comparability has been reached by rescaling the test scores which has been multiplied by two (it originally ranges from 0 to 5 because of the 5 questions per section).

TABLE 2

Results obtained for self-valuation and test in the six applications considered

MANAGING FILES (n = 888; ϱ = 0.58)		
	Mean	Coefficient of variation
Self-valuation	6.8	35%
Test	5.8	52%
WORD PROCESSING (n = 842; ϱ = 0.62)		
	Mean	Coefficient of variation
Self-valuation	6.3	40%
Test	5.6	46%
SPREADSHEETS (n = 692; ϱ = 0.72)		
	Mean	Coefficient of variation
Self-valuation	4.3	67%
Test	3.6	89%
BASIC WEB SEARCH (n = 825; ϱ = 0.61)		
	Mean	Coefficient of variation
Self-valuation	5.8	43%
Test	5.0	52%
ACCESS DATABASE (n = 167; ϱ = 0.86)		
	Mean	Coefficient of variation
Self-valuation	0.9	244%
Test	0.8	250%
WEB PAGE CONSTRUCTION (n = 106 ; ϱ = 0.89)		
	Mean	Coefficient of variation
Self-valuation	0.6	300%
Test	0.4	400%

3.3. *The determinants of competence*

In order to understand if some specific individual characteristics do influence the degree of skills measured by the test[10], two different sort of analysis have been carried out, distinguishing between undoubtedly exogenous characteristics and possibly endogenous ones. The existence of a dependence of the personal knowledge from the characteristics of the first type, that are: *gender*; *age*; *educational level*; *employment status* (labour force, non labour force); *district*; *kind of district* and *to have taken training courses*, has been tested by using the "analysis of variance test" (ANOVA) for more classification factors (Scheffe, 1959). Instead, regarding the endogenous characteristics, that are: *occupation* (ISCO88 International Standard Classification of Occupations); *sector of activity* (ATECO2002 classification); *frequency of PC use*; *use of PC at work*; *use of PC at home*; *use of PC at school*; *use of PC for work reasons*; *use of PC for study, entertainment or information*, their interdependence with competence acquired has been measured and tested by applying the canonical correlation analysis. In fact, this analysis allows us to measure the correlation between a numerical variable (the evaluated knowledge) and a nominal variable (an interviewee's characteristic) quantifying the nominal variable, that is providing for each of its modalities the numerical value that maximize the correlation between the two variables (Anderberg, 1973; p. 80).

In the ANOVA, the averages of the test scores obtained by sub-groups of the persons defined by the modalities of the exogenous characteristics or, possibly, by combinations of them are compared by using an F-test. The null hypothesis of the test is that all those means are equal in the population (and, consequently, differences in the sample means are due only to the sampling error). This hypothesis is tested against

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[10] Very similar results have been obtained for the self-evaluation.

the alternative that the population means are not all equal. If the null hypothesis is rejected, it means the characteristic used to create sub-groups has an influence on the test score, since its average assumes for those groups values which differ from each other significantly. Results obtained from this analysis are reported in Table 3.

TABLE 3

Analysis of variance results for the score test

Characteristic	DF	Deviance	Variance	F	Pr > F
Gender	1	1444	1444	69	<.0001
Age (ten years ranges)	1	324	324	15	<.0001
Educational level	2	2280	1140	54	<.0001
Having taken training courses (yes/no)	1	772	772	37	<.0001
Gender*Age	1	79	79	4	0.0424
Age*Educational level	2	244	122	6	0.0031

For simplicity only results obtained for those characteristics resulting significant factors for the level of competence are reported. They are: gender, age, educational level, having taken training courses and the interaction between gender and age and between age and educational level. Finally, the "industrial district" and the "district typology", which are characteristics of the municipalities where the persons live, do not have a significant influence on the score obtained by the test. In general these variables used to stratify the sample are less relevant than the others reported in the table and this holds also in the analysis that will be described in the remaining section. In fact "industrial district" and the "district typology" are characteristics of the municipalities where interviewees live, while the variables considered until now concern their own characteristics.

Besides, it is possible to evaluate the influence of these characteristics connected to the use of computer applications on the basis of the differences between the group means compared by the test. Group means are given in Table 4, where the results of the analysis of variance test are provided for those characteristics leading to the rejection of the null hypothesis.

TABLE 4

Analysis of variance test results for characteristics with significant differences between group means

CHARACTERISTIC	MODALITIES	MEAN OF TEST
Gender	Male	12.7
	Female	9.7
Age	20-27	12.1
	28-35	10.3
Educational level	Up to lower secondary education	8.4
	Upper secondary education	11.3
	University degree	13.7
Have taken a training course	Yes	12.2
	No	10.1
Gender*Age	Male, 20-27	13.2
	Male, 28-35	12.2
	Female, 20-27	10.9
	Female, 28-35	8.4
Age*Educational level	20-27, Up to lower secondary education	10.3
	20-27, Upper secondary education	12.0
	20-27, University degree	13.8
	28-35, Up to lower secondary education	6.5
	28-35, Upper secondary education	10.6
	28-35, University degree	13.7

Some of these results were expected while some others are somewhat surprising. In particular, regarding the mentioned variables, the role of gender, age and education level agrees with findings of studies carried out on more general life skills (prose literacy, document literacy, numeracy and problem solving) (Gallina, 2005). Men gave on average three more correct answers than women. Someone (Gallina, 2005) explains the difference by referring to the greater opportunities of education, training and work that men still have in comparison with women. However, Gallina was referring to Italy as a whole, while our survey was carried out in Emilia-Romagna, where differences between genders in education and in the labour market are quite small, especially among young people who are our target population. Other authors (Valenduc and Vendramin, 2005) suggest another hypothesis for the gender gap in ICT in general, that is some features of work organization in the ICT profession (unpredictable working rhythms, costumer driven flexibility, continuous time pressure) but they refer only to working people. Then our paper confirms that gender plays, at least presently, a significant role in differentiating capabilities in the informatics field.

According to the findings of those other studies, people between 16 to 25 years old are less skilled than older persons, meaning people between 26 to 35, and this holds for different countries. In our case the contrary happens, because the number of correct answers provided decreases when the age increases, but this is obviously due to the particular capabilities investigated in our study.

Education is also an important feature which confirms its use as proxy to improve the evaluation of human capital. The score average obtained for different educational levels increases with the orderly modalities of this characteristic. The increase is about 2.9 points moving from "lower secondary education" to "upper secondary education" and of approximately another 2.4 points moving from this last modality to the modality of "university degree".

Regarding the interaction between gender and age, it should be stressed that on average men reach a much better result than women, whatever class of age men and women belong to. Looking at the averages obtained for the interaction between age and educational level, we observe that university graduates give on average the same number of correct answers whatever class of age they belong to, while for the other two educational levels the age plays an important role. This is particularly evident for the lower secondary education: the younger persons (class 20-27 years old) give on average four correct answers more than the older ones (class 28-35). From this evidence it seems possible to see the effect of social conditions: until few years ago who had a lower social status was excluded from PC utilisation and school was not able to help him, and only recently but quite quickly the gap has started to be overcame.

Taking into account endogenous characteristics, results of the canonical correlation analysis are reported in Table 5. For all of them the hypothesis of independence with the score test is rejected excepted for "the use of the computer at school". Evidence suggests that for young people, school is not important in learning informatics. It seems that school does not provide adequate informatics teaching and self-learning or learning assisted by parents/friends are more effec-

tive. The estimated correlation coefficients are not very high. Obviously, the variable connected to the highest correlation is "the frequency of computer use", that distinguishes between persons using the computer daily and persons using the computer from time to time.

TABLE 5

Canonical Correlation Results - Significant correlations (Ho : ρ = 0 rejected)

Characteristic	Correlation with the score
Frequency of computer use	0.38
Occupation (ISCO88)*	0.30
Sector of activity (ATECO2002)*	0.21
Use of computer for study, entertainment or information	0.27
Use of computer at home	0.20
Use of computer for work reasons*	0.19
Use of computer at work*	0.11

* Only for employees and unemployed persons

Also for these variables it is interesting to observe the differences between the averages of the test scores calculated for the sub-groups defined by their modalities (Table 6). The main differences between score means concern the "frequency of computer use" and "the use of computer for study, entertainment or information reasons". Daily computer use increases the overall score obtained, on average, by about 5 points, that means about 5 correct answers more than when computer is used only occasionally. About the same increase of the score average is connected with the use of computer for study, entertainment or information reasons in comparison to the absence of this kind of use. Consequently we conclude that it is not enough to study computer diffusion among households to understand the real degree of computer capabilities of population. Testing real knowledge owned seems necessary to appreciate the real human capital capabilities.

Regarding the "type of occupation" our expectations have been confirmed: the professions that obtained the highest score means are "technicians and associate professionals" (12.5) and "clerks" (12.2), while those obtaining the lowest score means are "service workers and shop and market sales workers" (6.4) and "elementary occupations" (6.3). The category of "legislators, senior officials, managers and professionals" reaches a high result (10.9), but it is not the highest one, which might have been expected. Even if there are evident differences in the scores showing strong differences in computer skills, an adequate knowledge on average is not found in any category essentially because of the large variability within each professional category.

Finally, findings concerning the "sector of activity" are in accordance with our expectations about the relevance of computer knowledge in the various economic sectors. The highest score averages are obtained by persons working in the finance (14.3) and in the "real estate activities, rental service, informatics, research, enterprise services" (13.2) sectors, while the worst performances are related to persons working in "hotels and restaurants" (7.7) and "health and social assistance" (6.8).

TABLE 6

Means calculated for the modalities of the relevant endogenous characteristics

CHARACTERISTIC	MODALITIES (n)	MEAN OF TEST
Frequency of computer use	Daily (685)	12.0
	From time to time (230)	7.2
Use of computer at work*	Yes (541)	11.4
	No (125)	8.8
Use of computer at home	Yes (757)	11.4
	No (158)	8.6
Use of computer for work *	Yes (571)	11.2
	No (95)	9.1
Use of computer for study, entertainment or information	Yes (793)	11.6
	No (122)	6.8
Occupation*	Legislators, senior officials, managers and professionals (37)	10.9
	Technicians and associate professionals (94)	12.5
	Clerks (237)	12.2
	Service workers and shop and market sales workers (42)	6.4
	Craft and related trades workers (15)	8.9
	Plant and machine operators and assemblers (93)	8.7
Sector of activity*	Agriculture (13)	10.5
	Manufacturing industries (202)	10.5
	Mining; production and distribution of electric power, gas and water (9)	8.5
	Buildings (26)	12.1
	Wholesale and retail trade (107)	9.1
	Hotels and restaurants (15)	7.7
	Transport, storage and communication (20)	11.6
	Finance (29)	14.3
	Real estate activities, rental, informatics, research, enterprise services (120)	13.2
	Public administration (36)	12.6
	Instruction (32)	9.9
	Health and social assistance (25)	6.8
	Other public, social and personal services (21)	9.1

 * Only for employees and unemployed persons.

3.4. *The analysis of different patterns of demosnstrated knowledge*

In the sections 3.1 and 3.2 we have measured the performance of each individual looking at the number of correct answers given on the whole. In that approach we did not consider the different combination of computer applications that persons could have. Now we concentrate on which particular computer applications (section of the questionnaire) persons are more/less capable and what are the combinations of competences more spread among individuals. With this purpose we analyse our survey information taking into account of the number of adequate answers provided in each computer applications and how the results for each application combines. In order to carry out such analysis the following standards of competence for each section have been adopted:

– if a respondent gave at least three correct answers to the five questions of a section s/he was considered to have an adequate practical knowledge (S) in that application;

– otherwise the respondent failed the test in that application (I).

Since we considered six types of computer applications, following this approach we get a total of $2^6 = 64$ different potential combinations (patterns) of

competences. Among them, 48 are followed by at least one respondent and the other 16 have frequency 0. Therefore several skill combinations arise pointing out the difficulty in defining the general degree of computer knowledge and the need to distinguish among different applications.

The most relevant patterns are reported in Table 7. Patterns observed for a very small number of respondents have been omitted (less than 1% of the set of 915 respondents). The resulting table then, refers to a sub-sample of 887 units.

Three patterns arise as the most frequent: a) *persons who failed in all the six applications* (14.5%); b) *persons having adequate competence in the three applications "managing files", "word processing" and "basic web-search"* (14.8%); c) *persons having adequate competence in the four applications "managing files", "word processing", "spreadsheets" and "basic web-search"* (14.1%).

The most important conclusions that can be drawn from these results is that competence in computer applications is not satisfactory (better quite poor) particularly because it is often limited to very few kinds of core applications. In fact a high proportion of individuals did not pass the test in any section, moreover 15.7% passed the test in just one section, and another large set of individuals was able to pass the test in just a couple of sections (23%) and, finally, only 23% of those who decided to try to answer the test shows a broad knowledge of the main computer programs used, broad knowledge being defined as passing the test in at least four sections whatever they are.

Probably these results depend on the fact that skills most commonly required at work places are mainly word processing or spreadsheet skills or because some persons use the computer only for entertainment (mostly basic web-searching). In any case, we cannot forget that another 20% of the population considered does not use computers at all.

TABLE 7

Different patterns of performances

N. of pattern	MANAGING FILES	WORD PROCESSING	SPREAD-SHEETS	BASIC WEB-SEARCH	ACCESS DATA-BASE	WEB PAGE CONSTRUC-TION	%
1	I	I	I	I	I	I	14.5
2	S	I	I	I	I	I	4.7
3	I	S	I	I	I	I	5.1
4	I	I	S	I	I	I	1.0
5	I	I	I	S	I	I	4.9
6	S	S	I	I	I	I	8.6
7	S	I	S	I	I	I	1.0
8	S	I	I	S	I	I	5.4
9	I	S	S	I	I	I	1.5
10	I	S	I	S	I	I	4.9
11	I	I	S	S	I	I	1.3
12	S	S	S	I	I	I	3.9
13	S	S	I	S	I	I	14.8
14	S	I	S	S	I	I	1.9
15	I	S	S	S	I	I	2.4
16	S	S	I	S	I	S	1.2
17	S	S	S	S	I	I	14.1
18	S	S	S	S	S	I	3.4
19	S	S	S	S	I	S	1.2
20	S	S	S	S	S	S	1.1

Some serious concerns arise from these figures which demonstrate that a very large part of the young population does not have adequate computer skills to face the challenges of the new economy. But another question arises: is it only a problem of lack in individual computer skills or do results also depend upon a scarce supply of qualified computer skills within firms operating in the region? These are important questions that would require further study.

A second aspect concerns the absence of a "hierarchy" among various skills. In fact the most relevant patterns are combinations of capabilities that do not seem to depend on each other. In fact three kinds of competence prevail, those related to "managing files", "word processing" and "basic web-search", which are associated with competences in different other computer applications.

From the evidence presented we conclude that in general, computer education is not systematic and mostly based on self-learning. Schools should pay more attention and devote more resources to teaching computer science and its applications.

Finally, knowledge on database management and building web pages is very rare, as demonstrated by the very low percentages of persons passing the tests in these sections (Table 8). The absence of these skills, which are considered to be crucial for businesses in the new economy, probably indicates an educational gap and a problem for businesses looking for qualified workers. It might also indicate a lack of demand from businesses for these skills because of the lag in developing new processing strategies and new goods.

TABLE 8

Demonstrated competence per application

APPLICATION	n	%
Managing files	582	63.6
Word processing	592	64.7
Spreadsheets	493	34.2
Basic web-search	529	57.8
Access database	147	7.4
Web page construction	98	4.0

The next question that should be addressed is to understand if some relationship between computer skills and particular individual characteristics can be found. In other words, are persons' computer skills independent from their socio-demographic characteristics? Are persons demonstrating approximately the same competences also similar with respect to some other characteristics? This analysis would be useful to shed light on the role played by demand for labor on human capital skills.

Not all patterns could be considered because of the sample size, therefore we focused on the largest and more significant subsets of respondents as those where individuals obtained the best and the worst results. In particular we decided to perform the analysis in two steps. First, the largest patterns (number 1, 13 and 17) have been considered. They represent the worst results (pattern 1), good results (number 17), and an intermediate situation (pattern 13). Next, we considered a different approach which consisted of looking at six groups of re-

spondents made up by people with adequate knowledge in each of the six sections, independently from their performance in the other sections. This second sort of analysis allows us to investigate possible connections between the characteristics of individuals and adequate knowledge of a single application.

In both steps the distributions of the mentioned patterns/subsets, according to both the endogenous and exogenous characteristics listed in section 3.3, were compared to those of the whole set of respondents (n=915). The comparison was carried out by performing a chi-square goodness-of-fit test for one-way tables, whose null hypothesis specifies equal proportions of the total sample size for each class. Findings of these tests highlight that some distributions are significantly different and patterns are strongly characterized by some individual features (Table 9[11]).

Persons failed in all sections (pattern 1, n = 133) are mainly occasional PC users. In fact this pattern is characterized by a higher incidence of the features connected to the lowest averages of the test score (higher percentage of women, persons with an "up to lower secondary education", older persons, part-time workers, "plant and machine operators and assemblers", see section 3.3).

On the contrary pattern 17 (n = 129), persons that passed the test in the four sections "managing files", "word processing", "spreadsheets" and "basic web-search", is characterized by higher percentages of those features associated to the highest average scores (university graduates, full-time workers, clerks and technicians and associate professionals, workers in "real estate activities, hiring, informatics, R&D, services to firms", persons having taken one or more training courses). All persons of this group use the computer daily and the score they obtained in the test (15.6) is much higher than that observed in the whole sample (10.6).

The last pattern (13, n = 135), containing persons with an adequate competence in the three sections "managing files", "word processing" and "basic web-search", represents an intermediate situation between the whole set of the respondents and the previous pattern (in fact it differs from pattern 17 only in the lack of "spreadsheet" abilities). This result is not surprising as this pattern is connected to a medium level of knowledge. It is interesting to note that the group is composed above all by students (40%) (students represent only 13% in the pattern 17 and only 25% in the whole sample) showing that students utilize only the very basic computer applications and in any case to applications do not finalized to data analysis.

Therefore the new evidence arising from this analysis, with respect to the results of the previous section, is that the three patterns analyzed are substantially representative of three individuals typologies: the part-time workers (pattern 1), the full-time workers (pattern 17) and the students (pattern 13).

Regarding the second step of analysis, we observe that the first four groups of persons who passed the test in "managing files" (n=582), "word processing" (n=592), "spreadsheets" (n=313) and "basic web-search" (n=529) show charac-

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[11] In table 9 results of the chi-square test are reported only for those groups and those characteristics leading to the rejection of the null hypothesis.

teristics very similar to the whole sample but their performance on the test was slightly higher. Obviously, this is due to the exclusion of individuals who failed in all the six sections that represent a large pattern as we have already seen. On the other hand, groups composed of those who passed the test in "access database" and in "web page construction" show very specific characteristics as reported in Table 9. Even though the small size of these groups limits the reliability of the analysis (respectively 68 and 37 units) it is useful to report on their characteristics. In the group of persons with an adequate knowledge of "access database", there is a high percentage of men, of university graduates, of workers, of technicians and associate professionals and of individuals who have taken a training course. This group also obtained particularly high scores in the other computer applications showing a high global practical knowledge of computer use. They achieved, an average a score of 19 in the test (the average of the total is 10.6). Also the group of individuals with adequate knowledge of "web page construction" is found to be highly skilled with an average score of 19, and with characteristics similar to those from the previous group.

TABLE 9

Features characterizing the most relevant patterns and different kinds of knowledge

PATTERN n.	Modalities of the relevant characteristics	Group %	Whole sample %
1	Female	75	56
	Up to lower secondary education	29	14
	Part-time workers	12	8
	Plant and machine operators and assemblers	30	17
	Workers in the sector of activity "Wholesale and retail trade"	20	12
	Persons using the computer from time to time	52	25
13	University graduates	19	18
	Students	41	25
	Clerks and technicians and associate professionals	26	36
	Workers in "real estate activities, rental, informatics, R&D, services to firms"	12	13
	Persons having taken a training course	27	26
	Persons using the computer daily	79	75
17	University graduates	28	18
	Full-time workers	60	50
	Clerks and technicians and associate professionals	53	36
	Workers in "real estate activities, rental, informatics, R&D, services to firms"	22	13
	Persons having taken a training course	34	26
	Persons using the computer daily	100	75
Adequate knowledge of	*Modalities of the relevant characteristics*	*Group %*	*Whole sample %*
Access database	Male	71	44
	University graduates	37	18
	Workers	81	71
	Persons having taken a training course	41	26
	Persons using the computer daily	91	75
	Persons working in the "real estate activities, rental, informatics, research, enterprise services" sectors	28	13
	Technicians and associate professionals	28	18
Web page construction	Male	73	44
	Persons with a upper secondary education and graduates	97	85
	Students	65	25
	Persons having taken a training course	32	26
	Persons using the computer daily	89	75
	Persons working in the "real estate activities, rental, informatics, research, enterprise services" sectors	24	13

It seems interesting to note that only a third of those who passed the test in "web page construction" also passed the test in "access database". This demonstrates that there is not a strong relationship between these two types of skills. Another interesting difference between the last two groups is related to "employment status", because the group with adequate knowledge of "web page construction" is characterized by the presence of a high percentage of students (35%), while that percentage is only 16% in the group "access database" (25% for all respondents). Therefore the knowledge of data base management seems to be more related to some specific professions.

4. CONCLUDING REMARKS AND FUTURE WORK

This paper presents the results of a survey carried out to evaluate computer skills of young people in the specialized districts of the Emilia-Romagna Region. We had two main goals. First to evaluate the practical knowledge of core computer applications of a large part of the population in a rich and high industrialized area of Italy. The results should serve to obtain insights about the Italian economy's ability to tackle the challenges arising from the new economy. The second goal was to experiment with and to identify a measurement strategy able to evaluate computer skills using a common survey strategy and questionnaire and avoiding the traditional psychological approach to the evaluation of skills which is time consuming, expensive and requires highly qualified staff. The idea was to test an instrument that can be applied frequently, and if possible, in connection with traditional labor force surveys, in order to obtain reliable statistics on human capital's practical skills. Moreover, we were interested in checking the reliability of data based on self-evaluations about personal skills, because of the difficulties associated with properly evaluating one's own capabilities.

To this purpose we designed a questionnaire whose questions concern the knowledge of some important and general computer applications. The questions asked were based on the European and Computer Driving License. As in a written examination, the criteria for judging individual skills was the number of correct answers. Test results were compared with those obtained from the self-evaluations.

The experiment has been successful and the evidence is interesting. People did not refuse to participate in the survey, and they were involved and interested in the survey-test. The average duration of interviews was about 20 minutes. Thus it seems clear that it is possible to apply the approach proposed here to further surveys. Survey results demonstrate that often self-evaluation fails to capture an accurate portrayal of actual individual knowledge. In many cases people's evaluation of their own skills was not confirmed by the answers given to the specific test questions on the computer applications in question. Consequently, another conclusion is that it is necessary to be cautious about using self-evaluation in the field of skills measurement.

On the basis of the findings presented we feel that our approach could be pro-

posed to collect data on other particular competences and skills. Since some data about skills requested by firms is available (Grubb, 1996; Moss and Tilly, 1996), our methodology could be used to obtain information on labor force skills, and subsequently to evaluate any mismatch between demand for and supply of qualified workers. This comparison would constitute a crucial aspect of the labor market analyses.

Finally, in a country like Italy with strong educational and occupational territorial differences, a comparison with other regions, above all with regions of the South, would be important for understanding and measuring the territorial disparities in the computer skills. For instance, from the multipurpose surveys carried out by ISTAT at national level, the "region" results as one of the strongest determinants of access to multimedia among children (Morrone and Zannella, 2004). Hence the extension of our experiment to other regions would be an important goal for future work.

Regarding the evidence stemming from the survey, some important issues were found. First of all we conclude that the spread of practical computer skills is unsatisfactory. This is especially true since the target population of this study is quite young (20-35 years old) and therefore should be quite familiar with computers and their applications. In fact, since computer use is widespread (80% of the population considered use computers), we found that about 1/3 of persons who tried to reply to questions failed the test in all applications or passed the test just in one of them. Thus, real practical knowledge of different (more than three) computer applications is limited to some small subsets of the whole population. This is especially true when the most sophisticated applications are considered, such as "data base management" and "web page construction", knowledge of which is very rare.

Secondly, we discover that competencies in computer skills are strongly correlated to some personal socio-demographic characteristics: gender, educational level, occupation and sector of activity. In particular, the best performances in the test, in terms of both global score and number of applications for which the competences are demonstrated, are mainly obtained by persons having particular features, such as "male", "university graduate", persons working in the "real estate activities, rental service, informatics, research, enterprise services" sectors and people working as "technicians and associate professionals. Similarly the worst performances are often observed jointly with some other particular features as "female", "up to lower secondary education", "part-time workers", persons working in the sectors of activity "wholesale and retail trade" and "health and social assistance" and persons working as "plant and machine operators and assemblers" or "service workers and shop and market sales workers". This evidence increases understanding which characteristics should be taken into account as proxies when it is necessary to incorporate human skills in the analysis but specific data on those skills are not available.

A third issue arises from our data: schools and companies need to make a serious and joint effort to improve computer knowledge, as demonstrated also from studies carried out in other countries (Valenduc and Vendramin, 2005). The "de-

signing of innovative ICT skills training solutions" is also one the European Commission's main priority actions. In particular, the EC is concerned to take into account the particular needs of women and different age groups, offering effective incentives and applying the most appropriate teaching and pedagogic techniques (European Commission, 2004). Moreover the need for Governments to develop specific training policies in order to compensate for the lack of highly skilled workers for high-skilled jobs, is highlighted in various studies (O'Sullivan and Lloyd, 2004; Gallina, 2005). These studies emphasize that the consequences arising from shortages of highly skilled labor force could be negative effects on employability, productivity development and competitiveness (European Commission, 2004).

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SUMMARY

Measuring competence in computer skills

The increasing importance of ICT in a knowledge-based economy highlights the need for statistical information on its diffusion. In Italy, a few information is collected from sample surveys on firms, while no information on labor force capabilities is available. We carried out a sample survey on individual skills, focusing on the use of core computer applications. The aim is to suggest an instrument that could be integrated into current labour force surveys for improving statistics on human capital. The experiment was successful and results highlight practical knowledge of different computer applications is limited to some subsets of the population.