The Front End of Innovation (FEI) in the context of Entrepreneurship Education

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Abstract

Entrepreneurship is a key component for answering the need for creating and strengthening businesses. The expected results of entrepreneurial activities are the creation of jobs and innovative firms. Therefore, entrepreneurship education plays a vital role in engaging students in the systematic practice of innovation. An entrepreneur committed to a management role has a significant perspective to innovation and entrepreneurship endeavor, both tasks demanding a management practice for creating change. In this context, the Front End of Innovation (FEI) plays a critical role. However, this is a challenging phase for entrepreneurs and companies as the FEI demands a variety of activities and approaches, necessary to overcoming the risks entailed in a new concept development, which hopefully will be unfolded as a new product or service, or even a business. The literature reflects this situation, with a variety of FEI approaches and works. This study builds on the results of research that aimed at overcoming this issue by proposing the FEI Integrative Ontology (FEI^2O). This paper details the manner by which the FEI Integrative Ontology offers an appropriate novel conceptual model for entrepreneurship education providing a cross-analysis of the FEI^2O and the Content Standards for Entrepreneurship Education considering the "Entrepreneurial Process" that is part of the "Entrepreneurial Skills" section of the standard. Therefore, it explores the benefits of adopting the FEI^2O canvas to support innovation projects in the classroom, and ultimately the management of the FEI. Lastly, the work evaluates the FEI^2O answers for FEI Critical Success Factors, such as strategy, resources, processes, climate and leadership. Given the clear relationship between the subset of skills required for entrepreneurship education and the concepts handled at the front-end of innovation, our results demonstrate that the in-depth understanding of the FEI ontology could help entrepreneurship educators to enrich entrepreneurship and management skills by the use of an organized body of knowledge. In sum, this comprehensive tool is helpful to translate into action the management of the FEI contributing as a novel approach to education for entrepreneurship.

Keywords: Front End of Innovation, Entrepreneurship Education, New Concept Development, Entrepreneurial Competences, Management Competences.

1. Introduction

Peter Drucker said that "what all the successful entrepreneurs I have met have in common is not a certain kind of personality but a commitment to the systematic practice of innovation", and added, "innovation is the specific function of entrepreneurship, whether in an existing business, a public service institution, at a new venture started by a lone individual in the family kitchen." (Drucker, 2002). This picture should be in the educator's minds when thinking about entrepreneurship education. The Front-End of Innovation (FEI) is the first of the three stages in the so-called innovation funnel. As a result, the FEI represents a key component of the entrepreneurial process. An in-depth understanding of this part of the innovation process will help educators to best tune their efforts, by adjusting the learning outcomes of their courses to the desired result.

Research shows that FEI optimization and improvement lead organizations to positive results by increasing chances of innovation development (Boeddrich, 2004; Koen, Bertels, Klein, & Kleinschmidt, 2014; Markham, 2013; Stevens & Burley, 2004; Verworn, Herstatt, & Nagahira, 2008; Williams, Kochhar, & Tennant, 2007). This initial part of the innovation process entails considerable complexity, due to its distinctive multidisciplinary nature, portrayed by researchers as of an experimental and fuzzy nature. The literature reflects this situation, with a variety of FEI approaches and works.

This paper builds on the early results of this research that aimed at overcoming this issue by proposing the FEI Integrative Ontology, considering an ontology as a comprehensive formal reference knowledge model.

The process of how to manage the entire FEI, from the identification of an opportunity until the achievement of a new concept development is not always clear for the entrepreneur. One of the causes for this difficulty is the lack of understanding of the beginning of the innovation process (FEI). Moreover, regarding management skills, other difficulties may arise from the need to consider the size of the company, the decision-making style, the organizational culture and frequency of new products introduction, in order to choose a front-end solution (Khurana & Rosenthal, 1997).

Research suggests that entrepreneurs need both entrepreneurial and managerial competencies, considering of special importance managerial competencies as the business grows and to support successful business growth (Mitchelmore & Rowley, 2010).

In this context, we would like to understand how these entrepreneurial skills relate to the skills needed to support the Front End of Innovation. To this end, we considered the National Content Standards for Entrepreneurship Education Toolkit (http://www.entre-ed.org/Standards_Toolkit/), designed to provide the necessary tools for developing curriculum for entrepreneurship programs. Subsequently, we discuss how they relate to FEI activities. With this approach, we aim at widening educators' perspectives in the process of curricula preparation in Entrepreneurship.

The study presented in this paper results from the instantiation of the above research results in the Content Standards for Entrepreneurship Education. We assessed its matches and, assessed the alignment and compatibility of the CSEE and the FEI Ontology. It became evident the key role that the FEI plays in entrepreneurship education.

The FEI Integrative Ontology (FEI^2O) concepts demonstrated a strong relationship with the skills represented in the Entrepreneurial Process by the Content Standards for Entrepreneurship Education (The National Consortium for Entrepreneurship Education, 2016).

This novel approach of looking at entrepreneurship education makes it possible to bring into this process the whole body of knowledge developed so far in the context of the FEI. Moreover, the FEI^2O will extend those standards to further key organizational skills and roles, so that entrepreneurship education may be as well preparing the new Intra-organizational entrepreneurs.

2. Overview

Encouraging excellence in education and skills development is one of the key initiatives of the Innovation Union (European Commission, 2010). The European Institute of Innovation and Technology (EIT) has a strong focus on innovation, entrepreneurship, creativity and leadership. This attention encompasses one of the key objectives of the Innovation Union: to create more business and jobs through fast-growing, innovative firms (EIT, 2017).

The Europeans aged 15 to 25 are most likely to be unemployed; Table 2.1 demonstrates recent findings of this phenomenon.

	Adults aged 15 to 25 %	**Adults aged 26 to 60 %**	**Adults aged 61 and older %**
Employed full time for an employer	26	54	6
Employed full time for self	3	8	5
Employed part time, do not want full time	10	7	8
Unemployed	11	7	1
Employed part time, want full time	12	6	2
Out of workforce	39	19	77

Table 2.1: Employment Status in the European Union. Source: Business Journal, June 16, 2016 (Gallup World Poll, 2014)

Another important finding, from the Gallup World Poll (2014), emphasizes the key role played by new business start-ups concerning the job creation. As to Portugal, the report "Análise Informa D&B 2016" stated that between the years of 2007 and 2015, a number of 309 550 new ventures were registered. Moreover, the findings point out to a higher number of individual and smaller initiatives, representing a change from previous periods. Other highlight concerns that almost two-thirds of the cases (64%) the entrepreneur is facing its first experience as an entrepreneur. Furthermore, 76% of the entrepreneurs assume the management of the company.

An entrepreneur embodied by a management role is an essential demand considering that "Innovation and entrepreneurship are inherently about management practice and creating change" (Bessant & Tidd, 2007). In this context, the Front End of Innovation plays a critical role. Because, the in-depth understanding of the FEI is a promising starting point for innovation, as this part of the innovation process can foster the coordinated process of product or service concept development (Wagner, 2012).

Entrepreneurs and companies face a challenge when it comes to managing the beginning of the innovation process. This phase is a vital area that demands a variety of activities and approaches, necessary to overcome the challenges entailed in a new concept development, that hopefully will be unfolded as a new product or service, or even a business.

The next sections will provide an overview of the interrelationship between the FEI and Entrepreneurship education.

2.1. Front End of Innovation (FEI)

The Fuzzy Front End is the earliest stage of the New Product Development – NPD and the NPD it is followed by the commercialization phase. These three parts are often regarded as the three phases of the innovation process. A more recent nomenclature, coined by (Koen et al., 2002) is Front End of Innovation, dissociating the notion of a fuzzy (or unmanageable phase).

The FEI contributes "to increase the value, amount, and success probability of high-profit concepts entering product development and commercialization" (Koen et al. 2002, p. 5). Hence, taking into consideration the benefits of gaining competitive advantage, it is important for entrepreneurs and organizations to have a solid understanding of this phase (Reid & De Brentani, 2004).

The FEI is responsible for opportunity and ideation; as well as other activities regarding technical feasibility demonstrations, early market research, financial viability analysis, business model development, and business plan preparation (Markham, Ward, Aiman-Smith, & Kingon, 2010). In this context, entrepreneurship plays a key role in the FEI, and activities performed in the FEI have a distinctive nature from the other phases of the innovation process.

FEI activities are often considered being experimental as well as chaotic. An understandable point of view as the FEI entails a multitude of activities with different responsibilities. While, the NPD is more focused, well-organized and goal-orientated with a well-defined project plan (Koen et al., 2002). Montoya-Weiss & O´Driscoll (2000) address the FEI as unstructured and Ad-Hoc. Regardless the "fuzziness" of this stage, the initial phase of the innovation process is the foundation for the generation of successful New Product Development (Martinsuo & Poskela, 2011).

This fuzziness may be counterbalanced with a management perspective to the FEI. It is well supported the benefits of management perspectives to the FEI (Boeddrich, 2004; Chang, Chen, & Wey, 2007; Cooper & Edgett, 2012; Khurana & Rosenthal, 1997). According to (Eliens & Xavier, 2015) fuzzy situation refers to situations that change. Eventually, it may be depicted that the speed of change can lead to even more fuzziness. Therefore, an accurate FEI process should consider uncertainty, equivocality, complexity and variability and should focus on the way information is managed and processed. One possible way to deal with this fuzziness is to apply a formal model to the FEI, for (Khurana & Rosenthal, 1998) formalization can benefit the management of the FEI by reducing uncertainty in the initial phase of the innovation process.

2.2. Entrepreneurship Education

For Timmons & Spinelli (2009, p. 101) "Entrepreneurship is a way of thinking, reasoning, and acting that is opportunity obsessed, holistic in approach, and leadership balanced for the purpose of value creation and capture." "Entrepreneurship" has become a term that is increasingly widespread around the world. According to a broad spectrum of key players in society, including policy makers, academics, entrepreneurs themselves as well as for the population at large, entrepreneurship tends to be associated with economic development and well-being of society" (Amorós & Bosma, 2014).

In practical terms, an entrepreneur is someone that is always searching for change; therefore he/she responds to it and exploit it as an opportunity (Drucker, 2006). Opportunity is a driver key concept for the FEI, as the opportunity drives the strategic purpose of the Front End of Innovation. In this context, entrepreneurs who take advantage of change as an opportunity are in fact using innovation as their precise tool (Drucker, 2006).

The same way enterprises use innovation as an engine to foster the business development, hence the study of the FEI in the context of entrepreneurship becomes a necessary subject. In fact, studies have shown that companies are likely to start the FEI without a clear picture of the process

of how to go from the Identification of an opportunity to the generation of the concept (that will feed the NPD). Hence, the FEI process is frequently aborted or forced to be restarted (Achiche, Appio, McAloone, & Di Minin, 2013).

Graduate teaching in New Product Development is a widespread discipline taught in universities (Martinsuo, 2009). However, the early phase of innovation has just begun to receive attention. One critical question raised by this author was "How should the challenging tasks of managing the early phase of innovation be taught in a university context?" (Martinsuo, 2009, p. 147). Answers to entrepreneurship education have been considering the need for both entrepreneurial and managerial competencies, considering of special importance managerial competencies as the business grows and to support successful business growth (Mitchelmore & Rowley, 2010).

However, it was not only until recently that universities began to pay attention to this vital and uncertain phase of the innovation process, the Front End of Innovation in an entrepreneurial context (Jaskari, 2015). The process of how to manage the whole thing, from the identification of an opportunity until the achievement of a winning concept development is not always clear for the entrepreneur. One of the causes for this difficulty is the lack of understanding of the beginning of the innovation process, the FEI. Moreover, regarding management skills, other difficulties may arise from the need to consider the size of the company, the decision-making style, the organizational culture and frequency of new products introduction, to choose a front-end solution (Khurana and Rosenthal, 1997).

In this context, to understand how these entrepreneurial skills relate to the skills needed to support the Front End of Innovation is an added value structure FEI courses and curriculum in a university context or even for in-company developments. To this end, the National Content Standards for Entrepreneurship Education (NCSEE) Toolkit (http://www.entre-ed.org/Standards_Toolkit/) may be a starting point for a cross-analysis. This toolkit was designed to provide the tools necessary for developing curriculum for entrepreneurship programs. It is, therefore, a valuable platform for discussing the toolkit relation with FEI activities. The expected results are: a) Widening educators' perspectives in the process of curricula preparation in Entrepreneurship; as well as b) enhancing students FEI competences.

3. Methodological approach

The analysis performed in the scope of this paper implies the existence of an underlying conceptual reference framework capable of giving a broad and comprehensive view of the front end of innovation. This was achieved by developing the so-called integrative FEI ontology in a Design Science Approach, Figure 3.1 illustrates this development process whose details are out of the scope of this paper (Internal report n. 8, The authors, 2017).

Two Information System Research Framewoks (Hevner et al., 2004; March & Smith, 1995) shaped the definition of the research activities and outputs. The Ontology Requirements Specification assisted the definitions of the overall guidelines to develop the artefact. And, the 101 Ontology Development Methodology (Noy and McGuinness 2001) provided the seven steps to develop the ontology. The first step concerned the definition of the domain and scope of the proposed ontology. The domain concerns the representation of the initial phase of the innovation process and its scope was outlined according to the so-called competence questions.

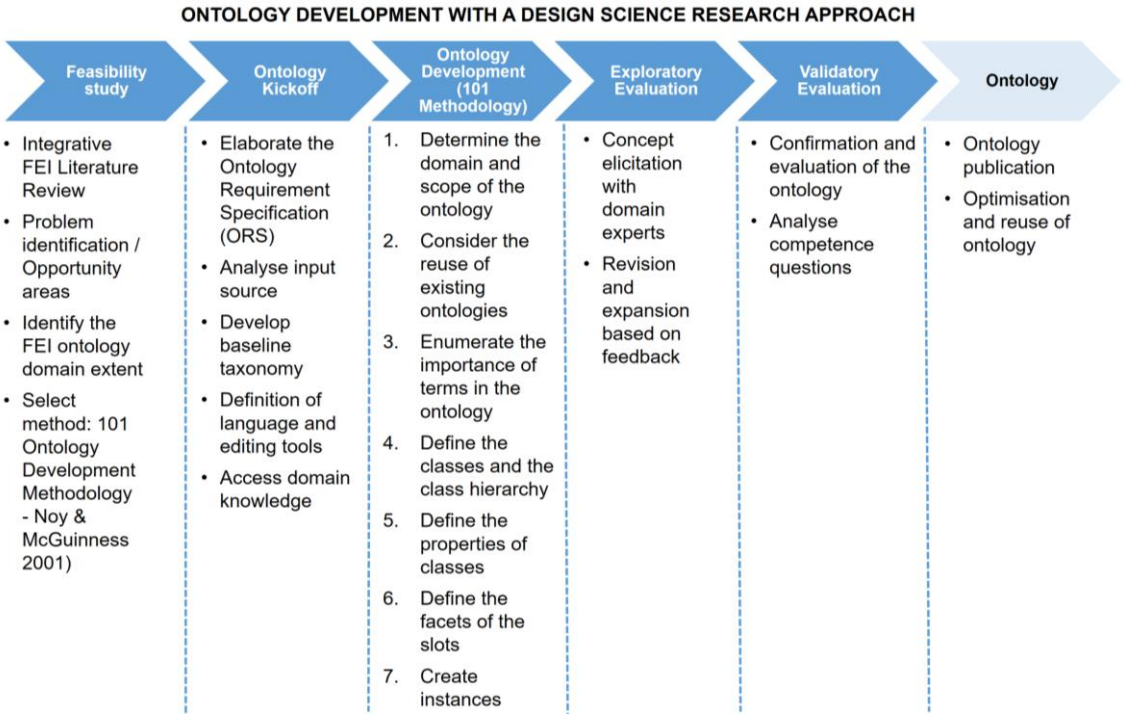

Figure 3.1. Summarized Ontology Development Process with DS adapted from (Staab, Studer, Schnurr, & Sure, 2001 and Shi, Liu, Jing, Xiong, & Zhang, 2009)

Many factors influenced the choice of the terms in the ontology. It was most important the analysis of the main FEI models and the assessment of which concepts were likely to be sufficiently significant to be part of the FEI Integrative Ontology – considering both the specialized literature and the terms elicitation with experts from the field. It was promoted the reuse of concepts from existing ontologies, for instance, Context Ontology (CO:), EO – Enterprise Ontology, BMO – Business Model Ontology, Agile Ontology and COIN Ontology – Collaborative Innovation Network Ontology. This fostered the conceptual integration of the developed ontology with other related ontologies.

Besides the use of the Ontology Requirements Specification (ORS), the ontology development comprised the following steps, according to the 101 Methodology (Noy and McGuinness, 2001):

1) It was determined the domain and scope of the ontology with the definition of the competence questions; The domain concerns the representation of the initial phase of the innovation process (The Front End of Innovation-FEI), and its scope is outlined accordingly to the so-called competence questions:
    a. Does the ontology allow the identification of which knowledge domains are present in the FEI?
    b. Which are the outcomes (results) of the Ontology?
    c. Which processes unfold in the context of the Ontology?
    d. Which are the stages related to the new concept development?
    e. Which are the outputs of the FEI Agile New Concept Development?
    f. Who are the actors in the FEI?
    g. Which are the roles played by FEI actors?

2) It was consider reusing existing ontologies, in this case, it was considered the contribution of concepts from the CO – Context Ontology, EO – Enterprise Ontology, BMO – Business Model Ontology, Agile Ontology and COIN Ontology – Collaborative Innovation Network Ontology.
3) For designing the ontology
    a. It was enumerated important terms in the ontology;
    b. It was defined the classes and the class hierarchy;
    c. It was defined the properties of classes—slots; and,
4) For evaluating the ontology, it was considered two phases, an exploratory and a validation phase.
    a. The Exploratory Phase was carried out from June/2016 until May/2017. It was performed a total of 18 interviews with 14 participants; this was responsible for the concept elicitation with domain experts. Therefore, this phase allowed the enrichment and refinement of the proposed artefact. The evaluation process advanced for the next phase only after data saturation was reached. Considering that data saturation was achieved when no additional new information had been attained (Fusch & Ness, 2015).
    b. The Validation Phase was responsible for the final evaluation of the artefact by means of a Focus Group. It gathered nine participants of which seven were present physically and two virtually. As one of the participants was not able to reply in the end of the session, only eight of the replies were considered in order to ensure that all of them were taken in the same conditions. Therefore, the eight acceptable results were analyzed according to An Attribute Agreement Method, its results provided enough evidence to claim the validation of the work.
5) The last step concerned the creation of instances. This step was necessary to demonstrate the utility of the artefact.
    a. The data triangulation was obtained by analyzing the FEI literature altogether with reusable ontologies; Interview and Focus Group as tools to elucidate the artefact developed and the Instantiation through the demonstration of application cases.
6) With the FEI formal model validated it was possible to put into action the by-products of the work. In an educational context, the conceptual model for supporting curriculum activities and a holistic teaching perspective for the FEI.

4. Conceptual Model for the Front End of Innovation

Although there is an ongoing and intense debate about the conceptualization of the competence "concept", in what regards entrepreneurial competencies it can be said that they represent a "specific group of competencies relevant to the exercise of successful entrepreneurship" (Mitchelmore & Rowley, 2010, p. 93).
The aim of this work is not to explore the FEI Integrative Ontology (FEI^2O), but to use it as a means for supporting entrepreneurship education. Table 4.1 shows an overview of the concepts of the FEI Formal Reference Model.

Sub-Ontology	Concepts present in the Sub-ontology
FEI Purpose *Focus on Opportunity*	• SOURCE OF OPPORTUNITY • OPPORTUNITY RECOGNITION • OPPORTUNITY CONFIDENCE • OPPORTUNITY • CO: REQUIREMENT • CO: THREAT • CO: STRENGTH • CO: WEAKNESS • CO: PROBLEM
FEI Purpose	• OPPORTUNITY • FEI EO: STRATEGIC PURPOSE • EO: STRATEGIC PLANNING • [BUSINESS] EO: PURPOSE • CO: CRITERION • EO: GOAL • EO: STRATEGIC GOAL • EO: TACTIC GOAL • EO: OPERATIONAL GOAL • EO: MISSION • EO: VISION
Portfolio Planning & Management	• FEI EO: STRATEGIC PURPOSE • PORTFOLIO PLANNING & MANAGEMENT • PORTFOLIO PLANNING • PORTFOLIO MANAGEMENT • MARKET SCANNING • TECHNOLOGY SCANNING • CAPABILITY DEVELOPMENT • EO: STRATEGIC PLANNING • PRODUCT AND PORTFOLIO STRATEGY • TECHNOLOGY ROADMAP • PRODUCT ROADMAP • ORGANISATIONAL FACTORS
Portfolio Planning & Management *Focus on Organisational Factors*	• ORGANISATIONAL FACTOR • STRUCTURE • SENIOR MANAGEMENT INVOLVEMENT • TEAM AND COLLABORATION • CULTURE • RESOURCES • CAPABILITY • CAPABILITY DEVELOPMENT • PARTNERSHIP

Sub-Ontology	Concepts present in the Sub-ontology
Portfolio Planning & Management *Focus on Organizational Factors [Resources]*	• BMO: RESOURCES • BMO: TANGIBLE ASSETS • BMO: INTANGIBLE ASSETS • BMO: PEOPLE BASED SKILLS
FEI Agile New Concept Development	• FEI AGILE NCD • A: AGILE METHOD • FEI EO: STRATEGIC PURPOSE • PORTFOLIO PLANNING & MANAGEMENT • FEI STAGE • FEI ITERATION • ITERATION INFORMATION • BUILD • MEASURE • LEARN • NEW CONCEPT
FEI Stage	• PRELIMINARY OPPORTUNITY IDENTIFICATION • PRODUCT CONCEPT DEVELOPMENT • FEASIBILITY AND PROJECT PLANNING • BUSINESS MODEL DEVELOPMENT
FEI Actors	• EO: ACTOR • EO: ACTIVITY • STAKEHOLDER • BMO: PEOPLE BASED SKILL • EO: ORGANIZATION UNIT • CO: POSITION • CO: ORGANISATION • EO: MACHINE • CO: ORGANISATIONAL ROLE • T-SHAPED SPECIALIST • LEADERSHIP ROLE • INNOVATOR ROLE • FACILITATOR • GATEKEEPER • SPONSOR • CHAMPION

Table 4.1 – FEI Integrative Ontology (FEI^{2}O) Contents

These concepts will be mapped and further analyzed, whenever possible, into the Entrepreneurship Education National Content Standards (NCSEE) skill list. As a result, we expect to understand how these two conceptual frameworks map into each other, and to assess how each model can build value by bringing both together. Considering the importance of having an encompassing curriculum able to cope with the entrepreneur's needs, the National Consortium for Entrepreneurship Education (a USA institution) developed the Entrepreneurship Education

National Content Standards (NCSEE). They carried out, through focus groups with business owners, a process of identifying what entrepreneurs do and what they need to know to do it. This process was performed in 2004, and it was subject to an update in 2016.
The NCSEE comprises fifteen major standards organized into three sections:

- Entrepreneurial Skills,
- Ready Skills, and
- Business Functions.

The Entrepreneurial Skill is a key section and its influence is projected into the Ready Skills and Business Functions. It comprises, for instance, the processes and traits/behaviors related to new and stablished ventures, and the activities related to create, to drive and to change – new: markets, products, businesses. Therefore, due to its key role and FEI representativeness, the Entrepreneurial Skills section was subject to an exploratory comparative analysis with the FEI^{2}O, focused on the "Entrepreneurial Process".
Table 4.2 shows a brief overview of concepts and processes related to the entrepreneurial process and their relations with the building blocks of the FEI Ontology.

Entrepreneurial Skills listed for the Entrepreneurial Process

NCSEE / Entrepreneurial Process / Discovery		**FEI Ontology**
A.01	Explain the need for entrepreneurial discovery	OPPORTUNITY FEI EO: STRATEGIC PURPOSE [BUSINESS] EO: PURPOSE PORTFOLIO PLANNING & MANAGEMENT FEI STAGE ACTIVITIES FEI AGILE NEW CONCEPT DEVELOPMENT
A.02	Discuss entrepreneurial discovery processes	
A.03	Assess global trends and opportunities	
A.04	Determine opportunities for venture creation	
A.05	Assess opportunities for venture creation	
A.06	Describe idea-generation methods	
A.07	Generate venture ideas	
NCSEE / Entrepreneurial Process / Concept Development		
A.09	Describe entrepreneurial planning considerations	FEI STAGE PORTFOLIO PLANNING & MANAGEMENT
A.15	Describe strategies to protect intellectual property	N/A
NCSEE / Entrepreneurial Process / Resourcing		
A.17	Distinguish between debt and equity financing for venture creation	FEI STAGE (FEASIBILITY AND PROJECT PLANNING)
A.21	Describe considerations in selecting capital resources	

NCSEE / Entrepreneurial Process / Actualization		
A.30	Develop and/or provide product/service	FEI AGILE NCD FEI STAGE
A.31	Use creativity in business activities/decisions	ORGANISATIONAL FACTORS RESOURCES PEOPLE BASED SKILLS FEI ACTORS
A.25	Explain the complexity of business operations	FEI STAGE (BUSINESS MODEL DEVELOPMENT)
A.27	Explain the need for business systems and procedures	
A.28	Describe the use of operating procedures	
NCSEE / Entrepreneurial Process / Harvesting		
A.35	Explain the need for continuation planning	PP&M ALIGNMENT WITH PRODUCT PORTFOLIO STRATEGY

Table 4.2 – Analysis of NCSEE Toolkit *versus* FEI Ontology

The exploratory comparative analysis, presented in Table 4.2, illustrates how the FEI^{2}O covers the "Entrepreneurial Process" as a skill set defined by the NCSSEE. A 1st conclusion that we may draw from the analysis of this table is that there is a clear relationship between a subset of skills required for entrepreneurship education and the concepts handled at the front-end of innovation. This may lead us to another perspective on the table above, where we would argue that the in-depth understanding of the FEI ontology will help entrepreneurship educators to enrich those skills, identified for entrepreneurship education, by reaching to an organized body of knowledge that will guide them through the process. Figure 4.1 illustrates just that, at a very high level, it highlights the role of the actor (entrepreneurs, entrepreneurial team and possible stakeholders - e.g.: investors) and their engagement in the process of new concept development. The figure further frames this process in a Strategic Purpose and Portfolio Planning and Management (PP&M), regardless of their formal existence, as it happens in a company. In fact, the entrepreneur may not have these as formally established documents, but these concepts will likely be in his/her mind along the entire process. The iterative nature of the process also emerges from the ontology, thus making it clear for the student the nature of the process.

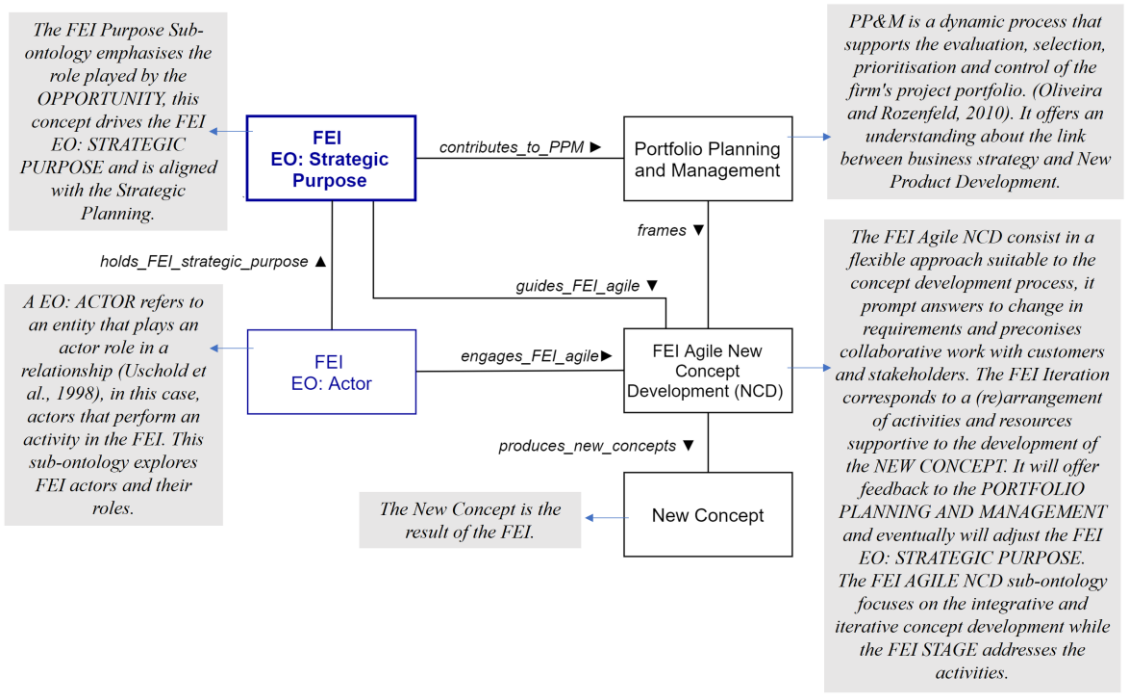

Figure 4.1. The High-Level Ontology (Internal report n. 8, The authors, 2017).

In this representation, the FEI EO: STRATEGIC PURPOSE **contributes to** the PORTFOLIO PLANNING AND MANAGEMENT(PPM). In its turn, the PPM frames the FEI AGILE NEW CONCEPT DEVELOPMENT (NCD) while the FEI EO: ACTORS **are engaged** in the FEI AGILE NCD to produce the NEW CONCEPT. The FEI AGILE NCD comprises a combination of iterations. These iterations consist of a configuration of activities integrated in the so-called FEI Stages. This process continues as long as necessary to achieve a successful NEW CONCEPT. The representation of FEI activities in a set of stages aims to facilitate the decision-making process as well as to provide a management perspective of all the responsibilities comprised by each stage. Figure 4.2 presents the Sub-ontology FEI Stage and Table 4.3 illustrates examples of activities found in each of the FEI STAGEs.

*EO: ACTIVITY **is_part_of** FEI STAGE*
*FEI STAGE **makes_use_of** CO: TOOLS*
*FEI STAGE **makes_use_of** METHODOLOGIES*
*CO: TOOLS **is_part_of** METHODOLOGIES*
*PRELIMINARY OPPORTUNITY IDENTIFICATION **is_a** FEI STAGE*
*PRODUCT CONCEPT DEVELOPMENT **is_a** FEI STAGE*
*FEASIBILITY AND PROJECT PLANNING **is_a** FEI STAGE*
*BUSINESS MODEL DEVELOPMENT **is_a** FEI STAGE*

Figure 4.2. Description in natural language of the Sub-Ontology FEI Stage (Internal report n. 8, The authors, 2017).

Example of activities unfolding in FEI stages
Ideation; Market Analysis; Technology Analysis
Identify Customer Needs / Wants / Fears; Identify Market Segments; Identify Competitive Scenario; Technology Evaluation; Problem-Solution Fit
Minimum Viable Product (MVP); Specify Resources Needed; Project Description; Market Feasibility; Technical Feasibility; Financial / Economic Feasibility; Organizational / Managerial Feasibility; Identify Key Risks and Challenges
Product Market Fit; Business Model Prototype; Sales & Marketing Roadmap; Scale Execution; Scale Organisation; Scale Operation

Table 4.3 - Example of FEI activities according to each FEI Stage (The author, 2017)

The FEI activities carry a dynamic and iterative flow among them enabled by the FEI ITERATION (BUILD/MEASURE/LEARN loop – part of the FEI Agile NCD). In this process, for each interaction and inside each FEI STAGE, tools and supporting methodologies will be used as adequate. Given the encompassing nature of the FEI^{2}O to frame supporting methodologies, this conceptual model may be helpful in the realm of entrepreneurship education as it will provide a perspective of which methodologies to apply to each of the FEI Stage and, as a comprehensive and integrative approach to the entire FEI process.

Overall, the adoption of the FEI^{2}O as a reference framework for entrepreneurship education, specifically associated to the identified NCSEE skills, will likely bring great value in the organization of the entire conceptual framework, and better guide students in navigating the entrepreneurial process. One would envision the following benefits:

- the systematization of the efforts applied to the beginning of the innovation process;
- the representation of the importance of actors' engagement in the process and which are their roles;
- an orientation towards the efforts to be applied in the opportunity screening and a set of steps to achieve the new concept development through the Agile development of FEI Activities;
- a solid FEI foundation that aims at providing effective management in developing a new concept;
- an effective NCD that may eventually lead to the unfolding of a new business;
- a supportive tool to shape the strategic purpose of the FEI, thus also framing this activity in an organizational context, offering the base to align the strategic purpose of the FEI with the business purpose of the company;
- the model shapes the FEI dynamic and guides the efforts to iterate and adjust the FEI purpose, eventually offering feedback to the Portfolio Planning and Management;
- the FEI^{2}O supports the mobilization of organizational resources to implement Portfolio Planning;

- it helps to identify the organizational factors critical to the execution of the business strategy;
- the model highlights existing organizational resources and capabilities helping to identify the gaps and needs of developing new capabilities and if necessary partnerships;
- it identifies the various actors and their roles in the activities of the beginning of the innovation process; and,
- lastly, the use of criteria to evaluate the EO: Business Purpose helps the decision-making process as it supports the resources allocations.

5. Conclusions

This paper explored in a high-level analysis the manner by which the FEI Integrative Ontology (FEI^{2}O) offers a novel conceptual model for entrepreneurship education. To illustrate this possibility, a cross-analysis was developed considering the FEI^{2}O and the National Content Standards for Entrepreneurship Education focused on the Entrepreneurial Skills section of the NCSEE, exploring the so-called "Entrepreneurial Process" skill list.

The analysis explored the benefits of the adoption of the FEI^{2}O to support innovation projects in the classroom, and ultimately the management of the FEI. Given the clear relationship between the subset of skills required for entrepreneurship education and the concepts handled at the front-end of innovation. This remark leads us to argue that the in-depth understanding of the FEI ontology will help entrepreneurship educators to enrich those skills, identified for entrepreneurship education, by reaching to an organized body of knowledge that will guide them through the process.

One of the vital ingredients to foster entrepreneurship competencies is to invest in the development of both entrepreneurial and managerial competencies. In this sense, entrepreneurship education may benefit of the knowledge developed in the context of the FEI, and a vital contribution may be found in the FEI Integrative Ontology. As this formal reference model explores skills and roles, so that entrepreneurship education may be as well preparing entrepreneurs who launch a business and intra-organizational entrepreneur.

The application of the FEI Integrative Ontology in educational contexts may be seen as:

a) A conceptual model helpful for organizing curriculum activities;

b) A holistic entrepreneurship teaching mindset building on the extensive FEI^{2}O perspectives, including the alignment of the Strategy and PP&M with the organizational factors; and,

c) A comprehensive tool and supporting methodology to translating into action the management of the FEI (The use of the FEI^{2}O Canvas as a supportive methodology in the classroom).

This exploratory study showed that the FEI Integrative Ontology is a promising artefact to support entrepreneurship education, both from the theoretical perspective and the practice. It provides the missing comprehensive framework that gives the mental reference for a process that was so many times pictured as chaotic and unmanageable. It is our vision that this proposal answers the call by (Giles & Cormican, 2014) stating that there are strong motivating factors for more effective management practices at the Front End of Innovation (FEI).

As stated, this exploratory study shows that there is an opportunity for in-depth research in this area, in order to bring a systematic approach such as the FEI^{2}O, that is capable of framing different methodologies used in entrepreneurship training, such as design thinking, lean-startup, into a comprehensive model.

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