Author's accepted manuscript (postprint)

Bringing an entrepreneurial focus to sustainability education: A teaching framework based on content analysis

Hermann, R. R. & Bossle, M. B.

Bringing an Entrepreneurial Focus to Sustainability Education: A Teaching Framework Based on Content Analysis

Roberto Rivas Hermann*[1], Marilia Bonzanini Bossle[2],
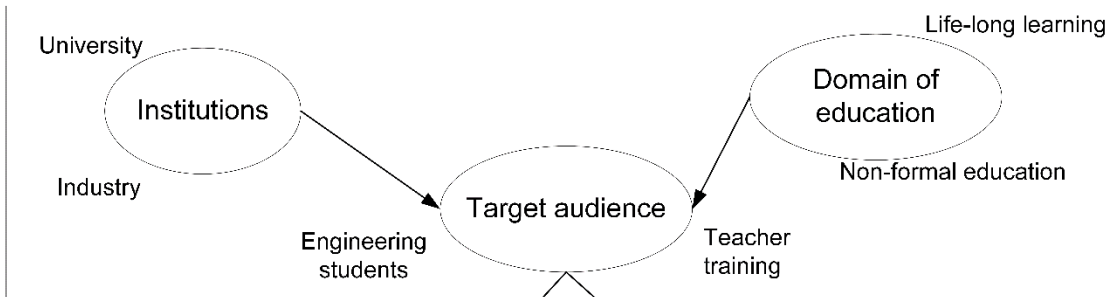
(1) *Corresponding author

Associate professor, Nord University Business School, Nord University, Universitetsalléen 11, 8026 Bodø
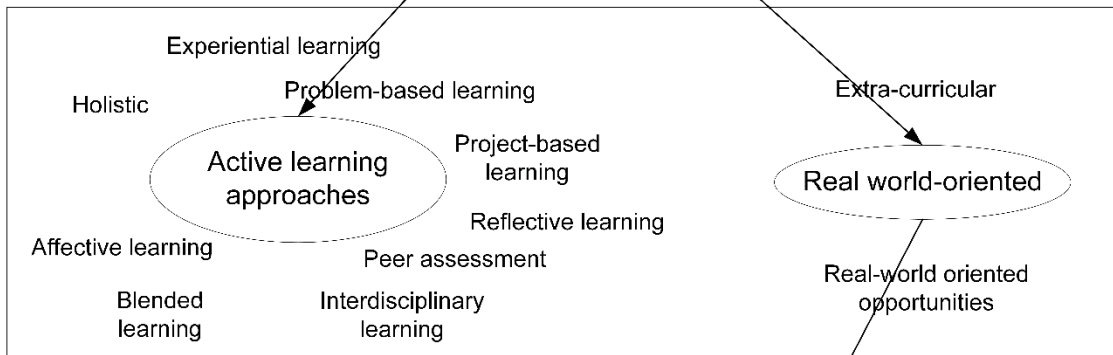
roberto.r.hermann@nord.no

+47 75 51 78 39

(2) Professor, Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Sul, Rector's Office, Bento Gonçalves, Brazil. marilia.bossle@viamao.ifrs.edu.br

Step 1: Educational focus

University

Institutions

Industry

Life-long learning

Domain of education

Non-formal education

Engineering students

Target audience

Teacher training

Step 2: Teaching learning approaches

Experiential learning

Holistic

Problem-based learning

Active learning approaches

Project-based learning

Reflective learning

Affective learning

Peer assessment

Blended learning

Interdisciplinary learning

Extra-curricular

Real world-oriented

Real-world oriented opportunities

Step 3: Themes

Innovation

Innovation-design

Design

Creativity

Social entrepreneuship

Entrepreneurship/ Ecosystem support

Corporate social responsability

Corporate/ Organizational aspects

Integrating leadership

Step 4: External collaboration

Capacity building

Practices

Community

Actors

Stakeholders

Bringing an Entrepreneurial Focus to Sustainability Education: A Teaching Framework Based on Content Analysis

Abstract

Research on sustainability education has neglected to integrate entrepreneurial skills into other relevant competences such as foresight, complex problem-solving, and interdisciplinarity. Previous research highlights possible convergences between sustainability education and entrepreneurship education; however, it does not address how to achieve this integration in practice. To address the gap between the literature and practice, this paper tackles the question: *How can entrepreneurial competences be taught in sustainability education programs in higher education?* We introduce a teaching framework based on a bibliometric method that combines topic-modeling with a content-analysis of selected articles. The focus of the analysis is the commonalities of both educational fields. Our results introduce a program for entrepreneurial-oriented sustainability education, providing a description of the educational focus, teaching-learning approaches, main themes, and external collaboration. The framework proposes educational for sustainable development across educational programs while implicitly addressing complex community problems through the development of solutions that can change the ways business and consumers relate with sustainability issues. These results contribute to the sustainability education literature by integrating the development of entrepreneurship competences into interdisciplinary programs. The framework could also be used as a practical guide for designing courses, at both the undergraduate and graduate level, that integrate both sustainability and entrepreneurship.

Keywords: bibliometric; sustainability education; entrepreneurship education; sustainable development goals; teaching framework; higher education

Bringing an Entrepreneurial Focus to Sustainability Education: A Teaching Framework Based on Content Analysis

1 Introduction

Societal challenges, such as inequality, violence and poverty, pushed global leaders to integrate 17 sustainable development goals (SDG) into the 2030 Agenda for Sustainable Development (UN, 2017). The SDG are anchored in seeking solutions to issues such as poverty, hunger, sustainable cities and communities, responsible consumption and production, and other community issues (UN, 2017). The origins of sustainability education are rooted in institutionalized international efforts, such as the UN General Assembly resolution 57/254 on the UN Decade of Education for Sustainable Development (DESD) (Wals, 2014) and the Stockholm Conference in 1972 (UNEP, 1972), which recognizes the role of higher education in environmental protection. The literature also refers to sustainability education as education for sustainable development (ESD) (Wals, 2014), education for sustainability (Smith and Stevenson, 2017; Vann et al., 2006) or environmental education (Lozano et al., 2013), among others. UNESCO has also discussed education for sustainable development (EfSD) and has called on study programs to integrate sustainability skills (Sipos et al., 2008).

Given the value-oriented, output-motivated nature of the SDGs, previous research has suggested a close relationship between sustainability education and transformative learning frameworks where the core activity is inspiring change that solves complex problems, like those linked to the SDG (Noy et al., 2017). In order to tackle these complex problems, a combination of skills and competences are needed (Lans et al., 2014); thus, a whole set of literature within sustainability education focuses on competence development. Lambrechts et al. (2013) refers to competence as how a person mobilizes cognitive and non-cognitive resources in a given situation. The literature suggests key competences for sustainability, including interpersonal

27 competences including responsibility, emotional intelligence, and personal and interpersonal

28 involvement. Competences to understand complexity and anticipate change, system-orientation

29 or system-thinking, future orientation or foresight thinking, action skills, strategic mentality,

30 and interdisciplinarity are also discussed (Lambrechts et al., 2013; Lans et al., 2014; Wiek et

31 al., 2011).

32 The definition of sustainable development, this being "development that meets the needs of the

33 present without compromising the ability of future generations to meet their own needs"

34 (WCED, 1987), introduces dynamic features since needs will change along with the future

35 shifts society will face. This dynamic aspect implies that sustainability is entwined with

36 concepts such as entrepreneurship (Bossle et al., 2016). Extant research increasingly highlights

37 the role of entrepreneurs in identifying market externalities and exploiting business

38 opportunities (Demirel et al., 2017). In particular, personal competences and previous

39 knowledge about the nature of problems enable entrepreneurs to identify solutions with market

40 potential (Shane, 2000). Entrepreneurs are thus seen as key actors in the process of achieving

41 the SDGs by creating value and new business while tackling pressing problems like global

42 warming, poverty, biodiversity loss and pollution (Shepherd and Patzelt, 2017). A growing

43 research stream analyzes the role of sustainability-oriented entrepreneurs crafting solutions to

44 problems that overlap with the SDGs (Dean and McMullen, 2007; Gibbs, 2006; Pacheco et al.,

45 2010; Shepherd and Patzelt, 2011). Despite this potential, entrepreneurial mindsets to craft

46 solutions to complex societal problems seem to be a missing competence in sustainability

47 education.

48 Wyness et al. (2015) indicates a lack of integration between higher education programs in

49 sustainability and those in entrepreneurship education. Some efforts at higher education

50 institutions have been reported in the literature as examples of how to integrate sustainability

51 courses into business programs (Lans et al., 2014; Lourenço et al., 2013; Wyness et al., 2015).

52   These studies have focused on many different issues, including competences (Lans et al., 2014;

53   Mindt and Rieckmann, 2017), level of integration and fit between both program contents

54   (Wyness et al., 2015) or the content of sustainability in the education entrepreneurs (Lourenço

55   et al., 2013). Research gaps remain in finding appropriate pedagogical approaches to combining

56   sustainability and entrepreneurship in university programs, but pilot studies indicate there is

57   potential for adding elements of sustainability education that can enhance entrepreneurs'

58   potential to identify "green" opportunities (Lourenço et al., 2013). This paper replies to calls

59   from previous work that call for a better understanding and further theorizing on how to

60   integrate sustainability and entrepreneurship education (Lans et al., 2014; Mindt and

61   Rieckmann, 2017; Wyness et al., 2015). In contrast to previous efforts, we propose a

62   methodological approach that relies on a comprehensively developed teaching framework,

63   which not only includes competences but also teaching-learning approaches and content.

64   This paper fills the literature gap by addressing the question: *How can entrepreneurial*

65   *competences be taught in sustainability education programs in higher education?*

66   To answer this question, this article uses a bibliometric approach that allows researchers to a)

67   identify emerging scientific communities in a domain, enabling them to infer the differences

68   between the conceptual bases of "entrepreneurship education" and "sustainability education",

69   and b) model the main topics in both fields to discuss the key discourses in each field. The

70   framework is thus based on a combination of the delineation of scientific communities and the

71   mapping of dominant topics. This research has theoretical implications. We contribute to the

72   sustainability education literature by providing a teaching framework that goes beyond listing

73   competences or teaching-learning approaches; instead, we integrate both entrepreneurship and

74   sustainability by using themes and increasing collaboration with external parties.

75   The results also offer practical implications. The framework includes key concepts that should

76   be considered when developing courses blending sustainability and entrepreneurship outcomes.

The paper is organized as follows: In the following section, the authors present a literature review of previous research on the intersections between entrepreneurship and sustainability education. The third section presents the materials and methods. The fourth section summarizes the findings. The fifth section discusses the results considering previous systematic reviews and methodologies. The sixth section gives the conclusion and suggestions for further research.

2   The crossroads of entrepreneurship and sustainability education: State of the art

An emerging perspective within the literature considers entrepreneurial action as a mechanism for tackling sustainability challenges. Shepherd and Petzelt (2017) theorize that entrepreneurial action is a process which requires two important inputs: prior knowledge and motivation. Prior knowledge includes knowledge about the natural environment as well as entrepreneurship, while motivation includes altruism or prosocial-motivation. This combination allows individuals to notice the threats for the natural or communal environment, hence transforming the person-opportunity belief into entrepreneurial action and resulting in a two-sided outcome – sustainability (nature preservation and community preservation, among other benefits) and development (financial or non-financial gains for the person or others).

In the context of entrepreneurship, changes are foreseen in five entities of the value chain: creation of new products or services, discovery of new geographical markets, discovery of new materials of production, improvements of methods of production and organizational changes (Schumpeter, 2003). When these changes are about addressing externalities in the industrial production, consumption or disposal processes, they generate business opportunities for new entrants or established firms (Dean and McMullen, 2007). We define entrepreneurial opportunities according to Shane (2000, p. 451): "Those situations in which new goods,

101 services, raw materials and organizing methods can be introduced and sold at greater than their
102 cost of production".

103 Sustainable development dimensions (social, economic and environmental) can offer major
104 competitive advantages to firms. Therefore, a firm must demonstrate that along with being
105 profitable, it is also able to increase its social quality and improve the environment (Criado-
106 Gomis et al., 2018; Jolink and Niesten, 2015). Conventional entrepreneurs' main interest is the
107 enterprise's economical accountability by ensuring the firm generates enough income to grow.
108 The kind of entrepreneurship related to the "social" strand creates businesses with a goal of
109 improving the social wellbeing of a given society (Zahra et al., 2009). Environmental
110 entrepreneurship exploits market imperfections and related opportunities; examples of this
111 include nature-oriented enterprises (e.g. tourism), environmental technology, environmental
112 management services and environmental products (Linnanen, 2002). "Ecopreneurs" combine
113 the environmental and the economic aspects of sustainability. Pastakia (1998) defines them as
114 entrepreneurs that introduce eco-friendly products or services into markets. Isaak (2002)
115 highlights this focus on a product or service's environmental aspects by considering a "green-
116 green" behaviour as the ecopreneurs' marking condition. Environmental protection should be
117 embedded in their products and in the production chain. Conversely, Schaltegger (2002)
118 evaluates ecopreneurs as those organizations or individuals that start a business for the mass
119 market, but with environmental performance goals as a core part of the business. Finally,
120 "sustainability" entrepreneurs integrate the three dimensions of sustainable development into
121 their process of creating a company (Young and Tilley, 2006). Tilley and Young (2009),
122 therefore argue that "sustainable" entrepreneurship goes further than "environmental" or
123 "social" entrepreneurship in that it includes a broader and more comprehensive range of
124 sustainable development dimensions.

125 *2.1 Conceptualizing sustainability and entrepreneurship education*

126 A governance perspective also helps to understand the increasing role of higher education

127 institutions as key actors in governance, and therefore key players in sustainability (Lehmann

128 et al., 2010). Universities have endorsed and institutionalized sustainability through a whole set

129 of charters— nationally, internationally and sectorally (Filho et al., 2018). As result, higher

130 education programs across the world have discovered multiple ways of integrating

131 sustainability into higher education, ranging from specialized courses, extension programs,

132 research and community-driven initiatives. In all of these programs, the goal is to influence

133 students and other societal stakeholders to make a change towards sustainable development

134 (Wals, 2014). As result, there is a plethora of initiatives seeking outcomes related to

135 environmental sustainability as well as many conceptions about how graduates should

136 understand about sustainability issues, learn the skills to act sustainably, and gain the personal

137 and emotional attributes required to do so (Shephard, 2008). Summing-up, the adoption of the

138 sustainability concept in higher education is still perceived in terms of the roles of universities,

139 but is also framed in terms of how the university's operations include environmental impact

140 and sustainability-performance communication. In the business sector, sustainability is adapted

141 slightly differently. Overall, a larger emphasis is placed on operationalizing sustainability into

142 goals and targets that can be accounted for. Environmental management systems and other

143 accounting approaches are practices arising from the business sector and it is believe that

144 universities can learn from these tactics (Lozano, 2006).

145 Sustainability education can be seen as a radical, innovative idea (Lourenço et al., 2013). This

146 radical, innovative idea must be increasingly adopted by universities through sustainable

147 development principles in day-to-day activities (Lourenço et al., 2013), which is not easily

148 implemented in universities and their traditionally Newtonian and Cartesian educational

149 programs linked to reductionist training (Lozano et al., 2013). Hence, integrating sustainability

150   education may imply a two-sided paradigm shift. On the one hand, sustainabilty education aims

151   to integrate sustainability transversally across educational programs (Wyness et al., 2015).

152   Meanwhile, on the other hand, it aims to foster a particular type of education based on values

153   and ethics (Lambrechts et al., 2013). Sustainability education relies on effective learning –

154   hitherto related to values, attitudes, and behaviors – and hence is less about the cognitive

155   learning of knowledge and its application (Shephard, 2008).

156   In order to train students to gain competences in sustainability, some researchers have

157   connected competences with certain teaching methodologies. A common characteristic of these

158   pedagogies is their multidisciplinary integration, problem-based approaches, and integrated

159   active learning. Wiek et al. (2011) provide a comprehensive mapping of competences, but do

160   not list pedagogical approaches to teach these competences. Instead, the focus is on

161   methodologies linked to each of the competences. A commonality between all of the different

162   methodologies is that they are multidisciplinary. Wals (2014) assessed teaching practices in

163   sustainability education around the world. He identified multi-stakeholder-oriented pedagogy

164   but also a number of programs that integrate "new forms of learning" such as problem-based

165   learning, value-based learning, experiential learning, and social learning. Shephard (2008)

166   expanded on this concept by proposing approaches that promote affective learning, including

167   teaching-learning activities such as discussions, open debates, peer involvement, role-playing,

168   problem-based learning, and simulation games.

169   In the entrepreneurship literature the concepts lack definition, especially in entrepreneurship

170   education and enterprise education (Mwasalwiba, 2010). Entrepreneurship education is more

171   narrow, referring to business startups, while enterprise education is concerned with a broader

172   set of skills in business relations. Jones and Iredale (2010) consider the main difference to be

173   the foci. Entrepreneurship education's primary focus is how to start and maintain a business,

174   including launching a new venture, and growing and managing a business over time; the

175   primary subject is self-employment. Enterprise education has a broader scope that goes beyond

176   opening a new business to include effective aspects linked to the functioning of market relations

177   and attitudes as enterprising individuals. It relies on active-learning approaches to close the gap

178   between enterprise, university, and a wide range of actors (Jones and Iredale, 2010). In this

179   paper, we generally use entrepreneurship education as an umbrella term while acknowledging

180   the concept of "enterprise education" in our review.

181   There is no single accepted teaching-learning approach to entrepreneurship education although

182   some researchers have tried to develop a unifying framework. Fayolle (2013) acknowledges

183   that the field lacks a common framework reflecting the key philosophical and didactical

184   dimensions of entrepreneurship education. A direct consequence of this lack of ontological and

185   epistemological positions in the field is that most of the entrepreneurship education literature

186   focuses on competences and pedagogical approaches to teaching entrepreneurship.

187   Entrepreneurship education relies on a variety of pedagogical approaches. Based on research in

188   this area, the adoption of a given pedagogical approach has been idiosyncratic. However, the

189   approach used can be traced to how entrepreneurship is understood. Neck and Green (2011)

190   classify pedagogy into three groups. One approach is planning and prediction, whereby the

191   focus is on teaching entrepreneurship as a process with an entry and an exit at the extremes of

192   enterprise development. Pedagogical components include developing business plans and using

193   case studies. The second approach is the "entrepreneur world", which is influenced by

194   traditional teaching, lectures, and a more passive pedagogical approach; the focus is on the

195   personality traits of great entrepreneurs. Finally, the third approach starts from the

196   understanding that entrepreneurship is non-predictable and it adopts pedagogy that are team-

197   based and give students the opportunity to practice exploring opportunities (Neck and Greene,

198   2011). In general, there is increasing interest in pedagogy that goes beyond the "entrepreneur

199   world" approach to entrepreneurship. A number of institutions are adopting pedagogy that

200   include group and action-based learning. In these cases, groups take responsibility for a small

201   business over a business lifecycle that runs throughout the duration of the course. Thus, students

202   apply a "real-world" approach to the business (i.e. attending meetings, selling stock) while

203   teachers and businesspeople act as mentors (Oosterbeek et al., 2010).

204   *2.2   Commonalities between sustainability and entrepreneurship education*

205   The literature acknowledges a similar importance in understanding which competences

206   education should develop in both fields (Morris et al., 2013). While competences such as

207   interpersonal collaboration or complex problem-solving are commonly mentioned in the

208   literature, few studies analyze cases where these are combined in a course or study program.

209   To tackle this gap, Mindt and Rieckmann (2017) define a relationship between sustainability

210   and entrepreneurship education by highlighting the role entrepreneurs play in developing

211   solutions (products/services) that contribute to sustainable development. Competences for

212   sustainability-driven entrepreneurship differ from general entrepreneurs in areas such as

213   system-thinking competences, complex problem-solving, and interdisciplinarity.

214   The literature emphasizes complexity-understanding and problem-solving pedagogy in both

215   fields. Sustainability solutions call for an education that grasps complexity rather than being

216   reductionist (Lozano et al., 2013). In the sustainability education literature, entrepreneurship

217   skills are neither explicitly mentioned in the competence framework, nor as part of the concepts

218   in the five competences (Wiek et al., 2011). However, it is acknowledged in previous research

219   that a "change-agent" framework is required to alter the status-quo. In the literature,

220   characteristics such as challenging the status-quo or solving sustainability problems are often

221   portrayed in entrepreneurs (Wiek et al., 2011).

222   This indicates that a possible relationship between sustainability and entrepreneurship

223   education is where the sustainability competences can be developed at the individual level.

224   While problem-solving competences help illuminate complexity, they also facilitate the skills

225   to work with others and analyze future implications. Entrepreneurial competences can also be

226   taught through action-based pedagogies, such as creating a business as part of a course

227   (Oosterbeek et al., 2010). Thus, the task of managing a business beyond its inception echoes

228   the approaches in problem-based sustainability education.

229   A second common competence found in entrepreneurship and sustainability education is the

230   development of interdisciplinarity and interpersonal collaboration skills. In the literature, this

231   is often portrayed as real-world learning and active learning in collaboration with stakeholders.

232   In both fields, this calls for pedagogies that take the students out of the classroom and give them

233   more involvement in the learning process than is common in traditional passive teaching

234   methods. Thus, in this type of environment, students have a larger share of decision-making in

235   their learning process and can apply the learning in real-world settings (Jones and Iredale,

236   2010). Neck and Greene (2011) call for a methodological approach in the teaching of

237   entrepreneurship that has many similarities to sustainability education. First, their approach

238   requires going beyond passive learning and lectures and embraces current real-life challenges,

239   especially including hands-on practice. In addition, their approach relies on a portfolio of

240   techniques to practice entrepreneurship, similar to the practical components in sustainability

241   education. The pedagogical approach suggested by Neck and Greene (2011) also shares

242   similarities with sustainability education, involving simulations, observation, and practice.

243   *2.3   Integrating entrepreneurship and sustainability education: An overview of previous*

244   *efforts*

245   The limited research connecting the fields of sustainability and entrepreneurship education

246   highlights important aspects, such as how to develop educational programs linking

247   sustainability goals with entrepreneurship education. Lourenço et al. (2013) advocate

248   pedagogical approaches that provide easily learned conceptual bases while stimulating tangible

249 benefits to potential entrepreneurs. Nonetheless, they do not include a comprehensive teaching-

250 learning framework for sustainable entrepreneurship teaching. Mindt and Rieckmann's (2017)

251 review presents the state of the art of the fields of entrepreneurship education and sustainability

252 education, but it does not present a competence teaching framework either. Similarly, Lans et

253 al. (2014) made the first effort to theorize a (pedagogical) framework for linking sustainability

254 and entrepreneurship education, but did not outline how to operationalize it. Their

255 methodological approach – through a survey with students and teachers – unveils the

256 commonalities between both fields; however, it does not produce a comprehensive teaching

257 framework as it lacks definition of the audience, external collaborations, didactics, and

258 assessment methods.

259 Teacher's own interest greatly influence the degree of integration of sustainability and

260 entrepreneurship in programs. Results from a survey among entrepreneurship teachers in higher

261 education highlight four archetypes for integrating sustainability into entrepreneurship training

262 (Wyness et al., 2015). Lans et al. (2014) propose a competence framework aimed at nurturing

263 the education of entrepreneurs to develop sustainable solutions. Competences to teach such

264 programs comprise the centrality of complex problems, the importance of novelty and

265 creativity, the importance of self-involvement, the combination of exploration and exploitation,

266 and the importance of engagement with others.

267 *2.4 Contingencies in the integration of sustainability and entrepreneurship education*

268 Extant research highlights a number of contingencies between sustainability and

269 entrepreneurship education, which also indicates some difficulties in developing curricula with

270 shared goals.

271 The first difficulty emerges from clashing values. Recent theorizing on entrepreneurship

272 education stresses the need to deviate from the idea of entrepreneurs being educated to be

273   hedonistic and individualistic and pursuing profit generation while disdaining other goals

274   (Sheperd and Patzelt, 2017). This traditional idea linked to entrepreneurship education contrasts

275   with the conceptions within sustainability education, which is often prone to societal

276   contribution (Wyness et al., 2015).

277   Tensions also emerge as result of the lack of triple bottom line goals when developing

278   competencies for sustainable entrepreneurship. Sustainability, however, encompasses triple

279   bottom line objectives (Adams et al., 2004; Henriques, 2004). Many programs include social

280   entrepreneurship courses as an alternative to sustainability; in fact, some instructors consider

281   social entrepreneurship sufficient for addressing sustainability learning objectives (Wyness et

282   al., 2015). Research also agrees that sustainability learning objectives are considered as add-

283   ons or extra courses rather than integrating them as a cross-cutting issue incorporated into all

284   courses within a program (Jose, 2016; Wyness et al., 2015). In parallel, faculty members face

285   a lack of motivation to integrate sustainability in their "own" courses because this is not

286   commonly accepted in most curricular designs – at least in some developing countries – thus

287   hampering their potential to earn tenure and promotions (Jose, 2016). In addition, sustainability-

288   related content seems to be introduced to study programs as a requirement rather than a

289   conviction or real interest, especially in business schools (Jose, 2016).

290   Overall, the dominant discourse in the literature is that sustainability aspects are integrated

291   within the practices and pedagogical approaches in teaching entrepreneurship, which results in

292   the field of entrepreneurship education becoming dominant in terms of content, basic

293   competencies and didactics. In these courses, the focus on sustainability is limited to narrow,

294   usually short-term-oriented solutions. As argued by Mindt and Rieckmann (2017), teaching-

295   learning approaches and methods from education for sustainable development and education

296   for entrepreneurship must be equally combined to develop unique educational programs that

297   enhance a real sustainability-oriented education in higher education.

298   Based on the extant literature, Figure 1 summarizes the commonalities and difficulties between

299   sustainability and entrepreneurship education. Sustainability complements entrepreneurship

300   education following the idea that discovering, creating or exploiting opportunities lay in the

301   need to address problems in the realms of society, environment and economy (Wyness et al.,

302   2015). This is further stressed by Lans et al. (2014) who propose the most important purpose of

303   sustainability elements within entrepreneurship education is to provide managers with new

304   lenses to view new ventures or existing firms and to assess business opportunities at the

305   intersections of responding to environmental and societal needs. Therein, preparing these lenses

306   is not an automatic process but requires a systematic development of skills and competencies,

307   which are acquired through training. The purpose of theorizing how to better train students in

308   practice is the focus of this research.

309   [Insert Figure 1 about here]

310   **3   Materials and method**

311   Bibliometric methods are increasingly used in many scientific domains for analyzing emerging

312   trends in the literature (Chen et al., 2002; Herrera-Viedma et al., 2016; Nobre and Tavares,

313   2017). Contrary to other methods such as systematic literature review methods, bibliometric

314   methods seek to qualitatively and quantitatively assess the convergences between research

315   communities to identify new ones and gaps in current knowledge (Chen et al., 2010). This

316   research design (Figure 2) adapts and slightly modifies the multiple-perspective document co-

317   citation analysis (DCA) proposed by Chen et al. (2010). The research design is framed in three

318   phases: data collection, "automated" content analysis methods, and conceptualization based on

319   a "human" content analysis of the previous step.

320

321   [Insert Figure 2 about here]

322

3.1   Data collection

The researchers relied on bibliometric data from Web-of-Science (WoS) following the same

logic as previous research (García-Lillo et al., 2017; Wang et al., 2017). WoS provides some

advantages as it is considered a repository of high-quality research, and the data export feature

fits well with the bibliometric software CiteSpace, which was used for the DCA analysis (Chen

and Song, 2017). In addition, WoS text data is the main input for the text analysis module of

CiteSpace (Chen, 2016). A key issue in bibliometric research is identifying the key terms to be

used to collect the documents in the database. The authors carried out an initial screening of

previous reviews of sustainability and entrepreneurship education with the broad search

combination "Sust* education" OR "Entr* education" OR "Enterprise education". This broad

search resulted in 13 review papers; however, only 5 presented a list of search terms in their

methods section (Aikens et al., 2016; Gangi, 2017; Kamovich and Foss, 2017; Mindt and

Rieckmann, 2017; Pittaway and Cope, 2007). Based on the terms of this list, the authors created

a final list of key terms that could capture all possible extant research in both areas of

sustainability education and entrepreneurship education (Table 1).

[Insert Table 1 about here]

After including the key terms listed in Table 1 in a Boolean search, the authors refined the

outputs to include the following criteria: Only peer-reviewed papers in the English language;

articles and reviews; included in SCI-Expanded, SSCI, and ESCI. Furthermore, the selected

papers were published between 2000–2017. The final sample comprised 986 focal articles,

which were used in the further steps of co-citation analysis and topic modeling.

346 Entrepreneurship education has journals focused on small business research (*International*

347 *Journal of Entrepreneurial Behaviour & Research; Journal of Small Business Management;*

348 *Journal of Business Venturing*) and management research (*Academy of Management Learning*

349 *& Education*). The literature on sustainability education has predominantly been published in

350 outlets that have an interdisciplinary focus (*Journal of Cleaner Production*) or have a clear

351 focus on sustainability education (*Environmental Education Research*).

352

353 *3.2   Analytical method*

354 Subsequently, after having removed redundant or incomplete bibliographic references, the

355 second step in the research design was an automated content analysis. Document co-citation

356 (DCA) and topic modeling were the most reliable methods.

357

358 *3.2.1   Document co-citation*

359 Co-citation methodologies help cluster publications based on similarities, with the ultimate aim

360 of finding emerging patterns (Chen, 2004). With the advent of information technologies, co-

361 citation studies are being progressively used in fields such as entrepreneurship (Kakouris and

362 Georgiadis, 2016), education (Tang et al., 2016), and sustainability (Franceschini et al., 2016).

363 Different approaches to co-citation are possible, like author co-citation (ACA) or document co-

364 citation analysis (DCA) (Chen et al., 2010). DCA relies on the premise that research papers

365 address a closely related issue if they share certain references between them. This stems from

366 Small's (1978) argument that citations represent a symbolic meaning of a given concept, ideas

367 or methodologies linked to the particular cited document (Small, 1978).

368 DCA therein provides the possibility of understanding the underlying relationships among

369 documents (Leydesdorff, 2005). A method developed by Chen et al. (2010) expands the

16

370   conventional DCA analysis of clustering documents by generating a network of co-citing

371   documents. These co-citing clusters are subsequently "tagged" with text information from the

372   titles and abstracts to generate a textual summary of each of the clusters, making the data easier

373   to analyze. This method, facilitated by the CiteSpace software, has become relatively common

374   in bibliometrics-inspired research papers (Qian, 2014).

375   The bibliometric data of the 986 focal documents were imported from WoS in the form of a

376   text file. This included conventional data, such as author, publication, year and title, as well as

377   the references included in each article. This DCA data then produces a network diagram that

378   indicates the most commonly cited publications and establishes the thematic boundaries within

379   the main clusters in a given field (Chen and Song, 2017). The co-citation was complemented

380   with citation bursts (Kleinberg, 2003), a method that helps to identify an article with an

381   especially frequent number of citations within a timeframe. This tool is considered an

382   appropriate indicator of the attention paid to an article by the scientific community. It addresses

383   a drawback of solely counting the number of citations – which tend to be accumulative over the

384   years – but provides little knowledge on whether these publications are still relevant to the

385   scientific community (Chen and Song, 2017).

386

387   *3.2.2   Topic modeling based on LLR measurement*

388   The DCA analysis was complemented by a text analysis based on a co-word analysis (Kakouris

389   and Georgiadis, 2016). Co-word analysis relies on automated content analysis software

390   (Neuendorf, 2017). CiteSpace 5.0 incorporates a text analysis module that identifies the most

391   frequent tags based on the provided abstracts (Chen, 2016). The purpose of topic modeling is

392   to identify complementarities and differences on how concepts are being addressed in both

393   "entrepreneurship education" and "sustainability education".

394   Following DCA clustering, each cluster is assigned one of three different tags: LSI (latent

395   semantic index), LLR (log-likelihood ratio) and MI (mutual information) based on unstructured

396   text from titles, abstracts, or keywords (Chen and Song, 2017). LSI represents a general

397   summary of the concepts surrounding each DCA cluster, LLR provides a more concrete

398   description of the topics within the cluster, and MI represents the shared information among

399   clusters (Chen and Song, 2017). LLR is therefore used to model the topics within each cluster

400   as well as the overall field (Chen et al., 2010). LLR is calculated following equation (1)

401   (Dunning, 1993), where λ represents the likelihood ratio, p represents a probability, and m

402   represents a transmitted message of information.

403     $-2log\lambda = 2(\log L(p_1, m_1, n_1) + logL(p_2, m_2, n_2) - logL(p, m_1, n_1) - logL(p, m_1, n_1))$ (1)

404

405   Appendix A provides a link to the comprehensive data table, which includes the automated

406   topic modeling for entrepreneurship education. Appendix B links to the table summarizing the

407   topic modeling for sustainability education.

408

409   *3.3   Output analysis and conceptualization*

410   The primary output of the automated content analysis is two large lists of key topics

411   (Appendixes A and B). This data is the main input for the subsequent "human" content analysis

412   process, which is the basis for conceptualizing "entrepreneurial-oriented sustainability

413   education" (Neuendorf, 2017). The researchers adapted Neuendorf's (2017) "human" content

414   analysis procedure by using a two-step approach (Figure 3).

415

416   [Insert Figure 3 about here]

417

418   First, the topic modeling lists were generated by the software CiteSpace (Appendixes A and B),

419   which generates the topics based on the abstracts and title information. These topics are grouped

420   according to the co-citation clusters, and, therefore, some of them are repeated across clusters.

421   A numeric value indicates the relative importance of the topic within the cluster. To identify

422   the overall importance of the topics across clusters, the clusters were merged into a single list.

423   The topics were subsequently listed alphabetically and irrelevant topics were highlighted, e.g.

424   discourse, discourse analysis or impact, as these have no relation to pedagogy or educational

425   approaches. Repeated topics were also eliminated.

426   The first organization of topics led to 204 unique topics for entrepreneurship education and 225

427   for sustainability education. These figures resulted from combining the topics of each cluster

428   for entrepreneurship and sustainability education, respectively.

429   The second and last step involved grouping the topics into categories. These topics were

430   subsequently coded according to categories indicating the particularities of entrepreneurship

431   and sustainability education (Mindt and Rieckmann, 2017): i) educational focus, ii) paper type,

432   iii) scope of the described teaching and learning, iv) teaching-learning approaches, v)

433   interdisciplinarity, vi) cooperation formats, vii) type of learning outcomes, viii) competence

434   frameworks referred to by authors, and ix) theme in relation to entrepreneurship. In addition,

435   the emerging coding resulted in categories, including geographical focus, research method,

436   individual entrepreneurs, and other issues.

437   Following this grouping, complementarities between both frameworks were identified. This

438   enabled both a mapping of how the different topics fit within the categories and a start to the

439   conceptualization, in an inductive way, of "entrepreneurial-oriented sustainability education".

440   Therefore, the topics included in the framework were the result of the following process: i) the

441   numeric value produced by CiteSpace and ii) the category it belonged to. As part of the

442   conceptualization process, the definitions of the topics were identified according to the

443   publications that mentioned them.

444

445   **4   Results**

446   The topic modeling summarizes the research domains of sustainability and entrepreneurship

447   education into three areas: educational focus, teaching-learning approaches, and cooperation

448   with external partners. In addition, many topics were not linked to the knowledge domains

449   above but fit into the main themes in relation to the disciplinary domains of sustainability or

450   entrepreneurship education so they are included as the category "themes"

451   *4.1   Educational focus perspective*

452   In terms of educational focus, the results indicate differences between sustainability and

453   entrepreneurship education. However, the content analysis indicates commonalities in

454   institutions, target audiences and domain of education as the topics most often mentioned in

455   both fields (Figure 4).

456

457   [Insert Figure 4 about here]

458

459   In terms of institutions, university and industry are common to both educations. Regarding

460   universities, most papers acknowledge higher education institutions as the academic origin of

461   sustainability and entrepreneurship education programs at all levels. Extant research considers

462   industry to provide practice-oriented complementarities to existing study programs in

463   sustainability education, such as interior design studies in Turkey (Afacan, 2014) and

464   engineering in Sweden (Hanning et al., 2012). Collaboration experiences with industry take

465   place in university-business settings. Universities expect this collaboration to enhance the

466   competences and practical skills that cannot solely be taught in the classroom (Nakagawa et al.,

467   2017).

468   Two topics related to the target audience show commonalities between entrepreneurship and

469   sustainability education. Research featuring "engineering students" often highlights the need to

470   integrate new competences in engineering education besides the hard sciences and technical

471   competence, such as entrepreneurship (Maresch et al., 2016). A similar method is followed in

472   sustainability issues training, this method analyzes how to teach environmental gate-keeping

473   concepts to undergraduate engineering students or manifest skepticism towards climate issues

474   (Shealy et al., 2017). Sustainability education is often taught following problem-oriented

475   learning, with students working in groups to solve an engineering challenge linked to an

476   environmental issue (Guerra, 2017). Another topic is "teacher training" programs. These are a

477   common target audience at the undergraduate and graduate level in different European countries

478   (Spain, Romania, Serbia, Sweden, and Finland). Within entrepreneurship education, research

479   discusses the role of practical experiences in entrepreneurship learning, e.g. through incubators

480   or practice enterprises, in teacher training programs (Seikkula-Leino, 2011). Regarding

481   sustainability education, the discussion seems to be focused on whether training teachers has

482   positive outcomes on the general awareness of sustainability (Andersson et al., 2013).

483   Concerning the domain of education, commonalities were found to be life-long learning and

484   non-formal education. "Lifelong learning" is connected to entrepreneurship education after

485   formalized education, often through university-business collaboration that relies on problem-

486   based learning (Rossano et al., 2016). Similarly, lifelong learning is set to be key to achieve

487   competences in sustainability vis-à-vis the formalized higher education loop. NGOs are key-

488   players in this regard, e.g. through practical work and action research in close collaboration

489   with universities (Haigh, 2006). The second commonality, "non-formal education", in the

490   context of entrepreneurship education relies on experiential-based learning complementing

491   university courses. For example, experiences in Croatia increase students' self-efficacy and thus

492   the likelihood of starting their own business after the program (Sedlan-Konig, 2016). In

493   sustainability education, NGOs are key players in developing sustainability competence

494   through non-formalized learning, particularly for people without formal sustainability training

495   backgrounds (Haigh, 2006).

496   *4.2   Teaching-learning approaches in entrepreneurship and sustainability education*

497   The review indicated two broad categories of teaching-learning approaches, which we group as

498   "active learning" and "real-world" (Figure 5). Commonalities in active learning approaches are

499   grouped into nine active learning approaches. In entrepreneurship education, "affective

500   learning" is framed into courses that integrate experiential learning. Students participating in

501   such courses show higher levels of self-efficacy and a higher probability of becoming

502   entrepreneurs in the future (Loi and Di Guardo, 2015). In sustainability education, affective

503   learning is used by combining physical learning and interaction spaces, such as "eco-gardens"

504   (Cheang et al., 2017) or gaming simulations linked with issues such as waste to create

505   consciousness about sustainability (Yeung et al., 2017). "Blended learning" is used in

506   entrepreneurship education through a combination of classroom and on-the-job workplace

507   learning (Maritz et al., 2010). In sustainability education, blended learning is used in

508 combination with other methods, including technology, remote locations, and praxis work.

509 Praxis work combines students on campus with online students and allow them to interact

510 (Tomas et al., 2015). In an entrepreneurship context, "reflective learning" is defined as when

511 entrepreneurs consider incidents shaping their business but are not on thick about them.

512 Reflective learning and learning through experience are complementary to each other (Pittaway

513 and Thorpe, 2012). In sustainability education, "reflective learning" is integrated in the

514 development of a course that combines high-impact educational practices and community-

515 based learning. Reflection is used at the final stage, when students present their results to a host

516 company and are told to "sell" the idea (O'Brien and Sarkis, 2014). "Interdisciplinary learning"

517 is used in both entrepreneurship and sustainability education. One approach at the graduate

518 level is combining active-learning pedagogy. Hill and Kuhns (1994) describe an

519 entrepreneurship class where interdisciplinary groups investigated technology transfer issues

520 using the NASA as the case organization. Likewise, Noy et al. (2017) integrate

521 interdisciplinarity skills into sustainability teaching. Similarly, interdisciplinarity is achieved

522 through project-based, problem-based learning, where engineering students work on specific

523 cases – for example the design of water infrastructure in a building (Apul and Philpott, 2011).

524

525   [Insert Figure 5 about here]

526

527 The term "holistic" is used in entrepreneurship education, teacher education, and pharmacy in

528 Ireland and the UK (Danaher and Slattery, 2015; Refai et al., 2015). In the context of an

529 entrepreneurship course, holistic was used to imply a two-step approach in entrepreneurship

530 teaching: First, introducing the basics of a business start-up and second, integrating attitudinal

531 aspects (Danaher and Slattery, 2015). In sustainability education, holistic is used to articulate

532   sustainability across different disciplines, infusing concepts such as triple bottom line, science

533   literacy, sense of place, emphatic reason-making, and interdisciplinary collaboration. From a

534   pedagogical point of view, holistic goals are articulated through placement work (Armstrong et

535   al., 2016).

536   Different experiences rely on "project-based learning" although it is more popular in the

537   teaching of sustainability. These experiences take place at the undergraduate and graduate level,

538   usually through project-based learning as one element in a course (Okudan and Rzasa, 2006).

539   One benefit of project-based learning is that it works as an arena for exchange and development

540   for both students and faculty members (Okudan and Rzasa, 2006). Closely related to this

541   methodology is "problem-based learning" (PBL), which is sometimes used in combination with

542   projects (Brundiers et al., 2013). We identified experiences from Denmark, the UK, and

543   Germany in areas of business and engineering at both the undergraduate and graduate level. In

544   entrepreneurship education, Rossano et al. (2016) used PBL in entrepreneurship education in

545   the framework of university business collaboration (UBC). This approach was characterized by

546   four elements: 1) a student-centered approach, 2) authenticity, whereby the problems emerge

547   from the business owner, 3) lecturer as facilitator, and 4) real-life business problems put forth

548   by the private partners from the UBC consortium. Sustainability capabilities have also been

549   taught through PBL, and research highlights the similarities between PBL and sustainability

550   education (Guerra, 2017).

551   In entrepreneurship education, "experiential learning" is used as a participatory approach,

552   where learners are immersed in a particular environment (Bell and Bell, 2016). Bell and Bell

553   (2016) apply experiential learning through a mentored initiative in which student groups receive

554   support from professional consultant mentoring, using a competition to win business start-up

555   funding. In sustainability education, experiential learning is used when students apply their

556 knowledge on cleaner production and, in close collaboration with the companies, they identify

557 opportunities for cleaner production (McPherson et al., 2016).

558 We identified a second category of teaching-learning approaches, which we group under "real

559 world" (Figure 5). Commonalities between sustainability and entrepreneurship education

560 include the terms such as "extracurricular" and "real-world learning opportunities".

561 Extracurricular activities highlight different types of initiatives not included in formal subject-

562 teaching. The literature provides experiences from the UK, at both the graduate and

563 undergraduate level. Preedy and Jones (2015) highlight extracurricular activities in

564 entrepreneurship education, such as networking events, business advice sessions, and

565 workshops. These opportunities have been shown to result in student-led enterprises. In

566 sustainability education, a similar approach has been followed (Lipscombe, 2008).

567 "Real-world learning opportunities" can take multiple forms, including project and problem-

568 based learning, service learning, and internships. Students are exposed to challenges in real-

569 world settings, such as communities, businesses, and governments (Brundiers et al., 2010).

570 Real-world settings are inspired by principles of action learning, experiential learning, critical

571 reflection, and reflectivity. Overall, these approaches support the idea that knowledge is

572 gathered through sense-making rather than content (Jennings et al., 2015).

573

574 *4.3   How to cooperate in teaching and learning with external partners*

575

576 The literature in both scientific communities also points out similarities when it comes to the

577 importance given to collaboration with external partners (Figure 6). We identified

578 commonalities in terms of actors and practices, which can offer a point of departure for course

579 development in the domain of entrepreneurial-oriented sustainability education.

580

581   [Insert Figure 6 about here]

582

583   The discussion on "stakeholders" was found in 64 articles in our sample (Figure 7).

584   Commonalities are universities, students, business, and community. In the context of

585   entrepreneurship education, universities increasingly rely in external stakeholders for links to

586   innovation, technology commercialization, and support for their own incubation activities

587   (Amadi-Echendu et al., 2016). External stakeholders offer many learning opportunities as seen

588   through the real-world pedagogical approaches discussed above; thus, close collaboration with

589   stakeholders provides grounded applications for sustainability solutions and scenarios (Quist et

590   al., 2006).

591

592   [Insert Figure 7 about here]

593

594   The general term "community" can be used to mean many different things. First, a number of

595   articles refer to community in relation to actors involved in the knowledge production of a

596   university. Examples are "community of practice", meant as a group of academics or

597   practitioners working towards similar themes and contents, such as sustainability (Pedersen et

598   al., 2017). "Academic community" refers to staff within the university but also researchers and

599   academics collaborating in other universities or cities within a particular area of research

600   (Nowak, 2016; Wyness et al., 2015). "Online community" in sustainability education (Habron

601   et al., 2012) or "learning community" in entrepreneurship education (Gordon et al., 2012) are

602   also commonly used terms.

603　Community can also be seen from a stakeholder perspective. This is the case in

604　entrepreneurship education where several contributions connect educational programs and

605　action-based pedagogy with the "business community" (Toledano and Karanda, 2017); a

606　similar idea is "technological community", which involves not only academic actors but also

607　businesses and other institutions working on topics related to technological innovation (Benn

608　and Rusinko, 2011). Thus, "community" discussions in the educational context often consider

609　how an enterprise will fit into a community setting (Gibb, 2002; Kwong et al., 2012). One

610　approach to achieving this paradigm change is through community engagement and the

611　pedagogical practice of service-based learning (Belitski and Heron, 2017; Wiltshier and

612　Edwards, 2014).

613　A significant part of sustainability education research discusses the role of universities as

614　providers of programs and views the community as an equal partner in co-creating these

615　programs (Brundiers et al., 2010) or as being involved in events that link outdoor learning with

616　community well-being (Fischer et al., 2015). Community engagement is also present within the

617　literature of sustainability education in various forms, such as service-based learning (Kobori,

618　2009) and action-research projects inspired by situated knowledge discussions (Singh, 2013).

619　Activism and mobilization for ecological causes is highlighted as one form of linking

620　communities with sustainability education programs (Hills, 2001). Similarly, discussions on

621　active community participation in natural resource management and preservation has been

622　present in the literature since the 1990s (Maddock, 1991).

623　We classified "capacity building" as the only common topic on practices to create these

624　relations between the universities and external actors. The capacity building is used as an

625　umbrella term for experiences in creating specialized curricula for different themes, such as

626　intrapreneurship (Huq and Gilbert, 2017), renewable energy, nature preservation (Al-Subaiee,

627　2016), and coastal management (Kawabe et al., 2009). Capacity building is primarily used in

628   the context of international cooperation projects involving institutions rather than study

629   programs (Koehn et al., 2011).

630

631   *4.4   Specific themes*

632   We also identified thematic commonalities in three broad areas, which we have grouped

633   together as innovation-design, entrepreneurship ecosystem support, and

634   corporate/organizational aspects (Figure 8). Innovation-design comprises three topics dealt

635   with in both fields: creativity, innovation, and technology. Within the context of sustainability,

636   "creativity" means mental processes that lead to concrete outcomes of value, depending on the

637   social context (Sandri, 2013). At the undergraduate level, researchers have concluded that

638   creativity is not a pre-condition for enhancing entrepreneurship skills among students. They

639   have found that incubators and pedagogies promoting creativity can, however, enhance

640   entrepreneurial skills (Camacho-Miñano and del Campo, 2017). At the graduate level, Larso

641   and Saphiranti (Larso and Saphiranti, 2016) discuss an MBA program combining practice-

642   oriented learning, incubation and elective courses including design-thinking, art, design and

643   culture, and the contextual nature of creativity.

644

645   [Insert Figure 8 about here]

646

647   How innovation and technology are discussed in the literature also varies (Figure 9).

648   Innovation, for example, is often associated with discussions about pedagogical approaches to

649   teaching entrepreneurship or sustainability. Sengupta et al. (2017) discusses a project that

650   merged sustainability into educational programs dealing with manufacturing processes through

651   specialized sustainability modules. Both themes are also relevant to sustainability. Innovation

652   is often embedded in engineering education even at the undergraduate level. Boks and Diehl

653   (2006) present the case of integrating sustainability into product design engineering courses. In

654   practice, this meant having students integrate aspects of entrepreneurship into designing and

655   developing a product that addressed a common problem.

656

657   [Insert Figure 9 about here]

658

659   Technology is also discussed in different contexts. Abou-Warda (2016) described an

660   undergraduate course that enhanced entrepreneurship competences in educators. In

661   sustainability discussions, another example at undergraduate level in New Zealand combined

662   technology teaching for engineers with active-learning approaches (Leal Filho et al., 2009).

663   Social entrepreneurship is often defined as a particular form of entrepreneurship that leads to

664   increased social inclusion, puts societal improvement before profits, and generates positive

665   social spill-overs (Ashour, 2016). Social entrepreneurship education is increasingly being

666   offered by organizations other than universities. At public policy schools, their programs

667   attempt to better understand the contextual conditions that social entrepreneurship is offered,

668   and business schools focus on understanding market aspects (Mirabella and Young, 2012).

669   Other experiences propose a pedagogical framework for the teaching of social entrepreneurship

670   where the key element is to enhance the students' ability to develop a social identity and self-

671   efficacy, so they relate as social entrepreneurs themselves (Smith and Woodworth, 2012).

672   Leadership in entrepreneurship and sustainability education is commonly introduced at the

673   undergraduate level. In one teacher education program, leadership is a required skill in

674   improving environmental sustainability and leading the societal change necessary for

675   improving many environmental conditions. The same teacher education program proposes a

676 method to develop sustainability leadership skills through an approach involving design,

677 engineering and tangible elements (Jensen, 2016).

678 Corporate social responsibility (CSR) is often discussed in MBA programs. Stubbs and

679 Schapper (2011) described a three-part course. The first part, presents a sustainability challenge.

680 In the second part, students work in groups to develop a solution to the company challenge. In

681 the final part, students do a joint reflection about the case. Other research focuses on CSR and

682 a broader network of stakeholders since sustainability requires teaching approaches that

683 integrate a variety of stakeholders – not just industries or universities. In Australia, a number

684 of universities developed a course that departs from the concept of a technology community,

685 with the aim of integrating sustainability teaching into graduate education while enhancing the

686 scope of the relevant stakeholders involved in their programs (Benn and Rusinko, 2011).

687

688 **5   Discussion**

689 This research has addressed the need to make sustainability education more holistic and

690 grounded in the context of higher education institutions' (HEI) diversity of study programs. We

691 have highlighted current discussions within entrepreneurship about its potential to contribute to

692 sustainable development, asking: *How can entrepreneurial competences be taught in*

693 *sustainability education programs in higher education?* Relying on bibliometric mapping of

694 key topics within the literature, this study has sought a novel way of designing programs in

695 higher education by combining sustainability and entrepreneurship goals. The results indicate

696 that despite the apparent divergences of the two fields, several commonalities appear in the

697 literature. Based on a content analysis of these commonalities, we propose a teaching

698 framework for entrepreneurial-oriented sustainability education (Figure 10).

699

700   [Insert Figure 10 about here]

701

702   In terms of educational focus, sustainability education can integrate entrepreneurship through

703   industry and university collaboration, indicating the need for future programs to understand the

704   needs of industry in specific contexts. The results of this study indicate that common target

705   audiences for entrepreneurial-oriented sustainability education should diversify to other fields

706   besides engineering and teacher education. We assess this result considering the impact that

707   engineering has on the physical world and the degradation of the environment. Engineering

708   education has long experimented with integrating different approaches to sustainability

709   education (Guerra, 2017), and entrepreneurship skills are increasingly considered the soft skills

710   that engineers should learn (Da Silva et al., 2015). Similarly, many experiences around the

711   world highlight the need to train basic education teachers with pedagogical elements that help

712   them train new generations to understand increasingly complex sustainability problems while

713   also shaping their entrepreneurial mindsets. According to our review, this target audience is

714   often at the undergraduate level. However, our results suggest that there is room for other

715   domains of education in lifelong learning and non-formal educational settings, indicating a need

716   to go beyond the dichotomy of undergraduate/graduate programs and develop educational

717   programs for practitioners and other actors.

718   Active-learning educational approaches such as problem, project, experiential or blended

719   learning should provide students with better competences to tackle complex problems and

720   confront interactions between different subjects. While our review indicates that these active

721   learning approaches have been tested in many countries and disciplines, entrepreneurship and

722   sustainability learning objectives are always considered separately, without any real integration.

723   Contrary to previous research (Mindt and Rieckmann, 2017), we expanded our study beyond

724   teaching-learning approaches to emphasize how those approaches are interrelated to other

725 pedagogical elements, such as the main themes described above and collaboration with external

726 actors.

727 It is important for study programs to identify relevant communities to underpin the active-

728 learning approaches with which to collaboratively develop a given educational program.

729 Community can imply multiple stakeholders: industries, associations, public institutions,

730 businesses, or NGOs. The practice of "capacity-building" can be misleading, as it is often

731 associated with international cooperation projects with a North-South perspective. While we

732 identified some publications with this focus, it can also refer to practices linked to the elements

733 of lifelong learning and non-formal education. Educational programs could, potentially, target

734 practitioners to improve their professional skills within entrepreneurship and sustainability. Our

735 framework also identified the common themes that educational programs within this

736 intersection should develop. While our review highlights a blending in the targeted levels

737 (undergraduate and graduate), some common themes as "social entrepreneurship", describe

738 broad general programs that are context-specific . Thus, the entire context of where to develop

739 entrepreneurial-oriented educational programs must be reevaluated, as the range and types of

740 institutions offering programs has increased over time.

741 Competences are not explicitly discussed in the framework as these are extensively addressed

742 in both the entrepreneurship and sustainability education literature (Wiek et al., 2011). We,

743 therefore, refer to the framework of key competences established by Lans et al. (2014). The

744 teaching-learning approaches of the framework, integrating active learning and real-world

745 methodologies, are a good fit with the intended sustainability competences, such as systemic-

746 thinking competence, foresight competence, interdisciplinarity, and problem-solving

747 competences. Our findings suggest that entrepreneurship, hitherto not considered relevant,

748 should be considered an additional competence targeted by sustainability education.

749

5.1   Tension points in the integration of both fields

There are some gaps in knowledge and practice that provide some potential tension points concerning the different epistemological considerations of sustainability and entrepreneurship. First is the lack of reference to teaching frameworks, to which this article contributes. Entrepreneurship education as a field can benefit from a parallel research area (entrepreneurial learning) that contributes to understanding the cognitive aspects behind becoming an entrepreneur and how this is related to learning and reflection theories (Middleton and Donnellon, 2014; Rae, 2012). In the literature on sustainability education, the focus seemed to be on how to make sustainability as holistic as possible and not compartmentalized within modules or units of learning.

The second area of tension could be assessment. While we identified some publications referring explicitly to assessment, the theorizing in both fields seems to be connected to the teaching-learning approach in practice and no articles focused exclusively on assessment. Assessment is only marginally discussed in the literature. In addition, assessment was not one of the commonalities in the discourses in both fields, indicating the marginal place this topic holds in both fields. We suggest, therefore, designing courses with close connections between the teaching-learning approach and carefully considering what type of assessment method will be part of the course.

5.2   Theoretical and practical implications

This research contributes theoretically to the literature on sustainability education and the growing attention within it on how to integrate entrepreneurship themes. Previous research along this line has focused only on the effects of sustainability pedagogical elements within a general entrepreneurship course (Lourenço et al., 2013), overlapping competences between both fields (Lans et al., 2014), general appreciation of levels of integration from the teachers'

774 perspectives (Wyness et al., 2015), and teaching-learning approaches (Mindt and Rieckmann,

775 2017). This research provides a more encompassing framework on how to integrate these

776 approaches from the perspective of course organization and structure. Inspired by Fayolle's

777 (2013) generic teaching model for entrepreneurship education, we propose an integrative

778 framework reflecting the key philosophical and didactical dimensions of entrepreneurial-

779 oriented sustainability education.

780 A second theoretical contribution is to the management education literature and the discussions

781 on how to integrate sustainability topics. We propose going beyond a pedagogy where

782 sustainability is perceived as an add-on to already existing courses focused on other aspects of

783 business development (Jose, 2016; Wyness et al., 2015). Rather, our framework calls for a role

784 for sustainability when integrating it with business/entrepreneurship education. It calls for not

785 only suggesting its potential to facilitate the identification of sustainable/green opportunities

786 but also tackling "how" a combination of sustainability and entrepreneurship education aims to

787 achieve systemic-oriented, transdisciplinary, and more collective-oriented goals.

788 This paper also presents a practical implication in using the framework as a guide to better

789 integrate positive competencies from sustainability education into business education. This

790 framework includes taking into consideration diversity and transdisciplinary (Lans et al., 2014)

791 and competencies that would help students perceive the links and patterns across seemingly

792 unrelated issues (Wyness et al., 2015). It would also foster collective-societal achievements

793 compared to the individual drive or self-efficacy characteristics that are commonly linked to

794 entrepreneurship education (Lans et al., 2014). If the positive aspects of sustainability education

795 could be integrated into other competencies and the skill development characteristics of

796 entrepreneurship education, it would be possible to address common pitfalls of integrating

797 sustainability into business education, namely the lack of motivation from lecturers (Jose,

798 2016).

799　In practice, we recommend applying the framework in a set of four main stages in a process

800　(Figure 11). The first stage is the definition of the educational focus. Courses can be offered

801　through formal education programs at universities, but industries with continuous education

802　programs can also benefit from the training. The target audience is often engineers or teachers,

803　but other professions or studies can also be relevant. At the second stage, the teaching and

804　learning approaches should be defined; in this way, it is possible to connect with the intended

805　learning objectives of sustainability and entrepreneurship, which develop practical

806　competencies as well as theoretical knowledge. In our proposed framework, both active

807　learning approaches and real-world-oriented learning are suggested. The third stage comprises

808　identifying the themes that connect entrepreneurship and sustainability education. Three core

809　themes can offer good connections: innovation-design, entrepreneurship and corporate/

810　organizational aspects. The fourth stage involves collaboration with external stakeholders and

811　the community to respond to their needs and to connect the themes and the teaching-learning

812　approaches (i.e. real-world learning) with the realities that need to be improved.

813　　　　　　　　　　　　　[Insert Figure 11 about here]

814

815　**6　Conclusion**

816

817　As entrepreneurship education gains momentum across higher education institutions

818　worldwide, it is crucial to critically consider the contribution of entrepreneurship education in

819　training the next generation of entrepreneurs who will create value for stakeholders and the

820　environment, not just shareholders (Bocken et al., 2016; Freeman et al., 2010). In addition,

821　discourses across the private and public spectrum seem to converge to provide new potential

822　roles for entrepreneurs, such as those developing solutions for the sustainable development

35

823   goals or tackling market externalities. Research on how to combine these two honorable

824   objectives, incipient in the mainstream entrepreneurship education literature, is presented here.

825   Based on the findings of commonalities and the proposed framework, we define

826   "entrepreneurial-oriented sustainability education" as an education seeking to promote

827   sustainable development objectives across educational programs while implicitly addressing

828   complex community problems through the development of solutions which can change the

829   ways businesses and consumers relate with sustainability issues. This educational framework

830   is based on the use of active-learning pedagogy and involves close collaboration between

831   universities and external actors, enabling students and other learning actors to engage in real-

832   world problems in their learning process.

833   From the results, we can highlight some important issues that must be addressed to move

834   towards achieving an "entrepreneurial-oriented sustainability education". For increasing and

835   qualifying the integration of these concepts and practical application of the framework, we

836   stress the need for increased: (i) collaboration between industries and universities, which can

837   provide useful tools for the integration of entrepreneurship in sustainability education; (ii)

838   diversification of target audiences for entrepreneurial-oriented sustainability education to reach

839   fields other than engineering and teacher education; (iii) training of a new generation for

840   dealing with complex sustainability problems and developing new entrepreneurial mindsets;

841   (iv) integration of entrepreneurship and sustainability learning objectives; and (v) collaboration

842   with communities, such as industries, associations, public institutions, businesses and NGOs to

843   develop a particular educational program .

844   We also found that entrepreneurship should be considered an additional competence targeted

845   by sustainability education. Nevertheless, we can see that the oft-used approach is a non-formal

846   education that remains peripheral rather than being included in the formal university agenda.

847   While it is valuable to have complementary informal courses or workshops on these subjects,

848   there is also a need to steadily include sustainability education in the higher educational

849   institution's agenda in the form of formal courses, hackathons, workshops, etc.

850   Our research has implications for teachers in charge of designing new educational programs at

851   the undergraduate and graduate level. It can be used as a heuristic device, guiding the course

852   designers to consider these different elements when the aim is to facilitate students' acquisition

853   of competences around sustainability and entrepreneurship.

854   This paper provides a better understanding of how sustainability can be combined with

855   entrepreneurship education, developing a conceptual framework of how to make sustainability

856   education more entrepreneurially oriented in higher education. The result is largely based on

857   the extant literature from both fields and, contrary to previous efforts, provides a comprehensive

858   mapping of the key discussions in both domains.

859   Further research can test this pedagogical tool in the design of courses, through action-research

860   approaches, and by combining course design with qualitative methods to assess the

861   characteristics of entrepreneurial-oriented sustainability education. Furthermore, additional

862   research could analyze each element of the teaching framework. More insight is needed into

863   how and what combination of themes can work together within specific educational programs.

864   Our review indicates a large variety of educational programs are giving their students

865   sustainability and entrepreneurship experiences, ranging from outdoor teaching to integrating

866   components into nursing, pharmacy, engineering, architecture, management, and planning.

867   In our review, we did not identify social entrepreneurship as a salient topic, except as one of

868   the specific themes of entrepreneurship. Additional research could further explore the

869   relationship between sustainability education and social entrepreneurship. While sustainability

870   encompasses triple bottom line objectives (Adams et al., 2004; Henriques, 2004), many

871   programs include social entrepreneurship courses as an alternative to sustainability; some

instructors consider social entrepreneurship sufficient for achieving sustainability learning objectives (Wyness et al., 2015).

References

Abou-Warda, S.H., 2016. New educational services development. Int. J. Educ. Manag. 30, 698–717. https://doi.org/10.1108/IJEM-11-2014-0142

Adams, C., Frost, G., Webber, W., 2004. Triple bottom line: A review of the literature, in: The Triple Bottom Line; Does It All Add Up? Earthscan, London, pp. 17–25.

Afacan, Y., 2014. Introducing sustainability to interior design students through industry collaboration. Int. J. Sustain. High. Educ. 15, 84–97. https://doi.org/10.1108/ijshe-01-2013-0002

Aikens, K., McKenzie, M., Vaughter, P., 2016. Environmental and sustainability education policy research: A systematic review of methodological and thematic trends. Environ. Educ. Res. 22, 333–359. https://doi.org/10.1080/13504622.2015.1135418

Al-Subaiee, F.S., 2016. Socio-economic factors affecting the conservation of natural woodlands in Central Riyadh Area - Saudi Arabia. Saudi J. Biol. Sci. https://doi.org/10.1016/j.sjbs.2015.02.017

Amadi-Echendu, A.P., Phillips, M., Chodokufa, K., Visser, T., 2016. Entrepreneurial Education in a Tertiary Context: A Perspective of the University of South Africa. Int. Rev. Res. Open Distrib. Learn. 17, 21–35.

Andersson, K., Jagers, S.C., Lindskog, A., Martinsson, J., 2013. Learning for the future? Effects of education for sustainable development (ESD) on teacher education students. Sustainability 5, 5135–5152.

Apul, D.S., Philpott, S.M., 2011. Use of outdoor living spaces and fink's taxonomy of significant learning in sustainability engineering education. J. Prof. Issues Eng. Educ. Pract. 137, 69–77. https://doi.org/10.1061/(asce)ei.1943-5541.0000051

Armstrong, C.M.J., Hustvedt, G., LeHew, M.L.A., Anderson, B.G., Connell, K.Y.H., 2016. When the informal is the formal, the implicit is the explicit holistic sustainability education at Green Mountain College. Int. J. Sustain. High. Educ. 17, 756–775. https://doi.org/10.1108/ijshe-02-2015-0012

Ashour, S., 2016. Social and business entrepreneurship as career options for university students in the United Arab Emirates: The drive–preparedness gap. Cogent Educ. 3. https://doi.org/10.1080/2331186X.2016.1234425

Belitski, M., Heron, K., 2017. Expanding entrepreneurship education ecosystems. J. Manag. Dev. 36, 163–177. https://doi.org/10.1108/jmd-06-2016-0121

Bell, R., Bell, H., 2016. An enterprise opportunity for entrepreneurial students Student enterprise development and experience assessed through the student voice. Educ. Train. 58, 751–765. https://doi.org/10.1108/et-12-2014-0150

Benn, S., Rusinko, C., 2011. The technological community as a framework for educating for sustainability in business schools. J. Manag. Organ. 17, 656–669. https://doi.org/10.5172/jmo.2011.17.5.656

Bocken, N.M.P., Miller, K., Evans, S., 2016. Assessing the environmental impact of new circular business models, in: New Business Models: Exploring a Changing View on Organizing Value Creation. Toulouse.

Boks, C., Diehl, J.C., 2006. Integration of sustainability in regular courses: experiences in industrial design engineering. J. Clean. Prod. 14, 932–939. https://doi.org/10.1016/j.jclepro.2005.11.038

Bossle, M.B., Dutra de Barcellos, M., Vieira, L.M., Sauvée, L., 2016. The drivers for adoption of eco-innovation. J. Clean. Prod. 113, 861–872. https://doi.org/10.1016/j.jclepro.2015.11.033

Brundiers, K., Wiek, A., Redman, C.L., 2010. Real-world learning opportunities in sustainability: From classroom into the real world. Int. J. Sustain. High. Educ. 11, 308–324. https://doi.org/10.1108/14676371011077540

Brundiers, K., Wiek, A., Kay, B., 2013. The role of transacademic interface managers in transformational sustainability research and education. Sustainability 5, 4614–4636. https://doi.org/10.3390/su5114614

Camacho-Miñano, M.-M., del Campo, C., 2017. The role of creativity in entrepreneurship: An empirical study on business undergraduates. Educ. + Train. 59, 672–688. https://doi.org/10.1108/ET-08-2016-0132

Cheang, C.C., So, W.M.W., Zhan, Y., Tsoi, K.H., 2017. Education for sustainability using a campus eco-garden as a learning environment. Int. J. Sustain. High. Educ. 18, 242–262. https://doi.org/10.1108/IJSHE-10-2015-0174

Chen, C., 2004. Searching for intellectual turning points: Progressive knowledge domain visualization. Proc. Natl. Acad. Sci. 101, 5303–5310. https://doi.org/10.1073/pnas.0307513100

Chen, C., 2016. CiteSpace: A Practical Guide for Mapping Scientific Literature. Nova Publishers, New York.

Chen, C., Song, M., 2017. Representing Scientific Knowledge; The Role of Uncertainty. Springer, Berlin. https://doi.org/10.1007/978-3-319-62543-0

Chen, C., McCain, K., White, H., Lin, X., 2002. Mapping Scientometrics (1981-2001). Proc. ASIST Annu. Meet. 39, 25–34.

Chen, C., Ibekwe-SanJuan, F., Hou, J., 2010. The structure and dynamics of cocitation clusters: A multiple-perspective cocitation analysis. J. Am. Soc. Inf. Sci. Technol. 61, 1386–1409.

Criado-Gomis, A., Iniesta-Bonillo, M.Á., Cervera-Taulet, A., 2018. Sustainable entrepreneurial orientation within an intrapreneurial context: effects on business performance. Int. Entrep. Manag. J. 14, 295–308. https://doi.org/10.1007/s11365-018-0503-x

Da Silva, G.B., Costa, H.G., De Barros, M.D., 2015. Entrepreneurship in engineering education: A literature review. Int. J. Eng. Educ. 31, 1701–1710.

Danaher, M.P., Slattery, G.M., 2015. Opportunities for entrepreneurship education in an era of curriculum change in Ireland: The case of an innovative Irish second level school. J. Educ. Teach. Trainers 6, 52–61.

Dean, T.J., McMullen, J.S., 2007. Toward a theory of sustainable entrepreneurship: Reducing environmental degradation through entrepreneurial action. J. Bus. Ventur. 22, 50–76.

Demirel, P., Li, Q.C., Rentocchini, F., Tamvada, J.P., 2017. Born to be green: New insights into the economics and management of green entrepreneurship. Small Bus. Econ. 1–13. https://doi.org/10.1007/s11187-017-9933-z

Dunning, T., 1993. Accurate methods for the statistics of surprise and coincidence. Comput. Linguist. 19, 61–74.

Fayolle, A., 2013. Personal views on the future of entrepreneurship education. Entrep. Reg. Dev. 25. https://doi.org/10.1080/08985626.2013.821318

Filho, W.L., Pallant, E., Enete, A., Richter, B., Brandli, L.L., 2018. Planning and implementing sustainability in higher education institutions: an overview of the difficulties and potentials. Int. J. Sustain. Dev. World Ecol. 25, 713–721. https://doi.org/10.1080/13504509.2018.1461707

Fischer, D., Jenssen, S., Tappeser, V., 2015. Getting an empirical hold of the sustainable university: A comparative analysis of evaluation frameworks across 12 contemporary sustainability assessment tools. Assess. Eval. High. Educ. https://doi.org/10.1080/02602938.2015.1043234

Franceschini, S., Faria, L.G.D., Jurowetzki, R., 2016. Unveiling scientific communities about sustainability and innovation. A bibliometric journey around sustainable terms. J. Clean. Prod. 127, 72–83. https://doi.org/10.1016/j.jclepro.2016.03.142

Freeman, R.E., Harrison, J.S., Wicks, A.C., Parmar, B.L., de Colle, S., 2010. Stakeholder Theory; The State of the Art. Cambridge University Press, Cambridge.

Gangi, Y.A., 2017. The role of entrepreneurship education and training on creation of the knowledge economy Qatar leap to the future. World J. Entrep. Manag. Sustain. Dev. 13, 375–388. https://doi.org/10.1108/wjemsd-06-2017-0032

García-Lillo, F., Claver-Cortés, E., Marco-Lajara, B., Úbeda-García, M., 2017. Mapping the intellectual structure of research on 'born global' firms and INVs: A citation/co-citation analysis. Manag. Int. Rev. 57, 631–652. https://doi.org/10.1007/s11575-016-0308-5

Gibb, A., 2002. In pursuit of a new "enterprise" and "entrepreneurship" paradigm for learning: Creative destruction, new values, new ways of doing things and new combinations of knowledge. Int. J. Manag. Rev. 4, 233–269. https://doi.org/10.1111/1468-2370.00086

Gibbs, D., 2006. Sustainability entrepreneurs, ecopreneurs and the development of a sustainable economy. Greener Manag. Int. 63–78.

Gordon, I., Hamilton, E., Jack, S., 2012. A study of a university-led entrepreneurship education programme for small business owner/managers. Entrep. Reg. Dev. 24, 767–805. https://doi.org/10.1080/08985626.2011.566377

Guerra, A., 2017. Integration of sustainability in engineering education Why is PBL an answer? Int. J. Sustain. High. Educ. 18, 436–454. https://doi.org/10.1108/IJSHE-02-2016-0022

Habron, G., Goralnik, L., Thorp, L., 2012. Embracing the learning paradigm to foster systems thinking. Int. J. Sustain. High. Educ. 13, 378–393. https://doi.org/10.1108/14676371211262326

Haigh, M.J., 2006. Promoting environmental education for sustainable development: The value of links between higher education and non-governmental organizations (NGOs). J. Geogr. High. Educ. 30, 327–349. https://doi.org/10.1080/03098260600717422

Hanning, A., Abelsson, A.P., Lundqvist, U., Svanström, M., 2012. Are we educating engineers

for sustainability?: Comparison between obtained competences and Swedish industry's needs. Int. J. Sustain. High. Educ. 13, 305–320. https://doi.org/10.1108/14676371211242607

Henriques, A., 2004. CSR, sustainability and the Triple Bottom Line, in: The Triple Bottom Line; Does It All Add Up? Earthscan, London, pp. 26–33.

Herrera-Viedma, E., Martinez, M.A.A., Herrera, M., 2016. Bibliometric tools for discovering information in database, in: Fujita, H., Ali, M., Selamat, A., Sasaki, J., Kurematsu, M. (Eds.), Trends in Applied Knowledge-Based Systems and Data Science. Springer, Cham, pp. 193–203. https://doi.org/10.1007/978-3-319-42007-3_17

Hill, R.C., Kuhns, B.A., 1994. Experiential learning through cross-campus cooperation: Simulating and initiating technology-transfer. Simul. Gaming 25, 368–382. https://doi.org/10.1177/1046878194253005

Hills, P., 2001. Environmental education, community mobilization and sustainable development in Hong Kong: A comparative perspective. Int. J. Sustain. Dev. World Ecol. https://doi.org/10.1080/13504500109470071

Huq, A., Gilbert, D., 2017. All the world's a stage: Transforming entrepreneurship education through design thinking. Educ. Train. 59, 155–170. https://doi.org/10.1108/et-12-2015-0111

Isaak, R., 2002. The Making of the Ecopreneur. Greener Manag. Int. 38, 81–92.

Jennings, G., Cater, C.I., Hales, R., Kensbock, S., Hornby, G., 2015. Partnering for real world learning, sustainability, tourism education. Qual. Assur. Educ. 23, 378–394. https://doi.org/10.1108/QAE-03-2015-0010

Jensen, C.D., 2016. Action research to support development of engineering for sustainable development degree programs, part I: Collaborative community action research vignettes. J. Clean. Prod. 122, 164–175. https://doi.org/10.1016/j.jclepro.2015.09.088

Jolink, A., Niesten, E., 2015. Sustainable Development and Business Models of Entrepreneurs in the Organic Food Industry. Bus. Strateg. Environ. 24, 386–401. https://doi.org/10.1002/bse.1826

Jones, B., Iredale, N., 2010. Enterprise education as pedagogy. Educ. Train. 52, 7–19. https://doi.org/10.1108/00400911011017654

Jose, P.D., 2016. Sustainability education in Indian business schools: A status review. Ad-Minister 255–272. https://doi.org/10.17230/ad-minister.28.13

Kakouris, A., Georgiadis, P., 2016. Analysing entrepreneurship education: A bibliometric survey pattern. J. Glob. Entrep. Res. 6, 6. https://doi.org/10.1186/s40497-016-0046-y

Kamovich, U., Foss, L., 2017. In search of alignment: A review of impact studies in entrepreneurship education. Educ. Res. Int. https://doi.org/10.1155/2017/1450102

Kawabe, M., Kohno, H., Ishimaru, T., Baba, O., Horimoto, N., Ikeda, R., Kanda, J., Kudo, T., Matsuyama, M., Moteki, M., Oshima, Y., Sasaki, T., 2009. Education for sustainable development for Tokyo Bay: Developing a practice framework of university-based coastal ESD. Mar. Policy 33, 720–725. https://doi.org/10.1016/j.marpol.2009.02.002

Kleinberg, J., 2003. Bursty and hierarchical structure in streams, in: Data Mining and Knowledge Discovery. pp. 373–397. https://doi.org/10.1023/A:1024940629314

Kobori, H., 2009. Current trends in conservation education in Japan. Biol. Conserv. 142, 1950–1957. https://doi.org/10.1016/j.biocon.2009.04.017

Koehn, P.H., Deardorff, D.K., Bolognese, K.D., 2011. Enhancing international research and development-project activity on university campuses. J. Stud. Int. Educ. 15, 332–350. https://doi.org/10.1177/1028315310365540

Kwong, C.C.Y., Thompson, P., Cheung, C.W.M., 2012. The effectiveness of social business plan competitions in developing social and civic awareness and participation. Acad. Manag. Learn. Educ. 11, 324–348. https://doi.org/10.5465/amle.2011.0007A

1058   Lambrechts, W., Mulà, I., Ceulemans, K., Molderez, I., Gaeremynck, V., 2013. The integration
1059   of competences for sustainable development in higher education: An analysis of bachelor
1060   programs in management. J. Clean. Prod. 48, 65–73.
1061   https://doi.org/10.1016/j.jclepro.2011.12.034
1062   Lans, T., Blok, V., Wesselink, R., 2014. Learning apart and together: Towards an integrated
1063   competence framework for sustainable entrepreneurship in higher education. J. Clean.
1064   Prod. 62, 37–47. https://doi.org/10.1016/j.jclepro.2013.03.036
1065   Larso, D., Saphiranti, D., 2016. The role of creative courses in entrepreneurship education: A
1066   case study in Indonesia. Int. J. Bus. 21, 216–225.
1067   Leal Filho, W., Manolas, E., Pace, P., 2009. Education for sustainable development: Current
1068   discourses and practices and their relevance to technology education. Int. J. Technol. Des.
1069   Educ. 19, 149–165. https://doi.org/10.1007/s10798-008-9079-z
1070   Lehmann, M., Christensen, P., Johnson, B., 2010. Partnerships and sustainable regional
1071   innovation systems: Special roles for universities?, in: Sarkis, J., Cordeiro, J.J., Brust,
1072   D.V. (Eds.), Facilitating Sustainable Innovation through Collaboration: A Multi-
1073   Stakeholder Perspective. Springer, pp. 41–58. https://doi.org/10.1007/978-90-481-3159-
1074   4_3

1075   Leydesdorff, L., 2005. Similarity measures, author cocitation analysis, and information theory.
1076   J. Am. Soc. Inf. Sci. Technol. 56, 769–772. https://doi.org/10.1002/asi.20130
1077   Linnanen, L., 2002. An Insider's Experiences with Environmental Entrepreneurship. Greener
1078   Manag. Int. 38, 71–81.
1079   Lipscombe, B.P., 2008. Exploring the role of the extra-curricular sphere in higher education for
1080   sustainable development in the United Kingdom. Environ. Educ. Res. 14, 455–468.
1081   https://doi.org/10.1080/13504620802278803
1082   Loi, M., Di Guardo, M.C., 2015. A start-up generation approach for teaching entrepreneurship:
1083   An overview of affective learning results. J. Dev. Entrep. 20.
1084   https://doi.org/10.1142/s1084946715500272
1085   Lourenço, F., Jones, O., Jayawarna, D., 2013. Promoting sustainable development: The role of
1086   entrepreneurship education. Int. Small Bus. J. 31, 841–865.
1087   https://doi.org/10.1177/0266242611435825
1088   Lozano, R., 2006. Incorporation and institutionalization of SD into universities: breaking
1089   through barriers to change. J. Clean. Prod. 14, 787–796.
1090   https://doi.org/10.1016/j.jclepro.2005.12.010
1091   Lozano, R., Lukman, R., Lozano, F.J., Huisingh, D., Lambrechts, W., 2013. Declarations for
1092   sustainability in higher education: Becoming better leaders, through addressing the
1093   university system. J. Clean. Prod. pp. 10–19. https://doi.org/10.1016/j.jclepro.2011.10.006
1094   Maddock, M., 1991. Education, research and passive recreation: An integrated programme at
1095   the wetlands centre, Shortland. Int. J. Sci. Educ.
1096   https://doi.org/10.1080/0950069910130507
1097   Maresch, D., Harms, R., Kailer, N., Wimmer-Wurm, B., 2016. The impact of entrepreneurship
1098   education on the entrepreneurial intention of students in science and engineering versus
1099   business studies university programs. Technol. Forecast. Soc. Change 104, 172–179.
1100   https://doi.org/10.1016/j.techfore.2015.11.006
1101   Maritz, A., Brown, C., Shieh Chich, J., 2010. A blended learning approach to entrepreneurship
1102   education. Actual Probl. Econ. 12, 83–93.
1103   McPherson, S., Anid, N.M., Ashton, W.S., Hurtado-Martin, M., Khalili, N., Panero, M., 2016.
1104   Pathways to cleaner production in the Americas II: Application of a competency model to
1105   experiential learning for sustainability education. J. Clean. Prod. 135, 907–918.
1106   https://doi.org/10.1016/j.jclepro.2016.06.138
1107   Middleton, K.W., Donnellon, A., 2014. Personalizing entrepreneurial learning: A pedagogy for

facilitating the know why. Entrep. Res. J. 4, 167–204. https://doi.org/10.1515/erj-2013-0040

Mindt, L., Rieckmann, M., 2017. Developing competences for sustainability-driven entrepreneurship in higher education: A literature review of teaching and learning methods. Teor. La Educ. 29, 129–159. https://doi.org/10.14201/teoredu2017291129159

Mirabella, R., Young, D.R., 2012. The development of education for social entrepreneurship and nonprofit management: Diverging or converging paths? Nonprofit Manag. Leadersh. 23, 43–57. https://doi.org/10.1002/nml.21049

Morris, M.H., Webb, J.W., Fu, J., Singhal, S., 2013. A competency-based perspective on entrepreneurship education: conceptual and empirical insights. J. Small Bus. Manag. 51, 352–369. https://doi.org/10.1111/jsbm.12023

Mwasalwiba, E.S., 2010. Entrepreneurship education: A review of its objectives, teaching methods, and impact indicators. Educ. Train. 52, 20–47. https://doi.org/10.1108/00400911011017663

Nakagawa, K., Takata, M., Kato, K., Matsuyuki, T., Matsuhashi, T., 2017. A university-industry collaborative entrepreneurship education program as a trading zone: The case of Osaka University. Technol. Innov. Manag. Rev. 7, 38–49.

Neck, H.M., Greene, P.G., 2011. Entrepreneurship education: Known worlds and new frontiers. J. Small Bus. Manag. 49, 55–70. https://doi.org/10.1111/j.1540-627X.2010.00314.x

Neuendorf, K.A., 2017. The Content Analysis Guidebook, 2nd. Ed. ed. Sage, Thousand Oaks, CA.

Nobre, G.C., Tavares, E., 2017. Scientific literature analysis on big data and internet of things applications on circular economy: A bibliometric study. Scientometrics 111, 463–492. https://doi.org/10.1007/s11192-017-2281-6

Nowak, H., 2016. The role of the Polish higher education system in the development of entrepreneurship. Entrep. Bus. Econ. Rev. 4, 43–59. https://doi.org/10.15678/eber.2016.040104

Noy, S., Patrick, R., Capetola, T., McBurnie, J., 2017. Inspiration From the classroom: A mixed method case study of interdisciplinary sustainability learning in higher education. Aust. J. Environ. Educ. 33, 97–118. https://doi.org/10.1017/aee.2017.22

O'Brien, W., Sarkis, J., 2014. The potential of community-based sustainability projects for deep learning initiatives. J. Clean. Prod. 62, 48–61. https://doi.org/10.1016/j.jclepro.2013.07.001

Okudan, G.E., Rzasa, S.E., 2006. A project-based approach to entrepreneurial leadership education. Technovation 26, 195–210. https://doi.org/10.1016/j.technovation.2004.10.012

Oosterbeek, H., van Praag, M., Ijsselstein, A., 2010. The impact of entrepreneurship education on entrepreneurship skills and motivation. Eur. Econ. Rev. 54, 442–454. https://doi.org/10.1016/j.euroecorev.2009.08.002

Pacheco, D.F., Dean, T.J., Payne, D.S., 2010. Escaping the green prison: Entrepreneurship and the creation of opportunities for sustainable development. J. Bus. Ventur. 25, 464–480. https://doi.org/10.1016/j.jbusvent.2009.07.006

Pastakia, A., 1998. Grassroots ecopreneurs: change agents for a sustainable society. J. Organ. Chang. Manag. 11, 157–173. https://doi.org/10.1108/09534819810212142

Pedersen, K.W., Pharo, E., Peterson, C., Clark, G.A., 2017. Wheels of change in higher education A collaborative, multi-stakeholder project as a vehicle for sustainability education. Int. J. Sustain. High. Educ. 18, 171–184. https://doi.org/10.1108/ijshe-10-2015-0172

Pittaway, L., Cope, J., 2007. Entrepreneurship education a systematic review of the evidence. Int. Small Bus. J. 25. https://doi.org/10.1177/0266242607080656

Pittaway, L., Thorpe, R., 2012. A framework for entrepreneurial learning: A tribute to Jason

1158   Cope. Entrep. Reg. Dev. 24, 837–859. https://doi.org/10.1080/08985626.2012.694268
1159 Preedy, S., Jones, P., 2015. An investigation into university extra-curricular enterprise support
1160   provision. Educ. Train. 57, 992–1008. https://doi.org/10.1108/et-04-2015-0025
1161 Qian, G.G., 2014. Scientometric sorting by importance for literatures on life cycle assessments
1162   and some related methodological discussions. Springer Verlag.
1163   https://doi.org/10.1007/s11367-014-0747-9
1164 Quist, J., Rammelt, C., Overschie, M., de Werk, G., 2006. Backcasting for sustainability in
1165   engineering education: The case of Delft University of Technology. J. Clean. Prod. 14,
1166   868–876. https://doi.org/10.1016/j.jclepro.2005.11.032
1167 Rae, D., 2012. Action learning in new creative ventures. Int. J. Entrep. Behav. Res. 18, 603–
1168   623. https://doi.org/10.1108/13552551211253955
1169 Refai, D., Klapper, R.G., Thompson, J., 2015. A holistic social constructionist perspective to
1170   enterprise education. Int. J. Entrep. Behav. Res. 21, 316–337.
1171   https://doi.org/10.1108/ijebr-01-2014-0006
1172 Rossano, S., Meerman, A., Kesting, T., Baaken, T., 2016. The relevance of problem-based
1173   learning for policy development in university-business cooperation. Eur. J. Educ. 51, 40–
1174   55. https://doi.org/10.1111/ejed.12165
1175 Sandri, O.J., 2013. Exploring the role and value of creativity in education for sustainability.
1176   Environ. Educ. Res. 19, 765–778. https://doi.org/10.1080/13504622.2012.749978
1177 Schaltegger, S., 2002. A framework for ecopreneurship: Leading bioneers and environmental
1178   managers to ecopreneurship. Greener Manag. Int. 45–58.
1179 Schumpeter, J., 2003. The Theory of Economic Development. Joseph Alois Schumpeter, The
1180   European Heritage in Economics and the Social Sciences. https://doi.org/10.1007/0-306-
1181   48082-4_3
1182 Sedlan-Konig, L., 2016. Integrating entrepreneurial self-efficacy into education at universities.
1183   Ekon. Vjesn. 29, 311–321.
1184 Seikkula-Leino, J., 2011. The implementation of entrepreneurship education through
1185   curriculum reform in Finnish comprehensive schools. J. Curric. Stud. 43, 69–85.
1186   https://doi.org/10.1080/00220270903544685
1187 Sengupta, D., Huang, Y., Davidson, C.I., Edgar, T.F., Eden, M.R., El-Halwagi, M.M., 2017.
1188   Using module-based learning methods to introduce sustainable manufacturing in
1189   engineering curriculum. Int. J. Sustain. High. Educ. 18, 307–328.
1190   https://doi.org/10.1108/IJSHE-05-2015-0100
1191 Shane, S., 2000. Prior knowledge and the discovery of entrepreneurial opportunities. Organ.
1192   Sci. 11, 448–469.
1193 Shealy, T., Valdes-Vasquez, R., Klotz, L., Potvin, G., Godwin, A., Cribbs, J., Hazari, Z., 2017.
1194   Half of students interested in civil engineering do not believe in anthropogenic climate
1195   change. J. Prof. Issues Eng. Educ. Pract. 143. https://doi.org/10.1061/(asce)ei.1943-
1196   5541.0000323
1197 Shephard, K., 2008. Higher education for sustainability: Seeking affective learning outcomes.
1198   Int. J. Sustain. High. Educ. 9, 87–98.
1199 Shepherd, D.A., Patzelt, H., 2011. The new field of sustainable entrepreneurship: Studying
1200   entrepreneurial action linking "what is to be sustained" with "what is to be developed."
1201   Entrep. Theory Pract. 35, 137–163. https://doi.org/10.1111/j.1540-6520.2010.00426.x
1202 Shepherd, D.A., Patzelt, H., 2017. Trailblazing in Entrepreneurship. Palgrave Macmillan,
1203   Cham, Switzerland.
1204 Singh, P., 2013. Environmental education: Enhancing learning and awareness through
1205   assessment. Syst. Pract. Action Res. 26, 299–314. https://doi.org/10.1007/s11213-012-
1206   9252-x
1207 Sipos, Y., Battisti, B., Grimm, K., 2008. Achieving transformative sustainability learning:

Engaging head, hands and heart. Int. J. Sustain. High. Educ. 9, 68–86. https://doi.org/10.1108/14676370810842193

Small, H.G., 1978. Cited documents as concept symbols. Soc. Stud. Sci. 8, 327–340. https://doi.org/10.1177/030631277800800305

Smith, I.H., Woodworth, W.P., 2012. Developing social entrepreneurs and social innovators: A social identity and self-efficacy approach. Acad. Manag. Learn. Educ. 11, 390–407. https://doi.org/10.5465/amle.2011.0016

Smith, G.A., Stevenson, R.B., 2017. Sustaining education for sustainability in turbulent times. J. Environ. Educ. 48, 79–95. https://doi.org/10.1080/00958964.2016.1264920

Stubbs, W., Schapper, J., 2011. Two approaches to curriculum development for educating for sustainability and CSR. Int. J. Sustain. High. Educ. 12, 259–268. https://doi.org/10.1108/14676371111148045

Tang, K.Y., Wang, C.Y., Chang, H.Y., Chen, S., Lo, H.C., Tsai, C.C., 2016. the intellectual structure of metacognitive scaffolding in science education: A co-citation network analysis. Int. J. Sci. Math. Educ. 14, 249–262. https://doi.org/10.1007/s10763-015-9696-4

Toledano, N., Karanda, C., 2017. Morality, religious writings, and entrepreneurship education: An integrative proposal using the example of Christian narratives. J. Moral Educ. 46, 195–211. https://doi.org/10.1080/03057240.2016.1238819

Tomas, L., Lasen, M., Field, E., Skamp, K., 2015. Promoting online students' engagement and learning in science and sustainability preservice teacher education. Aust. J. Teach. Educ. 40, 79–107. https://doi.org/10.14221/ajte.2015v40n11.5

Tilley, F., Young, W., 2009. Sustainability Entrepreneurs: Could They Be the True Wealth Generators of the Future? Sustain. Dev. 79–93.

UN, 2017. The Sustainable Development Agenda [WWW Document]. Sustain. Dev. Goals, 17 goals to transform our world. URL http://www.un.org/sustainabledevelopment/development-agenda/ (accessed 8.12.17).

Vann, J., Pacheco, P., Motloch, J., 2006. Cross-cultural education for sustainability: Development of an introduction to sustainability course. J. Clean. Prod. 14, 900–905. https://doi.org/10.1016/j.jclepro.2006.01.002

Wals, A.E.J., 2014. Sustainability in higher education in the context of the UN DESD: A review of learning and institutionalization processes. J. Clean. Prod. 62, 8–15. https://doi.org/10.1016/j.jclepro.2013.06.007

Wang, J.-J.J.J., Chen, H., Rogers, D.S.D.S., Ellram, L.M.L.M., Grawe, S.J.S.J., 2017. A bibliometric analysis of reverse logistics research (1992-2015) and opportunities for future research. Int. J. Phys. Distrib. Logist. Manag. 47, 666–687. https://doi.org/10.1108/IJPDLM-10-2016-0299

WCED, 1987. Report of the World Commission on Environment and Development: Our Common Future. UN. https://doi.org/10.1080/07488008808408783

Wiek, A., Withycombe, L., Redman, C.L., 2011. Key competences in sustainability: A reference framework for academic program development. Sustain. Sci. 6, 203–218. https://doi.org/10.1007/s11625-011-0132-6

Wiltshier, P., Edwards, M., 2014. Managing knowledge transfer partnership for a rural community: The outcomes at Wirksworth, UK. Kybernetes 43, 629–651. https://doi.org/10.1108/K-07-2013-0128

Wyness, L., Jones, P., Klapper, R., 2015. Sustainability: What the entrepreneurship educators think. Educ. Train. 57, 834–852. https://doi.org/10.1108/et-03-2015-0019

Yeung, S.K., So, W.M.W., Cheng, N.Y.I., Cheung, T.Y., Chow, C.F., 2017. Comparing pedagogies for plastic waste management at university level. Int. J. Sustain. High. Educ. 18, 1039–1059. https://doi.org/10.1108/IJSHE-04-2016-0073

1258 Young, W., Tilley, F., 2006. Can businesses move beyond efficiency? The shift toward
1259   effectiveness and equity in the corporate sustainability debate. Bus. Strateg. Environ. 15,
1260   402–415.
1261 Zahra, S.A., Gedajlovic, E., Neubaum, D.O., Shulman, J.M., 2009. A typology of social
1262   entrepreneurs: Motives, search processes and ethical challenges. J. Bus. Ventur. 24, 519–
1263   532.
1264
1265

1266
1267

1268 **APPENDIX A – Topic modeling for entrepreneurship education**

1269 Please see additional material 1

1270

1271 **APPENDIX B – Topic modeling for sustainability education**

1272 Please see additional material 2

1273

1274

1275   Table 1. Key Terms Used for the Literature Collection Through Web-of-Science

Group 1: Terms referring to sustainability education	Group 2: Terms referring to entrepreneurship education	Group 3: Terms concerning the locus of the education initiative (higher education)
"environment* education" OR "sustainab* education" OR "education for sustainable entrepreneurship" OR "education for sustainability management" OR "education for sustainable business" OR "education for sustainability" OR "education for sustainable development" OR "sustainability education"	"entrepreneurship education curriculum" OR "entrepreneurship education pedagogy" OR "entrepreneurial learning" OR "entrepr* education" OR "enterp* education"	"higher education" OR "university" OR "tertiary education" OR "college"

1276

1277

Tensions

Clashing values

Sustainability narrowed-down to enhancing "Alertness" to green opportunities

Commonalities

Overlapping competences as interpersonal collaboration complex-problem solving and interdisciplinarity.

Real-world learning and collaboration with stakeholders.

A large emphasis on "problem-based" pedagogy in order to enhance the competences on complex thinking, collaboration and system-analysis.

Use of active-learning pedagogy, with students' ownership of their learning increasing.

Current real-life challenges through hands-on-practice as a pedagogy to develop competences

Lack of triple bottom line goals in competences for sustainable entrepreneurship.

"Social entrepreneurship" often enough to tackle sustainability-related challenges.

Diverting expectations regarding the figure of the "change agent"

Sustainability forced into the curriculum -as external requirement.

Sustainability as add-on to existing courses

Sustainability education

Entrepreneurship education

1278

1279 *Figure 1. Commonalities between sustainability and entrepreneurship education framed*
1280 *within tensions which lead to unintended eco-innovations*

1281

1282
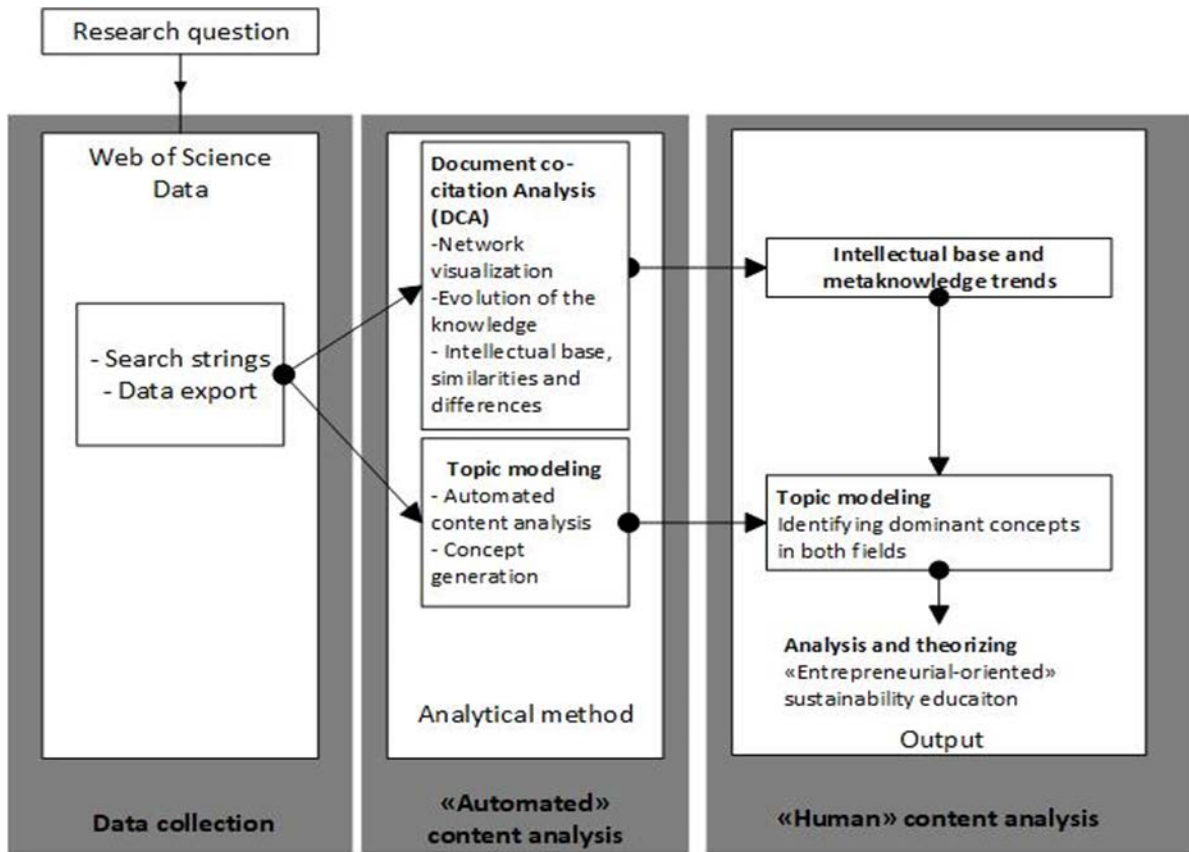
1283

1284 *Figure 2. Research design integrating DCA and topic modeling to identify conceptual*
1285 *convergences and differences between entrepreneurship and sustainability education*

1286
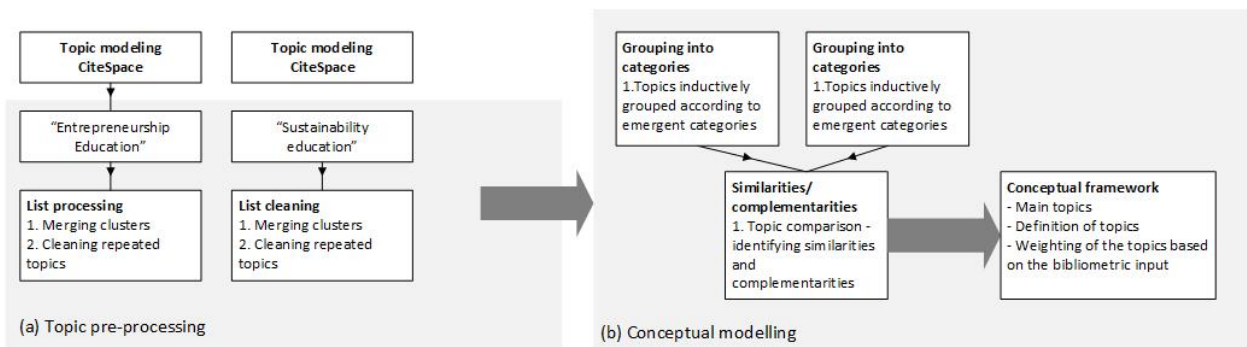
1287

1288 *Figure 3. Human content analysis procedure to develop the conceptual framework; adapted*
1289 *from Neuendorf (2017)*

1290

Entrepreneurship education

Institutions
small enterprise
entrepreneurial university

Target audience
graduate entrepreneur
graduate employability

Domain of education
enterprise education

Commonalities

Institutions
university
industry

Target audience
engineering students
teacher training

Domain of education
lifelong learning
non-formal education

Sustainability education

Institutions
NGOs
planning school

Target audience
individual faculty
practitioners
staff development

Domain of education

Entrepreneurship education ⟷ Sustainability education

1291

Figure 4. Educational focus in entrepreneurship and sustainability education

1293

Entrepreneurship education

Active learning approaches
intercultural learning
action learning

Real-world oriented
vocational education
role model

Commonalities

Active learning approaches
affective learning
blended learning
reflective learning
interdisciplinary learning
holistic
project-based learning
problem-based learning
experiential learning

Real-world oriented
extra-curricular
real-world learning opportunities

Sustainability education

Active learning approaches
active pedagogy
outdoor education

Real-world oriented
service learning

Entrepreneurship education ⟷ Sustainability education

1294

Figure 5. Teaching-learning approaches in entrepreneurship and sustainability education

1296

Entrepreneurship education

Actors

technology business incubators

university spin-outs

Practices

Principles

Commonalities

Actors

stakeholders

community

Practices

capacity building

Principles

Sustainability education

Actors

sustainability initiative

grassroots initiative

Practices

collaborative research

collaborative work

Principles

civics

citizenship

participatory competencies

Entrepreneurship education   Sustainability education

1297

1298   *Figure 6. Cooperation in teaching and learning with external parties*

1299

1300

1301   *Figure 7. Content analysis of stakeholders mentioned in the literature*

1302

Entrepreneurship education

Innovation-design
commercialization
design thinking

Individual skills promotion
entrepreneur intentions and motivation
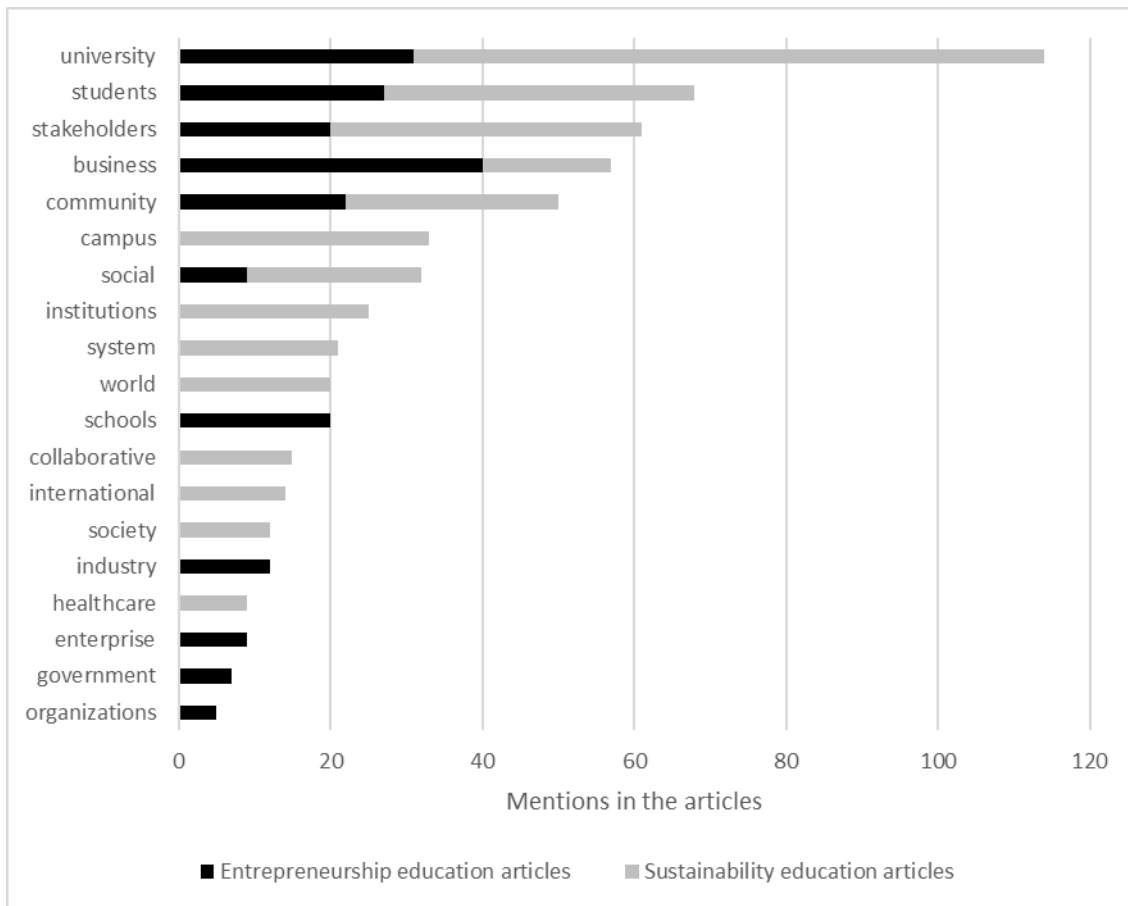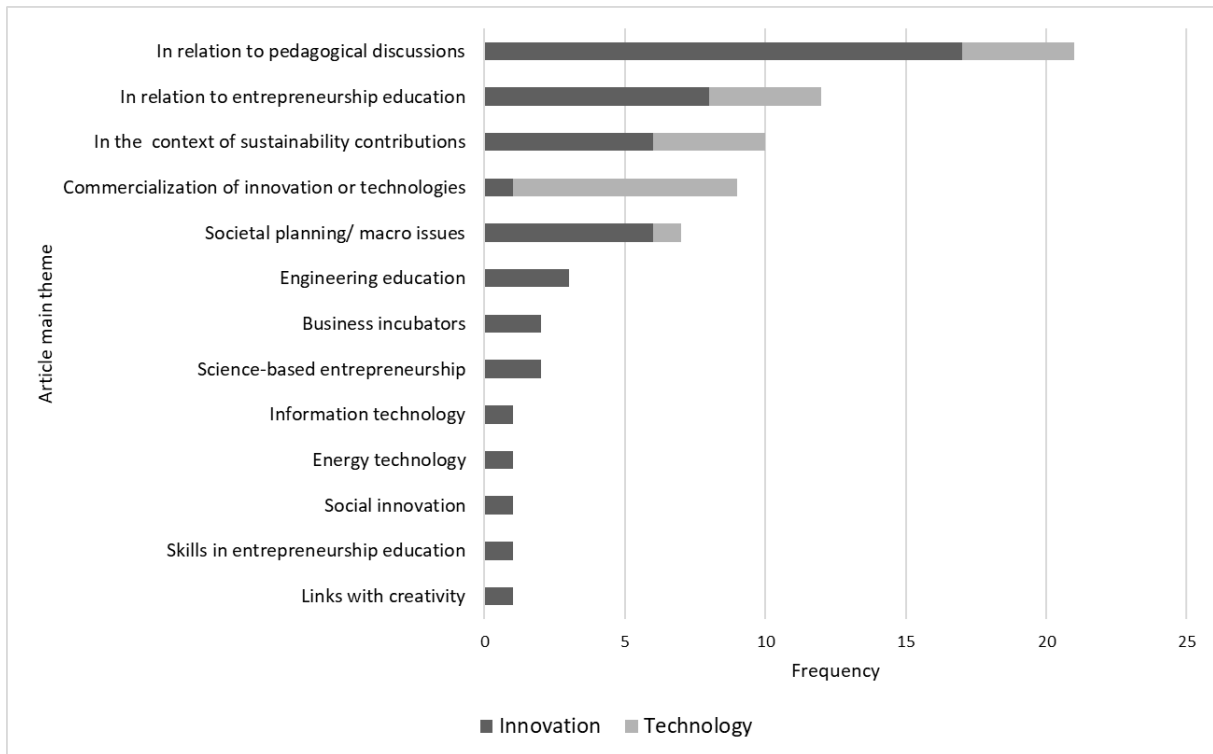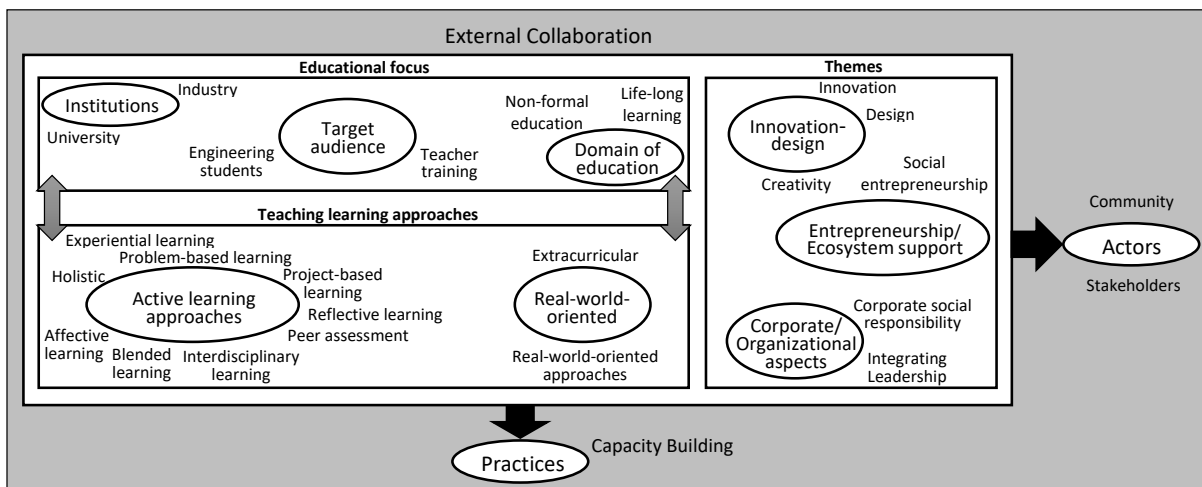entrepreneurial drive
entrepreneurial self-efficacy
entrepreneurial skills
entrepreneurial attributes
entrepreneurial capabilities
entrepreneurial culture

New venture creation
entrepreneurial development
entrepreneurial knowledge
entrepreneurial learning
entrepreneurial mindset
family influence

Entrepreneurship ecosystem support
collective entrepreneurship
institutional environment
technological entrepreneurship
technology transfer
female entrepreneurs

Commonalities

Innovation-design
creativity
innovation
technology

Entrepreneurship ecosystem support
social entrepreneurship

Corporate/ organizational aspects
integrating leadership
corporate social responsability

Sustainability education

Corporate/ organizational aspects
Corporate sustainability
sustainability assessment

Individual skills
environmental values
environmental attitudes
environmental behavior
environmental discipline

Sustainability literacy
environmental education
environmental knowledge
environmental literacy
environmental competence
environmental sensitivity

Sustainability theory
environmental work
sustainable development
sustainability canon
sustainability concept
sustainable societies
sustainable universities
systemic change process

Entrepreneurship education → **Sustainability education**

Figure 8. Main themes in relation to the disciplinary domains of entrepreneurship and sustainability education
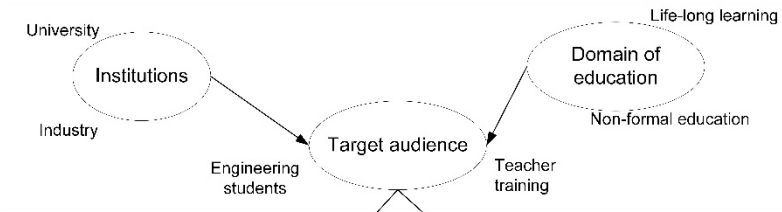
1307

Figure 9. Focus of the articles that include the topics of innovation and technology

1309

1310

1311

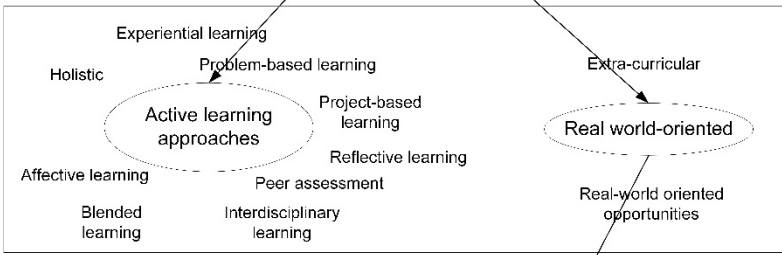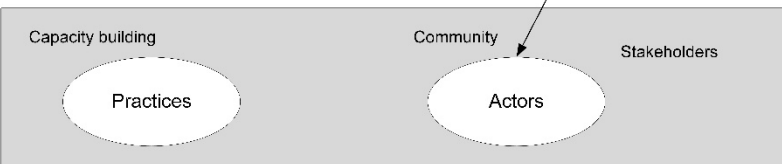*Figure 10. Conceptualization of entrepreneurial-oriented sustainability education*
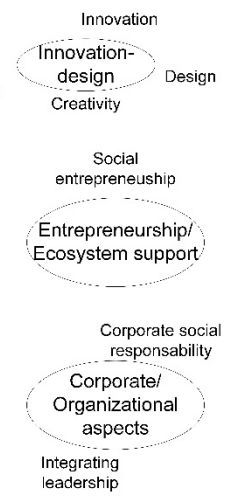
1313

1314

Step 1: Educational focus

University ⋯⋯ Institutions ⋯⋯ Industry

Life-long learning ⋯⋯ Domain of education ⋯⋯ Non-formal education

Engineering students → Target audience ← Teacher training

Step 2: Teaching learning approaches

Experiential learning
Holistic
Problem-based learning
Active learning approaches
Project-based learning
Reflective learning
Affective learning
Peer assessment
Blended learning
Interdisciplinary learning

Extra-curricular
Real world-oriented
Real-world oriented opportunities

Step 3: Themes

Innovation
Innovation-design — Design
Creativity

Social entrepreneuship
Entrepreneurship/ Ecosystem support

Corporate social responsability
Corporate/ Organizational aspects
Integrating leadership

Step 4: External collaboration

Capacity building
Practices

Community
Stakeholders
Actors

1315

1316   Figure 11. Suggested process to adapt the teaching framework in the practice