Evolution of Computer Science Degrees at Science School-University of Buenos Aires (FCEN-UBA)

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Abstract. This paper shows the evolution of the Computador Científico (Computer Scientist) undergraduate program of the University of Buenos Aires Science School, and how it evolve into Licenciado en Ciencias de la Computación (Computer Science Degree). The original curriculum content is shown, the attempts to modify the program are explained and finally a comparison is made between the early program and the beginnings of the Computer Science Degree from 1983. This evolution is analyzed taken into account the development of new areas in CS and the argentinean political situation in this period.

1. Introduction

In 1956 the University of Buenos Aires (UBA) was reorganized after peronist administrations of 1945-1955. The following period of 1956-1966 was probably the most prolific of this university, particularly its Science School (FCEN). This was due to several reasons, including changes in UBA internal structure, the return of intellectuals that had been forced to leave for political reasons and the creation of the CONICET (an organism to help developing research, similar French CNRS or the NSF in the EEUU) in 1958. This period finished with the General Onganía's coup, followed by the well-known violent intervention of UBA, called "Noche de los bastones largos".

As a result of the Science School reorganization the new "Instituto de Cálculo" (IC, Computing Institute) was created by Manuel Sadosky. It began activities in

1957 giving courses. The next year CONICET bought a Ferranti Mercury II scientific computer (named Clementina) to be used in the IC. The IC had an important production in many research areas like statistics, econometric models, theory of languages, differential equations resolution, fluid mechanics and operations research. The IC also produced high quality wide range applications for industry and government. Because of the intervention of UBA in 1966, most of the IC researchers (who also were professors and assistants) left the FCEN [1].

2. Computador Científico Undergraduate Program

"Computador Científico" (CC, Computer Scientist) program was created at the end of 1963 and was first taught in 1964 at the Mathematical Department. Manuel Sadosky was the main driver CC for its creation. The main program goals were: systematize the courses that IC already offered and to educate professionals fundamental skills, allowing them and not to depend on proprietary training by hardware providers companies like IBM or Borroughs. The graduate goal was to be assistant of scientists and engineers looking for massive computing [1]. The name of the program was chosen because of the use of *scientific computers* (as opposed to *commercial computers*, used for administrative systems).

During its first years, the relationship between CC people and the IC was crucial. Most of the teachers (professors and its assistants) were researchers at the IC; many students helped with research projects, and used the same computer the researchers used for work for their homework. So, the excellent and prolific production of the IC worked as a very good influence for generating a CC degree of great quality.

The CC program was three year and a half (seven periods) long. The courses to be taken were:

- six courses shared with mathematical students: *probability and statistics*, *algebra*, *geometry* (linear algebra) and *calculus I*, *II* and *III* ;
- four core courses of computer science: *data processing systems*, *operations research* and *numerical analysis I* and *II* ;
- plus 8 credits in three or four elective courses.

The core courses covered the followed subject:

- *Data processing systems*: comprised architecture and organization of a computer system, namely logical internal components (like ALU and CU), input output system, file organization, compilers and primitive operative systems(OS).
- *Numerical analysis I*: included FORTRAN programming bases, numeration system error propagation and methods for solving common problems like equation roots finding, interpolation, integration, curve fitting, resolution of linear equations systems, eigenvalues computing, etc.
- *Numerical analysis II*: comprised differential equations resolution methods.

- *Operations research*: included linear and integer linear programming with applications to problems of assignment of resources, flow, etc; game theory was also taught in the early courses.

2.1 Elective courses

In this section, we will cover the relevant elective courses for CC that were given from 1964 to 1981. In tables 1 and 2 we can see the list of all classes given and the year of its appearance.

In the second semester of 1964, the first elective courses, operations research II, curve fitting and programming complements, were first taught. The former included some embryonic topics (in 1964): stochastic simulation, queues theory, graph theory and later dynamic programming.

The subject of the latter was assembler language and its relationship with the OS. In 1965, a course that dealt with low-level hardware was taught a single time: logic of digital computers. This topic has never been approached again in that school[1].

From that year to 1967 some courses related do Varsavsky's econometric group were given: mathematical economy, macroeconomic, econometrics and economic models and econometric models. Probably, since Varsavsky's group left FCEN motivated by Onganía's intervention, this line of research was abandoned and so were its classes too.

At the end of 1960's, looking at the curriculum and considering that few elective courses were been given, we can infer that a graduate could choose between two mayor subjects: numerical analysis and operations research (including everything related to optimization of resources). This can also be noticed by looking at the names of the only argentinean graduate associations in 1960's: "Sociedad Argentina de Cálculo" (Computing Argentine Society) and "Sociedad Argentina de Informática e Investigación" (Operations Research Society).

However, in the following years, many of the techniques involved in operations research(OR) constituted its own courses as a reflex of its "emancipation" process. New courses related to "Systems" were added to the program and also some specific subjects "emancipated" from applied mathematics and electronic engineering. Alone with this process a shift of the focus from continuum disciplines to discrete ones can be observed (table 1 to table 2). This is similar the pure mathematics shift of subjects since beginnings of the twentieth century.

[1] This sort of subject was mainly developed at Engineering School of UBA

Table 1. Courses started between 1964 and 1970

Year	Systems	Operations research	Programming	CS new areas	Numerical analysis & app
1964	Programming complements	Operations research II			Curve fitting
1965	Digital computers logic	Stochastic sequences; Math economy			Experiments design
1966		Stochastic phenomena; Macroeconomic; Econometrics and economic models			Statistical inference
1967	Introduction to OS	Variations & optimization computing; Variations computing II; Simulations; Econometric models	Programming languages		
1968	Remote information processing	Optimum control theory	Computing exercises		
1969		Stochastic processes	Programming	Languages & compilers	
1970	Timesharing languages; Simulation & design of systems		Programming II	Introduction to sequential machines	

In the context of the "Systems" area, operative systems and remote information processing appeared. The latter included topics like communication network, timeshare systems and real-time systems, began to be used for flight reservations in 1970's. In 1979, that subject was revisited in a modern way by teleprocessing.

In 1967 programming languages focused on APL and PL/I, in 1969 programming on FORTRAN and Assembler, and in 1970 programming II on COBOL and administrative systems. But in 1974, programming had a big improvement moving its subject to modular and structured programming following Dijkstra's theory, and providing some functional programming concepts, which is very similar to the way programming is being taught today in FCEN. The first approach to functional programming was in 1972 with Lists programming which focused on Lisp.

Table 2. Courses started between 1972 and 1981

Year	Systems	Operations research	Programming	CS new areas	Numerical analysis & app
1972			Lists processing; Information structure	Math seminar; Compilers design	Integrals equations
1973			Adm. systems	Math, computability & complexity seminar; Information retrieval	Numerical process error bounding; Finite elements methods
1974		Graph theory			
1975	Systems simulation seminar	Dynamic programming			Biomath; Biomath seminar; Computing errors & CS theory seminar
1976		Matroids introduction			Mechanics for CS
1977			Programming III		Analogical-digital simulation
1978		Differential games		Databases	
1979	Teleprocessing			Computer graphics	
1980				Artificial intelligence	
1981	Data processing system eval.		Pascal & Ada languages.	Math. theory of comp; Logic & auto. inference	

In 1972 information structure taught the main mathematical containers (sets, maps, Cartesian products, etc.), some of its implementations (lists, balanced trees, hash tables, etc) and some applications too. In the following years, the last topic became more important leading the course to applications in databases.

In 1969 languages and compilers had been included using some primitive formalisms that were improved in the next year when "introduction to sequential machines" appeared. This course introduced the Halting Problem representing the first appearance of theoretical CS topics in the curriculum. Since 1975 biomathematics and biomathematics seminar started to study application of maths

and computing to circulatory system, biological systems and environment, using a large variety of techniques like graph theory, image patter recognition, simulation, differential equations resolution, curve fitting, etc.

In 1976 the so called "Proceso de Reorganzación" dictatorship begun. Many FCEN professors had to leave Argentina or were killed[2] and some recent improvements were rolled back. As an example of this, programming course left Dijkstra's theory and functional programming moving back to Assembler. For more examples see sect. 2.2

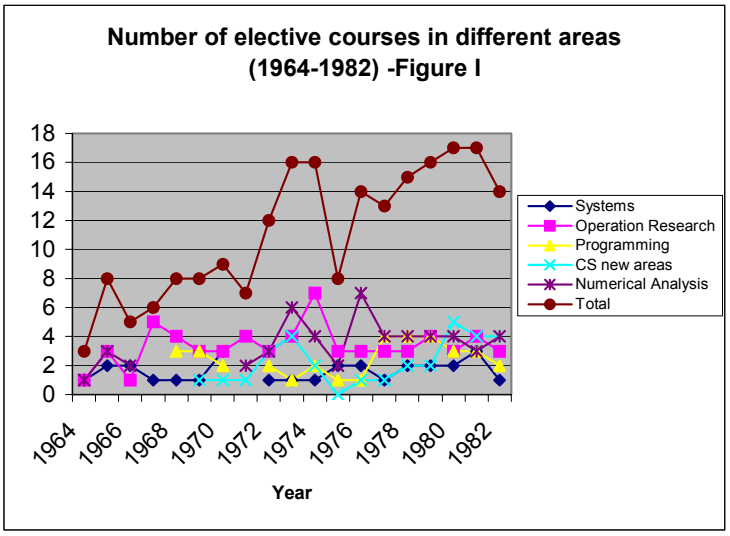
Though databases subject had been presented previously in information structure and data processing systems the database course started to be taught in 1978 and 1980 had very similar topics to current ones (for instance, relational database or distributed systems).

Data processing system evaluation taught established formal parameters and computational methods to evaluate systems giving birth of a software engineering area. Finally, logic and automatic inference focused on Prolog and its use to prove theorems.

2.2 Evolution of elective courses and politics

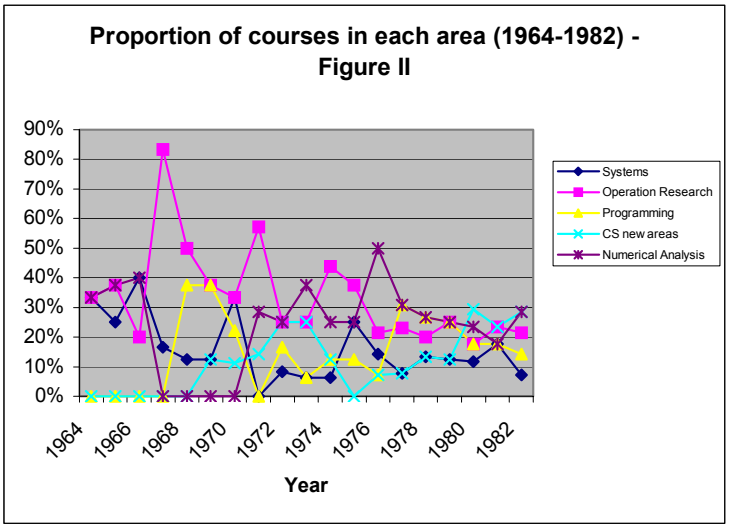
In this section we will try to analyze the influence of political changes on the development of new elective courses.

As a first remark, we can see a fall in the number of elective courses in the years related to changes of administration: 1966, 1971, 1975, and 1976-77. The only exception to this observation is the year 1973, and it was likely due to the return of democracy after 1966-1973 military administrations (see figure I).



[2] Actually, this process started one year before at the end of peronist administration

As a second remark, the proportion of new Operation Research courses grew in the years of *coup d'etats* (1966 and 1976) and in 1975, when the peronist administration in Argentina turn to the right. In addition, the proportion of new "Systems" courses was not altered in those years (see figure II). We will mention, as a possible explanation for these facts, that operation research area in Argentina was traditionally related to the army (in particular CITEFA, the research army institute) and "Systems" area were more related to business (less influenced by politics).



As a final remark, the fall of "Numerical Analysis" courses in 1966 shown the impact of IC researchers quits.

2.3 1973-1974: The failed creation of a Licenciatura en Computación

This section summarizes a process that is not known by the community, even in the FCEN. Since the middle of 1960's some problems of the curriculum were detected.

- The lack of training to work in business environment since it was a scientific degree. Companies had started to need professionals and there were no systems engineering degree in Argentina to supply the demand.
- Giving the huge evolution of CS, training was becoming insufficient to per form research activities.

Prior to the "Noche de los bastones largos", some discussion including professors and students had begun trying to find a curriculum for a Licenciatura (five years degree) similar to others in Science School like mathematics, physics or chemistry. The project was delayed because of the already explained consequences of the intervention in UBA.

In May of 1973 elected president Cámpora assigned new authorities for UBA that quickly approved making of Calculus III and Numerical Analysis II elective courses for those considering working in industry[3].

A year later, with some of the people that had left FCEN in 1966 back, the four and a half year Licenciatura en Computación plan was approved, with an intermediate degree after the first two years: Programmer. The goal of the last degree was to supply the companies needs of personnel, while the the first one was created thinking in scientists and project leaders working in business in mind.

The courses needed to become a programmer were:

- two courses shared with mathematical students: calculus I and algebra;
- introduction to CS, giving a first approach to several subjects of the program;
- programming I and II : following topics explained in sect. 2.1;
- systems I and II : the former related to hardware and the latter to batch processes, compilers, generation of computers, loaders, file systems, etc;
- programming lab;
- numerical applications: similar to Numerical Analysis;

The following were the extra courses needed to get the Licenciatura.

- improve mathematical concepts by complements on calculus, probability and statistics and logic;
- programming III : combinatorial algorithms and formalization of concepts presented in previous courses;
- operations research;
- introduction to compilers;
- another courses of system area: operative systems, system architectures and systems lab;
- three elective courses of certain area.

However, and as a result of the lack of policies followed by different argentinean administrations, Licenciatura was dissolved few month after its creation by new authorities in FCEN[4] and the program rolled back to CC degree. The reasons that authorities gave for taking that decision was that school had very few professors or assistants and with not enough formation to teach the degree.

Also, they argued that with this set of scholastics was not possible to educate researchers and that the goal of this school was not to form businessmen. Finally

[3] About 85% of students considered that option as record by a poll

[4] In 1974 a new peronist government, more rightist than the previous one, assumed in Argentina

the authorities suggested to form people in foreign countries or to hire experts to teach in FCEN in order to create a Licenciatura in the future.

Probably the reason for the lack of professors was due to massive resignations for political reasons, and it was intentionally left out of the considerations given by the authorities. As a prove of this massive resignations, the number of elective courses went down from 16 to 8 from the first months of 1974 to the beginning of 1975. This shows that the number of professors was reduced dramatically.

3. Beginning of Licenciatura en Computación: 1982 Curriculum

With the restoration of democracy in Argentina, in 1982, the need for a change in the undergraduate program became clear since it had been created to train programmers in numerical analysis and operation research, assistants for scientific of other disciplines. A Licenciatura had to be created since a new science had arisen and the new political situation made it possible.

The core of new curriculum included five mathematical courses (algebra I, geometry, probability and statistics, calculus I and II), numerical analysis I and II, introduction to CS, programming I and II (this one oriented to software engineering), two of systems (data processing systems and operative systems), operations research, artificial intelligence, programming languages theory and databases. Also, 15 credits in elective courses had to be accomplished to get the degree. The new curriculum was designed using the core courses of Computador Científico, plus some of its elective classes and introduction to CS.

Besides, this curriculum was similar to the ACM recommended one for CS in 1986[4], but considering the elective courses proposed by ACM as part of the core[5]. Some differences could be found in the number of numerical analysis courses and the approach to programming, that actually was more similar to the curriculum suggested by ACM in 1978[3].

4. Conclusion

In the 20 years analyzed it can be observed the large evolution that CS experienced, both in developing new areas and in teaching its subjects. However, the coming and goings of argentinean politics made the changes slower than they should have been, delaying the development of CS in Argentina and missing the chance given by the IC.

[5] This is as a fair approximation since a bachelor degree is 3 years long and a licenciatura is 5 years long

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