INTRODUCTION TO PROGRAMMING: PORTRAIT OF HIGHER EDUCATION IN COMPUTER SCIENCE IN PORTUGAL

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Abstract

The first contact with computational thinking and programming languages of students entering higher education in computer science courses is extremely important for the future professional of these students: if successful it may indicate a promising career, otherwise it often leads to early abandonment of these students.

The creation and maintenance of courses (1st cycle and 1st plus 2nd cycle integration) in information technology worries directors, coordinators and teachers of these courses. The area is in constant development and, despite the need for highly specialized technicians and almost zero unemployment, it seems that it is not the goal of most of the students who finish high school.

We found in Portuguese higher education 193 courses in computer science. Of these we have 106 1st Cycles, 15 Integrated and 1 Preparation; 66 different intuitions. We study these courses: type of education (public and private), denomination of courses and types (1st cycle, integrated master's degree or preparation). 59 are public education courses: those in private education do not have much information on the internet. Of these 59 courses only 46 have information available online. This article belongs to an investigation that is done around the university courses of computer science: a picture of what exists, which are the vacancies, averages, success rates, how computer science and programming are linked in curricular terms, or in terms of curricular units and in terms of programming languages.

This article focuses on the initial year and initial curricular units of programming of ten Portuguese computer courses that were considered more significant: languages, objectives, bibliography and type of evaluation. It is very important to study what is being done and how it is done.

Keywords: computer science beginners, higher education.

1 INTRODUCTION

The creation and maintenance of courses (1st cycle and 1st and 2nd cycle integration) in computer science is a matter of concern for those who are responsible for departments, coordination's of areas and courses, as well as teachers. The area is in constant development and despite the need for very specialized technicians and almost zero unemployment, it seems that it is not in the minds of most students who finish high school. This article belongs to an investigation that intends to portray higher education in the field of computer science. In an earlier article we describe how secondary education works in Portugal, as well as the entrance in Portuguese higher education. It was verified which courses have the most demand as well as those that do not constantly fill all the vacancies. The choice was made from the Technologies area: 193 courses. From these courses we extracted those who had in their name comput * and informát *; and another eight that seemed relevant to us like Management and Information Systems or information technologies.

We then had 122 existing courses, 106 1st cycle courses, 15 Integrated Masters courses (1st and 2nd cycle) and one preparation course. In all, there are 66 different intuitions. We highlight the institutions of higher education (public and private), denomination of courses and type (1st cycle, integrated masters or preparation). We find that private universities give little information: so we exclude courses from private universities because they do not have much information on their sites. We only had 59 courses that filled all the vacancies. Of these 59 courses, only 46 have course information available online. [1]

2 PROGRAMMING LANGUAGES USED AND NUMBER OF CURRICULAR UNITS (46 COURSES)

We verified by the curricular unit (CUs) records of these 46 chosen courses that there are several different perspectives regarding programming languages. In the following table, we can see how many courses use each of the programming languages listed.

Table 1. Programming language, 1st year; 46 courses.

Programming language	#
C	22
C+Haskell	4
C+java	2
Excel+C	1
java	10
Python	1
Python+HTML+java	1
Python+java	1
Scheme+C++	1
Scheme+java	2
XML+java	1

In the previous table, we can verify that C is the most used programming language at first semester/year in the 46 studied courses.

In relation to the number of curricular units of computer science / programming, it is verified that most of the courses present two CUs in the first year.

Table 2. Number of curricular units of computer science / programming in the first year; 46 courses.

Number of curricular units of computer science / programming in the first year	#
1	4
2	29
3	6
4	5
5	2

3 CHARACTERIZATION OF THE TEN SELECTED COURSES

For the present article, we extracted ten, the top 10. The choice of this one and not of other courses caused by having more number of places than the other courses, as well as the entrance grades being higher. The three courses are 2nd cycle; the other seven courses are undergraduate degrees, ie first cycle.

Table 3. The 10 courses chosen for this study (name, cycle, institution and city).

Our	Course Name	C	Institution	City
UNL	Engenharia Informática	*2*	Universidade Nova de Lisboa - Faculdade de Ciências e Tecnologia	Lisboa
ISEP	Engenharia Informática	*1*	Instituto Politécnico do Porto - Instituto Superior de Engenharia do Porto	Porto
UMinho	Engenharia Informática	*2*	Universidade do Minho	Guimarães
UC	Engenharia Informática	*1*	Universidade de Coimbra - Faculdade de Ciências e Tecnologia	Coimbra
FCUL	Engenharia Informática	*1*	Universidade de Lisboa - Faculdade de Ciências	Lisboa
UBI	Engenharia Informática	*1*	Universidade da Beira Interior	Covilhã
UTAD	Engenharia Informática	*1*	Universidade de Trás-os-Montes e Alto Douro - Escola de Ciências e Tecnologia	Vila Real
UA	Engenharia Informática	*1*	Universidade de Aveiro	Aveiro
IST	Engenharia Informática e de Computadores	*1*	Universidade de Lisboa - Instituto Superior Técnico	Lisboa
FEUP	Engenharia Informática e Computação	*2*	Universidade do Porto - Faculdade de Engenharia	Porto

Of these ten courses, we can verify that there was no vacancy in the placements and that the averages of the last position of the first phase were between 12.98 and 17.8 (Direcção geral do ensino superior, 2018).

Table 4. 1st and 2nd phase: vacancies, number of students, Grades.

	V 1ºPh	V 2ªPh	Entering 1ª	Entering 2ª	Vacancies not filled	Grad 1ºF	Grad 2ºF
Max	200	11	201	16	0	178	182,3
Average	122,2	3,4	122,4	8,1	0	154,08	160,67
Min	50	0	50	2	0	129,8	133,7

4 PROGRAMMING LANGUAGE, 1ST YEAR, TEN SELECTED COURSES

In the following table list the curricular units of programming in the first and second semester [2] [3] [4] [5] [6] [7] [8] [9] [10] [10].

Table 5. Curricular unit name: first and second semestre, ects number and programming language(s).

Our	1st semester	2nd semester	ECTS	PL
UNL	Introduction to Programming	Object-oriented programming	9+9	Java+java
ISEP	Algorithms and Programming	Programming Paradigms	6+6	Java+java
UMinho	Functional Programming	Imperative programming	5+5	Haskell+C
UC	Introduction to Programming and Solving Problems	Principles of procedural programming	6+6	Python+C
FCUL	Introduction to Programming	Algorithms and Data Structures	6+6	Java+java

UBI	Programming I	Programming II	6+6	C+C
UTAD	Procedural Programming	Object-oriented programming	6+6	C+C++
UA	Programming fundamentals	Object-oriented programming	6+6	Python+java
IST	Programming fundamentals	Introduction to Algorithms and Data Structures	6+6	Python+C
FEUP	Programming fundamentals	Programming	6+7,5	Python+C++

It is verified that the most used languages are C (8) and java (7); one of the curricular units analysed uses Haskell and four others use Python. We also can see that java+java and Phyton+C are the most used sequence of programming languages in the two semesters of the first year.

Table 6. Programming language 1st and 2ns semester, ten courses, twenty units.

LP	#
C	8
java	7
Python	4
Haskell	1

Table 7. Sequence of programming languages in the two semesters of the first year..

LP	#
Java+java	3
Python+C	3
C+C	2
Python+java	1
Haskell+C	1

5 OBJECTIVES, EVALUATION METHODS AND BIBLIOGRAPHY

From the previous point, we find that there are two different paths: the same programming language in the first two semesters or initially introducing a programming language like Python or Haskell and in the second semester to be based on C or java. This article does not make value judgments: we only intend to portray the curricular units of the first academic year.

The objectives are almost always based on the languages: build programs in Java or develop algorithms to implement in C. In the first semester units the objective is to use arrays, sorting, merge, strings, but also (in a few cases) stacks, queues and linked lists. Only one course uses flowcharts and another talks in entity-relationship diagrams. In the second semester units, the objectives focus on the concepts of object-oriented programming and recursion, but some still continue with arrays, queues, trees, stacks, and lists / pointers.

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The evaluation is almost always taking into account several items: practical part, theoretical part, evaluation of classes and project (sometimes individual and others in group). Only one of the twenty units has a formula that weighs 50% each of two written test scores.

We have verified that the bibliography of the curricular units is very focused on the chosen programming language: the books that are indicated are java, C (and C ++), Haskell and Python books, As we can see in the following exhaustive list:

java

A. Vermeulen et al., "The Elements of Java Style", Cambridge University Press, ISBN 9780521777681, 2000.
Bruce Eckel, Thinking in Java, 4th edition,, Prentice Hall, 2006, http://www.mindview.net/Books/TIJ/
Cay Horstmann, Java Concepts, 7th edition, Wiley, 2014.
David J. Eck, Introduction to Programming Using Java, Seventh edition, 2016.
E. Koffman e P. Wolfgang, "Data Structures: Abstraction and Design Using Java, 2nd edition" , Wiley, ISBN 978-0-470-12870-1, 2011.
J. Bloch, ”Effective Java, 2nd edition", Addison-Wesley, ISBN 0321356683, 2008.
J.Lewis & W.Loftus . Java software solutions: foundations of program design. 9a Edição. 2018
M. T. Goodrich e R. Tamassia, "Data Structures and Algorithms in Java", John Wiley & Sons, ISBN978-0-470-93439-5, 2010.
Walter Savitch, Java: An Introduction to Computer Science and Programming, 7th edition, Prentice-Hall, 2014.
F. Mário Martins, Java 6 e Programação por Objetos, FCA, 2009.
F. Mário Martins, Java 8 - POO + Construções Funcionais, FCA, 2017.
The Java Tutorials, http://docs.oracle.com/javase/tutorial/

C

Al Kelley, Ira Pohl. A Book on C, Fourth Edition
B. W. Kernighan e D. M. Ritchie. The C Programming Language. Prentice Hall, 1988
K.N. King. C Programming: A Modern Approach. Norton, 2008
Kernigan, B. e D. Ritchie. The C Programming Language
P. Darnell e P. Margolis. C: a software engineering approach. Springer-Verlag, NY, USA, 1996
Robert Sedgewick. Algorithms in C, Addison-Wesley Professional; 3rd Edition, 2001 ou 1997
A. M. A. da Rocha. Introdução à Programação Usando C. FCA - Editora de Informática, 2006.
António Manuel Adrego da Rocha. Estruturas de Dados e Algoritmos em C, FCA - Editora Informática, 2008
L. Damas. Linguagem C. FCA - Editora de Informática, 1999
Pedro Guerreiro "Elementos de Programação com C", 3ª Edição. FCA - Editora Informática, 2006
Wikibook, C Programming: A comprehensive look at the C programming language and its features. http://en.wikibooks.org/wiki/C_language

C++

Andrew Koenig, Barbara E. Moo; Accelerated C++. ISBN: 0-201-70353-X
Babak Sadr , Unified Objects – Objected-Oriented Programming using C++ , IEEE Computer Society ISBN 0-8186-7733-3.
Cay Horstmann, Timothy A. Budd; Big C++. ISBN: 978-0-470-38328-5
Deitel, H. M. , C++ how to program , ISBN 0-13-185757-6
H. M. Deitel, P. J. DeitelDeitel; C++ how to program. ISBN: 0-13-185757-6 (Existe uma versão mais actual (7/ed) com ISBN 0-13-611726-0)
Stroustrup, Bjarne , Programming: Principles and Practice Using C++ , Addison Wesley Longman, Inc. ISBN
Stephen Prata , C++ Primer Plus , Sams Press
Lippman, Stanley B.; C++ Primer. ISBN: 0-201-82470-1
Pimenta Rodrigues, Pedro Pereira e Manuela Sousa. Programação em C++ Conceitos Básicos e Algoritmos. 1998. FCA

Haskell

Graham Hutton. Programming in Haskell. 2nd edition. Cambridge University Press, 2016.
Richard Bird. Introduction to Functional Programming using Haskell. Prentice-Hall, 1998.
Simon Thompson. Haskell: the Craft of Functional Programming. 3rd edition. Addison-Wesley, 2011.
José M. Valença e José B. Barros. Fundamentos da Computação, Livro II: Programação Funcional. Universidade Aberta, 1999.

Phyton

Allen Downey; Think Python - How to Think Like a Computer Scientist, Green Tea Press, 2nd Edition, Version 2.2.23, 2015
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David Mertz; Functional Programming in Python, O’Reilly Media, 2015

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Jeffrey Elkner, Allen B. Downey, and Chris Meyers. How to Think Like a Computer Scientist: Interactive Edition
John Guttag; Introduction to Computation and Programming Using Python: With Application to Understanding Data, MIT Press, Second Edition, 2016. ISBN: 9780262529624
N. Dale and J. Lewis, “Computer science illuminated,” Jones & Bartlett Pub, 2006.
Wentworth Peter 070; Learning with Python 3
Steven F. Lott; Building Skills in Python - A Programmer's Introduction to Python, FreeTechBooks, 2010
Zelle J.M.. Python Programming: An Introduction to Computer Science. Franklin, Beedle & Associates. 2010
Ernesto Costa, “Introdução à Programação e Resolução de Problemas com Python”, DEI, 2011
João Pavão Martins; Programação em Python - Introdução à Programação Utilizando Múltiplos Paradigmas, Instituto Superior Técnico, 2ª edição, 2017. ISBN: 9789898481474.

6 CONCLUSIONS

This article was intended to draw the picture of the curricular units of introduction to the program in the first year of the ten courses chosen for this study. It is not our goal to make considerations or value judgments. Just list and analyse.

There are two paths: use the same programming language (C or java) in both curricular units (1st and 2nd semester of the first year) or different languages (Python / Haskell in the 1st semester and C / java in the 2nd semester). The objectives and the bibliography show that the great concern of the teaching of these curricular units is cantered in the chosen programming languages. The evaluation is made based on several items: practical, theoretical, class notes and sometimes project.

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