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40 **Abstract**

41 This paper explores the link between innovation and sustainability in the context of higher
42 education, with the purpose of investigating the fundamental barriers for innovation and
43 sustainable development in universities around the world. The method used involves both a
44 quantitative and a qualitative approach, gathering the views of 301 experts from 172
45 universities across all continents. The results show that there are similar barriers across
46 different geographical regions that require greater support from university administrations and
47 management. In particular, the willingness of leaders, policy makers and decision-makers to
48 envisage a sustainable future inside universities is often missing. Yet, without the support of
49 senior management within a university, bottom-up sustainable initiatives seem destined to fail
50 in the longer term due to a lack of investment and administrative support. This study also
51 identifies that in order to yield the anticipated benefits, barriers need to be tackled in an
52 integrated way, and that closer cooperation between sustainability researchers, university
53 administrations and students is needed.

54 **Key words:** sustainable development; innovation; sustainability; higher education; barriers;
55 research

56

57 **1. Introduction**

58 Much has been written about teaching and research that is focused on sustainable
59 development (Posch and Steiner, 2006) and the development of eco-innovation (Del Rio,
60 Carrillo-Hermossilla and Könnöla 2010; Hellström 2007). Comparatively little literature,
61 however, can be found that focuses on the nexus between innovation and sustainable
62 development. Despite this, there is a very close relationship between innovation and
63 sustainability (Vollenbroek, 2002).

64 Indeed, these two processes are highly related since, when they converge, they often
65 result in long term impacts and benefits. The relationship between innovation and
66 sustainability can be better understood if one considers their respective structures and areas of
67 application. A closer look at these two processes allows for the identification of the fact that
68 there are two main types of innovation when it comes to sustainable development:

69 a) Structural innovation, which involves changes in structures, hierarchies and
70 governance in an organization; for instance, the appointment of a sustainability coordinator at
71 a university to oversee its efforts in this field;

72 b) Operational innovation, which refers to the introduction of tools which may enhance
73 and maximize the operations of the institution; for example, the use of energy-saving bulbs.

74 Albeit rather simple and straightforward to understand in principle, these two main
75 types of sustainable development focused innovation are characterized by the need to carefully
76 reflect on their degree of applicability before they may be implemented. This fact lends them
77 some degree of complexity. It is a fact that changes in the organization of a university are not
78 easy, and that the appointment of a sustainability coordinator, for example, may not a matter

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79 enough for each university to do for financial reasons. Therefore, one has to assess the
80 conditions at each institution before an innovation or initiative in support of sustainable
81 development can be fully realized at the institutional level.

82 Therefore, one question that arises is, how can innovation and sustainability be
83 integrated in order to maximize their advantages for universities? The answer to this question
84 is not so simple, since a variety of factors – including support from the top level – may
85 interfere with the likelihood that a specific type of innovation is implemented at a university.
86 A second element which should be outlined is the fact that there are four main principles
87 which guide innovation in the field of sustainable development, knowledge of which is
88 necessary to allow their integration to succeed. Due to their importance, these four main
89 principles will be described below:

90 *Principle 1- Ingenuity:* innovation is often the implementation of a simple idea put
91 towards a greater use. The use of surface or sub-surface rainwater storage tools, as
92 implemented by the Hamburg University of Applied Sciences (Germany) as part of the project
93 AFRHINET (<http://afrhinet.eu/>) in Africa – to supply plantations with water in the dry seasons
94 , or to help to water gardens – is a very simple, yet quite efficient procedure to support
95 agriculture and crop production, especially in developing countries.

96 *Principle 2- Simple implementation:* the best types of innovation in the field of
97 sustainable development are those that are simple and easy to implement. At Manchester
98 Metropolitan University (UK), for example, efforts to manage waste and recycle paper have
99 yielded greater benefits when the containers to gather waste or paper were placed not in each
100 classroom - as is often the case - but in the corridors instead. This means that greater amounts
101 of waste (e.g. paper, cans, and general litter) can be collected with less effort, since cleaning
102 personnel do not need to enter each classroom to collect it.

103 *Principle 3- Environmental efficiency:* some types of innovation can lead to real
104 impacts in areas such as energy consumption and reductions in CO2 emissions. One example
105 is seen at many universities in North America, where lavatory lights have motion sensors,
106 which means that their lights are by default off unless someone enters the room when the
107 lighting is activated. The lights go off again, once that person leaves the room. Also, across the
108 world, water efficient taps are being used: with one push, a certain amount of water flows for a
109 few seconds and then automatically stops. This leads to greater environmental efficiency and
110 results in decreased pressure on environmental resources.

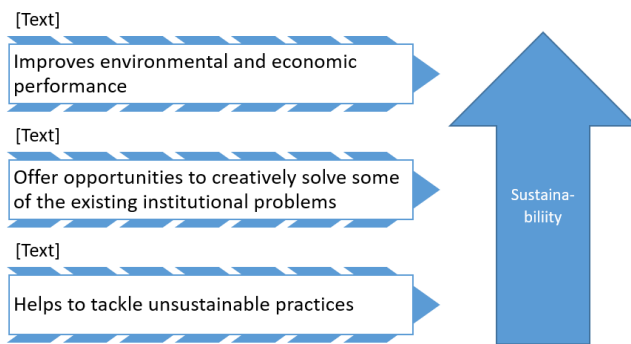
111 *Principle 4- Economic viability:* innovation in the field of sustainable development can
112 also help to reduce costs and minimize the loss of financial resources. For instance, in
113 universities across the world, millions of kilowatts of energy are wasted powering printers and
114 computers etc. when they're not in use, resulting in substantial amounts of needless
115 expenditure. While computers and notebooks are typically used all day, most printers are used
116 for only a few minutes in each working day, despite the fact that they are switched on
117 continuously. A simple innovation such as only turning printers on when they are needed can
118 substantially reduce both the energy consumption and the energy bill of a university.

119 These principles are derived from both the experiences of the authors on sustainability,
120 such as Leal Filho (2006) on a compendium on innovation, education and communication for
121 sustainable development, and also from a volume which explores innovative approaches to

122 education for sustainable development (Leal Filho and Salomone 2006). Further, some
 123 important published works on innovation and competence development (Barth al 2007) and
 124 on post-graduate training (Gombert-Courvoisier et al 2014) have analysed the role and
 125 relevance of innovation with regards to sustainable development.

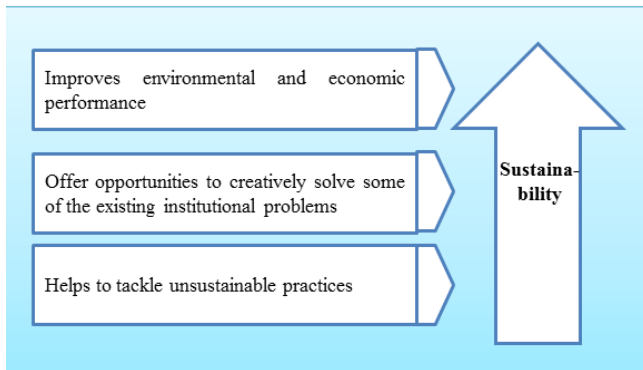
126 Unlike other areas, innovation in sustainable development is not characterized by a
 127 great degree of uncertainty: if properly implemented, it is proven to work. Sustainable
 128 development innovation can be simple to achieve provided it is based on a strong idea, and
 129 seldom entails any risks. Further, innovation in sustainable development may be advantageous
 130 to universities in a variety of ways, as outlined in Figure 1.

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135 **Figure 1- Advantages of innovation in sustainable development to universities**

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137 Nevertheless, despite the fact that universities are faced with increasing pressure to
 138 make use of their resources and consider sustainable development as part of their operations,
 139 many are still reluctant to revise their business models and incorporate the necessary changes.

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140 Part of the problem is that the investments required are often seen as a barrier, whereas the
141 benefits with respect to both environmental and economic performance are often overlooked.

142 This paper explores the links between innovation and sustainability within the context
143 of higher education. This is done with the purpose of investigating the fundamental barriers
144 for innovation and sustainable development in universities around the world.

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146 **2. The problems seen in innovation in sustainable development at universities**

147 Pursuing sustainability at universities is one of the main strategies to strengthen
148 society, especially where aspects of social and economic equity and a healthy environment are
149 taken into account, by means of teaching, research and outreach practices (Stir, 2006; Lozano
150 et al., 2013). University campuses can be understood as small towns, and it is possible to
151 transform such spaces as habitats for the development and implementation of new social and
152 technological innovations and as pilots for management strategies regarding sustainability
153 (Evans et al., 2015; Alshuwaikhat and Abubakar, 2008). The implementation of sustainability
154 at universities can expand their innovation potential, both within and outside the campus
155 walls. This can facilitate a continuous learning process between academia, local municipalities
156 and the private sector (Trencher, 2014).

157 Velazquez et al. (2005) identified four main strategies for universities to advance
158 innovation in sustainability: education, research, outreach/community and sustainability on
159 campus. This is similar to the 4C-model proposed by Jones, Selby, and Sterling (2010) which
160 acknowledges the role of sustainable development and innovation in Campus, Curriculum,
161 Community and Culture. It is natural that each of these four areas has obstacles and
162 challenges, which will be discussed later in this paper. But one of the major issues identified in
163 previous research is the lack of a holistic vision and of integrated approaches to innovation.
164 This is linked to the often lacking commitment of senior managers to embrace change and
165 strive for sustainable solutions, within and beyond the university.

166 Most sustainable innovations have focused on the campus of a university. Here, operational
167 innovations such as renewable energy installations, initiatives with solar arrays, wind turbines,
168 geothermal projects, biomass production facilities, conservation retrofits, and energy efficient
169 designs have been introduced (Thomashow, 2014). As Leal Filho et al (2015) have showed,
170 campus greening has a clear connection with innovative projects, transfer of models for the
171 surrounding community and the possibility to implement innovative green technologies. The
172 popularity and influence of university rankings has spawned large numbers of accreditation
173 schemes (Lauder et al, 2015). For example, Ecocampus (2017) and rankings such as the
174 People & Planet League in the UK were centered initially on the environmental management
175 of a university. More recently, the attention has shifted and attempts have been made to
176 include the core activities of a university, namely research, education and environment
177 indicators rankings (Lukman, Krajnc and Glavic, 2010). In terms of the curriculum, many
178 universities are still lagging behind and offer courses and programmes which either partly or
179 completely fail to incorporate aspects of sustainable development (Capdevila, Bruno and
180 Jofre, 2002; Müller-Christ, 2014). As far as research is concerned, even though there is a
181 plethora of scientific work and various studies published, they most often use well known
182 methods and techniques (e.g. surveys) but do not always exercise care to ensure the validity or

183 reliability of their data when it comes to innovation. As a result, many studies tend to repeat
 184 trends as opposed to offering a basis for ground-breaking innovation. The most common
 185 innovation in teaching and research is the availability of separate offerings, so for example a
 186 Master in CSR (Corporate Social Responsibility) or a research centre focusing on sustainable
 187 development or climate change. This has not been matched by structural innovations to embed
 188 sustainability or sustainable development across the curricula and across research centers.

189 With respect to community and student engagement, only a few universities have a
 190 vision of how all of these areas may support one another. There are some recent accreditation
 191 schemes which appear promising, such as the UK LiFE (Learning in Future Environments)
 192 Index, which encourages a holistic view of the university by considering four themes:
 193 leadership and governance, partnerships and engagement, facilities and operations, and
 194 teaching and research. However, many universities still miss opportunities to strategically link
 195 between these areas.

196 The willingness of leaders, policy makers and decision-makers to envisage a
 197 sustainable future inside universities is often lacking (Richardson and Lynes, 2007). Without
 198 the support of senior management within a university, bottom-up sustainable initiatives seem
 199 destined to fail in the longer term due to a lack of investment and administrative support. To
 200 develop this kind of initiative requires considerable amounts of time and financial resources,
 201 which are difficult to obtain without the support of the upper administration. As a result, staff
 202 and student entrepreneurs in sustainability often fail to progress with such initiatives.

203 Furthermore, appropriate instruments are often not in place because senior
 204 management tends not to define specific goals in this area, nor do they agree on a holistic
 205 vision. However, setting goals is important to define the intentions of the university with
 206 respect to sustainability as a whole, and in particular when it comes to innovation for
 207 sustainable development. Wright (2002) suggests that the University of Waterloo, the
 208 University of South Carolina, the University of Buffalo, the University of Toronto, and
 209 George Washington University, are examples of universities that have become leading
 210 universities in sustainability by elaborating and accomplishing their sustainable vision,
 211 objectives and goals.

212 Regardless of all of the outcomes achieved in implementing sustainability practices at
 213 universities, the examples provided by the many “role models” show that they also have to
 214 deal with obstacles (Hansen and Lehmann, 2006). Some of the specific challenges seen in
 215 order to pursue and improve campus sustainability are (Bero et al., 2012; Alnsour and Meaton,
 216 2015):

- 217 -A diverse community of students, faculty and staff, varying in their priorities and
 218 level of engagement;
- 219 -A great diversity of buildings and activities that include offices, laboratories, dining
 220 halls, dormitories and maintenance;
- 221 - A broad distribution of age and cultural perspectives;
- 222 -Limited financial and human resources for developing, implementing and maintaining
 223 sustainable initiatives.

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224 The Cambridge Programme for Sustainability Leadership (Courtice and Van der
225 Kamp, 2013) found that within a complex organization, sustainable leadership depends –
226 among other things – on the capability to employ systems thinking. Leaders with a sustainable
227 vision need to allow innovation to emerge bottom-up, through all the business practices within
228 the organization, as well as implementing it top-down, through strong leadership directives.

229 A university that is seeking a more sustainable path, either on an initial phase or a plan
230 that is already more advanced, will face a series of internal and external barriers (Brandli et
231 al., 2015). Dealing with these barriers in a systematic way is important to make the initiatives
232 work in an effective and continuous flow, and not to lose the interest of the people engaged.
233 Therefore, universities are seeking to enhance their levels of innovation in sustainability issues
234 through tools such as certification, environmental management systems and the development
235 of effective policies. These instruments should help to overcome challenges, partly by creating
236 a sense of identity for the university community (Clarke and Kouri, 2009).

237 Morland-Painter et al. (2015:18) argued that integrating sustainability into the
238 curriculum must be closely aligned with systemic institutional integration, which they define
239 as: ‘building a systemic capability towards sustainability, distributed and nurtured throughout
240 the organization, which creates the impetus towards change in students, faculty,
241 administrators, the institution as a whole, as well as organizations that hire its alumni’. Their
242 findings indicate that there are insufficient incentives for faculties to integrate sustainability
243 into their research and teaching activities. Often, sustainability entrepreneurs have to do these
244 activities in addition to their normal duties. Human resources policies regarding hiring, annual
245 performance reviews and promotion often do not reward sustainable innovation either.

246 These missing holistic visions and incentives are matched by transdisciplinary barriers
247 and a tendency for academics and departments to focus on one specific discipline in teaching,
248 and on an even more reduced topic in their research activities. Lozano et al. (2013: 10) argue
249 that, ‘In spite of a number of sustainable development (SD) initiatives and an increasing
250 number of universities becoming engaged with SD, most higher education institutions (HEIs)
251 continue to be traditional, and rely upon Newtonian and Cartesian reductionist and
252 mechanistic paradigms’.

253 Several academics have argued that highly specialized yet specific ‘areas of
254 knowledge’ are encouraged within universities and few incentives are given to encourage
255 trans-disciplinary collaboration. Universities therefore ‘produce’ graduates who have a narrow
256 understanding of their own discipline with a focus on ‘individual learning and competition
257 professionals who are ill prepared for cooperative efforts’ (Cortese, 2003; Winter and Cotton
258 2012; Djordjevic and Cotton 2011). Any effort to integrate sustainability in a university
259 context has to address these systemic issues in order to overcome communication barriers and
260 to integrate highly specialized knowledge. Aalborg University, for example, has taken this
261 approach: students from different disciplines have to study around ten projects during their
262 degree to find solutions for real-life sustainability problems (Simon and Lundebye, 2013).

263 In connection with this issue, the role played by a lack of internal political instruments,
264 such as policies, plans and programmes can also be seen. These instruments are important for
265 the strengthening of sustainable initiatives because they provide a legal background (Pereira,
266 2014). Research by Ryan et al. (2010) indicates the importance of policies in supporting the

267 smooth delivery of SD in the HE curriculum, including mechanisms such as open and clear
268 communication. Furthermore, changes in quality assessment and quality enhancement
269 processes are needed to support the delivery of 'effective learning and innovation for
270 sustainability' (Ryan and Tilbury, 2013:273).

271 Five other thematic obstacles identified from the literature review will now be
272 considered.

273 *i.Lack of specific working groups, committees and sustainability offices*

274 The existence of formal groups of committees or, ideally, dedicated sustainability
275 offices, is important in order to offer guidance. They need to be trans and multidisciplinary
276 and hierarchically multi-leveled, which may prevent conflicts of interests arising from within
277 these groups.

278 By creating settings such as "offices of sustainability" a university is able to hire
279 someone to deal (full-time or on a part-time basis) specifically with sustainability, as well as
280 creating a hierarchical position that fills the gap of leadership amongst the minor stakeholders
281 with decision-making power. The lack of a person to deal specifically with these issues inside
282 a university translates into the weakening of the sense of identity of the university
283 community. Having someone or some specific place to address doubts or observations about
284 sustainability issues is essential (Gudz, 2004)

285 Even for those cases where there is a dedicated person, the roles and responsibilities
286 may be confusing; an administrative or technical person may face resistance or they may lack
287 the necessary support from the local academia. For example, if an academic person is
288 delegated to the role, the issues and concerns regarding operations and infrastructure may go
289 unnoticed.

290 The University of Waterloo, by means of its WATgreen committee, developed a study
291 that allowed the university to perceive a series of weaknesses and barriers for its successful
292 green building projects within the campus, as well as presenting decision-makers with
293 recommendations about the matter (Richardson and Lynes, 2007).

294 *ii.Cultural and behavioral change*

295 In a case study developed at the University of Technology of Mara (UiTM) - Malaysia,
296 the authors concluded that pursuing sustainability at universities demands fundamental
297 changes in the mindset and lifestyle of its community, where trans and multidisciplinary
298 initiatives are required. Since sustainability is a broad issue that requires cooperation at
299 multiple hierarchical levels, isolated efforts may therefore be limited in terms of their impact
300 (Saleh et al., 2011).

301 This is corroborated by Levy and Marans (2012) through a case study at the University
302 of Michigan, who suggest that cultural changes are the best way to pursue sustainability. In
303 this paper, the researchers analysed the identity of its community regarding sustainability
304 issues and presented them to the decision-makers. The authors also presented key actions that
305 could lead to a more sustainable campus. These included: education/training through
306 coursework; eco-certification and community training; engagement through cultural liaison,
307 competitions and unit initiatives; and, assessment/monitoring through cultural indicators and
308 barrier surveys.

309 Changes made by decision-makers directly affect the continuity of sustainability
310 initiatives. Due to changes in deans every four years, the environmental and sustainable profile
311 of a given university can also change, as a result of divergent interests or priorities. Larrán
312 Jorge et al. (2014) discussed an approach to implement sustainability at Spanish universities in
313 their paper, and they identified how the senior management's will, opinion and perception of
314 the university's initiatives on sustainability were key for success.

315 *iii Lack of financial resources*

316 Elliot and Wright (2013) interviewed 27 Canadian university student unions'
317 presidents. They found that the greatest barrier to university sustainability was a lack of
318 financial resources. This was almost always the first (and main) barrier mentioned by the
319 respondents.

320 The financial resources of universities are usually related to the number of students
321 enrolled, the number of top research projects being developed, and by political influence.
322 Unfortunately, the environmental and sustainability field of research suffers by not being an
323 area of priority. This makes the whole chain fragile. What results is the deployment of
324 sustainable initiatives working on low incomes of funding and staffed and delivered most of
325 the time through the work of volunteers (Velazquez et al., 2005).

326 *iv. Lack of engagement between municipalities, companies and universities*

327 In general, the engagement of municipalities and the private sector within universities
328 consists of activities regarding capacity building, community outreach and problem based
329 research (Perkman et al., 2013; Shiel et al., 2016). Community outreach programs are kept on
330 a social level mainly through the initiation of academic staff or student bodies. Problem based
331 research, on the other hand, targets the cooperation of academia towards the pursuit of a
332 solution to an existing specific problem within the local municipality or the private sector. In a
333 study carried out by Perkman et al. (2013), it is proposed that when it comes to university and
334 industry cooperation, academic engagement is positively correlated with individual
335 characteristics that define senior, scientifically productive individuals. This indicates that it is
336 in line with the development of academic research activities, resulting in engagement being
337 less organizationally embedded but rather autonomously driven by individuals.

338 Alnsour and Meaton (2015) discussed the results of a study regarding the use of
339 research data by Jordanian planning authorities in their decision making processes, along with
340 the main factors that affect the use of research. Their findings revealed that the use of research
341 was quite low owing to various factors including: legal, administrative and technological
342 issues, in addition to financial, social and people related challenges.

343 Universities have the potential to play a leading role in enabling communities to
344 develop more sustainable ways of living. However, sustainable communities may only emerge
345 when there is the necessary facilitation, community learning and continual efforts to build
346 their capacities. Although capacity building and the promotion of sustainable development
347 locally, are on the agenda of most universities that take local and regional engagement
348 seriously, very little is published that illustrates or describes the various forms of activities that
349 take place in support of this. Further, there is a paucity of studies that have evaluated the work
350 performed by universities in building capacity for sustainable development at the local level
351 (Shiel et al., 2016).

352 *v. Lack of reporting and accountability mechanisms*

353 The United Nations has initiated the United Nation's Decade of Education for
354 Sustainable Development (2005-2014) and various other education for SD declarations. This
355 includes the Talloires Declaration, 1990 (ULSF, 2007), which was the first official statement
356 made by university presidents, chancellors and rectors related to sustainability. However, these
357 declarations largely lack discussion on a requirement for reporting or accountability
358 mechanisms. Lozano et al. (2013) propose that, although these initiatives are intended to serve
359 as supporting, guiding, and challenging documents, they alone cannot ensure that the signatory
360 institutions implement SD within their organizations. There might also be institutions that
361 have not yet signed a declaration or belong to any charter, but which are nonetheless actively
362 engaged in SD on their campuses.

363 Other significant reporting tools are AASHE's (The Association for the Advancement
364 of Sustainability in Higher Education) STARS and ISCN's (International Sustainable Campus
365 Network) Gulf Charter Report. STARS (Sustainability Tracking, Assessment & Rating
366 System) is a transparent, self-reporting framework for colleges and universities to measure
367 their sustainability performance designed for US universities, while the ISCN targets a global
368 member database of around 90 universities. The LiFE Index is another similar transparent,
369 self-reporting framework that is being increasingly utilized in Australasian universities and
370 colleges of advanced education (Macgregor, 2015).

371 An analysis made by Yarime and Tanaka (2012) on 16 accounting tools between 1993
372 and 2010, indicated that existing sustainability assessment tools are not sufficiently addressing
373 the importance of education, research and outreach activities in universities. In the
374 aforementioned study, a close look at the indicators and questions included in many
375 assessment tools revealed they tend to consider the environmental impacts of university
376 operations and issues related to governance.

377 Furthermore, a lack of detailed reporting and accountability mechanisms makes it
378 difficult for universities to track their in-house achievements or inadequacies in order to
379 support policies and learn from others' experiences.

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381 **3. Methodology**

382 Definitions of innovation and sustainability are numerous and clearly these terms refer
383 to different phenomena; however, in terms of adoption, there are common themes and barriers
384 within both (Bessant, Tidd, 2009). The research reported in this paper explores the barriers of
385 adopting innovation and sustainability initiatives within universities.

386 A mixed methods approach involving quantitative and qualitative methods was
387 adopted for this study (Phase 1 and Phase 2). It consisted of an online survey performed via
388 the software "Survey Monkey" where both university administrators and researchers were
389 asked to fill in a questionnaire with a set of questions related to the barriers they see and
390 perceive at their institutions when pursuing sustainability. **A total of 301 respondents from 172**
391 **universities around the world participated in the two phases of the research.**

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393 This design made it possible to elaborate a descriptive statement about a grouping and
 394 perform a description of trends and attributes, in addition to serving as a search engine about
 395 the context examined which would meet the definitions of Babbie (2009). The data was
 396 collected at various points in time throughout 2016 and was synthesized statistically (Hair et
 397 al., 2010).

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399 Phase 1 – Qualitative Approach

- 400 i. **Aim:** to identify the main barriers to innovation and sustainable development in
 401 universities worldwide and to have arguments to develop the questionnaire for use
 402 in Phase 2.
- 403 ii. **Sample:** In total, there were 51 respondents from Australia, Colombia, Ghana,
 404 South Africa, Austria, Cote d'Ivoire, Guatemala, Spain, Ecuador, Japan, Sweden,
 405 Brazil, England, Nigeria, Uganda, Chile, Finland, Philippines, United States,
 406 China, Germany, Portugal and Philippines. Those selected were: rectors of
 407 universities participating the Green Sustainability Metrics (2016); office managers
 408 of universities participating in the Green Sustainability Metrics; 20 researchers
 409 with significant numbers of publications on the subject in the database Web of
 410 Science; professors/lecturers and researchers with peer-reviewed impact
 411 publications on the subject of sustainability at universities
- 412 iii. **Data collection:** Data was collected during July and August 2016 using the *Survey*
 413 *Monkey* software, with the following questions: a) what is your position today in
 414 the institution? b) What are the main barriers encountered in the practices of
 415 sustainability related innovation in universities? c) Which processes/initiatives are
 416 most appropriate to increase the sustainable innovation capacity in universities? d)
 417 How can sustainability contribute to the creative process? e) How can
 418 sustainability/leverage the innovation process? f) Which partners are essential to
 419 engage in the process of innovation in universities? g) How can sustainability be
 420 incorporated into the innovation process in universities? h) What are the major
 421 gains that the university may obtain in adopting innovation and sustainability in its
 422 philosophy and in their practices? To carry out this study, the results were selected
 423 regarding answers to the following question: what are the main barriers
 424 encountered in innovation related to sustainability practices in universities?
- 425 iv. **Analysis procedure:** The qualitative approach adopted here followed the
 426 experiences documented by Bardin (2011). The technique involves reading and
 427 interpreting the material in a progressive and systematic way so that an inductive,
 428 constructive output emerges (Moraes, 1999). This resulted in a categorization of
 429 data. Following Vergara (2005), the categories were rearranged primarily based on
 430 the frequencies of common themes. Moraes (1999) suggests the following steps be
 431 applied: preparation of information (and encoding); notarization or transformation
 432 of the content into units of analysis; categorization or classification of units in
 433 categories; description; and interpretation and statistical treatment. The
 434 operationalization of the review process took place with the support of *Nvivo*
 435 software, which has been developed specifically to support qualitative studies
 436 (Mozzato and Grzybovski, 2001).

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Phase 2 – Quantitative Approach

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i. **Aim:** to evaluate the degree in which barriers influence the process of innovation and sustainable development at universities.

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ii. **Sample:** In total, there were 250 respondents from the following countries: Australia, Austria, Belarus, Belgium, Brazil, China, Cote d'Ivoire, Croatia, Czech Republic, Denmark, Ecuador, Finland, France, Germany, Ghana, Guatemala, Hong Kong PRC, India, Iran, Ireland, Italy, Japan, Latvia, Lithuania, Malta, Mauritius, México, Mongolia, Nigeria, Philippines, Poland, Portugal, Qatar, Scotland, Serbia, Singapore, South Africa, Spain, Syrian Arab Republic, Tanzania, Thailand, The Netherlands, The Republic of Belarus, Turkey, Uganda, United Kingdom and United States. With regards to a criteria of selection, the potential respondents were partly identified at the World Symposium on Sustainable Development at Universities, which was held 14th to 16th September 2016 at the Massachusetts Institute Technology in the United States of America.

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When it came to data collection, notifications were sent to potential respondents via email, inviting them to answer the questionnaires (available online from 10th the September to October 15th, 2016) using Google Docs®. The quantitative questionnaire was built according the content analysis, grouping similar words and similar attribute values obtained from the qualitative approach. This procedure indicated 25 categories of barriers, that generated 25 questions constructed around a 5-point likert scale (Likert, 1932) to measure the degree to which respondents agreed or disagreed with statements related to the barriers: 5 = totally agree; 4 = Agree; 3= Neutral; 2 = Disagree; 1 = Totally disagree. Malhorta (2006) confirms that the Likert scale enables respondents to indicate their degree of agreement (or disagreement) to statements about stimulus objects. In this case, the stimuli were barriers to sustainable development in universities.

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iii. **Analysis procedure:** The collected Data was analysed using the software 9.1® *Statistics*, SPSS - Statistical Package for Social Science. The barriers to innovation and sustainability were analyzed according to methods described by Hair et al. (2014), Montgomery (2001), Morrison (1984) for analyses of the degree of relevance of the barriers. The barriers obtained in this research were classified according the structure proposed by Macgregor (2014).

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4. Resulting barriers to Innovation and Sustainable Development in Universities

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Table 1 contains 25 categories (fundamental barriers) that were identified in Phase 1 of the research by the content analyses. The table also lists examples of reported studies (citations) that have investigated such barriers and these confirm that all of the barriers identified by the informants of Phase 1 have been also identified by previous research.

482 Table 1: Barriers to innovation and SD at universities identified from Phase 1

Nº	Categories that emerged from the interviews – Barriers	Authors of literature associated with the categories
1	Lack of planning and focus on the topic.	Brandli et al., (2015); Hansen and Grobe-Dunker (2013); Reidand Schwab (2006); Dahle e Neumayer (2001)
2	Lack of environmental committee.	Nidumolu, Prahalad, and Rangaswami (2009); Tauchen and Brandli (2006)
3	Lack of applicability and continuity of innovation and sustainability actions.	Brandli et al., (2015); Van Ginkel (1996)
4	Resistance to changes in behavior.	Barbieri et al., (2010); Brandli et al., (2015); Dahle e Neumayer (2001)
5	Lack of commitment towards innovation and sustainability.	Elliot e Wright (2013); Dahle and Neumayer (2001); Brandli et al., (2015)
6	Lack of Training and collaboration.	Brandli et al., (2015); Elliot and Wright (2013)
7	Strong culture and conservatism between people involved parties.	Brandli et al., (2015); Dahle and Neumayer (2001); Jackson (2005); Reid and Schwab (2006)
8	Lack of research and development (planning, projects, research).	Brandli et al., (2015); Veiga (2014); Elliot and Wright (2013);
9	Lack of awareness and concern (both staff and faculty)	Elliot e Wright (2013); Dahle and Neumayer (2001); Brandli et al., (2015)
10	Lack of building with appropriate sustainable performance.	Dahle and Neumayer (2001); Van Ginkel (1996)
11	Lack of support and involvement of the University administration.	Brandli et al., (2015); Dahle and Neumayer (2001); Hansen e Grobe-Dunker (2013); Leal filho, Shiel e Paço (2015)
12	Lack of appropriate technology.	Dahle and Neumayer (2001);
13	Lack of integration of teaching, research and extension (between campus and departments).	Waas et al. (2012); Brandli et al. (2015); Meyerson e Massy (1995)
14	Lack of dialogue (campus, departments and commissions)	Waas et al. (2012); Brandli et al. (2015); Meyerson e Massy (1995); Van Ginkel (1996)
15	Institutional barriers (excessive standards and requirements).	Brandli et al., (2015); Dahle and Neumayer (2001); Leal (2000); Leal Filho, Shiel and Paço (2015); Reid and Schwab (2006); Wright (2002)
16	Lack of support for the introduction of control system (resources and professionals).	Brandli et al., (2015); Cameron (1996); Crossan and Apaydin (2010); European Commission (2016); Ferreira e Dionísio (2016); Hart and Milstein (2003); Hockerts and Morsing (2008); Nidumolu et al., (2009); Paech (2007); Clugston (1999)
17	Lack of defined policies and practices.	Brandli et al., (2015); Leal Filho, Shiel and Paço (2015); Novicki and Souza (2010); Clugston (1999)
18	Lack of support in the introduction of control system (resources and	Crossan and Apaydin (2010); Glavik and Lukman (2007)

	professionals).	
19	Many restrictions and bureaucracy (excessive formalities and delay)	Wright (2002); Meyerson e Massy (1995); Dahle e Neumayer (2001)
20	Lack of Knowledge and education about the topic.	Brandli et al., (2015); Barbieri and Silva (2011); Cars and West (2015); Dahle and Neumayer (2001); Elliot and Wright (2013); Leal Filho (2000)
21	Lack of capacity for decision making (on part of managers.	Dahle e Neumayer (2001); Brandli et al., (2015)
22	Lack of Entrepreneurship and public-private partnerships (few relationships between the public and private institutions).	Waas et al. (2012); Riera (1996); Creigghton (1999); Dahle e Neumayer (2001)
23	Social barriers (conflicts between approaches, consumption behavior and unsustainable actions).	Waas et al. (2012); Brandli et al. (2015); Dahle e Neumayer (2001)
24	Government barriers (economic and political model of actions not included; Lack of legislation and guidelines for sustainability and innovation.	Brandli et al., (2015); Dahle and Neumayer (2001); Leal (2000); Leal Filho, Shiel e Paço (2015); Reid and Schwab (2006); Wright (2002)
24	Legislation and guidelines.	Waas et al. (2012); Meyerson e Massy (1995)

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484 The list of barriers obtained in this study is aligned with much research that has been discussed
 485 for some time, although some of them are only focused on the implementation of Sustainable
 486 Development at universities (Glavič and Lukman, 2007; Waas et al, 2012; Brandli et al, 2015,
 487 Leal Filho, Shiel e Paço, 2015) or on innovation at universities (Cameron, 1996; Clugston,
 488 1999; Crossan and Apaydin, 2010; Dahle and Neumayer, 2001; Hart and Milstein, 2003;
 489 Paech, 2007; Hockerts and Morsing, 2008; Nidumolu et al., 2009; Barbieri and Silva, 2011;
 490 Hockerts and Morsing, 2008; Cars and West, 2015; European Commission, 2016; Ferreira
 491 and Dionísio, 2016), and do not have an integrated vision about innovation and SD. The
 492 evaluation of the importance of the barriers identified in Table 1 points out the fifteen most
 493 significant barriers according to the results of the Likert scale (for each scale there was a
 494 weight correspondent, for example, the scale 5 expressed a greater degree of relevance in
 495 comparison to weight 1). Table 2 shows the results of the statistical analysis and Figure 2
 496 illustrates the score of importance of the barriers in terms of the degree with which they
 497 influenced the process of innovation and sustainable development at universities.
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Comentário do avaliador.
 This is not well formulated (...with WHAT HAVE many researches...).

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Table 2: Results of statistical analysis Phase 2

Nº	Variable – Barriers	Average*	Standart deviation	Variance	Sum
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11	Administration	3.9	1.0	1.0	134
12	Technology	2.7	1.0	1.0	95
09	Conscience and concern	2.6	1.1	1.2	90
02	Environmental Committee	2.6	1.2	1.5	89
10	Building	2.6	1.2	1.4	89
24	Government Barriers	2.5	1.1	1.2	85
08	Research and development	2.4	1.1	1.4	84
18	Support for the introduction of control systems	2.4	1.0	1.1	82
23	Social barriers	2.3	1.1	1.2	81
25	Legislation and guidelines	2.3	1.3	1.8	81
20	Knowledge and education	2.3	1.1	1.3	79
3	Applicability and continuity	2.2	1.1	1.3	78
6	Training and collaboration	2.2	1.1	1.4	78
15	Institutional barriers	2.2	1.1	1.3	78
17	Practice and policies	2.2	1.0	1.0	78
16	Incentives for innovation	2.2	1.3	1.7	76
19	Restrictions and bureaucracy	2.2	1.1	1.2	75
01	Planning and focused	2.1	1.0	1.0	74
07	Culture and conservatism	2.1	0.8	0.6	74
22	Entrepreneurship and public-private partnerships	2.0	1.0	1.1	71
14	Dialogue	2.0	1.0	1.0	70
05	Commitment towards innovation and sustainability	1.9	1.1	1.2	67
21	Capacity and decision	1.9	0.7	0.5	67
13	Integration of teaching, research and extension	1.9	0.9	0.9	65
04	Resistance to changes in behaviour	1.8	1.0	1.1	62

502 *Average has been calculated according the value attributed to score of Likert Scale: 5 =
503 totally agree; 4 = Agree; 3= Neutral; 2 = Disagree; 1 = Totally disagree.

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506 **5. Analyses of the barriers to innovation and sustainability at universities**

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Although the values attributed by the interviewees was low (on average, most of them considered the barriers neutral), the results can indicate a distribution in the weight of barriers, which means that a group of barriers may affect innovation and SD at universities.

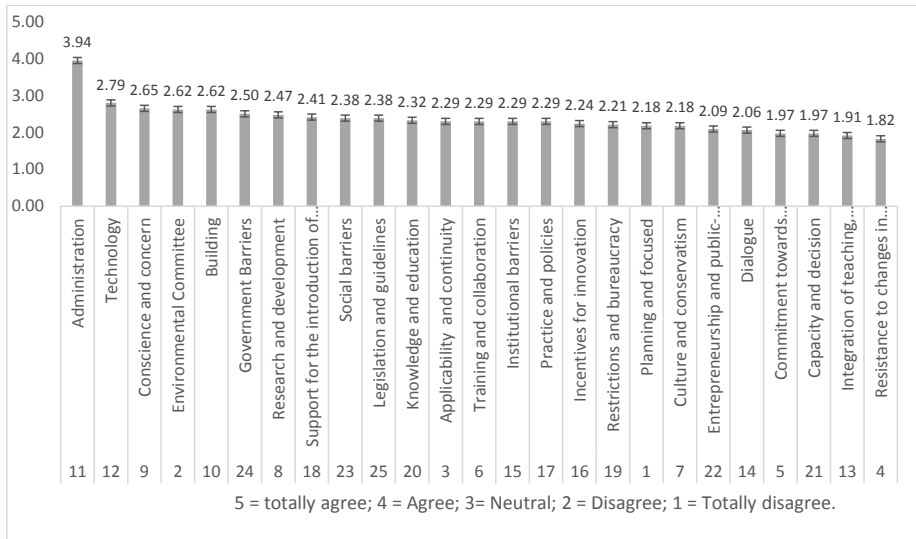


Figure 2: Relevance of the barriers to innovation and SD at universities

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515 The administration of the universities is the main barrier that influences the process of
516 innovation and sustainable development at universities. This is followed by a lack of
517 technology, lack of conscience and concern, lack or inefficiency of environmental committee
518 and a lack of sustainable buildings. Also cited are governmental barriers, research and
519 development, support for the introduction of control systems, social barriers, legislation and
520 guidelines, knowledge and education, applicability and continuity, training and collaboration,
521 institutional barriers, and practice and policy barriers.

522 A broad understanding of the nature and magnitude of the barriers to innovation and
523 sustainability at universities in an international context is important to managers, the academic
524 community and especially to campus managers, who seek to develop strategies and actions in
525 this area. The results gathered from the study performed in the context of this paper, show that
526 the largest number of barriers are within the area of management (i.e. university
527 administration, environmental committees, in research and development, in the introduction
528 and/or support of control systems, in terms of legislation and formal guidelines, and with
529 respect to knowledge and education). Other barriers are in the areas of policies, infrastructure,
530 resources, capacity and institutional culture. A university that is seeking to go towards a more
531 sustainable path is bound to face a series of internal and external barriers (Brandli et al., 2015).
532 It is therefore necessary to deal with these barriers in a systematic manner, so that they may
533 not negatively influence further developments and not lead to a loss of interest from the side of
534 the community involved.

535 One particular barrier, namely the lack of support from the university administration
536 (score: 3.94) seems to be the biggest obstacle according to the respondents. One of the major
537 problems among university administrators is that there may not be an understanding that

538 sustainability and innovation in universities are among the main strategies to help them to
 539 address social and economic inequalities. Operationally, such integration could be achieved by
 540 means of the creation of a sustainable campus and by fostering the training of students through
 541 teaching practices (Stir, 2006; Lozano et al., 2013). But one may ask whether or not current
 542 university administrations are aware (or give importance) to work in this area or support to
 543 actions in these fields. It is observed that a lack of support from university administrations has
 544 a direct influence on the other barriers, which are essential for the development and integration
 545 of the university campus.

546 The integration of sustainability principles on a university campus can be achieved by
 547 perceiving such campuses as places where new ideas can be tested, new opportunities can be
 548 explored, and by regarding them as habitats where the development and implementation of
 549 new technologies, new innovations and new management strategies with a focus on
 550 sustainability in scale can take place (Evans et al., 2015; Alshuwaikhat and Adam, 2008).
 551 Universities should be seeking to improve the possibilities of expanding innovations out of
 552 their "walls", through a process of continuous learning, not only within the universities
 553 themselves, but in close collaboration with municipalities and the private sector (Trencher,
 554 2014). Dlouhá, Glavič and Barton (2016), when analyzing the critical factors for
 555 sustainability transition in HEI, argue that to reach ESD innovations, research activities and
 556 innovation in the context of university curricula, extensive changes in teaching/learning
 557 processes are essential.

558 According to the participants of this study, a lack of appropriate technology (score: 2.79)
 559 and a lack of suitable buildings (score: 2.71) are some of the other major barriers that prevent
 560 the development of many actions, projects and the integration of sustainability principles on
 561 campuses. Therefore, a better performance in these areas is important in order to achieve
 562 structural and operational improvements, to better engage the various actors, and to generate
 563 ideas and the involvement of the academic community. It is especially important to raise the
 564 awareness of and concern for these issues from both staff and students (score: 2.64). These
 565 measures may help to overcome the challenges, and may also help to create a sense of identity
 566 between universities and the community (Clarke and Kouri, 2009).

567 The fourth major barrier when it comes to the development of innovation and sustainability, is
 568 the lack of formal settings, such as an "environmental committee" (score: 2.61). Such
 569 committees have a key role to play as they assist in the development of more sustainable
 570 universities through actions towards the reduction of their environmental impacts, as well as in
 571 the promotion of education, research, and the development of new initiatives for sustainable
 572 development.

573 An analysis indicates that many universities have not yet advanced in a number of
 574 areas that are required for the full implementation of sustainable development principles. In
 575 most cases, adjustments in campus operations are required, to be supported by best practices to
 576 improve both performance and the fostering of relationships with the key actors both within
 577 and without universities.

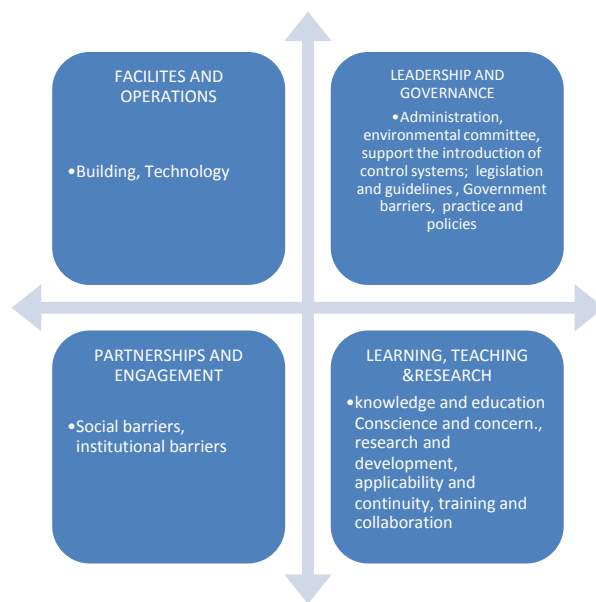
578 In terms of the domains of campus innovation, Velazquez et al (2005) propose four
 579 areas (research, campus, education, outreach). Jones, Selby and Sterling (2010) also
 580 demonstrate a structure, but with a key difference: they include culture and research as an
 581 integral part of curriculum. Analyzing the barriers obtained for an area, it can be noted that no

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582 single one of these structures is suitable. An adaptation that includes the “Leadership and
583 Governance” and “Partnership and Engagement” in the structure proposed by Macgregor
584 (2014) seems to be appropriate for the framing of the barriers.

585 Figure 3 shows the structure based on Macgregor (2014) and the classifications of the
586 barriers. The barriers presented illustrate areas where development is lagging behind in this
587 process of innovation and SD at universities, especially with respect to leadership and
588 governance and learning, teaching and research.

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593 **Figure 3 – Barriers according to the domains**

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595 **Conclusions**

596 There has been a noticeable increase in the number of discussions regarding teaching
597 and research when it comes to sustainable development over recent decades. Despite this,
598 there are not many studies which investigate the relationship between innovation and
599 sustainability, even when there is evidence to suggest that by converging these two processes
600 long term impacts and benefits are achieved.

601 This research has identified a set of gaps in knowledge which need to be fulfilled. First
602 of all, when a university seeks to implement sustainability initiatives as part of its daily
603 activities, a set of barriers are encountered. As this paper has pointed out, even though many

604 of these barriers are well known, they still exist. Additionally, the main barriers found for the
 605 deployment of innovation and sustainability tend to be associated with management (i.e.
 606 university administration, environmental committees, the introduction and/or support of
 607 management systems; management in terms of policy and formal guidelines). Other barriers
 608 faced are those associated with technology, resource availability and institutional culture.
 609 However, even if these other barriers are tackled, without addressing issues associated with
 610 management little progress may be expected.

611 A further item worthy of attention here is the fact that a lack of support from the
 612 university administration is one of the most important obstacles faced when trying to
 613 implement sustainability within the institution. Unfortunately, this study showed that many
 614 university leaders do not yet see the importance of innovation and sustainability when it comes
 615 to addressing issues such as social and economic inequalities throughout the university. It is
 616 important that decision makers and the general community see campuses as places for
 617 opportunities and areas that can be the birthplace for new management strategies and the
 618 deployment of technologies.

619 Moreover, this study has shown that many universities which participated in the
 620 research need several adjustments in their campus operations. Most have not yet elaborated a
 621 document that states their goals or overall mission when it comes to sustainability. Further, a
 622 number of universities have not established and/or are not pursuing sustainability goals, and
 623 have not yet fostered effective relationships with stakeholders from within and outside of the
 624 university.

625 The implications of the research here are clear: there is a need for a change of thinking
 626 with respect to the fact that sustainability should not only be part of campus operations, but
 627 that it should also be a part of teaching and research. Sustainability should be embedded in the
 628 relationships with external partners (e.g. industry) in order to unlock opportunities for
 629 investments in education, infrastructure and technological research.

630

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