Foundations of Programming: a Teaching Improvement

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Abstract. The ESPUMA project is a university project directed to the improvement of teaching in first-year subjects of programming. The ESPUMA project was born three years ago with the main aim of improving the quality of teaching and motivating the student to learn the foundations of programming. This project involves both the use of the new technologies in the classroom and the development of attractive graphical environments to help the student to study the topics of the subjects. In this paper we present the ESPUMA project and evaluate its three-year application by showing main results in terms of academic results and acceptation from the student point of view.

1. Introduction

During the last decade, *Teaching* has emerged as one of the most exciting fields of research. It is well known the importance of teaching in the society. Evidence of the success of the research in the teaching field can be found in the increasing number of papers published on different subjects of teaching. One of these subjects is the *Education in Computing* [3,5,6,7,9] that is the topic treated in this paper.

The School of Computer Studies (denoted as SCS) at the University of Málaga offers two degree-programmes (i.e., SCS-Management and SCS-Systems), each of which is a three year full time course. The first academic year is very important to consolidate the basic concepts necessary to understand each topic of the full programme. *Foundations of Programming I* and *Foundations of Programming II*, denoted as *FP I* and *FP II* respectively, are two subjects corresponding to the first academic year in each of these degree-programmes. By the end of the year, the student is expected to be familiarised with the main notions of the structured programming, to have

some ideas on the concept of 'good style' in programming, and to understand the notions of abstract data types. Thus, the student should be able to write and modify small-scale programs using an imperative programming language including management and design of libraries. In the University of Málaga, these subjects are taught not only in the SCS but also in all remaining Engineering studies. This provides an indication of the importance of these subjects [8].
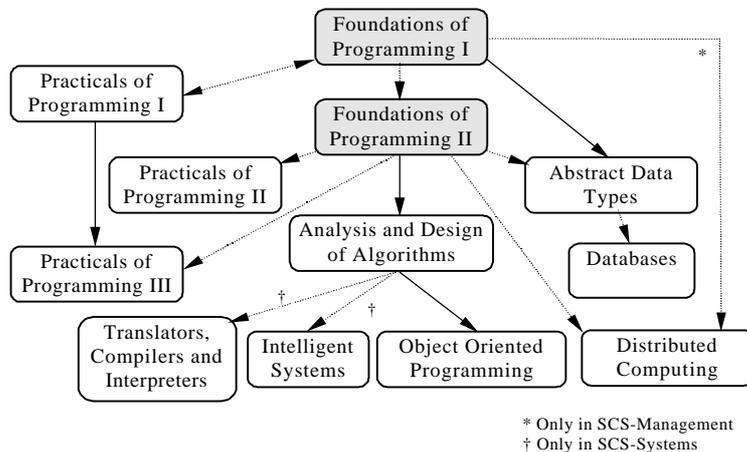
Figure 1. Subjects in the SCS depending on the topics taught in FP I and FP II.

The correct learning of the concepts taught in FP I and FP II is essential to understand correctly the topics taught in further academic years (see Figure 1). The poor results obtained in these subjects in terms of the number of students taking and passing the final exams in the past years motivated the developing of the ESPUMA project. This project is leaded by a group of lecturers that are involved in the integration of the new technologies in the teaching field. The ESPUMA project was born three years ago with the aim of improving the teaching quality in the subjects FP I and FP II in the SCS at the University of Málaga. This project tries to complement the typical lectures of a lesson with new tools (resulting from the capacities provided by Internet) that help the student to a better understanding of the topics of the subject.

In this paper we describe the ESPUMA project and show the main results obtained after three years of application.

2. Academic Framework and Objectives

As mentioned above, the subjects FP I and II are very important since they introduce the basic concepts necessary to complete the three year SCS course. The experience shows the existence of a high rate of academic failure for the first year students. Figure 2 shows the results corresponding to both June examination and September examination of these subjects in the academic years 95-96 and 96-97. Note that the rate of students passing the exams with respect to the number of student taken them is under the 28% and 45% in June and September examinations respectively.
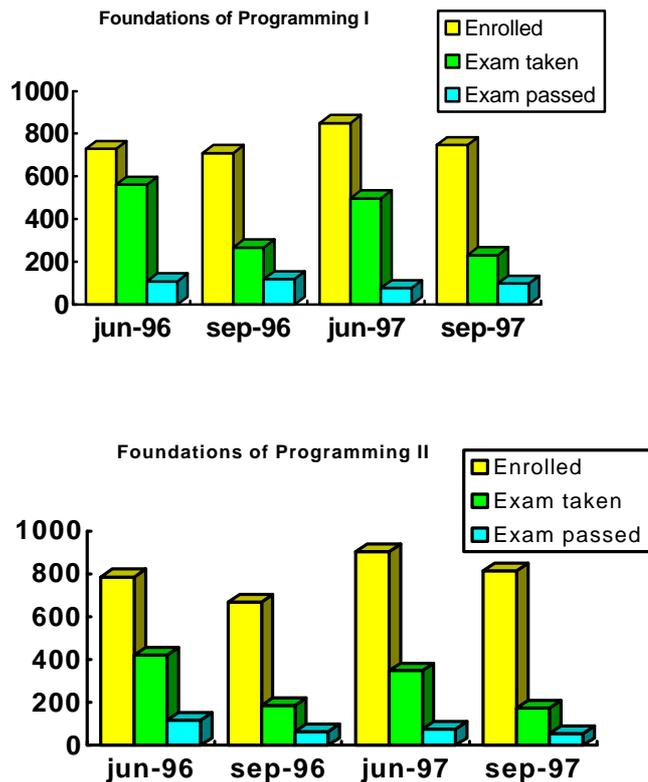

Figure 2. Academic results in FP I and FP II in the years 95-96 and 96-97.

Moreover, the problem of absenteeism among the students is worrying. Generalising, about the 57% and 71% of the students enrolled at these subjects do not take the exam in any of these examinations (June and September). This is a problem that must be considered seriously since,

occasionally, the number of students attending a lesson is under the half of the enrolled students. Among others, we have detected some reasons for this:

- The problem of overcrowding in the classroom;
- Old-fashioned (and even obsolete) methods of teaching;
- Old-fashioned teaching material that has failed to move with the times.

Consequently, we considered that a renovation of the teaching programme as well as the teaching methodology was necessary. Then, the ESPUMA project was born in the academic year 1997-98 with the aims of *attracting the students* to the learning of the topics explained in the subjects FP I and FP II and of *increasing the quality* of teaching by:

(1) increasing the <u>active participation</u> of the students during the lectures,
(2) promoting the <u>attendance</u> of the students,
(3) proposing <u>complementary tasks</u> to give the students the opportunity to work on concrete concepts and
(4) supplying to the students new <u>software tools</u> that help them to mature the concepts acquired in the lectures.

It is important to mention that our project has managed to interest a lot of teachers and lecturers of other subjects and Engineering schools.

3. Description of the Project

In this section we describe the ESPUMA project by identifying our two main proposals: (1) a new teaching methodology and (2) novelty software tools as well as additional material of teaching.

3.1. Methodology

In the traditional lessons, the lecturer explains concepts by using just a blackboard and/or slides to complement the explanation. These resources are valid for a lot of theoretical subjects but are insufficient in more practical subjects as those treated in this paper. Therefore, we propose the integration of the new technologies with the traditional lectures of a lesson. Specifically, we propose the use of *hypermedia systems* as an alternative to the current teaching methods. Hypermedia is defined as the science of the relations to structure, present and provide to the users direct accesses to the contents inside a concrete domain of information by making use of video, audio and

text [1]. Hypermedia systems provide the typical elements necessary to motivate the students because they mean:

(1) A powerful and flexible way to introduce concepts.
(2) A way to construct tools with capacities to be extended.
(3) A way to combine documents on different supports.

According to [4], teaching must be open, multifunctional, co-operative and presented on multimedia environments. These are the main guidelines we have put into practice in the ESPUMA project.

3.2. Software Tools and Teaching Material

We consider that students need additional motivations to understand the concepts explained during the lessons. Thus, we have constructed, or are being constructed, a novelty set of software tools and teaching material to complement the explanations of the lectures.

3.2.1. Proposed Tools

We propose the following additional resources to be used in the teaching of FP I and FP II:

(a) Attractive slides (see an example in Figure 3),
(b) A development environment to program in a programming pseudo-language that helps the student to understand the global concepts of programming without particularising on a concrete programming language (see Figures 5 and 7).
(c) An environment for executing interactive graphical animations leaded to a better understanding of the concepts acquired in the lectures (see Figures 4 and 5).

As complementary information, we also provide:

(a) *A virtual class teacher:* an e-mail address is available for all the students enrolled in the subjects of FP I and FP II so that each student has a direct channel to ask doubts concerning to these subjects. Each query is firstly answered directly to the student who submit it and later centralised and answered globally in form of FAQs (Frequently Asked Questions) in the web.
(b) *A discussion forum* in form of newsgroup (relative to these subjects). This is under construction and we hope it will be working soon.

(c) Administrative information relative to the subjects FP I and FP II in the web.

3.2.2. Current Services

In this section, we describe the services that are currently totally operative and that have been applied in the last three years.

a) *Slides*. The main concepts and topics of the programmes of FP I and FP II have been summarised in a set of full-coloured slides revised by the lecturers teaching these subjects. This means that all the lecturers use the same slides. Also most relevant exercises have been summed up in these slides so that we get the students used to paying attention to the concepts and not to the writing of the exercises. The slides corresponding to each topic are available to the students with, at least, in advance one week.
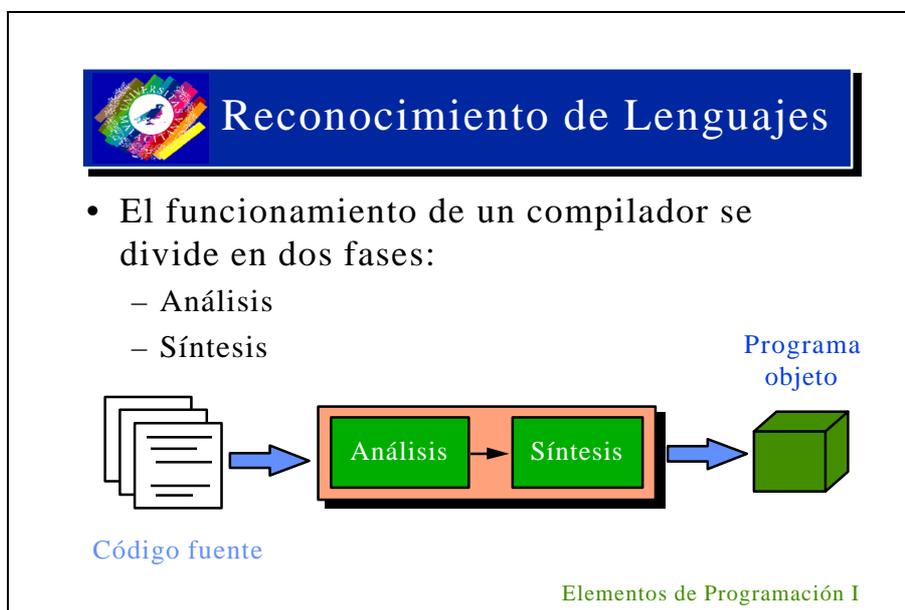

Figure 3. Example of the new format of the slides.

b) Virtual class teacher: the e-mail address *tutor-EP@lcc.uma.es* was created to answer the queries of the students.
c) Design of Graphical Interactive Tools: we have developed a set of graphical tools to visualise (graphically) concepts related to the subjects (e.g., pointers). These tools are graphical environments that interacts with the student (see Figures 4 and 6). They have been developed in the

programming language Java [2] and only require for their use a navigator program for Internet.
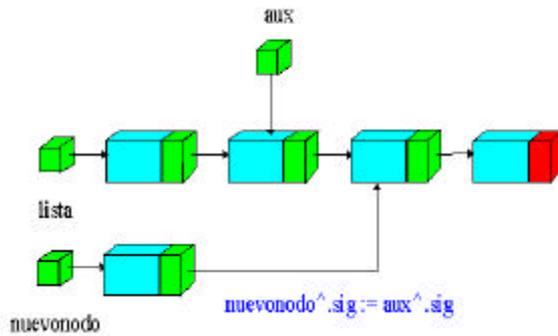

Figure 4. Graphical visualisation of inserting an element in a linked list.

```
Pseudocódigo del algoritmo

Asignar (nuevonodo, Tamaño (Nodo))
(* Introducir información en nuevonodo *)
nuevonodo^.sig := NIL
SI lista = NIL ENTONCES
      lista := nuevonodo
EN OTRO CASO
      aux := lista
      MIENTRAS (aux <> NIL) AND
            (aux^.info < nuevonodo^.info) HACER
            ant := aux;
            aux := aux^.sig
      FIN MIENTRAS
      SI aux <> NIL ENTONCES
            nuevonodo^.sig := aux^.sig
            aux^.sig := nuevonodo
      EN OTRO CASO
            ant^.sig := nuevonodo;
      FINSI
FINSI
```

Figure 5. Code in the programming pseudo-language (in Spanish) associated to the operation of inserting an element in a linked list.

We also have the following services on trail:

(a) Tool to consult the marks in the web.
(b) Tool to program in a programming pseudo-language (see Picture 7).
(c) WWW address of the subjects. This address contains links to both the service of consulting marks and the services of complementary information.
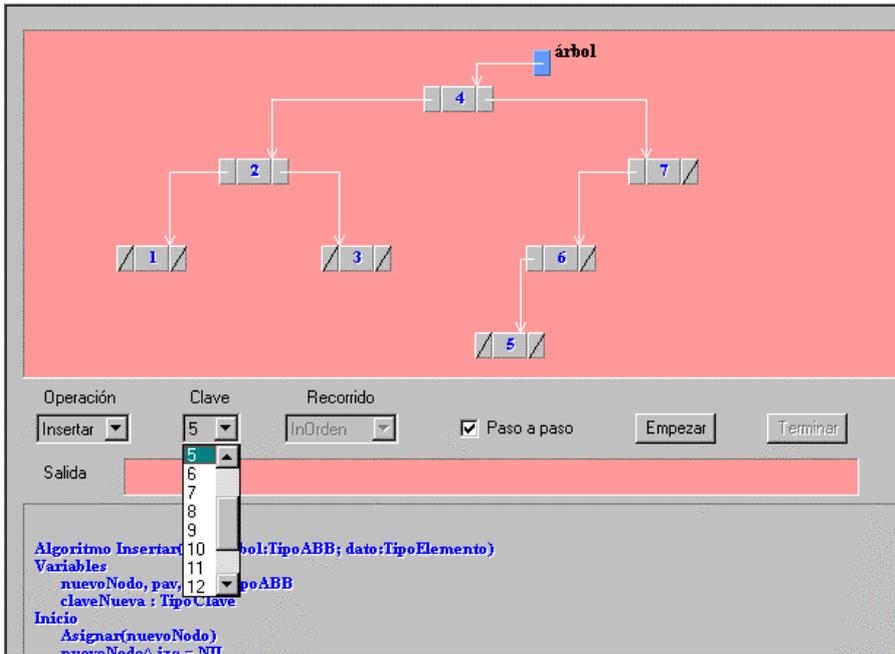
Figure 6. Interactive program that shows graphically binary search trees.
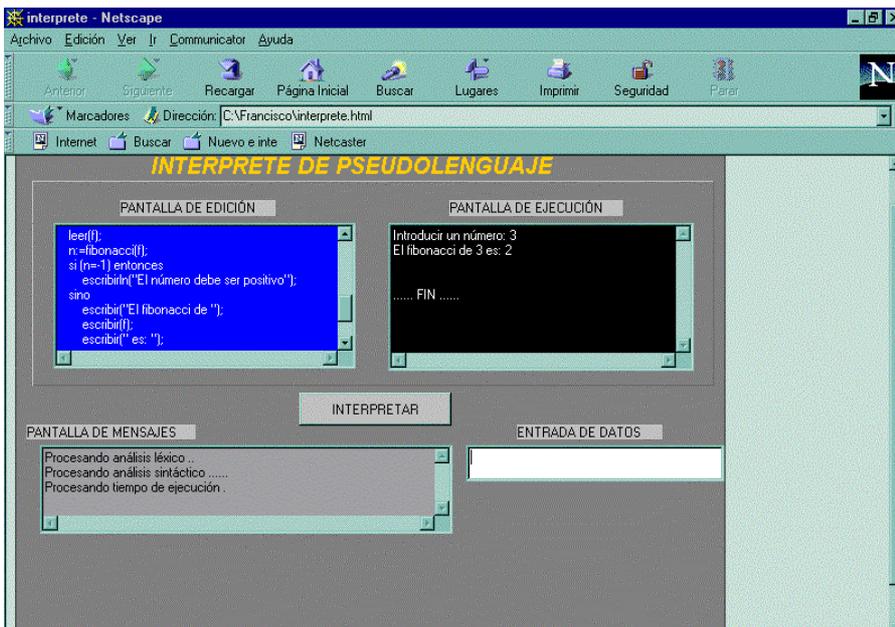

Figure 7. Tool for programming in the pseudo-language.

4. Results Analysed

The ESPUMA project is now three academic-years old and we have evaluated the results during this period.

4.1. Results compared

We have observed satisfactory results with respect the number of students passing the exams. From our point of view this is very positive since it means that it is possible to motivate the students to improve their academic performance. Moreover, from the statistics we deduce that the decreasing tendency of students passing the exams is replaced for an increasing tendency. This seems to be result of the 'renewed' motivation of the students. Although the ESPUMA project is not totally completed since there are a lot of services on trial, the results encouraged us to continue it.

Also, the change of programme and teaching material is interesting for the students repeating academic year since these attend the lessons as a novelty with a more practical approach. Moreover, the virtual class teacher service is a valuable help for these students since they do not have to attend all the lessons and can select the more interesting ones by asking via e-mail the contents of each lesson.

Figures 8 and 9 show that the rate of students passing the exams in the last academic years has increased significantly with respect to previous years. However, we are still worried about the high rate of students that do not take the exams.
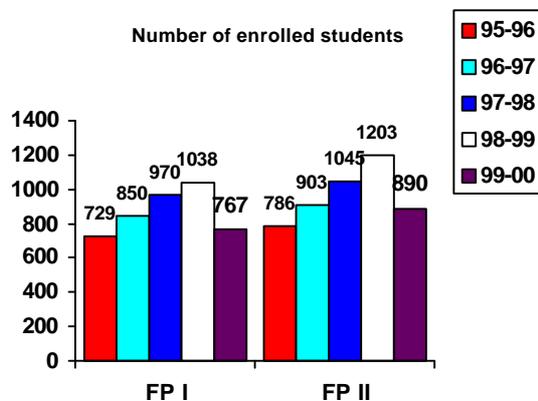

Figure 8. Number of enrolled students in FP I and FP II.

Rate of students passing the exams

Legend: 95-96, 96-97, 97-98, 98-99, 99-00

FP I: 19,4 15,5 27,9 34,9 30,28
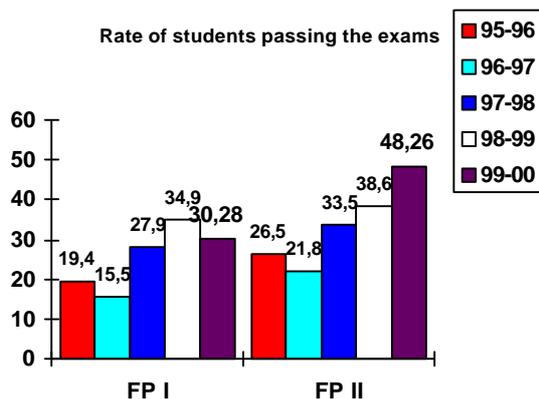FP II: 26,5 21,8 33,5 38,6 48,26

Figure 9. Percentage of students that pass the June exam with respect to the students taken the June exam in the last academic years in FP I and FP II.

4.2. Student opinion

We are also interested in the opinion of our students so that this year we have written a questionnaire to know what they think about the current teaching methodology. The questionnaire consisted of 20 questions about different aspects of the subjects FP I and FPII such as the teaching ability of the lecturer, the material used in the subjects, the programme, topics explained, the additional material, software tools provided and other topics related. Each question was evaluated between 1 and 5 where:

- 1 corresponded to "I do not like at all. It is very bad",
- 2 to "there is still room for improvement",
- 3 to "it is good",
- 4 to "it is very good" and
- 5 to "it is great!".

The overall evaluation was about 3.6. We interpret this mark as "quite good" and consider that the current material is appropriate for the lessons. This is the first year that we have evaluated this questionnaire and it is necessary more years for a more complete evaluation. Anyway, the global mark near to 3.6 encourages us to follow the ESPUMA project.

5. Conclusions and Further Work

As future work we plan to add new material to avoid the decreasing of the interest of the student (mainly with respect the students repeating academic year). Also we are developing new software tools to help the student to a

better understanding of the concepts explained in the subjects (i.e. new graphical simulations of theoretical explanations in the web).

We are also developing a tool to allow the student to self-evaluate. This tool would allow the students to evaluate their knowledge by means of theoretical queries and check their progress during the academic year.

Also to promote the interest of the students, we plan to organise seminars in which different groups of students will be encouraged to program more specific problems related with the subjects. Moreover, we plan to foster forums directed to the implementation of practical programs such as games. We think that these meetings are very attractive for the student since they can verify that the theoretical concepts acquired can be applied in practical problems. The aim is that the student get a higher motivation to learn and not only to pass the examinations.

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