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Training New Professionals in Service Engineering: Towards a Transdisciplinary Curriculum for Sustainable Businesses

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Abstract: The service sector provides employment for more than 70% of the active population in developed countries, in areas as varied as tourism, commerce, logistics, finances, services, and personnel, amongst others. Despite the fact that society increasingly needs more professionals who are oriented towards this sector, there are hardly any specific plans that will provide them with appropriate training. The appearance of service science, management, and engineering (SSME) has led to a significant advance as regards understanding the skills required by a service professional. It is a transdisciplinary field that integrates aspects of business management, along with information and communication technologies and engineering, and social sciences, in addition to providing the foundations for the growth of sustainable business. This paper presents a curriculum for the training of professionals in service engineering, which has been designed and taught at a Spanish public university. This curriculum, which the university created in collaboration with SSME experts and service sector companies, stands out for two reasons: the transdisciplinary approach employed, which is one of the features of this emerging and integrative knowledge discipline, and the fact that it is providing a response to the need for higher education curricula for sustainable business development. The paper describes the method followed to create the curriculum for the Bachelor's Degree in Service Engineering, a comparative study with other related degrees, and the results of the deployment of the degree in terms of employability.

Keywords: service sector; service science management and engineering; service engineering; transdisciplinarity; curricula; sustainable businesses

1. Introduction

The service sector does not produce material goods, but rather covers a wide range of activities, such as commerce, transport, communications, finance services, education, health, and tourism, among others. The inclusion of services in the manufacturing sector has given rise to a phenomenon known as servitization, which has broadened the dimension of this sector to an even greater extent [1]. In terms of the world economy, the service sector is now, therefore, responsible for the employment of approximately 65% of the active population. These data vary, with values of over 78% in countries such as the United Kingdom, Sweden, Denmark, Canada, and the United States, but suffice it to say that between 60% and 80% of the populations in the majority of developed countries are employed in the service sector (source: World Bank data: http://www.worldbank.org/).

Several important professionalization initiatives for the service sector have appeared in recent years. These include research organizations and institutions, such as the SRII (Service Research and

Innovation Institute, http://www.thesrii.org/) in the US, promoted by a set of leading companies from the sector, the ERISS (European Research Institute in Service Science, http://www.tilburguniversity.edu/research/institutes-and-research-groups/eriss/) whose headquarters are at the University of Tilburg's Business School, or the ISSIP (International Society of Service Innovation Professionals, http://www.issip.org/). The objective of all of the above is to improve the professionalism and quality of the service sector.

This is because a service society requires professionals with specific training that will allow them to tackle the challenges that have come about as a result of this transformation, one of which is sustainable development. The complexity and importance of the service sector signifies that it requires personnel who are qualified in service systems, i.e., dynamic configurations of people, technologies, organizations, and shared information that create and deliver value to customers, providers, and other stakeholders [2]. In other words, there is a need for professionals who understand and can take charge of the complete service system lifecycle, from the conception of new services, to their innovation, design, production, marketing, commercialization, etc., whilst paying attention to the sustainability of these systems and their integration into sustainable businesses. A service professional, therefore, requires a foundation in knowledge attained from different areas, such as economy, marketing, business management, ICT, social responsibility, etc.

A new discipline denominated as Services Science, Management, and Engineering (SSME) made a forceful appearance several years ago. The objective of SSME is to integrate aspects of business management, engineering and technology, and social sciences with the objective of helping organizations defined by service systems to improve their productivity, innovation, and sustainability through the use of skills not possessed by the people who work in each of these separate disciplines [3,4]. In a society in which employment is principally generated by the service sector, it is necessary to train professionals in this new discipline, which tackles the development of service systems in sustainable businesses [5]. SSME is a new and different field. Its mission is to discover the underlying logic of complex service systems and to establish common languages and shared frameworks for service innovation [3]. Several authors have stated that an interdisciplinary approach should be adopted for the research and education regarding services systems, and that this should be supported by both businesses and governments.

The sphere of education has now begun to take steps in the direction of providing training in SSME [6,7]. This has, therefore, led to the creation of white papers regarding service science [8,9], which are intended to be the first step as regards creating study plans for the training of professionals in this field. However, any university students who wish to attain an education in this domain must currently design their own curricula, which will involve studying subjects from different bachelor's degrees, master's degrees, or specialized courses. Universities must, therefore, begin to provide a solution to this challenge [2].

One of the pioneers of service science, Jim Spohrer, gave 10 reasons why universities are of importance in the sphere of SSME [2], one of which was the fact that universities have important knowledge related to innovation in services, although it is contained in 'silos,' or isolated disciplines, such as economy, marketing, operations, systems engineering, etc. He, therefore, stated that SSME could assist universities to move from teaching in silos to transdisciplinary teaching, thus adapting to the real needs of a service economy. Various authors consequently discuss the need to train people to become 'T-shaped' professionals, who are highly competent problem solvers in their home discipline but are also capable of interacting with and understanding specialists from a wide range of disciplines and functional areas [3,5]. These professionals are key aspects in the development of sustainable businesses.

It is for all of the aforementioned reasons that educational proposals related to the sphere of SSME have begun to appear in the last few years. Although the majority of university SSME education programs are in the form of master's degrees, some universities have also created bachelor's degrees (see Table A1 in Appendix A). Various authors discuss interdisciplinary or multidisciplinary knowledge,

but that which can be best adjusted to the needs of a degree of this nature is transdisciplinary knowledge, since it is a new type of knowledge that appears as the result of integrating other already existing types of knowledge and goes further than the knowledge in the disciplines from which it has been obtained. The idea of transdisciplinarity is explained in Section 2 of this work, along with its impact on sustainability. Training a professional in SSME does not, therefore, imply an 'additive' education in knowledge obtained from different disciplines. SSME is a new discipline with its own body of knowledge and study objective: Services and service systems.

In this paper, we propose a curriculum for the training of professionals in SSME at bachelor's degree level, the Bachelor's Degree in Service Engineering, using a holistic and transdisciplinary approach. Although, as stated previously, there are other proposals for bachelor's degrees in this discipline, almost all of them cover only parts of what would be SSME, and very few degrees employ a holistic and transdisciplinary approach. This is the only bachelor's degree of this nature in Spain.

The proposed curriculum is the result of a design and deployment project carried out by a public university (Rey Juan Carlos University) in close collaboration with three significant service companies, each from a different sector: IBM (IT services), EULEN (facility services), and MELIA Hotels International (tourism services). The project has been reviewed and backed by various organizations, such as the ERISS, the SRII, the ISSIP, and the IBM Service Research Centre in Almaden. It is currently being taught in both classroom-based and on-line forms. This year is the third in which students will graduate in the classroom-based format and the first as regards the on-line format. The experience is proving to be highly satisfactory, since it leads to a high level of employability and very positive evaluations of its degree-holders by companies.

The present work is structured as follows: Section 2 presents the body of knowledge required for service science, management, and engineering, and Section 3 provides a summary of the proposed curriculum. Section 4 summarizes the work method followed in order to define the curriculum and presents a comparative study of the proposed training plan and other related degrees, while Section 5 presents the results of the deployment of the degree in terms of employability. Finally, Section 6 presents our principal conclusions and open lines of work for the consolidation of SSME training programs.

2. Defining a Body of Knowledge for Service Science, Management, and Engineering (SSME)

The first step required in order to create a new curriculum for the training of professionals in SSME is the definition of the body of knowledge for this new discipline. This concerns identifying both the knowledge that this discipline should contain, i.e., the "*what*", and the most appropriate model with which to teach that knowledge—the "*how*". In these times in which services have taken on the pivotal place in the economy, it is essential to develop, evaluate, and revise a theoretical framework that will support service science research and development, along with its related disciplines [10].

2.1. What Knowledge Areas Does SSME Include?

There are various proposals regarding the body of knowledge that SSME teaching should cover. In 2004, in the document "Service Science: A New Academic Discipline?" IBM stated that service science could bring together ongoing work in the more established fields of computer science, operations research, industrial engineering, mathematics, management sciences, decision sciences, social sciences, and legal sciences to create new skills and markets that offer services that will help transform, optimize, and manage business-support functions in organizations [9]. The Cambridge Service Science, Management, and Engineering Symposium of 2007 [3] similarly stressed the importance of uniting the knowledge originating from computer science, operations research, industrial engineering, business strategy, management sciences, and social and legal sciences, with the objective of training professionals who will help improve organizations' success through the innovation of services. It is also necessary to consider orientation towards sustainable businesses. One of the differentiating aspects as regards training in services is the integration of these types of knowledge into one single body of knowledge, as will be seen in the "*how*".

Although there are several proposals concerning what the aforementioned body of knowledge should be in SSME [6,8,11], they all coincide as regards indicating three key types of skills that a service engineer should have: Business and management skills, information systems engineering skills (or technological skills), and socio-organizational skills. The knowledge related to these skills provided at universities is generally taught on different bachelor's and master's degrees that can be grouped in three large areas (Figure 1): Business and processes, engineering and technology, and people and culture [6].

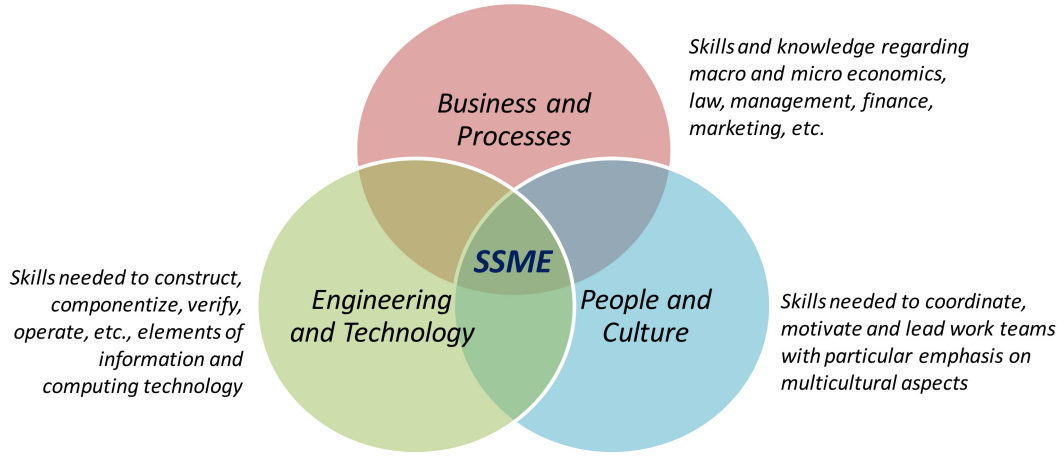

Figure 1. Relationship between service science, management, and engineering (SSME) professionals' knowledge and skill areas.

In SSME, the study object is the service, independently of the sector, and whether or not this is supported by technology. Its objective is, meanwhile, to study the laws that regulate the behavior of the complex service systems and to establish a common language and body of knowledge for service innovation [12].

SSME seeks to integrate teaching in these areas by designing a curriculum that will permit the training of professionals who are highly capable of working in different fields related to services and sustainable businesses. In order to satisfy these needs, SSME defends the concept of a new type of professional for the service sector: The service engineer. This professional is trained by combining the areas of knowledge of SSME with a T-shaped profile [13].

Service engineers must have in-depth knowledge (the vertical part of the T) of at least one discipline (business, information technology, etc.), and of at least one domain (health, IT, tourism, etc.). They must also complete their professional profiles with transversal knowledge (the horizontal part of the T), such as: a capacity to understand and communicate with professionals with different profiles, the capacity to work in a team, leadership, project management, critical thought, systematic thought, languages, adaptation and flexibility, multiculturalism, globalization, etc. [4].

2.2. How Can the SSME Knowledge Areas Be Integrated into a Service Engineering Curriculum?

The challenge of providing training in SSME lies in not only linking together the basic types of knowledge required for the discipline in a curriculum, but also (and perhaps more importantly) the approach employed to integrate them. This integration can be tackled in different ways [3] according to what the knowledge in the new discipline is considered to be:

- **Multidisciplinary:** This implies the union of knowledge or skills from different disciplines. This multidisciplinary knowledge can be obtained by either uniting all the knowledge from the disciplines of which it is formed (superset) or uniting parts of the knowledge from the original disciplines (subset) (Figure 2a).

- **Interdisciplinary:** Interdisciplinarity implies the integration of knowledge that has originated from different disciplines (Figure 2b).
- **Transdisciplinary:** Transdisciplinarity also integrates the knowledge from other disciplines, but goes one step further since, as its name indicates, it transcends these disciplines in order to create new knowledge (Figure 2c).

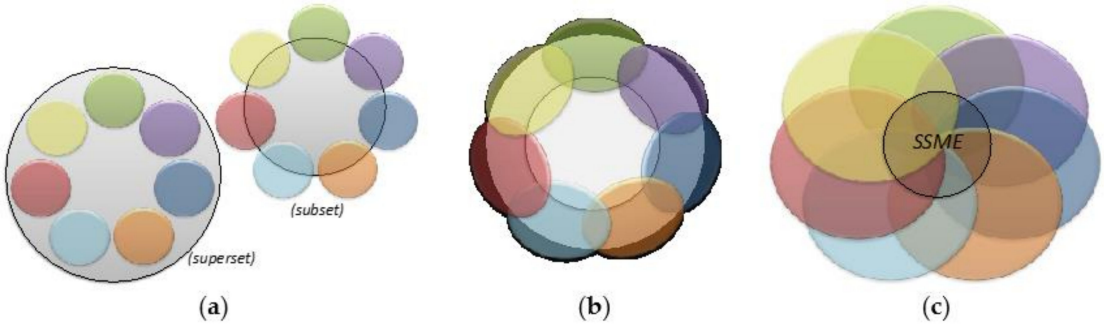

Figure 2. Approaches for the integration of disciplines. (**a**) Multidisciplinary, (**b**) interdisciplinary, (**c**) transdisciplinary.

When applied to education, a *transdisciplinary* approach implies obtaining *holistic learning and tasks* that transcend and go further than the traditional disciplines of knowing and knowledge. This approach is optimum for the training of professionals in service engineering, since there is a body of knowledge and its study object (the service and service systems), which can be applied to all the disciplines and which transcend the knowledge and fields of study of each of them [3].

The argument above led us to consider the best way in which to integrate the concepts from the different disciplines in order to attain a body of knowledge specific to SSME. Two possible models for bachelor's degrees are proposed in [14]:

- **Topical sequence** (Figure 3a): The model traditionally employed to carry out multiple teaching is the topical sequence model. A topic is taught to whatever depth of understanding is required before moving on to the next one.
- **Spiral sequence** (Figure 3b): During which the learner explores the same topics in different phases, starting with the basics of each topic and then learning about them in increasingly greater depth.

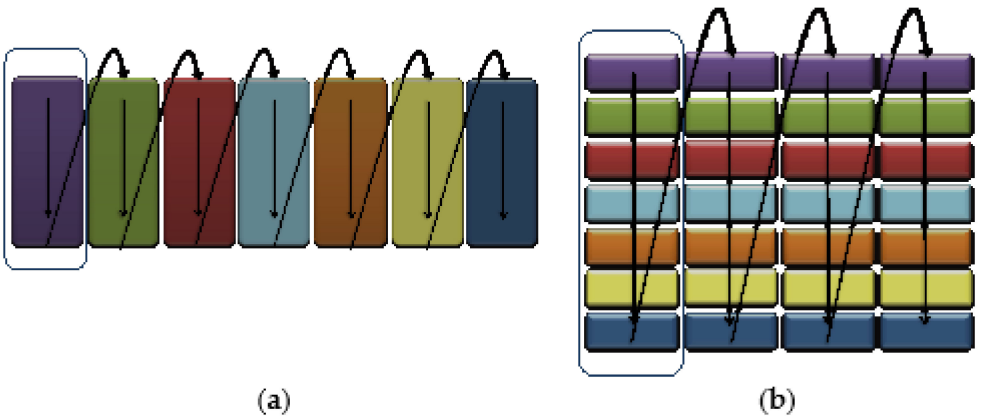

Figure 3. Means of integrating concepts from different disciplines. (**a**) Topical sequence, (**b**) spiral sequence.

The topical approach is appropriate for teaching of a multidisciplinary nature, in which the most important aspect is to transmit the knowledge related to the disciplines implied, but the order in which that knowledge is taught is not important.

The spiral approach considers that the materials from the different disciplines should be taught in a logical sequence, since the knowledge from certain disciplines is integrated with that from others. Although [14] states that this approach is suitable for the teaching of SSME, we consider that this type of design is more suitable for interdisciplinary rather than transdisciplinary teaching.

On a service engineering degree, there should be a logical sequence among the materials from the various disciplines of which it is composed. But its transdisciplinary nature signifies that not only is the sequence of the materials important, but also their content, and this content also requires a different approach to that employed in the specific discipline from which it originated and should be specific to the new discipline, in this case SSME. As is stated in [15] "transdisciplinary work moves beyond the bridging of divides within academia to engaging directly with the production and use of knowledge outside of the academy." We, therefore, propose a new approach for the teaching of material on a service engineering degree in an attempt to reflect the idea of the holistic teaching of services. This integration approach is shown in Figure 4, in which there is a three dimensional spiral sequence, and in which the idea of service (represented in the circle in the center of the figure) is the common thread of the teaching. Note that the materials from the various disciplines are represented using different colored circles. Each color represents a discipline, while the central circle indicates that all of these study objects are services, be they from a technological, humanistic, or business dimension. This approach is also appropriate as regards incorporating the concepts of sustainability into higher education curriculums [16,17].

Figure 4. Holistic sequence: Integration for a transdisciplinary curriculum in service engineering.

Despite the importance of and the need to create appropriate professional profiles for the service sector by bringing together the knowledge and skills from different areas in a transdisciplinary profile in order to train professionals that are capable of working in different fields related to services, of creating sustainable businesses and of managing information technologies for a more human/social perspective, there is currently a significant "gap" between the training needs demanded by service companies and the training plans currently offered by universities.

In the following section, we present the Bachelor's Degree in Service Engineering developed at the Rey Juan Carlos University in which this transdisciplinary approach and holistic teaching are used with the intention of covering this gap. We shall analyze the materials included in the degree, along with the way in which those materials are taught throughout the course. A comparison of the different academic programs that currently exist at an international level is provided in Section 4

3. A Service Engineering Curriculum. Inductive-Deductive Approach

Since the first work related to SSME appeared, various universities worldwide have begun to create study plans in order to cover education in this area [6]. The majority of the initiatives that currently exist are master's degree Programs.

We present the Service Engineering Curriculum developed at the Rey Juan Carlos University (RJCU). When designing a curriculum in service engineering by means of the approaches established in the previous section, we followed a multidimensional inductive-deductive approach. In the deductive dimension we, therefore, carried out a literature review and we collected the opinions of experts in this matter (defining *what* to include), while in the inductive dimension we explored the reality of professors working in this area and the way in which they perceive the relevance, usefulness, and the evidence itself as regards the concepts of service engineering when teaching it (defining thus *how* to teach).

3.1. "What" to Include

The proposals of various experts in SSME [3,6,14], along with an analysis of the different curricula taught at an international level [18–20], were employed as a means to identify the principal materials that should be taught. These materials have been grouped in blocks, denominated as modules, in order to establish groups of materials whose themes are related to each other. The relationships among these modules and the three large areas of which SSME is composed, as proposed in the previous section, are shown in Figure 5. The modules defined are:

- **Foundations:** This involves attaining a base in the knowledge of mathematics and statistics, along with other basic concepts required by a service professional, such as the theory of systems, the history of services, and the basic ethical and legal aspects of any profession. This knowledge is principally related to the areas of *engineering and technology* and *business and processes*.
- **Business and management:** This involves knowledge related to business management, sustainable businesses, human resources and marketing. This block of materials is encompassed in the area of *business and processes*.
- **Social science:** This involves knowledge from economics and sociology degrees. This knowledge is related to the areas of *business and processes* and *people and culture*.
- **Information systems:** This involves knowledge of information systems and databases. These materials are related to the areas of *engineering and technology* and *business and processes.*
- **Information technology and communications (ITC):** This involves knowledge related to technical and computer engineering skills, such as architectures, hardware, programming, networks, operating systems, etc. These materials are from the area of *engineering and technology.*
- **Service management:** This involves knowledge related to service management in organizations, such as service engineering, service management, quality of services, service process management, etc. This type of knowledge, which is fundamental from the point of view of services, is related to the three large areas of SSME.
- **Psychology and communications:** This involves knowledge regarding psychology and communication and is related to social skills, such as communication skills, emotional intelligence, the management of work teams, leadership, etc. These materials are encompassed within the area of *people and culture*.

Each of these modules is made up of materials, and each material may have one or more subjects, as shown in Tables 1–3. Each of these subjects allows the student to acquire a set of competences and skills.

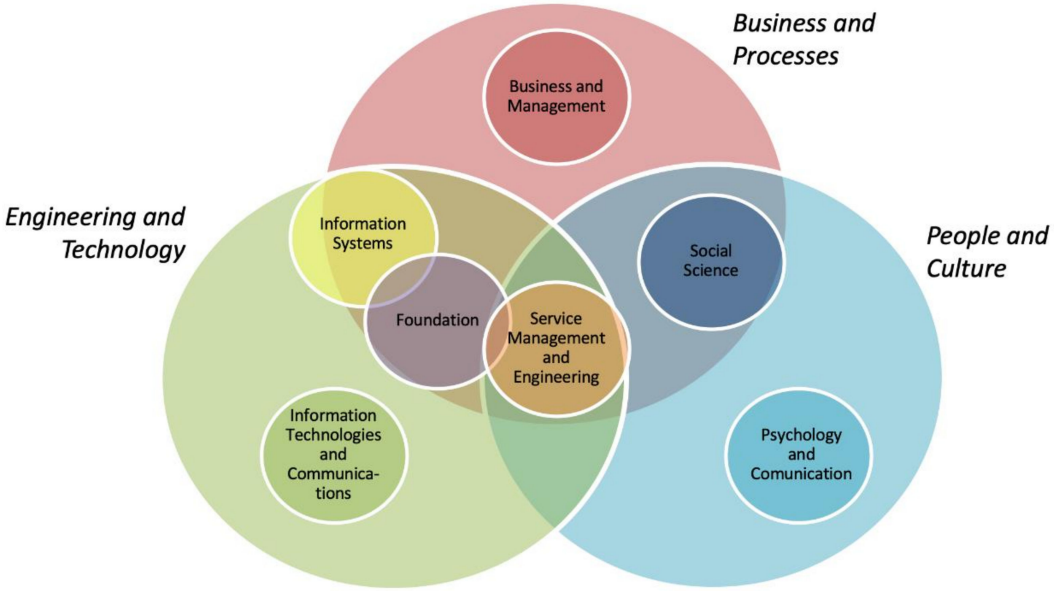

Figure 5. Relationships among modules according to areas in SSME.

Table 1 includes the subjects and topics related to "Foundation" and "Business Management" modules. The Foundation module has been organized in six materials that include the basic knowledge required by a service professional, such as mathematics and logic, statistics and operation research, history of services and systems theory, in addition to basic subjects required by Rey Juan Carlos University, such as modern languages and ethical and legal issues. The Business and Management module has been organized in just one material that includes seven subjects according to the module's training needs and whose topics have been adapted to the management and business of the service sector.

Table 2 includes the subjects and topics related to "Social Science" and "Psychology and Communications" modules. The Social Science module is structured around two materials, economics and sociology, and includes four subjects whose topics have also been adapted to the service sector, such as service science economics or service sociology. The Psychology and Communications module is structured in two materials and three subjects focused on the development of social and communication skills.

Subjects and topics related the modules of "Information and Communication Technologies," "Information Systems," and "Service Management and Engineering" are described in Table 3. The **Information and Communication Technologies** and **Information Systems** modules are both organized around one material that includes different subjects that cover the specific training needs of each module, and with topics focused on the study of service technologies and service systems. The **Service Management and Engineering** module is organized around four subjects that cover the knowledge of service management and engineering, along with elective subjects (four, in accordance with the regulations of Rey Juan Carlos University) that include specific knowledge of applications in different areas of the service sector, such as public administration, banking and insurance, tourism, health, etc.).

Table 1. Rey Juan Carlos University (RJCU) SSME Service Engineering Curriculum. "Foundation" and "Business Management" modules.

Module	Subject	Topics
Foundation		
Modern Languages	Modern Languages	Grammar. Oral expression. Written expression. Characteristics of language in commercial and business spheres.
Mathematics and Logic	Mathematics for Computation and Services	Discrete Mathematics. Linear algebra. Boolean algebra. Relationships. Graphs. Calculus.
	Logic	Introduction to logic. Logic of propositions. First order predicate logic.
Statistics and Operation Research	Statistics	Descriptive statistics. Probabilities and random variables. Simulation. Statistical models. Position measures. Sampling and population.
	Operation Research	Introduction to operation research. Methodology and model formation. Linear and non-linear programming. Multi-objective linear programming.
History	History and Fundamentals of Services	History of services. Concept of services. Characteristics of services. Types of services. Service views (business services, electronic services, technological services, etc.). Service Model. Service Science.
Systems Theory	Systems Theory	Systematic thinking. Biological systems. Basic concepts of systems. Characteristics and properties. General Systems Theory. Constructive elements. Types of cycles. Generic structures: archetypes.
Legal issues	Ethical, Legal, and Professional Aspects	Ethics. Social corporative responsibility. Competencies of Service Engineers. Profiles. Roles. Professional Outlets. Ethical aspects of Service Sciences and Management. Computing Legislation. National and European legislation.
	Private Law	Sourced from Civil Law. Sourced from Mercantile Law.
Business and Management		
Business and Management	Business Organization	The business and its objectives. The company's relationship with its environments. Managers at the Company. Decision Making. Functions of Management. The organization's functional areas. Sustainable Business.
	Service Operation Management	Service companies vs. Industrial companies. Service vs. Process. The function of Operations. Processes. Localization. Capacity. Plant Layout. Service Quality. Environmental Protection.
	Strategic Management of Businesses and Service-Oriented Business Consultancy	The Nature of Strategic Management. Strategic Management Processes. Vision, Mission, Values. Strategic Analysis. Internal Analysis. Use of Strategies. Sustainable Business Models. The Service Professionals' Company. The Company's Evolutive Process.
	Business Initiative	The Entrepreneurial Spirit. The creation of a sustainable enterprise. The creation of a business plan. Production plans. Financial-economic plans. Marketing plans.
	Human Resources	Human Resources at the company. Workflow management and job analysis. Human Resource planning. Staffing and Development Processes. Evaluation and compensation processes.
	Service Marketing	Concept of marketing. Marketing's role within the company. Market research, product and pricing policies, commercial distribution, sales management. The fundamentals of the Marketing mix in services. Environment and Market. Fundamentals of international commerce.
	Business Communication	Principles and concepts of communication. Communication plans. Internal communication. External communication Dossier programming.

Table 2. RJCU SSME Service Engineering Curriculum. "Social Science" and "Psychology and Communications" modules.

Module	Subject	Topics
Social Science		
Economics	Service Science Economics	Principles of macroeconomics. Market analysis and structure. Economic models. Principles of accountancy and national taxation.
	Financial Economics and Accounting	Introduction to financial markets. Introduction to financial mathematics. Investment values. Profitability and share and portfolio risks. Investment management. Share value models. Markets and portfolios. Fixed income markets. Sustainable finance.
	Microeconomics	The principles of microeconomics. The analysis and structure of economic agents. Economic models.
Sociology	Service Sociology	Social aspects of services. The social role of service providers and consumers. Social relationships applied to services. Collaborative services.
Psychology and Communications		
Psychology	Emotional Intelligence	Rational intelligence and emotional intelligence. Emotional self-control. Basic emotional intelligence capabilities. Emotional intelligence in the workplace. Emotions and moods. Negotiation.
	Leadership and Group Work	Theories and types of leadership. Leadership skills. Vision, mission, and beliefs. Teamwork. Group work. The importance of group work in a company. Systematic vision of teams. Time management.
Communication	Communication Skills	Types of Communication: verbal and non-verbal communication. Communication strategies and techniques. Analysis of the barriers that have a negative effect on communication efficiency.

3.2. "How" to Teach

Table 4 shows the distribution of the subjects, corresponding to each of the SSME modules, throughout the four years of the degree. As will be noted in Tables 1–3 (contents of subjects) and Table 4 (sequence of subjects), the model of the curriculum corresponds to the holistic model, which is proposed as being the most recommendable for transdisciplinary teaching, as is the case of SSME. Table 4 shows that each of these areas is developed gradually, in increasingly greater depth, while Tables 1–3 show that the contents of the subjects are focused on services.

Figure 6 shows how the teaching of each subject is distributed throughout the four years, along with the credits for the subjects taught in each of the modules. As will be noted in the graphics, both the first and second years have a high percentage of subjects corresponding to foundations. The service management and engineering subjects are taught fundamentally in the third year. The fourth year includes credits for placements at businesses (work experience) and the dissertation, and those credits that are not classified for a specific module.

Many of the degrees offered at an international level have been conceived as specializations: Either specializations in service-based information technologies for business studies graduates, or specializations in services management for computing studies graduates. SSME is not, however, a specialization in business or computing studies. It is a scientific discipline that has arisen as a result of the confluence of various disciplines.

The students at RJCU receive an integrated multi-disciplinary education with a combined perspective from the very beginning. The acquisition of the interdisciplinary skills related to services takes place gradually throughout the degree and allows them to progress steadily in all the disciplines until they attain the level of maturity required for their target sphere of employment. The use of innovative and modern educational methodologies, classes very focused on problem solving and the use of more attractive techniques for students [21], are undoubtedly other strengths of this training.

Table 3. RJCU SSME Service Engineering Curriculum. "Information and Communication Technologies," "Information Systems," and "Service Management and Engineering" modules.

Module	Subject	Topics
Information and Communication Technologies		
Information and Communication Technologies	Operating Systems and Networks	Fundamentals. Communication network, intra-computing and between computer models. Communication protocols and standards. Wireless communication networks. OS and Network Security.
	Introduction to Programming	Fundamentals. The principles of computing. Programming elements. Object oriented programming. Concepts of encapsulation, visibility, overloading, inheritance and polymorphism, exceptions, interfaces.
	Service Development	Communication protocols among services. XML technologies. Service technologies. Service languages and standards. Discovery of services. Service-based programming and associated tools.
	Mobile and Ubiquitous Services	Fundamentals of mobile and ubiquitous computing. Mobile service development and execution platforms. Ubiquitous computing-based applications and systems development. Context-aware programming and service adaptation. Sensor networks.
	Service Design and Maintenance	Architectonic styles. Service-oriented architectonic patterns. Service design and integration design patterns. Deployment, testing and monitoring of service-oriented systems. Service security.
	Human-Computer Interaction and Multimedia	Human factors. Adaptation to sensorial and intellectual disabilities. Friendly interface design methods. Help systems design. Principles of graphic design. Multimedia application programming.
	Computer Architecture	Historical perspective of computers. Central Processing Unit. Memory hierarchies. Input and output organization.
	Software Engineering	Introduction to Software Engineering. Lifecycles. The concept of processes and development methodologies. Introduction to systems specification: modelling languages and automata theory.
Information Systems		
Information Systems	Information Systems	The concept of information systems. Business information systems. Types of basic information systems. Evolution of information systems. Integrated information systems.
	Business Architectures	Business architecture lifecycles. The establishment of vision, internal and external state of a company via its business architecture. Business architecture components. Specific business architectures.
	Business Information Systems	Fundamentals of business management systems. ERP. Evolution, architecture,, and general characteristics of ERP systems. Selection criteria of ERP. CRM, SCM. E-business systems.
	Business Intelligence and Analysis	Data mining techniques. Web mining. Decision support systems. Balanced scorecard. Company business intelligence. Competitive intelligence within the organization.
	Data Bases	Files. The concept of DB and DBMS. Architecture and components. Data conceptual models. The Relational Model. The SQL language. Data-base design. DB security.
	Information Systems Architecture	The fundamentals of distributed systems. Communication architectures for distributed systems. Service-based architectures. Business-based architectures. Enterprise Architecture Integration (EAI). Business-to-Business/to-Consumer (B2B, B2C).
	Technologies for the Management of Large Volumes of Data	Introduction to Data Stores: architecture and components. Data store. OLAP tools. Data store design. Data store maintenance. Extraction, transformation, and load processes. Non-structured data management
Service Management and Engineering		
Service Management and Engineering	Service Management	Service portfolio. Service levels. Availability, capacity. Supplier management. Design coordination. Incidents, problems, configuration, change. ITIL. Service quality.
	Service Engineering	The fundamentals of Service Engineering. Service lifecycles. Service-oriented development methods. Requirements Engineering for the discovery of services. Service analysis and modelling.
	Project Management	Fundamentals of project management. Project planning. CASE Tools. Project estimation. Risk Management. Agile Project Management.
	Business Process Engineering	Business process management (BPM). Process oriented management systems. Process modelling languages. Business process re-engineering. The evolution and modernization of business processes.
	Optional/Elective	Service Applications: Public Administration, Education and Science, Residential and Urban, Banking and Insurance, Industrial, Services in Energy and Utilities, Tourism, Health, Commercial Distribution, Telecommunications, Information Technology, Consultation.

Table 4. Distribution of subjects per term in the RJCU Service Engineering Curriculum.

First Year	Credits	Term	Second Year	Credits	Term
Mathematics for Computation and Services	6	1	English	6	Annual
Theory of Systems	3	1	Statistics	6	1
History and Fundamentals of Services	6	1	Private Law	6	1
Service Sociology	6	1	Communication Skills	6	1
Introduction to Programming	6	1	Service Design and Maintenance	3	1
Computer Architecture	3	1	Data Bases	6	1
Logic	3	2	Operation Research	3	2
Ethical, Legal, and Professional Aspects	6	2	Business Communication	6	2
Business Organization	6	2	Economy in Service Sciences	6	2
Emotional Intelligence	3	2	Software Engineering	3	2
Service Development	6	2	Information Systems Architecture	6	2
Operating Systems and Networks	6	2	Information Systems	3	2
Third Year	**Credits**	**Term**	**Fourth Year**	**Credits**	**Term**
Service Operation Management	3	1	Dissertation	6	Annual
Microeconomics	3	1	Work Experience	24	Annual
Leadership and Teamwork	3	1	Recognition of Credits/SSME Seminary	6	1
Business Information Systems	6	1	Strategic Business Management and Service-Oriented Business Consultation	3	1
Technologies for the Management of Large Volumes of Data	6	1	Business Architectures	3	1
Service Engineering	6	1	Elective: Service Applications	3	1
Project Management	3	1	Elective: Service Applications	3	1
Service Marketing	6	2	Business Initiative	3	2
Financial Economy and Accounting	3	2	Human Resources	3	2
Mobile and Ubiquitous Services	3	2	Elective: Service Applications	3	2
Human-Computer Interaction and Multi-media	6	2	Elective: Service Applications	3	2
Business Intelligence and Analysis	3	2			
Business Process Engineering	3	2			
Service Management	6	2			

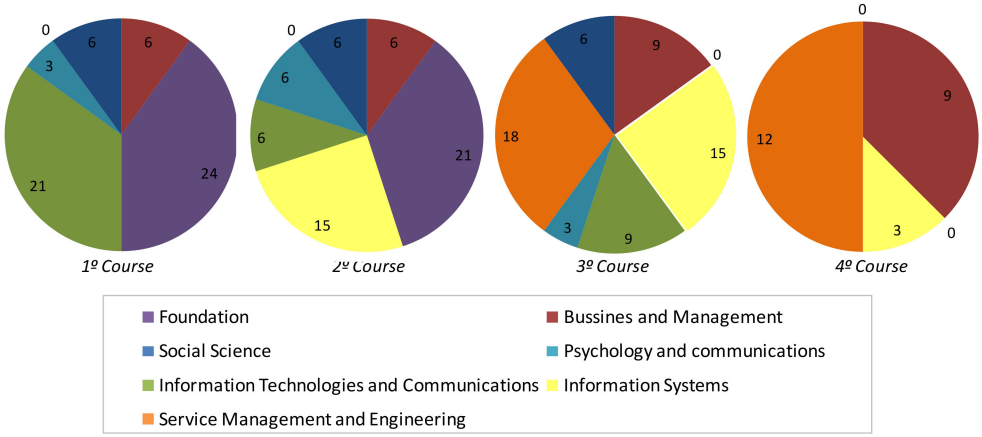

Figure 6. Distribution of credits per module in the RJCU Service Engineering Curriculum.

4. Work Method. Analysis and Comparison of the Proposed Degree with Other Degrees

The proposed degree is formed of a set of subjects from different disciplines that have been integrated by following a transdisciplinary model and holistic teaching. These disciplines, which unite what is considered to be the key knowledge required by SSME professionals, are also present in the majority of bachelor's and master's degrees taught at an international level (Appendix A, Table A1).

Figure 7 provides a summary of the work method followed to create the proposed curriculum. Once the need for a new type of professional for the service sector was detected, and before beginning to define the curriculum, one important part of the work was the data collection. This involved collaborating with service companies in order to discover their training needs and analyzing similar bachelor's and master's in the area. Such analysis and comparison are presented below in this section.

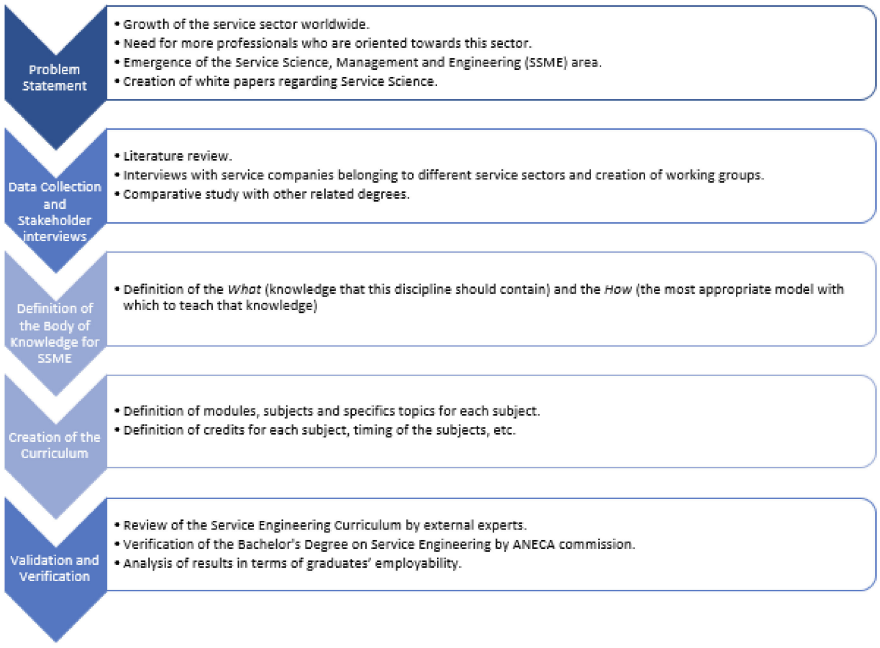

Figure 7. Work method for the development of the RJCU Service Engineering Curriculum.

The validation and verification of the Service Engineering Curriculum were first carried out by reviewing experts belonging to different service organizations (such as the ERISS, the SRII, the ISSIP, and the IBM Service Research Center in Almaden), and were later formally verified by the Spanish governmental agency in charge of the assessment and accreditation of higher-education programs (ANECA— Agencia Nacional de Administración de la Calidad y Acreditación). A study of the employability of the first students to graduate from the proposed degree is presented in the following section of this work.

The degrees in SSME that are currently available are shown in Table 5. One important difference that will be observed in the degrees in SSME that are currently being taught is the influence of those areas most closely related to SSME, such as engineering, information technology, and business management. The degree profiles most closely related to information technology, which is taught at schools of computer science, are clearly different to those more closely related to business management, which are principally taught at business schools. There are also various degrees that have a strong component of the classical types of engineering, such as industrial engineering, telematic engineering, or that related to telecommunications. Despite the fact that all the degrees analyzed herein are focused on the concept of service, some are clearly more oriented towards the IT service or digital services, while others are more focused on service management and the management of services as a business activity.

Table 5. Comparison of Degrees in SSME.

Id	Title	University-School	Profile	Representative Topics
1	BSc in Business Administration and Service Management	Copenhagen Business School	Business + Service Management	Managerial Economics, Financial Accounting, Macroeconomics, Service Management Foundations, Public Regulations
2	Service EngineeringBachelor of Engineering	Frankfurt University of Applied Science	Mechanical/Electrical Engineering + Service Management	Industrial Engineering, Electrical Engineering, IT, Electronic, DB Management, Applied Programming, Service Management, Accounting, Marketing, etc.
3	Service Management	Furtwangen University (HFU)-Business Administration and Engineering	Business + Service Management	Applied Mathematics, Business Accounting, Electrical Engineering with laboratory, Marketing and Services, Physical Engineering with laboratory, General Business Administration, Design and Manufacturing, Technical Mechanics, etc.
4	IT Service Science major - Bachelor of Computer and Information Sciences	Auckland University of Technology - Computer and Mathematical Sciences	ICT + Service Management	Applied Communication, Programming, Computing Technology in Society, Foundations of IT Infrastructure, Computer Network Principles, Enterprise Systems, IT Project Management, IT Service Provision, Data and Process Modelling, IT Strategy and Control, IT Service Management, etc.
5	Bachelor of Science in Industrial Management Engineering minor in Service Management (BS IME-SM)	De La Salle University - Gokongwei College of Engineering	Industrial Engineering + Service Management	Economic Analysis, Marketing, Probability and Statistics, Financial Accounting, Industrial Engineering Mathematics, Industrial Cost Accounting, Production/Operations Management, Operations Research, Industrial Engineering Economy, Human Behavior in Organization, Fundamentals of Financial Management, Product Design, Management of Service Operations, Management of Food Service Systems, Retail Management, Introduction to Banking Industry, Business Process Outsourcing, Introduction to Healthcare Management, etc.
6	Bachelor's Degree in Information Technology and Services	Universitat Autònoma de Barcelona-Escuela Universitaria de Informática "Tomàs Cerdà"	ICT + Services	Mathematics for Computing and Services, Principles of Programming, Service Sociology, Service Company Business Model, Person-Computer Integration, Web and Multi-Media Application Design, Databases, Service-Orientated Architecture, Project Management, Service Design and Motorization, Service Analysis and Modelling, Service-Oriented Business Consultation Methodology, Knowledge Management and Innovation, Auditing and Service Quality, etc.
7	Bachelor's Degree in Telecommunication Technologies and Services Engineering	Polytechnic University of Madrid-Technical School of Telecommunication Engineers	Telco + Digital Services	Physics, Programming, and Management, Electronic Devices, Circuit Theory, Foundations of Networking, Computer fundamentals, Fundamentals of Business Organization, Electronic Circuits, Signals and Systems, Communication Theory, Networking ArchitecturesDesign of telematic services, Telematic Applications, Integration of Digital Systems, Multimedia Communications, etc.
8	Bachelor's Degree in Telecommunication Technologies and Services Engineering	Polytechnic University of Valencia-School of Telecommunications Engineering	Telco + Digital Services	
9	Bachelor's Degree in Service Engineering	Rey Juan Carlos University-Faculty of Social Science	ICT + Human + Service Management	See Table 4
10	Baccalauréat Universitaire en Systèmes d'Information et Science des Services	University of Geneva-Institute of Information Service Science	ICT + Digital Service	Data and information, Modelization, Design and analysis, Programming and Digital services, Networks and Security, Ethics and Regulations, Innovation and Design, etc.
11	Bachelor of Science in Industrial and Service Engineering and Management	Nile University	Engineering + Service Management	Production and Manufacturing, Engineering Management, Service Engineering and Management, Human Factors and ergonomics, Logistics and Supply Chain Management, Quality Engineering and Management, etc.
12	Information Technology Services	Mississippi State University	ICT + Business	Computer Applications, Database Management, Spreadsheet Design & Analysis, Computer Repair and Maintenance, Design Technology, Information Technology Project Management, Introduction to Data Networks, Graphics and Web Design, Delivery and Evaluation of Technology, Financial and Managerial Accounting, Legal Environment of Business, Principles of Macroeconomics and Microeconomics, Principles of Management, Human Resource Management, Web Development, Management Information Systems, etc.

The degrees that are less influenced by information technology and classical engineering would appear to be closer to the idea of an SSME degree, since new knowledge arises from the synergy of various disciplines (technologies, business, human aspects) and are more focused on service management. A classification of the current degrees according to their relationship with the main SSME disciplines, along with the aforementioned tendencies as regards integrating the concept of services, is shown in Figure 8.

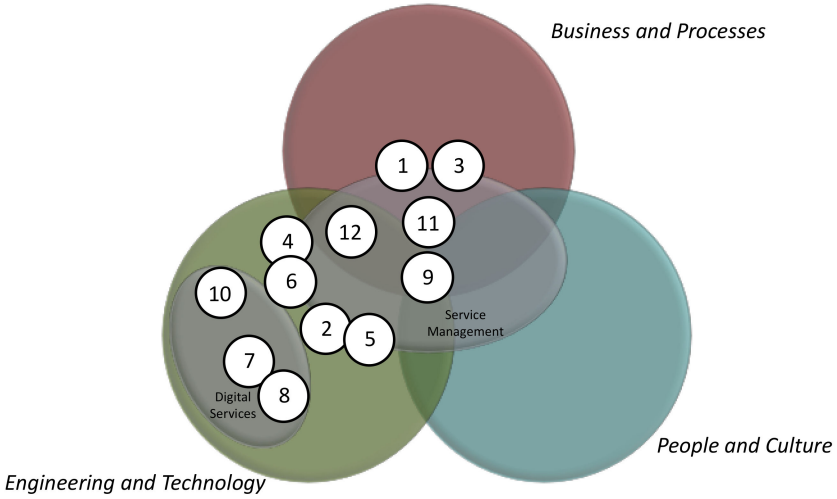

Figure 8. Classification of SSME degrees.

Of the degrees analyzed, four have contents that are more closely related to the area of information and communications technology (ICT): (4), (6), (10), and (12). As will be noted in Table 5, these degrees provide a considerable amount of training in traditional ICT or IS subjects, such as programming, networks, databases, IT project management, etc. In the case of degree (10), the knowledge regarding services is focused on providing students with the skills required to develop and create digital services.

There are, moreover, other degrees that are more closely related to classical engineering, and it is here that we find the interdisciplinary degrees (2) and (5), which integrate knowledge concerning mechanical and industrial engineering with that of business management and services in an attempt to contribute towards providing a more complete professional profile for manufacturing companies. Degrees (7) and (8) are fundamentally degrees in telecommunications engineering that integrate skills for the development of digital and telematic services.

Some of the degrees that are most influenced by the area of business management and which are available at business schools are (1) and (3), which combine classical business knowledge with concepts of service management, with the idea of creating a profile that is more oriented towards the service business and markets. Degree (11) provides training in service engineering and management and is focused on industry, but has aspects of engineering, human factors, and management integrated into it.

As mentioned throughout this work, in the specific case of the degree taught at RJCU (9), there has been particular interest in creating a study plan that will make it possible to educate graduates to attain a transdisciplinary SSME profile. This aspect is reflected in the balanced distribution of subjects and contents in the areas of the degree. Moreover, the concept of sustainable business and its implications for management have also been incorporated.

5. Graduates: Analysis of the Employability and Need for the Profile

In order to nurture human resources who can adapt to different changes across the economic and social landscape, the field of education should not only focus on imparting knowledge related to specific majors but also enable students to understand and adapt to the demands of a rapidly changing society [22].

"Educators should also help students develop competencies that will enable them to comprehensively analyze and resolve the diverse problems of such a society" [22] (p. 1). Putting the Service Engineering Curriculum into practice has, therefore, been a great challenge. In keeping with the requirement to train students to reflect on, analyze, and resolve problems in the area of services, the analysis of the employability associated with graduates, along with the suitability of those graduates for a particular job, proved to be key indicators.

The service-centered and transdisciplinary training profile proposed and developed by RJCU would appear to be well adapted to the labor market in Spain. In order to verify the level of employability of those who have completed this degree, we carried out a survey of the graduates, to which 37 out of 73 responded.

Of all those who responded, 89% are currently working (see Figure 9). This is a relatively high percentage of employment if we compare it with percentages concerning the employment of those who have graduated from related degrees, such as business administration (77.4%), engineering and its related professions (80.1%), or computer science (84.6%) [23]. It is important to note that graduates in service engineering have a relatively new and different profile, and beyond improving the percentage of employment in this area, the important point is their adjustment to the specifics needs of the service sector in terms of knowledge and skills.

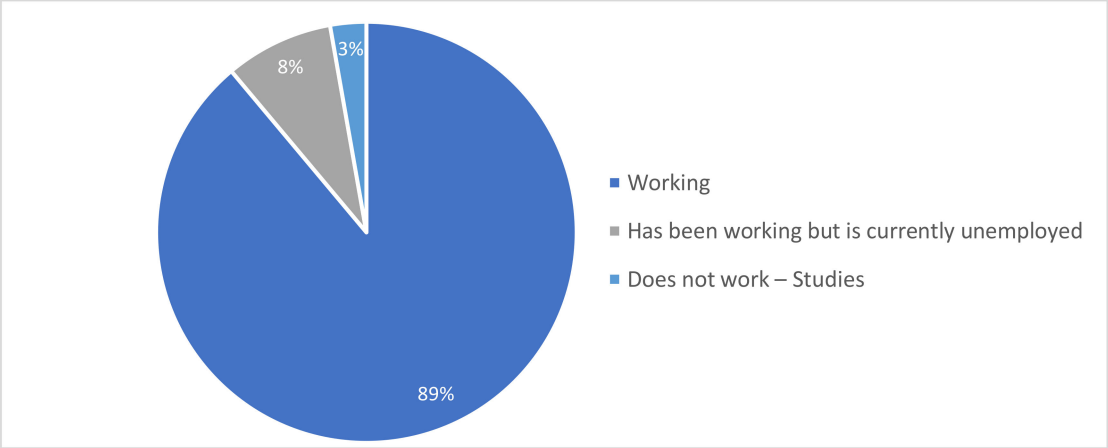

Figure 9. Graduates' employment status.

The posts occupied by the service engineering graduates are principally related to consultation (48%) and management (31%). The remaining graduates' jobs are technical (development, maintenance, etc.), or concern marketing, UX design, and sales, among others. It is also important to stress that 78% of the graduates have permanent contracts with their companies and that the majority of them (81%) have been working for more than six months.

In order to assess the way in which the graduates evaluate the education that they received, we asked them to indicate, on a scale of 1 to 10, the suitability of the competences and skills that they acquired on the degree for the job that they are currently doing. Fifty percent of them considered that they were highly appropriate (scores of between 8 and 10), 39% considered that they were of a medium level (scores of between 4 and 7), while the remaining 11% considered that they were of a low level (scores of between 1 and 3). Figure 10 shows the mean scores obtained, taking into account the duties that they actually perform during the course of their work. It will be noted that the highest scores were obtained from those working in management and UX design, while the lowest scores were obtained from those working in marketing. This coincides with the expectations of the training since it was not a degree in marketing but rather a type of training that would allow the graduates to adapt to this type of work.

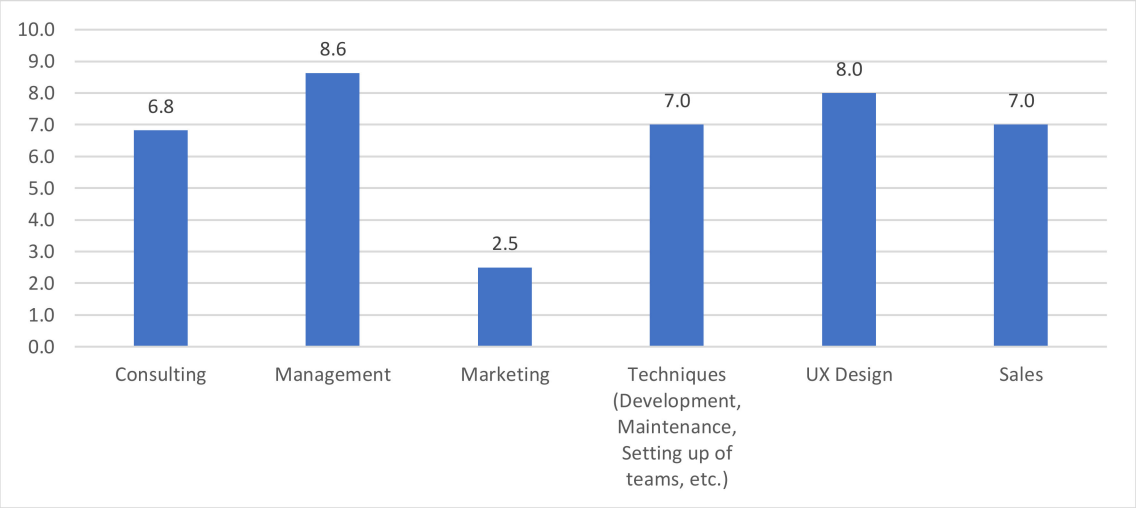

Figure 10. Average scores (out of 10) as regards the suitability of the competences and skills acquired in relation to the duties performed during the course of the graduates' work.

With regard to seeking employment, 28% of the graduates stated that they did not have to seek employment because they were taken on by the company at which their work experience took place, while 5% were offered employment directly. Of those who sought employment (61% of the graduates), 64% stated that they found work after one month or less, while the remaining 36% did so in 2 to 3 months.

From a more qualitative point of view, it is important to highlight that one of the main advantages of the degree is the wide range of jobs open to the graduates (sales, design, management, consulting, etc.). Another benefit is undoubtedly the employment situation that is open to recent graduates; note that a high percentage of them begin in consulting or management posts at a level that is not usually accessible for recent graduates owing to their lack of experience. In addition to requiring technical and specific knowledge, these positions also require personal and social skills that traditional graduates do not tend to have, and which are generally acquired over time.

The need for graduates with this type of profile has been shown by many service organizations, which currently operate more endogenously and form this profile in an ad-hoc manner using their internal training plans. This subsection shows some of the statements obtained after carrying out interviews with service sector professionals and which confirm this requirement (contents of the Service Engineering MOOC available online: https://miriadax.net/web/ingenieria-de-servicios).

Mar Ruiz, service manager of the EULEN Group and Oscar García, head of the Facility Services Project at the same company consider that "the education traditionally provided by universities is no more than the gateway into our company; our employees then have to be trained by means of internal training plans, which prepare them to become service managers."

The transdisciplinary profile is also a fundamental requirement for many organizations that discover that this is lacking in their professionals. Vicente del Poyo, vice-president of MELIA Hotels International commented that the vast majority of the managers in his organization have an education based on economics and financing, but do not have leadership skills or technological knowledge. Lourdes Ripoll, associate vice-manager to the CEO of MELIA Hotels International, stated the need for engineers in the tourism sector: "The traditional training in tourism is perfectly valid for some positions in the sector. But we also require professionals with the capacity to plan, design and manage both material and human resources."

Elisa Martin Garijo, director of technology and innovation at IBM Spain, stated that the training required by a service professional is also carried out internally at IBM, "but it is very long training based on day-to-day experience". Sra. Garijo considers that it vital to have a basis in service training: "It is very important to begin to train people who understand these concepts from the outset and who

think about these concepts in a systematic manner from the very beginning. This type of professionals should have highly multidisciplinary profiles, and not just knowledge of mathematics and humanities, but also of laws, social relations, formalizations, and communication. It is a very varied profile, and the responsibility for the creation of this type of profile lies with universities."

Ricardo Gabarro, who is the EULEN Group's R+D+I manager, considers that "the type of training most required in the future will be that of service engineers, and they will probably be the most polyvalent, as were industrial engineers in their time, since they were valid for any type of engineering. A service engineer will be valid for every aspect of the world of services, i.e., commercial operative and technical activities, and everything will be services in the future."

6. Conclusions

This paper presents a project involving the creation of a service engineering degree at a public university in Spain: Rey Juan Carlos University. As has been explained, this is the first degree in SSME to have a holistic and transdisciplinary focus, as would be expected for this emerging discipline. The degree was designed by SSME experts from the university and the service sector.

One of the principal challenges was precisely the difficulty involved in creating a transdisciplinary degree, in addition to attempting to explain the difference between the proposed degree and other already functioning degrees of an inter- or multi-disciplinary nature. As is shown in this paper, education in SSME implies providing a new type of professional for the service sector. This professional is educated by combining the SSME knowledge areas with a T-shaped-type profile.

This work makes three main contributions:

For the company: The training of professionals specific to a sector that is clearly growing at a worldwide level. This will make it possible to improve the productivity of service sector companies, owing to the availability of service experts with a holistic vision of those services, from their conception to post-sales. It is clearly committed to the management of sustainable business.

For the student: They will receive training in an emerging discipline that nevertheless has a great business fabric. This signifies that future graduates will have a high level of employability, along with excellent work prospects that can only improve, since they are expected to be the future managers and executives of service companies from different spheres.

For society: This is directly derived from the two previous reasons. Public universities' responsibility as regards giving something back to society should not be forgotten, and this degree could contribute to improving the most important sector for the economies of the majority of developed countries at what is a difficult moment for those economies. This contribution could also be extended to developing countries, since the growth of the services sector is the immediate consequence as their economy progresses, and having professionals already trained in the sector is an appropriate measure by which to further promote their development.

As has been shown, the degree leads to a high rate of employability and its graduates are incorporated into companies at higher levels than the holders of other degrees such as computer engineering. The contracting companies are highly satisfied with the graduates' training and are demanding more with this type of profile.

New companies from other spheres, such as transport and organizations like IFMA (International Facility Management Association, https://www.ifma.org/), are currently being incorporated into this project. This new group has led to the need to review the contents of the degree in order to ensure that there are no gaps in some of the service sector spheres. We are also beginning to establish collaborations for the teaching of classes, such that the students will have both an academic and a business perspective. Moreover, we continue following up the graduates' progress as regards their employability and their results at companies, etc., and all of this will undoubtedly lead us to once again revise the degree program.

One of our next steps will be to set up master's degree and doctorate programs, which will make it possible to provide the students with continuity, and the degree will additionally benefit

from the synergy of research. In this respect, the university already has a transdisciplinary SSME research group, which was involved in designing the degree presented herein. This group is composed of SSME experts from the areas of business, ICT, communication, and humanities. The creation of transdisciplinary research groups is, therefore, a challenge that may additionally provide interesting results when tackling social and economic problems from a broader perspective.

Author Contributions: Conceptualization, E.M., V.D.C., M.-L.M.-P., and J.M.V.; formal analysis, M.-L.M.-P. and J.M.V.; investigation, E.M., V.D.C., M.-L.M.-P., and J.M.V.; methodology, E.M. and V.D.C.; project administration, E.M.; supervision, V.D.C.; visualization, J.M.V.; writing—original draft, E.M.; writing—review and editing, V.D.C. and M.-L.M.-P. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Current undergraduate and graduate SSME programs.

Denomination	University—School	Country
BSc in Business Administration and Service Management	Copenhagen Business School	Denmark
Service Engineering Bachelor's Degree in Engineering	Frankfurt University of Applied Science	Germany
Service Management	Furtwangen University (HFU)—Business Administration and Engineering	Germany
IT Service Science major—Bachelor of Computer and Information Sciences	Auckland University of Technology—Computer and Mathematical Sciences	New Zealand
Bachelor of Science in Industrial Management Engineering minor in Service Management	De La Salle University—Gokongwei College of Engineering	Philippines
Bachelor's Degree in Information Technology and Services	Universitat Autònoma de Barcelona—Escuela Universitaria de Informática "Tomàs Cerdà"	Spain
Bachelor's Degree in Telecommunication Technologies and Services Engineering	Polytechnical University of Madrid—Technical School of Telecommunication Engineers	Spain
Bachelor's Degree in Telecommunication Technologies and Services Engineering	Polytechnical University of Valencia—School of Telecommunications Engineering	Spain
Bachelor's Degree in Service Engineering	Rey Juan Carlos University—Faculty of Social Science	Spain
Baccalauréat Universitaire en Systèmes d'Information et Science des Services	University of Geneva—Institute of Information Service Science	Switzerland
Bachelor of Science in Industrial and Service Engineering and Management	Nile University	Nigeria
Information Technology Services	Mississippi State University	USA
Denomination	University—School	Country
Business Administration and Engineering—Sales and Service Engineering	Furtwangen University (HFU)—Business Administration and Engineering School	Germany
Master's Degree in Service Engineering and Management	Universidade do Porto—Department of Industrial Engineering and Management	Portugal

Table A1. *Cont.*

Denomination	University—School	Country
Master's Degree in Service Science, Management, and Engineering	Masaryk University—Faculty of Informatics	Czech Republic
Master's Program in Information and Service Management	Aalto University—School of Business	Finland
Service Management and Design (SMD)	University of Warwick—WMG—International Manufacturing Centre	United Kingdom
Master's Program in Service Management	Karlstad University—Faculty of Arts and Social Sciences	Sweden
MSc in Social Science in Service Management	Copenhagen Business School	Denmark
Master's Degree in Service Design	Politécnico de Milano—PoliDesing	Italy
Master's Degree in Business, Product and Service Management	Polytechnic University of Valencia—Faculty of Business Administration and Management	Spain
Master's Degree in Strategic Design of Products and Services	Mondragon University	Spain
M.F.A. in Service Design	Savannah College of Art and Design	USA
Master's Program in Service Management	Lund University—Department of Service Management and Service Studies	Sweden
Master's Program in IT Service Management	University of Northampton—Northampton Business School	United Kingdom
International Master's Degree in Service Engineering	University of Tilburg—European Research Institute in Service Science (ERISS), University of Stuttgart.	The Netherlands, Germany, Greece
Master's Degree in Service Design and Engineering	EIT ICT Labs Master School. University of Trento, TU Eindhoven, Aalto University and ELTE Budapest.	Italy, The Netherlands, Finland, Hungary.
Services Management concentration in the MBA program	North Caroline State University—College of Management	USA
Service Engineering and Management	University Politehnica of Bucharest—Faculty of Automatic Control and Computers	Romania
Master of Science Degree in Foreign Service	Georgetown University—Faculty of the School of Foreign Service	USA
Master of Science Degree in Public Service Management	DePaul University—College of Liberal Arts and Social Sciences	USA
MSc in Service Innovation and Management	University of Jyväskylä—Faculty of Information Technology	Finland
Master's Degree in Social Sciences and Social Service Management	The University of Hong Kong—Faculty of Social Sciences	China
Master's Program in Service Management	University of Eastern Finland—Faculty of Social sciences	Finland
Master's Degree in Design for Services	University of Dundee—Faculty of design	United Kingdom
Master's Degree in Global Operations and Service Management	Aston University—Aston Business School	United Kingdom
Master's Degree in Service Management	Universidade Católica Portuguesa—Faculty of Social sciences	Portugal
Master's Degree in Engineering Management	University of Nicosia—Faculty of Social sciences	Cyprus

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