BARRIERS TO INNOVATION AND SUSTAINABILITY AT UNIVERSITIES AROUND THE WORLD

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Published at the Journal of Cleaner Production, Volume 164, 15 October 2017, Pages 1268-1278 https://www.sciencedirect.com/science/article/pii/S0959652617314531

Highlights:

There are strong links between innovation and sustainability in a higher education context

The barriers exist in different geographical regions

Greater support from university administrations to implement sustainability are needed

Closer cooperation between university administrations and sustainability researchers are needed.

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Abstract

This paper explores the links between innovation and sustainability in a higher education context, with the purpose of investigating the fundamental barriers for innovation and sustainable development in universities around the world. The method used involves both a quantitative and a qualitative approach, gathering the views of more than 300 experts from various universities across all continents. The results show that there are similar barriers in different geographical regions, requiring greater support from university administrations and management. In particular, the willingness of leaders, policy makers and decision-makers to envisage a sustainable future inside universities is often missing. Yet, without the support of senior management within a university, bottom-up sustainable initiatives seem destined to fail in the longer term due to lack of investments and administrative support. The study also identified the fact that in order to yield the expected benefits, the identified barriers need to be tackled in an integrated way, and that closer cooperation between sustainability researchers, university administrations and students, are needed.

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

1. Introduction

Much has been written about teaching and research on sustainable development (Posch and Steiner, 2006) and the development of eco-innovation (Del Rio, Carrillo-Hermossilla and Könnöla 2010; Hellström 2007). But comparatively little literature can be found on the nexus between innovation and sustainable development. Yet, there is a very close relationship between innovation and sustainability (Vollenbroek, 2002).

Indeed, these two processes are well related since, when they converge, they often lead to long term impacts and benefits. The relations between innovation and sustainability can be better understood, if one considers their structure and areas of application. A closer look at these two processes allows the identification of the fact that there are two main types of innovation on sustainable development:

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

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

Albeit rather simple and straightforward to understand in principle, these two main types of innovation on sustainable development are characterized by the need to carefully reflect on their degree of applicability before they may be implemented. This fact lends them some degree of complexity. It is a fact that the changes in the organization system of a university are not easy, and that the appointment of a sustainability coordinator, for example, may not a matter that each university can do (or may wish to do) for financial reasons. Therefore, one has to assess the conditions at each institution before an innovation or initiative in support of sustainable development can be fully realized at the institutional level.

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

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

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

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

Principle 4- Economic viability: innovation on sustainable development can also help reduce costs and minimize loss of financial resources. For instance, in universities across the world, millions of kilowatts of energy are wasted powering printers and computers etc. when they're not in use, implying substantial amounts of money is being spent needlessly. While computers and notebooks are typically used all day, most printers are used for only a few minutes in each working day, despite the fact that they are switched on continuously. A simple innovation such as only turning printers on when they are needed can substantially reduce both the energy consumption and the energy bill of a university.

Unlike other areas, innovation on sustainable development is not characterized by a great degree of uncertainty: if properly implemented, it has proven to work. Sustainable development innovation can be simple to achieve provided it is based on a really good idea, and seldom entails any risks. On the contrary, innovation on sustainable development may be advantageous to universities in a variety of ways, as outlined in Figure 1.

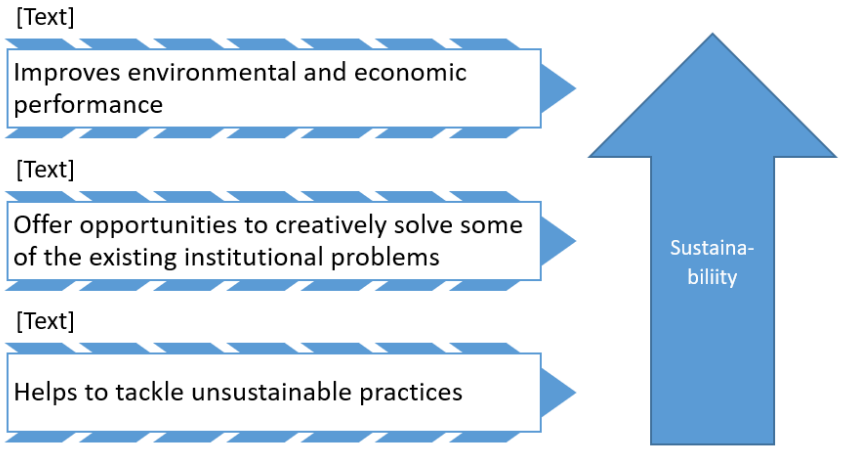


Figure 1- Advantages of innovation on sustainable development to universities

Nevertheless, despite the fact that universities are faced with increasing pressures to use of their resources and consider sustainable development as part of their operations, many are still reluctant to revise their business models, and incorporate the necessary changes. Part of the problem is because of the investments required are seen as a barrier, whereas the benefits in respect of both environmental and economic performance are often overlooked.

This paper explores the links between innovation and sustainability in high education context, with the purpose of investigating the fundamental barriers for innovation and sustainable development in universities around the world.

2. The problems seen in innovation on sustainable development at universities

Pursuing sustainability at universities is one of the main strategies to strengthen society, especially where aspects of social and economic equity and a healthy environment are taken

into account, by means of teaching, research and outreach practices (Stir, 2006; Lozano et al., 2013). University campuses can be understood as small towns, translating such spaces as habitats for the development and implementation of new social and technological innovations and management strategies regarding sustainability in a pilot scale (Evans et al., 2015; Alshuwaikhat and Abubakar, 2008). The implementation of sustainability at universities can improve the possibilities of expand their innovation potential, both within and outside a campus' walls, facilitating a continuous learning process between academia, municipality and the private sector (Trencher, 2014).

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

Most sustainable innovations have focused on the campus of a university. Here, operational innovations such as renewable energy installations, initiatives with solar arrays, wind turbines, geothermal projects, biomass production facilities, conservation retrofits, energy efficient designs has been introduced (Thomashow, 2014). As Leal Filho et al (2015) have showed, the campus greening has a straight connection with the innovative projects, transfer of models for the surrounding community and possibility to implement innovative green technologies. The popularity and influence of university rankings has spawned large numbers acreditation Schemas (Lauder et al, 2015), .for example Ecocampus (2017) and rankings such as the People & Planet League in the UK were centered initially on the environmental management of a university. More recently, the attention has shifted and attempts have been made to include the core activities of a university, namely research, education and environment indicators rankings (Lukman, Krajnc and Glavic, 2010). In terms of the curriculum, many universities are still lagging behind and offering courses and programmers which either fully or partly fail to incorporate aspects of sustainable development (Capdevila, Bruno and Jofre, 2002; Müller-Christ, 2014). As far as research is concerned, even though there is a plethora of scientific works and studies published, they most often use well known methods and techniques (e.g. surveys) but do not always exercise care to ensure the validity or reliability of their data, under an innovation perspective. As a result, many studies tend to repeat trends as opposed as offer a basis for ground-breaking innovation. The most common innovations in teaching and research is to have separate offerings, so for example a Master in CSR or a research centre focusing on sustainable development or climate change; this has not been matched by structural innovations to embed sustainability or sustainable development across the curricula and across research centers.

In respect of community and student engagement, only a few universities have a vision how all these areas may support each other. There are some recent accreditation schemes which appear promising, such as the UK LiFE (Learning in Future Environments) Index, which encourages a holistic view of the university by considering four themes: leadership and

governance, partnerships and engagement, facilities and operations, and teaching and research. However, many universities still miss opportunities to strategically link between these areas.

The willingness of leaders, policy makers and decision-makers to envisage a sustainable future inside universities is often missing (Richardson and Lynes, 2007). Without the support of senior management within a university, bottom-up sustainable initiatives seem destined to fail in the longer term due to lack of investments and administrative support. To develop these kinds of initiatives requires considerate amounts of time and financial resources, which are difficult to obtain without the higher administration support. As a result, staff and student entrepreneurs in sustainability often fail to progress with such initiatives.

Furthermore, appropriate instruments are often not in place because senior management tend not to define specific goals in this area, nor agree on a holistic vision. Yet, setting goals is important to define the intentions of the university in respect of sustainability as a whole, and innovation for sustainable development in particular. Wright (2002) suggests that the University of Waterloo, the University of South Carolina, the University of Buffalo, the University of Toronto, and George Washington University, are examples of universities that have become leading universities in sustainability by elaborating and accomplishing their sustainable vision, objectives and goals.

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

-A diverse community of students, faculty and staff, varying in its priorities and level of engagement;

-A great diversity of buildings and activities that include offices, laboratories, dining halls, dormitories and maintenance;

- A broad distribution of age and cultural aspects;

-Limited financial and human resources for developing, implementing and continuing sustainable initiatives.

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

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

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

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

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

In connection with this issue, the role played by a lack of internal political instruments, such as policies, plans and programme can also be seen. These instruments are important for the strengthening of sustainable initiatives because they provide a legal background (Pereira, 2014). Research by Ryan et al. (2010) indicates the importance of policies in supporting the smooth delivery of SD in the HE curriculum, including mechanisms such as open and clear communication. Furthermore, changes in quality assessment and quality enhancement processes are needed to support the delivery of 'effective learning and innovation for sustainability' (Ryan and Tilbury, 2013:273).

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

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

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

By creating settings such as "offices of sustainability" a university is able to hire someone to deal (full-time or on a part-time basis) specifically with sustainability, as well as creating a hierarchical position filling the gap of a leadership amongst the minor's stakeholders with decision-making power. The lack of a person to deal specifically with this issue inside the

university translates in the weakening of the sense of identity of the university community. Having someone or some specific place to address doubts or observations about sustainability issues is essential (Gudz, 2004)

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

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

ii.Cultural and behavioral change

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

Levy and Marans (2012) affirm, through a case study at the University of Michigan, that cultural changes are the best way to pursue sustainability. On this paper, the researchers identified the identity of its community regarding sustainability issues and presented them for the decision-makers. The authors also presented key actions that can lead to a more sustainable campus. These included: education/training through coursework; eco-certification and community training; engagement through cultural liaison, competitions and unit initiatives; and, assessment/monitoring through cultural indicators and barrier surveys.

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

iii.Lack of financial resources

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

The financial resources of universities are usually related to the number of students enrolled and number of top research projects being developed and by political influence. Unfortunately, the environmental and sustainability field of research suffers by not being a priority field. This aspect makes the whole chain fragile, what can be noticed is the deployment of sustainable initiatives working of low incomes of funding and most of the times with volunteering work (Velazquez et al., 2005).

iv.Lack of engagement between municipalities, companies and universities

In general, the engagement of municipalities and private sector with universities consists of activities about capacity building, community outreach and problem based research (Perkman et al., 2013; Shiel et al.,2016). Community outreach programs are kept on a society- level mainly by initiation of academic staff or student bodies. Problem based research on the other hand targets the cooperation of academia in pursuit of finding a solution to an existing specific problem of the municipality or the private sector. In a study carried out by Perkman et al. (2013), it is proposed that regarding university and industry cooperation, academic engagement is positively correlated with individual characteristics that define senior, scientifically productive individuals, indicating that it is in line with furthering their academic research activities, resulting engagement being less organizationally embedded but rather autonomously driven by individuals.

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

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

v. Lack of reporting and accountability mechanisms

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

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

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

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

3. Methodology

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

A mixed methods approach involving quantitative and qualitative methods was adopted for this study (Phase 1 and Phase 2). It consisted of an on-line survey performed via the software "Survey Monkey" where both university administrators and researchers were asked to fill in an on-line questionnaire with a set of questions related to the barriers they see and perceive at their institutions when pursuing sustainability.

This design made it possible to elaborate a descriptive statement about a grouping and perform a description of trains and attributes, in addition to serving as a search engine about the context examined, going to meet the definitions of Babbie (2009). The data were collected at a various points in time –during 2016- and synthesized statistically (Hair et al., 2010).

<u>The Phase 1 – Qualitative Approach</u>

i. **Aim:** to identify the main barriers to innovation and sustainable development universities worldwide and to have arguments to develop the questionary for use in Phase 2.

ii. **Sample:** In total, 51 respondents from Australia, Colombia, Ghana, South Africa, Austria, Cote d'Ivoire, Guatemala, Spain, Ecuador, Japan, Sweden, Brazil, England, Nigeria, Uganda, Chile, Finland, Philippines, United States, China, Germany, Portugal and Philippines. Criteria of selection: rectors of universities participating the Green Sustainability Metrics (2016); office managers of universities participating in the Green Sustainability Metrics; 20 researchers with the greater numbers of publication on the subject in the database Web of Science; professors/lecturers and researchers with peer-reviewed impact publications on the subject of sustainability at universities

iii. **Data collection:** Data was collected during July and August 2016 using the *Survey Monkey* software, with the following questions: a) what is your position today in the institution? b) What are the main barriers encountered in the practices of sustainability related innovation in universities? c) Which processes/initiatives are

most appropriate to increase the sustainable innovation capacity in universities? d) how can sustainability contribute to the creative process? e) How can sustainability/leverage the innovation process? f) Which partners are essential to engage in the process of innovation in universities? g) How can sustainability be incorporated into the innovation process in universities? h) What are the major gains that the university may obtain in adopting innovation and sustainability in its philosophy and in their practices? To carry out this study, the results were selected the following question: what are the main barriers encountered in innovation related to sustainability practices in universities*?*

iv. **Analysis procedure**: The qualitative approach adopted here followed the experiences documented by Bardin (2011). The technique involves reading and interpreting the material in a progressive and systematic way so that an inductive, constructive output emerges (Moraes, 1999). This resulted in a categorization of data. Following Vergara (2005), the categories were rearranged based primarily on the frequencies of common themes. Moraes (1999) suggests the following steps be applied: preparation of information (and encoding); notarization or transformation of the content into units of analysis; categorization or classification of units in categories; description; and interpretation and statistical treatment. The operationalization of the review process took place with the support of *Nvivo* software, which has been developed specifically to support qualitative studies (Mozzato and Grzybovski, 2001).

The Phase 2 – Quantitative Approach

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

ii. **Sample:** In total, 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. Criteria of Selection: The potential respondents were partly identified from 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.

iii. **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 questionnaire contained 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. The questionnaire was designed according the data obtained in Phase 1, following the statements: Lack of planning and focus on the topic; Lack of environmental committee; Resistance to changes in behavior; Lack of applicability and continuity of innovation and sustainability actions; Lack of commitment towards innovation and sustainability action; Lack of training and cooperation about innovation and sustainability(team actions and the academic community). Strong culture and conservatism between people involved parties; 8. Lack of research and development (planning, projects, research) ;Lack of awareness and concern (both staff and faculty). Lack of building with appropriate sustainable performance; Lack of appropriate technology; Lack of integration of teaching, research and extension (between campus and departments); Lack of dialogue (campus, departments and commissions); Institutional barriers (excessive standards and requirements), Lack of incentives for innovation/funding; Lack of defined policies and practices; Lack of support in the introduction of control system (resources and professionals); Many restrictions and bureaucracy (excessive formalities and delay); Lack of knowledge and education about the topic.; lack of capacity ofr decision making (on part of managers); Lack Entrepreneurship and public-private partnerships (few relationships between the public and private institutions); Social barriers (conflicts between approaches, consumption behavior and unsustainable actions); Government barriers (economic and political model of actions not included; Lack of legislation and guidelines for sustainability and innovation.

iv. **Analysis procedure**: Data collected were analysed using the software 9.1® *Statistics*, SPSS – Statistical Packge for Social Science. Barriers to innovation and sustainability were analyzed according to methods described by Hair et al. (2014), Montgomery (2001), Morrison (1984)

4. Results of the barriers to innovation and SD at universities

The Table 1 contains 25 categories (fundamental barriers) that were identified in the 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 all the barriers identified by the informants of Phase 1 have been identified previous research.

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

N°	Categories that emerged from the interviews – Barriers	Authors of literature associated with the categories
01	Planning and focus	Brandli et al., (2015); Hansen and Grobe-Dunker (2013); Reidand Schwab (2006); Dahle e Neumayer (2001)
02	Environmental Committee	Nidumolu, Prahalad, and Rangaswami (2009); Tauchen and Brandli (2006)
03	Applicability and continuity	Brandli et al., (2015); Van Ginkel (1996)

04	Resistance to changes in behavior	Barbieri et al., (2010); Brandliet al., (2015); Dahle e Neumayer (2001)
05	Commitment towards innovation and sustainability	Elliot e Wright (2013); Dahle and Neumayer (2001); Brandli et al., (2015)
06	Training and collaboration	Brandli et al., (2015); Elliot and Wright (2013)
07	Culture and conservatism	Brandli et al., (2015); Dahle and Neumayer (2001); Jackson (2005); Reid and Schwab (2006)
08	Research and development	Brandli et al., (2015); Veiga (2014); Elliot and Wright (2013);
09	Conscience and concern	Elliot e Wright (2013); Dahle and Neumayer (2001); Brandliet al., (2015)
10	Building	Dahle and Neumayer (2001); Van Ginkel (1996)
11	Administration	Brandli et al., (2015); Dahle and Neumayer (2001); Hansen e Grobe-Dunker (2013); Leal filho, Shiel e Paço (2015)
12	Technology	Dahle and Neumayer (2001);
13	Integration of teaching, research and extension	Waas et al. (2012); Brandli et al. (2015); Meyerson e Massy (1995)
14	Dialogue	Waas et al. (2012); Brandli et al. (2015); Meyerson e Massy (1995); Van Ginkel (1996)
15	Institutional barriers	Brandli et al., (2015); Dahle and Neumayer (2001); Leal (2000); Leal Filho, Shiel and Paço (2015); Reid and Schwab (2006); Wright (2002)
16	Incentives for innovation	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	Practice and policies	Brandli et al., (2015); Leal Filho, Shiel and Paço (2015); Novicki and Souza (2010); Clugston (1999)
18	Support for the introduction of control systems	Crossan and Apaydin (2010); Glavik and Lukman (2007)
19	Restrictions and bureaucracy	Wright (2002); Meyerson e Massy (1995); Dahle e Neumayer (2001)
20	Knowledge and education	Brandli et al., (2015); Barbieri and Silva (2011); Cars and West (2015); Dahle and Neumayer (2001); Elliot and Wright (2013); Leal Filho (2000)
21	Capacity and decision	Dahle e Neumayer (2001); Brandli et al., (2015)
22	Entrepreneurship and public-private partnerships	Waas et al. (2012); Riera (1996); Creigghton (1999); Dahle e Neumayer (2001)
23	Social barriers	Waas et al. (2012); Brandli et al. (2015); Dahle e Neumayer (2001)
24	Government Barriers	Brandli et al., (2015); Dahle and Neumayer (2001); Leal (2000); Leal Filho, Shiel e Paço (2015); Reid and Schwab (2006); Wright (2002)
25	Legislation and guidelines	Waas et al. (2012); Meyerson e Massy (1995)

The list of barriers obtained in this study is aligned with many researchers have been discussing for some time, although some of them have the focus only in the implementation of the Sustainable Development at universities (Glavik and Lukman, 2007; Waas et al, 2012; Brandli et al, 2015, Leal filho, Shiel e Paço, 2015) or in innovation at universities (Cameron, 1996; Clugston, 1999; Crossan and Apaydin, 2010; Dahle and Neumayer, 2001; Hart and Milstein, 2003; Paech, 2007; Hockerts and Morsing, 2008; Nidumolu et al., 2009; Barbieri and Silva, 2011; Hockerts and Morsing, 2008; Cars and West, 2015; European Commission, 2016; Ferreira and Dionísio, 2016), and do not have an integrated vision about innovation and SD.

The evaluation of importance the barriers identified in the Table 1 point out fifteen highest barriers according the results of Likert scale. Table 2 shows the results of statistical analysis and Figure 2 illustrates the score of importance of the barriers in terms of degree with them influence in the process of innovation and sustainable development at universities.

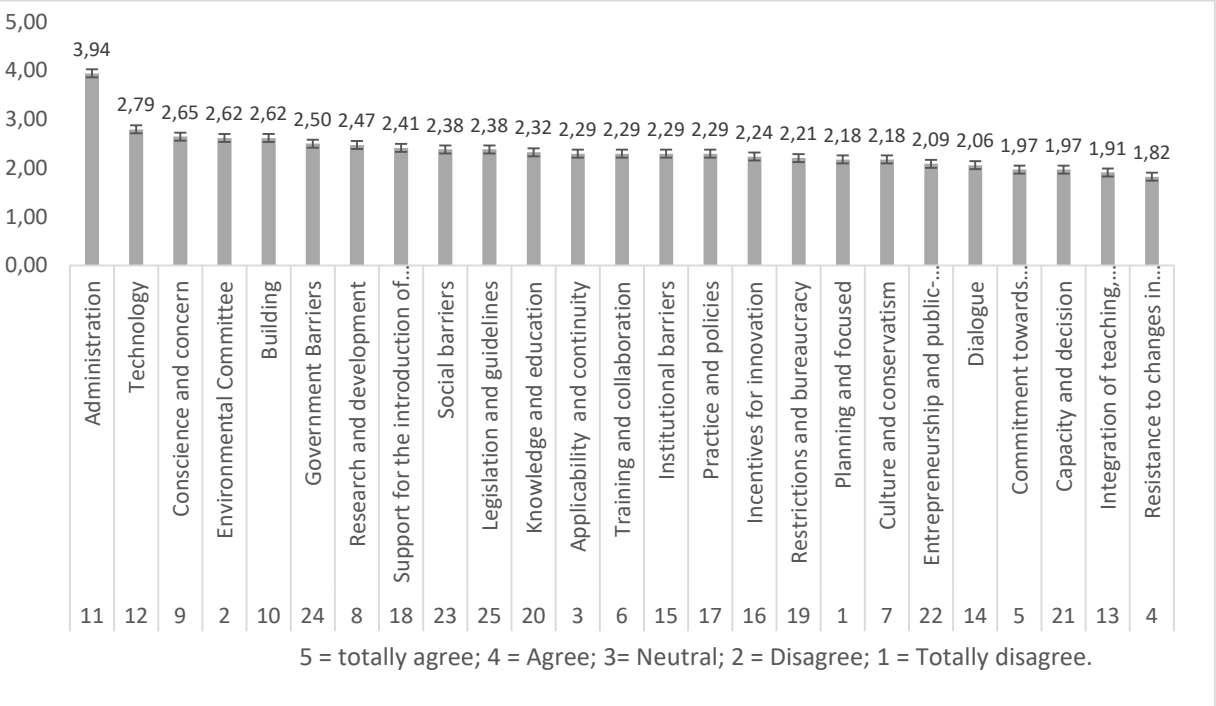
Table 2: Results of statistical analysis Phase 2

N[9]	Variable – Barriers	Average*	Standart deviation	Variance	Sum
11	Administration	3,9411765	1,013280794	1,026737968	134
12	Technology	2,7941176	1,038046293	1,077540107	95
09	Conscience and concern	2,6470588	1,124987621	1,265597148	90
02	Environmental Committee	2,6176471	1,255646782	1,576648841	89
10	Building	2,6176471	1,206414821	1,45543672	89
24	Government Barriers	2,5000000	1,134847473	1,287878788	85
08	Research and development	2,4705882	1,18667588	1,408199643	84
18	Support for the introduction of control systems	2,4117647	1,076403863	1,158645276	82
23	Social barriers	2,3823529	1,128547092	1,273618538	81
25	Legislation and guidelines	2,3823529	1,371013911	1,879679144	81
20	Knowledge and education	2,3235294	1,173458711	1,377005348	79
3	Applicability and continuity	2,2941176	1,168511401	1,365418895	78
6	Training and collaboration	2,2941176	1,194162868	1,426024955	78
15	Institutional barriers	2,2941176	1,168511401	1,365418895	78
17	Practice and policies	2,2941176	1,030722364	1,062388592	78
16	Incentives for innovation	2,2352941	1,304045536	1,700534759	76
19	Restrictions and bureaucracy	2,2058824	1,122211339	1,259358289	75
01	Planning and focused	2,1764706	1,028991511	1,058823529	74
07	Culture and conservatism	2,1764706	0,833778847	0,695187166	74
22	Entrepreneurship and public-private partnerships	2,0882353	1,083419029	1,173796791	71
14	Dialogue	2,0588235	1,013280794	1,026737968	70

05	Commitment towards innovation and sustainability	1,9705882	1,114240987	1,241532977	67
21	Capacity and decision	1,9705882	0,758199387	0,574866310	67
13	Integration of teaching, research and extension	1,9117647	0,965076447	0,931372549	65
04	Resistance to changes in behaviour	1,8235294	1,086294459	1,180035651	62

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

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



Although the value attributed by the interviewees is low (On average, most of them consider the barrier as neutral), the results can be indicating a distribution in the weight of barriers, which means that a group of barriers may difficult innovations and DS at universities.

The administration of the universities is the main barriers that influence in the process of innovation and sustainable development at universities, following the lack of technology, lack of conscience and concern, lack or inefficiency of environmental committee and lack of sustainable building. In other level, are cited the government barriers, research and development, support for the introduction of control systems, social barriers, legislation and guidelines, knowledge and education, applicability and continuity, training and collaboration, institutional barriers, and practice and policies.

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

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

One particular barrier, namely lack of support from the university administration (score: 3.94) seems to be the biggest obstacle according to the respondents. One of the major problems among university administrators is to understand that sustainability and innovation in universities are among the main strategies to help them to address social and economic inequalities. Operationally, such integration could be achieved by means of the creation of a sustainable campus and by fostering the training of students through teaching practices (Stir, 2006; Lozano et al., 2013). But one may ask the question if current university administrations are aware (or give importance) to works in this area or support to actions in these field? It is observed that lack of support from university administrations, have a direct influence on other barriers, which are essential for the development and integration of the university campus.

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

According to the participants of this study, lack of appropriate technology (score: 2.79) and the lack of suitable buildings (score: 2.71) are some of the barriers that prevent the development of many actions, projects and the integration of sustainability principles on campuses. Therefore, a better performance in these areas is important in order to achieve structural and operational improvements, better engage the various actors, and in seeking to generate ideas, the involvement of the academic community, and especially the awareness and concern from the side of the staff and students (score: 2.64). These measures may help to overcome the challenges, also creating a sense of identity between universities and the community (Clarke and Kouri, 2009).

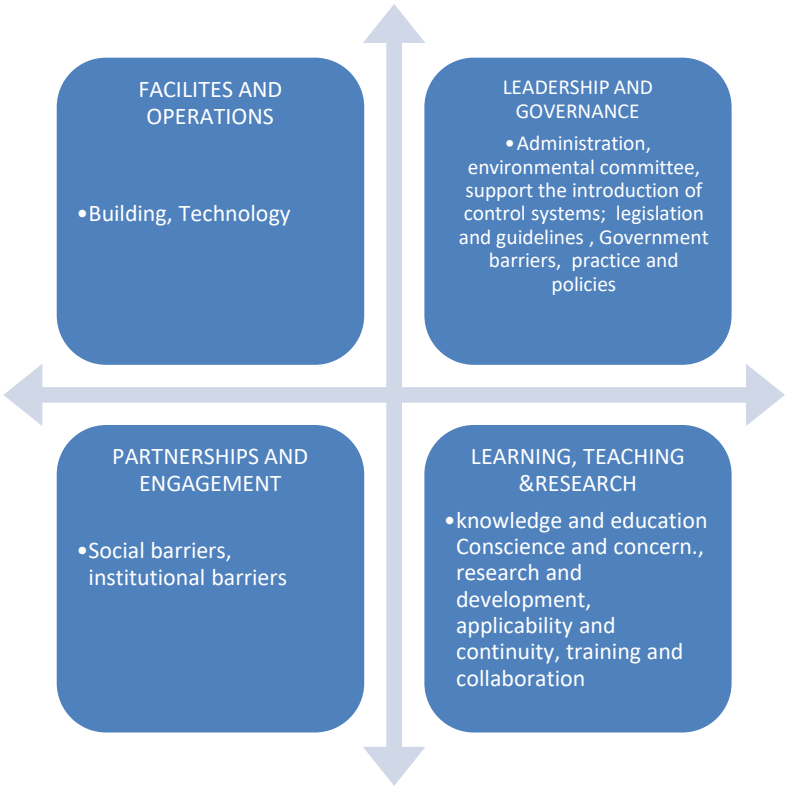
The fourth barrier considered essential for the development of innovation and sustainability, is the lack of formal settings, such as an "environmental committee" (score: 2.61). Such committees have a key role to play as they assist in the development of more sustainable universities through actions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

An analysis indicates that many universities have not yet advanced in the several areas required for a full implementation of sustainable development principles. In most cases, adjustments in campus operations are required, to be supported by best practices to improve both, performance and foster their relationships with the key actors within and outside universities.

In terms of domains of campus innovation, Velazquez et al (2005) propose four areas (research, campus, education, outreach). Jones, Selby and Sterling (2010) also show a structure, but with a difference: they include the culture and research is an integral part of curriculum. Analyzing the barriers obtained for area, can be noted, no one of these structure is suitable. An adaptation including the "Leadership and Governance" and "Partnership and Engagement" in the structure proposed by Macgregor (2014) seems to be appropriate for the framing the barriers.

The Figure 3 shows the structure based in Macgregor (2014) and the classifications of the barriers. The barriers presented illustrate areas whose development is lagging behind in this process of innovation and SD at universities, especially in respect Leadership and governance and Learning, teaching and research.

Figure 3 – Barriers according the domains



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592 **Conclusions**

593 There has been a noticeable increase in the discussions regarding teaching and research
594 on sustainable development over recent decades. Despite this fact, there are not many studies
595 which investigate the interface between innovation and sustainability, even when there are
596 evidences that by converging these two processes long term impacts and benefits are achieved.

597 This research has identified a set of gaps in knowledge, which needs to be fulfilled. First
598 of all, when a university seeks to implement sustainability initiatives as part of its daily
599 activities, a set of barriers are encountered. Even though many of these barriers are well know,
600 they still exist as this paper has pointed out. In addition, the main barriers found for the
601 deployment of innovation and sustainability is seen to be in respect of management (i.e.
602 university administration, environmental committee, in the introduction and/or support of
603 management systems; in terms of policy and formal guidelines). Other barriers faced are in
604 respect of technology, resources availability and institutional culture, but without addressing the
605 management ones, little progress may be expected.

A further item worthy attention on this conclusions section is the fact that lack of support from the university administration is one of the most important obstacles faced when trying to implement sustainability at universities. Unfortunately, the study showed that many university leaders do not yet see the importance of innovation and sustainability for addressing issues such as social and economic inequalities throughout the university. It is important that decision makers and the community see campuses as places for opportunities and a birthplace for new management strategies and technologies deployment.

Moreover, this study has shown that many universities which participated in the research need several adjustments on their campus operations. Most have not yet elaborated a document stating their goals or mission on sustainability. Also, a number of them have not established and/or are not pursuing sustainability goals, and have not yet fostered effective relationships with stakeholders from within and outside the university.

The implications of the research here are clear: there is a need for a change of thinking in respect of the fact that sustainability should not only be part of campus operations, but that it should be part of teaching and research, and embedded on the relations with external partners (e.g. industry), unlocking opportunities in respect of investments in education, infrastructure and technological research.

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