Dec-CS: The Computer Science Declining Phenomenon

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Abstract— **Contrary to the continuing growth of the informatics industry in Europe the number of computer science experts (students, graduates, teachers, etc.) is declining.**

This decline is producing some negative consequences in the technology field that affect other sectors like the economic and educational ones.

In order to analyze this situation and in view of providing solutions to stop the decline, it is primordial to understand the reasons that attract students to choose computer science as a domain of study and retain them in the field .

This paper presents the results of a survey that sheds light on student motivations to follow or reject computer science studies. The main goal of the survey was to identify the reasons that cause this rejection and use them as opportunities to enhance the career in the future. This study is a preliminary phase of a larger research goal which aims to identify strategies to foster interest in computer science amongst students and professionals in Europe.

Index Terms—**Business Technology, Engineering Economy, Financial Engineering, Gender Engineering,**

I. Introduction

In their last report (2000 - 2006) the Eurostat Directorate-General of the European Commission reported that the number of high school students choosing computer science as a career is decreasing [1]. After the publication of this study, investigations were made about the possible consequences of this decline; highlighting various negative results that might take place if no measures are taken to stop this phenomenon [2]. In order to develop preventive strategies for retaining interest in computer science, it is important to first understand why students are motivated to choose or reject this field of study. This paper presents findings from a survey conducted in 2010 amongst 140 university students who were asked to explain why they did or did not choose computer science as a career.

Manuscript received July 19, 2010. This investigation was possible with the collaboration of many European partners (in appendix). Telecom & Management SudParis, France. +33.1.60.76.44.47.

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The contents of this paper is organised as follows:

- Section one presents official statistics that show the decline in the number of students enrolled in computer science studies in Europe and in other comparable countries in North America;
- Section two lists the negative economic and societal consequences linked to the declining number of computer scientists in Europe;
- Section three presents the results of our investigation providing insight into the motivations of students that reject this career;
- Section four presents the conclusions from our investigation and plans for our future work consisting in the formulation of strategies to promote interest in computer science amongst students.

II. Background and Related Work

This section provides background information from previous investigations which indicate that knowing the reasons of the declining interest in computer science is essential to understanding and controlling this problem.

Some studies agree that the reason why a student does not feel attracted by technology is related to the image these careers reflect. A European orientation study suggested that *"The choice of the students is essentially determined because of the image of the professors in the scientific and technological areas and by the content and quality in the discipline"* [3].

Another hypothesis suggests that a number of students reject computer science as a result of a decreasing number of job offers. In 2002, Robert Pretchter presented his investigation about the "dot.com crash". This study showed that there was an increase in economic activities related to computer science and the opportunities the market was offering [4]. However, in 2004, the market suffered a dramatic drop in the computer science performance, similar to the one we are suffering these days [5].

The Computer Science Teacher Association (CSTA) also produced statistics with some analysis in 2010 that attests the decreasing numbers in computer science students and courses related to this field that are offered to students in schools [6].

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III. Statistics about the declining interest in computer science in Europe

In an effort to provide research-based information for educators, decision-makers and researchers, the Computing Research Association (CRA) with the Eurostat, regularly conducts surveys amongst high school computer science teachers and disseminates its results to the educational community. These studies reflected a low number of students enrolled in computer science [1, 6].

Decreasing numbers of student enrolments, graduates and computer science courses offered in curricula have set off a general alarm in Canada, the United States and Europe [1]. Some experts called this situation "*a serious warning sign*" [5] as they discover that fewer schools are offering computer science classes, which means fewer students are being formed with computer science skills. Other related concerns are teacher certification levels and a lack of solid information to help understand and fight this problem [6].

According to the CSTA research, the number of advanced placement computer science courses offered in high schools has dropped significantly in the last four years and so have the number of students enrolled in them.

In 2009, for example, their investigation determined that only 5,9% of schools in the United States and Canada were offering introductory computer science classes, compared to 73% in 2007 and 78% in 2005 [3]. The results of this survey are represented in Figure 1.

Results from other investigations underway in Europe will demonstrate similarities to the North American studies: a declining interest in scientific and technological careers, while the number students enrolled in tertiary education is rising [1]. This phenomenon will have an impact on the computer science field and the information technology (IT) industry.

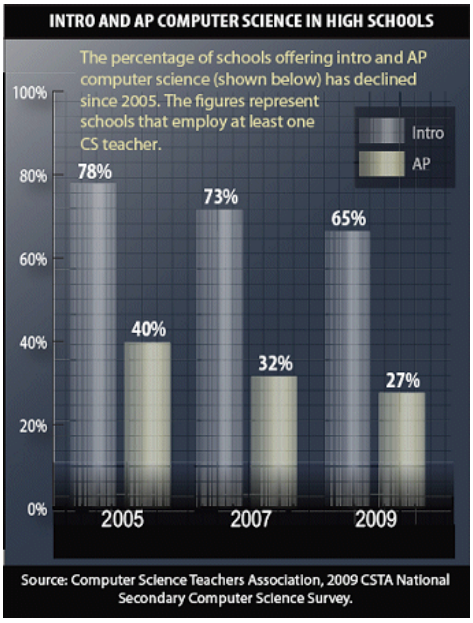

Figure 1. Computer Science Teaching Association, 2009 CSTA National Secondary Computer Science Survey [3]

IV. Consequences of a declining interest in computer science in Europe

European industries are suffering an imbalance in the low number of students choosing to follow computer science and the high demand from industry. Because of this, previous studies have identified economic and educational consequences as their main concern [2].

A. Economic consequences

1) Rising prices for computer science development

As explained in the economic model of elasticity, the price of a product is determined by its offer in the market [7]. If the number of information technology developers decreases; then their products will become more expensive and scarce while the demand remains constant. This theory is illustrated in Figure 2. Thus, it is crucial to maintain a large number of students and experts in information technology in order to keep development costs down and in order to sustain the growth of this industry in Europe.

2) Migration of the Information Technology industry

The increasing prices of IT development in Europe and the decreasing numbers of professionals to satisfy the demands from industry have driven European companies to redirect or migrate their labor forces to foreign countries where IT development work is not only as efficient as in Europe, but also where there is a greater available production capacity at a lower cost. Endeavouring to maintain low operating costs, European companies are purchasing and developing software in countries where it is cheaper.

While purchasing IT development work from outside Europe represents a great opportunity for those countries where the work is done and the development of other professions in Europe (like purchasing); this scenario could have negative consequences for the European: a decrease in IT developed locally that could result in industrial; the migration of the work force (hence unemployment of local workers); the reduction of actual and future jobs and a reduction in revenues from income tax payments [2].

Predictions about job losses related to shifting high-technology work to low-wage nations with strong education systems, like India and China, were greatly exaggerated. As remarked by Lohr, S. 2006, "*The concern is that misplaced pessimism will deter bright young people from pursuing careers in computing, and, in turn, would erode the skills in a field that is crucial to the nation's economic competitiveness*" [8].

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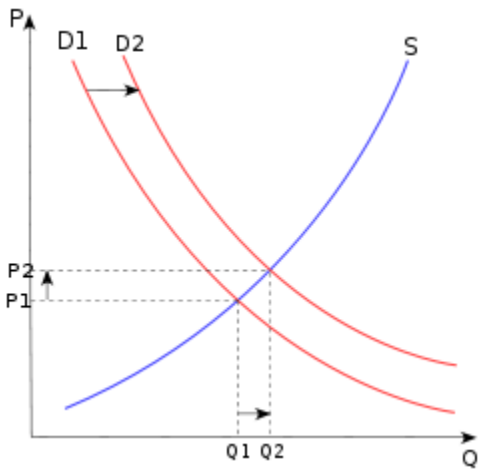

Figure 2. Elasticity of the price of a product (P, price; Q, quantity; D, demand; S, elastisity)

B. *Consequences for education*

1) *Increase in management careers*

As developed in the previous section, the number of students entering university is increasing and the number of students enrolled in computer science studies is decreasing in Europe. The official European statistics also show that studies in professions like business and social sciences are currently the ones that are increasing these days. In fact the global increase in the demand from industry for information technology is providing opportunities for successful careers in management, purchasing, marketing and international commerce; because the technology that is not being developed in Europe is being purchased from other countries [1].

2) *The need to learn cultures and languages from countries outside Europe and North America*

Because of the growing migration of the computer science development and the need of companies to extend their commercial exchanges, there is an increasing need to learn other languages to succeed in negotiations with countries outside Europe.

However the cultures and languages of the countries which are involved in technology are not related to the European. Therefore, European languages such as English, French, German and Spanish (the most widely spoken languages in Europe and in the world) may become less useful to European industry than Chinese or Russian and possibly no longer be needed [9]. Many studies point to the importance of learning foreign languages and to facilitate the migration for business. "*As access widens, unique educational modules, courses and programs are being designed and evaluated throughout other regions, evidencing issues, challenges, opportunities and initiatives related to this education*" [10].

3) *Changes in curricula*

European curricula should be adapted in order to offer courses of study that will train students for the kind of language and management skills that will be needed by competitive European industries playing in global markets [11].

V. Building a Strategy to Prevent Decline in Interest in Computer Science and Negative Consequences

Our research involves the creation of a management plan to overcome the imbalance in the offer and demand of IT development work carried out in Europe. As a first step we will attempt to analyze the conditions which contribute to decline the interest in computer science studies and careers. Previous investigations indicate that knowing the reasons of this decline is essential for finding solutions. The studies blame the negative perception of IT careers fostered in high school suggest that industry could do more to improve the image of IT jobs and help develop a more positive stereotype [12]. With this objective in mind, we conducted a study in order to identify the reasons that influence European students to choose studies and careers in information technology.

VI. Understanding the Reasons of Rejection of Computer Science Studyes in European Countries (March– May, 2010)

A. *Investigation Description and Objectives*

We conducted our study to identify the different motivations a student has to choose or reject computer science as a career. The study was designed to better understand the social perception of computer science and to identify how these perceptions influence a student's choice.

B. *Target and demography coverage*

Our investigation was conducted amongst a sample of 140 people; between them master's students, PhD students, and professors from two institutions of higher education: Telecom SudParis and the Polytechnique University of Cataluña and students attending the Joint European Summer School on Technology Enhanced Learning 2010.

The survey was completed by a total of 140 persons and 24 European countries, as shown in Figure 3.

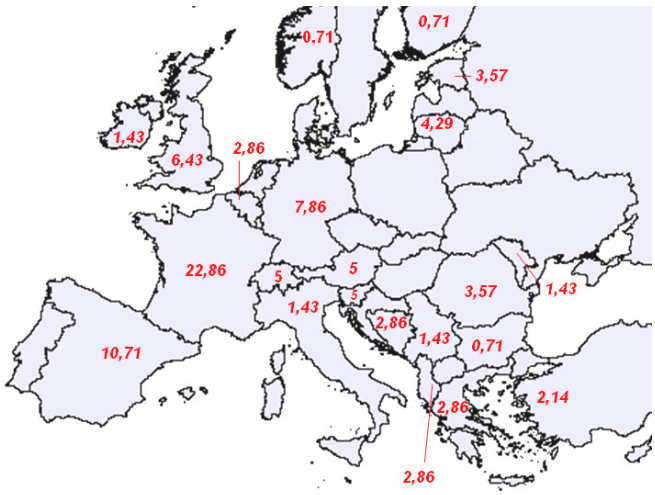

Figure 3. Geographic coverage of the survey

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The survey was designed to find answers for the following targets:

a) Students: that will identify the perceptions of computer science and IT (amongst people enrolled in these programs as compared to others who are not enrolled in them). They were asked the question: Why did you feel attracted or not to computer science?

b) Experts (graduated): working as computer scientists that will provide an important list of incentives that can not be persuade before taking the choice of study, and that can be determine without certain experience.

The target distribution was: 73% students enrolled in computer science studies and other 27% experts in information technology, working in the field (see Figure 4).

An analysis of the responses made it possible to list some reasons why a student decides to follow or reject careers in computer science.

Between the obtained answers: attraction to computer science studies is low, the perceived degree of difficulty is a barrier, a misconception of the social function also matter, the unclearness of the domain, etc.

An important number of previous studies corroborate our findings and are included after each answer.

C. Motivation and reasons to follow studies in computer science

Question two: What are the motivations you have to follow this domain of study?

Both students and professionals attracted to follow computer science studies were "highly passionate" for technology.

Represented in Figure 5, a total of 59% agree that this was the reason that helped them make their choice of study. A minority pointed out that they "just liked it" and that the word "passionate" was too strong to define their motivation.

Only a small number of the participants (14%) said that a high salary and job opportunities attracted them to follow ICT studies. Thus we might suggest that job offers and salaries in industry could be enhanced in order to attract more people to this field.

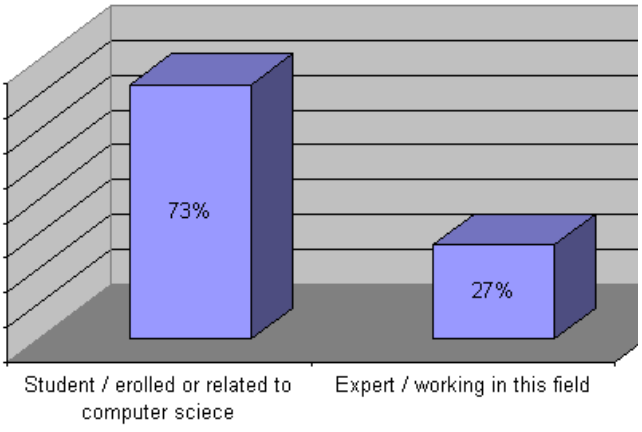

Figure 4. Survey target group

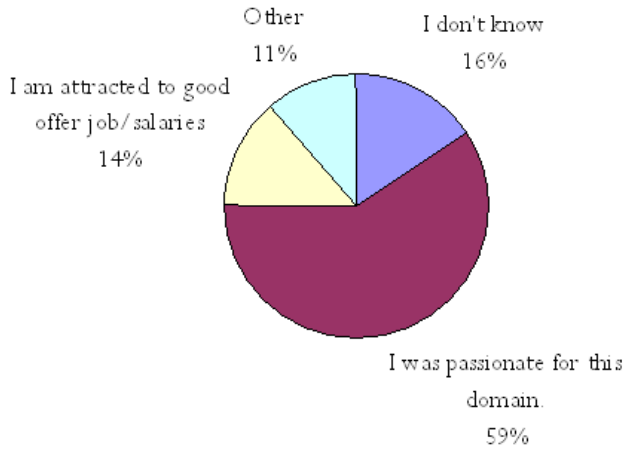

Figure 5. Reason to follow computer science studies

Question three: What do you think are the positive points of the career you choose?

In order to include all possible answers to this question, we left the field open on our questionnaire. Curiously all the responses were the same as in question 2.

The responses provided by professionals and students also pointed to the same motivations.

Other authors suggest that industry could do more to improve job offer and salaries to valorize the career [12].

D. Reason to reject computer science

Question Four: In your opinion, what are the reasons that prevent a person from following computer science studies?

1) High degree of difficulty

The fact that computer science requires a strong background in mathematics and algorithms is a major fear which prevents students from enrolling.

However, the professionals in our survey commented that this difficulty is easy to overcome when you really wish to become a scientist.

They suggest that resources should be provided to students to improve their level in these subjects to help them affront their fear of computer science.

It can be concluded that the difficulty of mathematics might be over estimated by students before making the career choice, but it should not really represent a justifiable reason to reject it.

Some references agree that the reason why a student does not choose computer science or does not feel attracted to technology as a filed of study is related to the degree of difficulty these careers reflect, presuming that this is determined by the content and quality in the discipline" [3].

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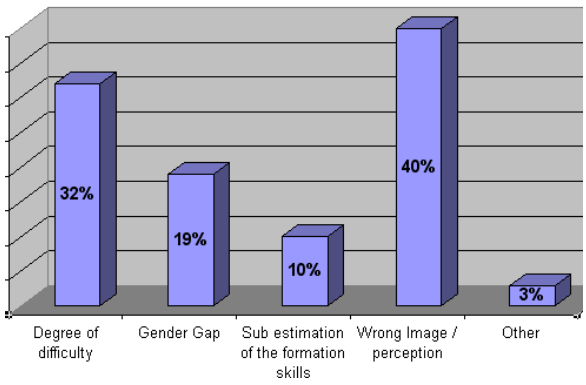

Figure 6. Reasons to reject computer science as a career.

2) Gender Gap

Question six: Do you think computer science is still affected by the low number of women in it? This question allowed us to see that women still feel that some scientific careers related to computer science are difficult to accomplish: the time requirements, the lack of other women that will accompany them in their careers, the negative image the career has when it comes to feminine motivation, etc.

It is important to remark that strategies designed to attract women to computer science represent a great opportunity to increase the total number of students in this field.

Other investigations are making an effort to increase gender diversity in engineering degrees, because they estimate that the number of women enrolled is still very low [14].

3) Under estimation of the formation skills

An interesting point of view that seems to be repeated several times is the fact of IT being adapted to almost everyone. New technologies allow a person to easily acquire computer science knowledge such as html or JavaScript, thanks to useful autodidactic tools.

These skills are recognized as important for the people, e.g. for including them as proficiencies that can represent much in their curriculum. However they think is not necessary to dedicate a complete career to learn them.

Experts in the computer science faculty are likewise concerned with student attitudes: "*computer science is just programming;*" [15]. Faculty must consider ways to move students toward the idea that "*The work you do in computer science in the real world requires a lot of creativity*," not only programming and that it can be dynamic. Students in this domain complain that the curriculum in computer science covers many disconnected topics and highlight that students perceived the career as very difficult and assistance demanding [16].

4) Wrong Image perception of the career

One of the main reasons computer scientists thinks is retaining students from following technology studies, is the image perception this career reflects. Between the answers words like "geek", "nerd" or "lab rat" were applied in order to identify this image, meaning that the person that follow this studies is identify as not very success in social life.

This stereotype is not always true, but still is changing the mind of high school students, who as teenagers will reject the idea of becoming social-rejected in university.

The perception of the career was one of the hypotheses we had at the beginning, for this reason it was possible to make the answers more clear to this matter.

E. Perception of the career

Question five: In your words, what is the definition of Computer Science and what is the definition of a Computer Scientist? It exist certain incoherence from the part of students while answering to the description of computer science or scientist.

By recollecting the information we realize that this concepts are fuzzy even for students enrolled in it, or that they does not identify themselves as computer scientists even when they are involved in studies such as: information technology, system engineering or computing researcher.

They pointed out that the social image is not well represented as a role in society: "*Other careers like medicine, military and even a builder are more clear to us as they are represented with lots of examples and defend their role in society in a better way*".

A very important study completed by the Polytechnic University of Cataluña and supported by HiPEAC European Network of Excellence and the Ministry of Science and Technology of Spaniard, brought as a result many related reasons [17]:

- Most of the students that completed this interview (71%) do not know or are not directly related to any computer scientist. Those who do, is because they know a professor or they are relatives to this person, which almost never happens to be the mother, evidencing the gender problem when it comes to attract women to computer science.
- Almost 40% of them can not define the exact role of an informatics related to a determined role.

Other authors will justify this position because neither the model of professional profile promoted, nor the global approach of the mission is attractive or appealing [14].

Other studies affirm that the lack of knowledge of the professional profile in the computer science field is the main reason of its decrease [18]. Added to this, teenagers and undergraduates do not have clear models in their lives (neither real people nor fictional characters). Consequently they do not know the kind of job an IT professional performs, and do not pursue the corresponding degrees (Computer Science and Computing Engineering) as an option relevant to their future career [14].

VII. Conclusion and Future Work

After analyzing the possible consequences of the declining interest in computer science studies, it is determined that understanding the reason of this decline is very important to control and provide strategies that manage this phenomenon.

As a future work it is recommended to take the results of

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this investigation to create strategies that can reduce the impacts of a low number of computer scientists in Europe.

The solution may be not only be to increase the number of students in computer science but also modify the curricula to adjust some bad tendencies, make it more dynamic and therefore attract more people to it.

An opportunity for these changes is presented while we enter the new Bologna plan, which provides the occasion for readjustments in the European curricula to enhance the education and the future of professionals. A strategy could be to attract people to computer science by enhancing the image of the career, clarifying the role of its actors in society, incentivize the market in terms of salary and, taking into consideration the Bologna process to create lower profile careers related to technology that can solve the salary issue and the perception of the difficulty level. Other studies propose real projects only to involve undergraduate students in computer science degrees [19].

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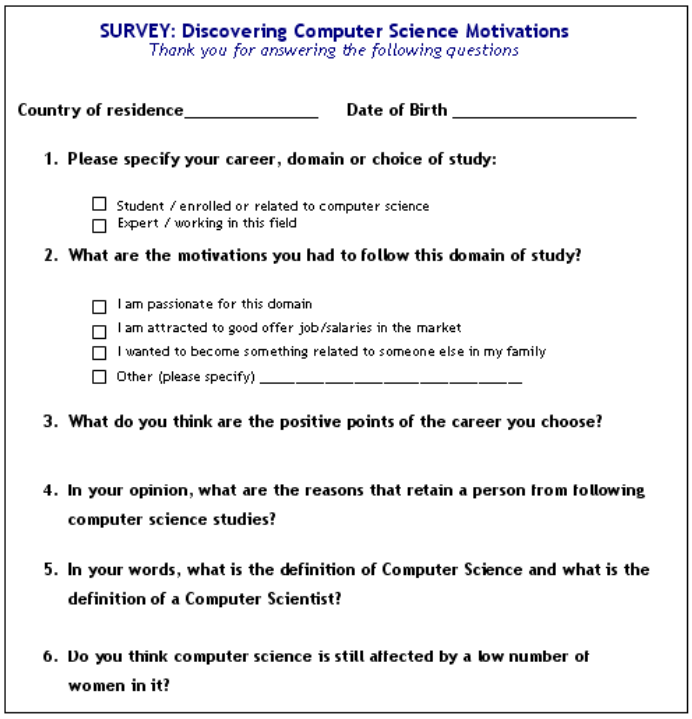
APPENDIX

Survey results are available at: marcelaporta.com/survey



SURVEY: Discovering Computer Science Motivations

Thank you for answering the following questions

Country of residence_____ **Date of Birth** _____

1. **Please specify your career, domain or choice of study:**
   - ☐ Student / enrolled or related to computer science
   - ☐ Expert / working in this field
2. **What are the motivations you had to follow this domain of study?**
   - ☐ I am passionate for this domain
   - ☐ I am attracted to good offer job/salaries in the market
   - ☐ I wanted to become something related to someone else in my family
   - ☐ Other (please specify) _____
3. **What do you think are the positive points of the career you choose?**
4. **In your opinion, what are the reasons that retain a person from following computer science studies?**
5. **In your words, what is the definition of Computer Science and what is the definition of a Computer Scientist?**
6. **Do you think computer science is still affected by a low number of women in it?**

Figure 7. Questionaire: Discovering Computer Science Motivations

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