Considerations Regarding the Creation of a Post-graduate Master's Degree in Free Software

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Abstract Free software has gained importance over the last few years, and can be found in almost any sphere in which 'software processes' are important. However, even when universities and higher education establishments include subjects concerning free programming and technologies in their curriculums, their graduates tend to attain limited technological, organisational and philosophical knowledge that limits them as regards their participation in, management and development of free software projects. This gap in skills and knowledge has recently led to a series of post-graduate studies whose objective is to offer students the possibility of acquiring competencies that will allow them to become experts in free software. This paper presents a study concerning the offers for post-graduate studies in free software that currently exist, with the intention of creating similar post-graduate studies in Ecuador.

1 Introduction

In the present-day world, society is developed on the basis of information technology, and software has a particularly important function in this, thus demonstrating that humanity's knowledge has evolved by means of computing. For this knowledge to be within everyone's reach, the use of free software is essential. Free software can, moreover, currently be found in a multitude of environments, if not in all of them, and has come to be of prime importance over the last few years [5].

European and South American governments have now created laws and decrees for the use of free software [1], which in Ecuador consists of Decree 1014. The need to train personnel who are qualified in the sphere of free software is therefore being investigated. The European Union has recommended that research should be carried out in this sphere, since it alleges that the habitual lack of knowledge as regards code does not permit the auditing of real functioning, which could seriously compromise the security of some countries, thus leaving them in the hands of companies that create private programmes [3].

We should also mention that free software attracts the attention of companies and public administrations throughout the world, and it is in this way

that countries such as Spain, Brazil, Mexico, Venezuela, Columbia, Peru, Chile, Argentina and, essentially, Ecuador foment its use and development [4],What is more, many large technological companies such as IBM, Apple, Facebook or Google support the free software movement by both freeing some of their star products, such as WebKit, MySQL, Android, and participating in the development of projects such as Eclipse and Linux, among others [6].

Even when universities and higher education establishments include free technologies in their curriculums, their graduates normally lack the training needed to be able to carry out the tasks that are necessary to successfully participate in a free software project [2]. It is therefore common for universities to teach programming. However, although this is one vital requirement as regards providing code, it is not the only one, since to be able to take part in a free software project it is also necessary to have knowledge of development tools (e.g. the version system), conventions (such as sending code) and even organisational skills (who to ask).

The existence of this knowledge gap is the reason why university graduates must therefore supplement their knowledge by means of auto-didactic learning. This gap in curriculums has therefore led to the emergence of proposals for post-graduate studies that will allow students to acquire the skills and knowledge needed to become experts in free software. This type of studies includes not only technological aspects, but also the management of projects, business models and even philosophical aspects.

This paper is organised as follows: the methodology used in this research is described in Section 2, while Section 3 shows a study carried out in order to create a post-graduate course in free software in Ecuador. The results of the analysis of post-graduate courses offered by some possible universities are presented in Section 4, while our conclusions and future work are shown in Section 5.

2 Methodology

Much of the research that is carried out considers a literature review, although the eventual objective is not the review in itself, but rather that it constitutes a technique that can be used to understand the state-of-the-art of the theme being tackled. What is more, a state-of-the art study constitutes the basis for the formulation of proposals of greater reach.

Computing disciplines, of which software is one, are very recent in comparison to other science disciplines, signifying that there are no methodologies with which to guide the development of systematic reviews in them, Kitchenhan [7], therefore proposed a method with which to carry out systematic [10] reviews that is based on the guidelines developed for medical research which were adapted to be used by a team of researchers in the sphere of software engineering.

In this research, the systematic review has been carried out by using the Google Scholar search engine to search for references to 'Master's degrees in Free Software'. The results and information obtained from its websites are shown in the following sections. .

3 Post-graduate studies in Free Software

According to the Royal Academy for the Spanish Language, a Master's degree is a post-graduate course in a particular speciality, while a post-graduate course is a cycle of specialisation studies that take place after graduation.

The Higher Education Organic Law of Ecuador[1], in Art. 120, defines it as follows: "it is an academic degree which seeks to broaden, develop and explore in greater depth a discipline or specific area of knowledge. It provides people with the tools that will enable them to explore the field of knowledge in greater depth, both theoretically and instrumentally".

3.1 Openings for professionals with Master's degrees in free software

A Master's degree in Free Software provides professionals with capacities in the four areas defined in the professional capacities profile report generic to ICT created by the *Career-Space*[2] [9] consortium that are necessary to carry out their activities as regards all that is related to the use, application and development of In each of the areas, the qualification re-enforces the following professional roles:

– Technicians in communications software development.
– Software project managers.
– Communication network designers.
– Application programmers.
– Software engineers.
– Information technology business consultants.
– Electonics business consultants.
– Business analysts.
– Information strategy management consultants.
– Systems implementation technicians.
– Integration systems technicians.
– Project managers ITC.

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[1] LOES by its acronym in Spanish: `http://www.utelvt.edu.ec/LOES_2010.pdf`
[2] Career Space is a consortium that is formed of eleven ICT companies and analyses the need to provide professionals with capacities in this sphere `http://www.space-careers.com/`

3.2 Existing Free Software Master's degrees

The Internet has been used to search for academic offers of Master's degrees in Free Software in Europe and South America [8]. It has thus been possible to find the following university entities, which offer the following studies[3]:

– Official Master's degree in Free Software from the Universidad Rey Juan Carlos[4] (Madrid, Spain),
– Official Master's degree in Free Software from the Universitat Oberta de Catalunya (Open University of Catalonia)[5] (UOC) (Catalonia, Spain),
– Master's degree in Open Code Software from the University Institute of Lisbon[6] (ISCTEC, Lisbon, Portugal),
– Master's degree in Free Software Engineering (MISWL) from the Polytechnic Senior Lleida[7] (Lleida, Spain),
– Master's degree in Free Software from the Autonomous University of Bucaramanga[8] (UNAB, Bucaramanga, Colombia),
– Master's degree in Free Software from the Autonomous University of Chihuahua[9] (UNACHI, Chihuahua, Mexico),
– Master's degree in Free Software from the University of Extremadura[10] (Extremadura, Spain),
– and the Master's degree in Software Open Source Management from the University of Pisa[11] (Pisa, Italy).

3.3 Analysis of existing Master's degrees in Free Software

Having identified the Master's degrees in Free Software, we shall now go on to investigate each one in detail using the publicly provided information from their websites. Table 1 provides a summary of the most important qualititive aspects of these Master's degrees, which are classified in the following manner:

– Country: This refers to the country in which the Master's degree is offered.
– Modality: This refers to the mode of studies, such as (Physical presence, Virtual).

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[3] Please note that this study is not intended to be complete, but is rather a representative sample of Master's degrees in Free Software. The authors would like to apologise for any other initiative that has been omitted from this study.
[4] `http://master.libresoft.es`. This Master's degree is also offered in conjunction with the Igalia company in Galicia
[5] `http://estudios.uoc.edu/es/masters-universitarios/software-libre/`
[6] `http://iscte-iul.pt/cursos/mestrados/10702/apresentacao.aspx`
[7] `http://www.udl.cat/estudis/masters_cast/programario_libre.html`
[8] `http://www.unab.edu.co/portal/page/portal/UNAB/programas-academicos/software-libre-virtual?programa=MSOL`
[9] `http://www.uach.mx/investigacion_y_posgrado/2010/10/28/maestria_en_software_libre/`
[10] `http://www.eweb.unex.es/eweb/msl/index.html`
[11] `http://www.master.netseven.it/index.php?page=/master/home`

– Duration: Length of time that the Master's degree course lasts.
– Professionals: Towards which type of professionals the Master's degree is ori-
ented, such as: Information and Communication Technologies (ICT), General
(any professional with a university degree).
– Credits: This refers to the ECTS.
– Placements: This refers to whether or not the student is required to partici-
pate in an industrial placement during the Master's degree.
– Final Project: This refers to whether or not the student is required to produce
an end-of-degree project.
– Options: This refers to whether or not the Master's degree contains optional
subjects.
– Agreement: This refers to whether or not the Master's degree is carried out
via agreements with other universities.
– NK: This refers to the fact that Nothing is Known about the aspect in ques-
tion, and no information is provided on the website.

Tabla 1. Comparison of Universities Offering Master's degrees in Free Software

Comparison of Universities Offering Master's degrees in Free Software							
Universities							
	URJC	**UOC**	**ISTEC**	**U Lleida**	**UNAB**	**UNACHI**	**Extremadura**	**U Pisa**
Country	Spain	Spain	Portugal	Spain	Colombia	Mexico	Spain	Italy
modality	Presence	Virtual	Presence	Presence	Virtual	Presence	Presence	Presence
Duration	1 year	1 year	1 year	2 year	2 year	NK	1 year	1 year
Professional	General	General	ICT	ICT	ICT	ICT	ICT	ICT
Credits	60	60	60	60	43	NK	60	60
Practices	yes	no	no	yes	no	Nk	Nk	Nk
Final Project	yes	yes	no	yes	yes	Nk	Nk	Nk
Electives	yes	yes	no	no	no	Nk	Nk	Nk
Agreement	UOC	no	UOC	no	UOC	Nk	Nk	Nk

The students for whom the Master's degrees are intended are those with a
technical professional profile (ICT), since the objective of these degrees is to
study technology and skills in greater depth, thus supposing that the students
will already be knowledgeable as regards programming and engineering. Two
exceptional cases are those of the Master's degrees offered by the URJC[12] and
the UOC, since these universities have broadened their curriculums to include
any type of entrance profile and offer, on the one hand level 0 subjects in order to
allow students to attain the previous requirements for the subjects, and on the
other a wide range of subjects including those with a socio-technical element,
such as communication management, business models, etc

There are Master's degrees which are taught both in the students' physical
presence or virtually, although in the cases in which the students are actually

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[12] http://master.libresoft.es

present, we have observed the use of an e-learning environment (generally Moodle[13]), which has led us to conclude that this type of teaching is, to a great extent, backed up with on-line elements. The URJC explicitly states that its Master's degree is considered to be a form of *blended learning*, since many of the course activities are carried out virtually, and the students' physical presence is limited to that required by law.

The majority of the Master's degrees are designed to last one or two years, although this is initially delimited by the students' dedication. This signifies that the most interesting column in the table is that which indicates the ECTS[14] credits that the student must exceed to obtain the degree. One ECTS credit is obtained after an average of 25 hours' work by each student, including classes in which they are physically present, the preparation needed for these classes, the tasks and activities carried out, exam preparation, and even the exams themselves. It will thus be observed that, in general, Master's degree students must exceed 60 ECTS credits, which is equivalent to a year's work by the student. The academic years may therefore be longer or shorter, depending on the amount of time available to the student. The universities offer various possibilities in order to adapt to the students. The Master's degree at the URJC can therefore be obtained by solely attending classes on Fridays – rather than Thursdays and Fridays – throughout a single academic year. The subjects that take place on Thursdays in even academic years are moved to Fridays in the odd academic years, and vice versa. This facilitates the students' participation, since they are from professional environments, signifying that their time is always limited. Another example is the UOC which allows its students, who are generally professionals with families, to take the course at their own pace, choosing 10 or 15 ECTS per course.

The design of the Master's course curriculums may differ as regards certain characteristics. We have therefore investigated three of these elements:

– The need to go on industrial placements. On some Master's courses, the students must show that they have had experience in professional environments related to free software. They are therefore required to go on industrial placements at companies in the sector at which they gain experience. At some universities agreements have not only been reached with software companies, but also with foundations, thus allowing the students to carry out the practical element of the course in foundation projects.
– The realisation of an end-of-degree project. In order to obtain the degree it is compulsory to produce an end-of course work which is, if possible, a research work that is carried out by the student under the supervision of a tutor. This work must be presented in the form of a report and must be publicly defended in front of a committee.

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[13] http://www.moodle.org
[14] ECTS (European Credit Transfer System) (BOE 2003). ECTS credits are established by measuring the amount of work that the student has carried out both inside and outside the classroom to pass a subject.

Tabla 2. Curricular Planning of Free Software Master's Degree (URJC)

Name of subject	Description of Minimum Content	Type	ECTS	Seminars	Character
Introduction to free software	Introduction, motivations, definition and history of free software. Introduction to legal, economic, social and technological framework of free software	theorist	3	1^O	obligatory
Legal aspects of free software	Intellectual property, legal aspects, licences	theorist	3	1^O	obligatory
Economic aspects of free software	Introduction to economic aspects of software, types of business models, business plans and case studies.	theorist	3	1^O	obligatory
Developers and their motivations	Profile of developers, motivations, roles and leadership in free software. Evolution of participation and integration programmes in projects	theorist-practical	3	1^O	obligatory
Free software development. Tools	Development environments, version control systems, defect and task management in free software projects. IDEs and collaborative tools. Case studies specific to free software project development	practical	3	1^O	obligatory
Free software project evaluation	Introduction to software quality. Light evaluation methodologies. Project information extraction tools, quality evaluation atomisation and specific case studies	practical	3	1^O	obligatory
Case studies I - II	Free projects, including themes related to technological, organisational, legal, economic and governmental themes	seminary	9	1^O y 2^O	obligatory
Free software Project management	Introduction to free software Project creation, Infrastructure, communication and management of community elements	theorist	3	2^O	obligatory
Advanced free software development	Advanced tools and advanced technical aspects of free software development.	practical	3	2^O	elective
System integration	Introduction to systems administration, storage, networks, security and virtualisation with free software	practical	3	2^O	elective
Free software instalment	Instalment of free software. Free software in desktops and servers. Cost analyses, requirements and study of infrastructure deployment using free software	theorist	3	2^O	elective
Free software communities	Free software communities from the empirical viewpoint, data collection tools, database management. Introduction to the evolution of software and the study of free software communities. Specific case studies	practical	3	2^O	elective
Industrial placements	Industrial placements at companies	practical	12	1^O y 2^O	obligatory
End-of-degree project	Development of Project focused on free software	Project	12	1^O y 2^O	obligatory

– Options: The Master's degree curriculums may offer a series of subjects from which the students may choose. These options allow the student to specialise, and are therefore highly advantageous. However, their drawback is that they only make sense if there are a considerable amount of students enrolled on the course.

Finally, we have observed that many universities have recognised agreements with the Open University of Catalonia (UOC). This allows students to begin their studies by being physically present and then, if necessary, change to the UOC, which is completely on-line.

3.4 Curricular design

The Master's degree curriculums are organised in a series of subjects. It is interesting to note, as will be shown below, that there is a great similarity in the Master's degrees studied as regards the contents that are offered. This is because there have been many cases of close collaboration among the universities that

offer a Master's degree in free software when designing their curriculums. The Master's degree that has been in existence for the longest period of time, which is that offered by the Open University of Catalonia since 2003, is therefore assessed by professors from the URJC. Since this was the first Master's degree on this theme, and owing to other universities' agreements with the UOC, it is possible to find this general schema in other Master's degrees.

This paper shows the curricular design of the Master's degree offered by the URJC, which is divided into subjects of 3 ECTS (75 hours' worth of dedication per student), while that of the UOC has subjects of 5 ECTS (125 hours per student). This signifies that the Master's degree from the URJC, although it has the same content as that of the UOC, is atomised to a greater degree, thus permitting us to show the contents on offer in a better manner.

Table 2 shows the subjects in the Master's degree at the Universidad Rey Juan Carlos, together with a description of contents, the amount of ECTS credits, the semester in which they are taught, and whether the subjects are obligatory or optional. In order for this degree to be awarded the title of University Master's degree (the official title of the European Higher Education Area – EHEA – and therefore valid in all the countries in the OECD), its course design had to be approved by the Spanish ANECA agency (National Agency for the Evaluation of Quality and Accreditation).

According to their type, the subjects can be classified as: (i) theoretical: subjects taught with the purpose of the students acquiring knowledge; (ii) practical: subjects which are focused on the acquisition of technological skills, with a highly practical structure; (iii) seminaries: A cycle of talks, generally given by speakers invited from the free software community, at which the students can gain firsthand experience of the *reality* of the movement; and (iv) ohers: The practicum and final work of the Master's degree, explained previously.

The Master's degree contains four optional subjects, of which two must be chosen. Two itineraries are therefore recommended: (a) *Technological*, which consists of the subjects *Systems integration* and *Advanced free software development*, and is intended for those students who wish to develop a more technological profile; and (b) *Management*, which consists of the subjects *Free software installation* and *Free software communities*, and is intended for those students who prefer to specialise in community management and consultation tasks at an organisational and deployment level.

4 Analysis and Results

The analysis carried out has allowed us to conclude that, as is shown in Table 3 the Master's degrees in free software offered by other universities share a schema similar to that of the Universidad Rey Juan Carlos.

As will be noted, there are various common contents, although some subjects are only offered by the URJC and are of two types: (a) The *Case Studies I* and *Case Studies II* eminaries which, owing to their idiosyncratic nature, only take

Tabla 3. Analysis of Universities' Subjects with Regard to the URJC

Analysis of Universities' Subjects with Regard to the URJC						
Subject	URJC	UOC	ISTEC	U LLEIDA	UNAB	UNACHI
Introduction to free software	yes	yes	yes	yes	yes	NK
Legal aspects of free software	yes	yes	yes	yes	yes	NK
Economic aspects of free software	yes	yes	yes	yes	yes	NK
Developers and their motivations	yes	no	no	no	no	NK
Free software development. Tools	yes	yes	yes	yes	yes	NK
Free software project evaluation	yes	no	no	no	no	NK
Case studies I	yes	no	yes	yes	yes	NK
Free software Project management	yes	yes	no	yes	no	NK
Case studies II	yes	no	yes	yes	yes	NK
Prácticum	yes	yes	yes	yes	no	NK
End-of-degree project	yes	yes	yes	yes	yes	NK
Advanced free software development	yes	yes	yes	yes	yes	NK
System integration	yes	yes	no	yes	yes	NK
Free software instalment	yes	yes	yes	yes	yes	NK
Free software communities	yes	no	no	no	no	NK

place at the URJC, and (b) Subjects with which the URJC has research experience, as is the case of *Free software Project evaluation* or *Developers and their motivations*. In order to cover these subjects, the other Master's degrees are inclined to offer technological subjects related to GNU/Linux systems administration, web application development or databases. Table 3 shows a comparison of the universities that currently offer a Master's degree in free software with regard to the URJC's schema of subjects.

5 Conclusions and Future Work

This paper presents a study of the offers that are currently available as regards post-graduate studies in the field of free software. It begins by arguing why it is important to have experts in free software at present, and by explaining that students finish their university studies without having attained the knowledge and skills needed by the free software industry and community. Universities and higher education establishments therefore have the possibility of teaching these aspects by offering post-graduate degrees that are oriented towards those professional profiles that wish to specialise in the area of free software [8].

Various European and South American post-graduate initiatives have been found, and the degree of affinity as regards the content of their curriculums is shown in Table 3, principally with regard to historic and organisational matters. The curricular schema of the Universidad Rey Juan Carlos has therefore been used, which provides details of: the existence of a general curriculum, along with the materials available that facilitate the tasks of those universities that wish to offer a Master's degree in free software.

As will be observed in the section in Table 1 entitled 'Analysis of existing Master's degrees in free software', the research has not located any Master's degrees of this kind in English-speaking countries.

This research will continue to review whether professional university graduates who have taken post-graduate degrees in free software have more possibilities of obtaining employment. We shall also verify the evolution that the universities offering Master's degrees in free software have undergone.

Acknowledgements

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