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# A bibliometric study on “education for sustainability”

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## Abstract

The scientific production on “education for sustainability” has been growing in recent years what demonstrates the attention this subject has gathered. To better understand and characterize this trend, a bibliometric study of international papers on the subject was developed. The results show that the production has been growing since the middle of the last decade, focusing on the field of the applied social sciences, environmental sciences, energy, management, engineering, humanities and psychology. Australia, United Kingdom, United States, New Zealand, Spain, Israel and Canada are the countries that stand out, and it was possible to characterize the evolution of the production in each of these countries in the last 10 years, as well as to indicate the most used journals, the associated sub-themes, the most cited papers, the most productive authors and their affiliations. This allowed us to understand how the research on “education for sustainability” is being developed, showing its level of maturity and the most frequent themes and journals that have published more papers in the area. It was also possible to identify some themes which present research opportunities. The practical results of this study serve as a guideline for researchers, helping them to explore the available bibliography and the better ways to convey their production.

**Keywords:** Bibliometric study, Education for sustainability, Scientific production analysis, Articles production

## Introduction

In the mid twentieth century, Bush (1945) considered the difficulties a researcher faced to find the results that hundreds of researchers had attained. He observed how difficult it was to deal with great quantities of information and the increasingly time it took to keep updated and to produce academic works. Even though the Internet has been offering the tools, which could potentially solve this issue, especially via Web and the Indexation basis of journals, a kind of vicious cycle has been created that impacts the search process. There is an increasingly number of publications, easily created with online systems, to disclose the ever-growing number of scientific researches. Indexation systems like Web of Science and Scopus make millions of articles available to the public. Therefore, we can see that the situation Bush (1945) faced has not changed, once researchers are still dealing with the same difficulties to select the most relevant facts amidst immense bibliographic oceans. Consequently, the bibliometry gained traction as the researchers are trying to understand what is happening in their field of study (Tague-Sutcliffe 1992).

In fact, for decades, bibliometry has provided scientific concepts and technical elements to measure the scientific production (Tague-Sutcliffe 1992; Price 1961, 1976), but its usage was restricted to librarians and researchers from the field of the Information Sciences (De Bellis 2009). Such a scenario has changed with the availability of online systems for cataloging and indexing, which facilitate to retrieve Information from the ever-growing number of electronic scientific journals. Basis like Web of Science and Scopus display thousands of scientific articles about bibliometry, or use bibliometric techniques, as well as well many other basis of journal indexation do. Nevertheless, the wider availability of indexation systems is just an operational explanation. In fact, it is important to verify which are the motives that led to the constant development of bibliometric studies.

Bibliometry offers elements to strategic evaluations and decisions making, such as grants for a given research, enhancing collections, analysis of the performances of scientists and publications, prospection of emerging themes for research, analysis of invisible colleges and collaboration nets, among many other possibilities (Andrés 2009). The present paper was developed under this perspective, considering the importance that the theme “education for sustainability” has been acquiring, especially from the last decade on. This was considered as a great opportunity to characterize the production on the mentioned subject, showing to the scientific community how it is being developed. The results show that there is a growing interest from the applied social sciences and from the environmental sciences on “education for sustainability, as well as from many other science fields. The practical implication of the present study is to be a reference for researchers, helping them to explore not only the available bibliography but showing them the best way to convey their production.

## Background

The generation of knowledge depends on the development of new studies and their disclosure to the scientific community. Using the concepts and techniques derived from the bibliometry, the analysis of the dynamics of the scientific production, on a given field, can reveal a lot about it and can offer a more precise picture of the field itself or the theme. When this kind of analysis characterizes the evolution of the scientific production, it shows the main scientific areas working on a given theme, indicates the more productive authors and institutions, the more cited articles and the more consulted scientific journals, among many other possibilities (Holden et al. 2012; De Bellis 2009). Other than that, comparison analysis can show the maturity of some areas or the themes that the researchers are interested on (Torbatí and Chakoli 2013; Kawamura et al. 2000).

At its origin, bibliometry was concentrated on the studies of the more quantitative aspects of the scientific production and its diffusion (Tague-Sutcliffe 1992). With the availability of online services, there were many developments in indexations that made the search for scientific Information easier to do. Little by little, bibliometry encompassed concepts and techniques like scientometry and infometrics, causing an overlapping of areas, as identified by Hood and Wilson (2001). Scientometry allowed bibliometry to work with models related to production and divulgation of the technologic and scientific knowledge (De Bellis 2009). On its turn, infometrics led bibliometry to evaluate the quantitative aspects of information in a social group, not necessarily

formed by scientists (De Bellis 2009). Currently, bibliometric studies comprise a quantitative analysis of the scientific production and its evolution, they also have a more flexible and comprising perspective (Gorraiz and Gumpenberger 2015). Recent studies supply elements to analyze the performance of scientists and publications (Abramo and D'Angelo 2015; Blagus et al. 2015; Ellegaard and Wallin 2015), to prospect the emerging themes of research (Dong and Chen 2015), to analyze the invisible colleges and collaboration nets (Dong and Chen 2015; Holden et al. 2012; Vogel 2012), to identify the more prominent researchers and the strategies to promote research (Heidler and Hallonsten 2015).

Among the tools that bibliometry provides, we can highlight the Law of Lotka (Pillai Sudhier 2013), which allows us to evaluate the degree of maturity of the scientific production from a given group or field. In scientific groups that are more developed, a few authors concentrate a high scientific production, while the greater majority present a more reduced production (Urbizagastegui 2009, 2011); The Law of Bradford helps us to identify the publications that concentrate more articles on specific themes (Xu 2011). According to this law, journals that feature specific themes are more searched by authors that work with this very same theme. This generates a virtuous cycle that feeds itself; The Law of Zipf is used to identify key words that better characterize a theme or a field of knowledge (Bence and Oppenheim 2004; Tague and Nicholls 1987). Nevertheless, it is important to consider that the use of the above-mentioned laws is not exempt of criticism, and may result in controversial conclusions due to the means of the measurement, the parameters of the evaluation, tests and interpretation (Raas 2005).

## Methods

The present study was developed aiming to present the international production of scientific articles about “education for sustainability” and was conducted with the specific bibliography support (Blagus et al. 2015; Tsai 2015; Dong and Chen 2015; Gerring 2012; Holden et al. 2012). The databases Web of Science and Scopus were searched to gather data. To search in these databases the followings queries were used:

1. Web of Science—TOPIC: (“education for sustainability”) Refined by: DOCUMENT TYPES: (ARTICLE) Timespan: All years Search language = Auto;
2. Scopus—TITLE-ABS-KEY (“Education for Sustainability”) AND DOCTYPE (ar) where (ar) restricts the search to scientific articles.

From the information obtained in the two databases, 294 scientific articles were analyzed, many of which are found both in the Web of Science and in Scopus. The group of analyzed articles comprised publications from 1993 to 2015 (partial). The following information from all the 294 articles was downloaded:

- Authors' name, affiliations and countries.
- Document title.
- Year of publication.
- Source title/journal name.
- Volume, Issue, Pages.

- Citation count.
- Abstract.
- Keywords.

The data were processed in the Automax applicative, a system used for processing bibliographic and bibliometric data. The Tropes software was also used for analyzing texts of abstracts and keywords. The results of the data processing were grouped as follows and the results were exported to an Excel spreadsheet, allowing the preparation of the charts included in this article:

- Evolution of the international production
- Evolution of the Australian production of international articles
- Production trend of international articles in the United Kingdom
- Evolution of the American production of international articles
- Production trend of international articles in New Zealand
- Production trend of international articles in Spain
- Production trend of international articles in Israel
- Production trend of international articles in Canada
- Main areas that concentrate articles on “Education for Sustainability”
- Lotka’s law applied to the production of articles
- More productive authors and their affiliations
- More cited papers
- More used journals
- The most used scientific methods

It is important to consider that for an item to be accounted for the production of a country, it is necessary that at least one of the authors is associated with a teaching or research institution in the related country. Thus, it is possible that the same scientific article is accounted for more than one country.

According to this survey strategy and data analysis, it was possible to understand how the research subject “education for sustainability” is being developed and which are its perspective for the future. Using the search key “education for sustainability” (applied to the title, abstract, and keywords) 279 articles, produced by 157 different authors from 36 countries, were analyzed. Processing these data led to the results that are presented and discussed as follows.

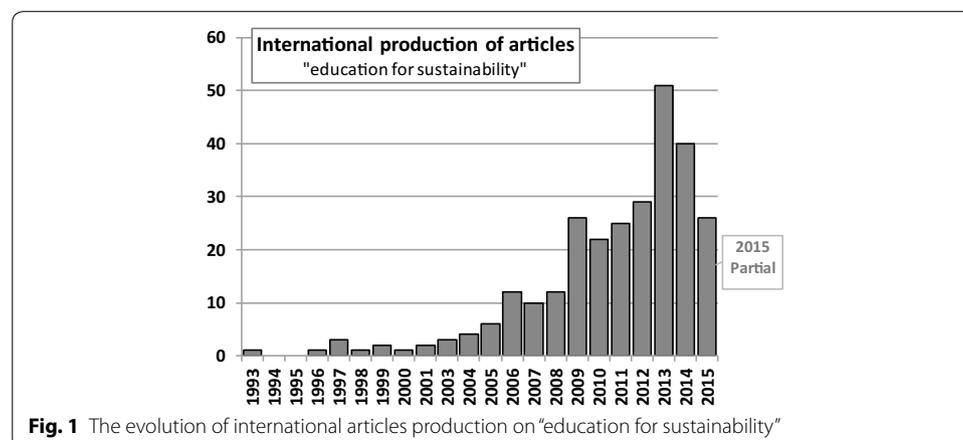
## **Results and discussion**

The production of scientific articles about “education for sustainability” first appears, although very incipiently, in the 1990’s with works like Carroll’s (1993), that considered the challenges to be faced in order to reach a sustainable development, this very same vision was retaken by Johnston (1997). With the perspective of the United Nations as an inducer of public policies, inclusively in the education field, Smyth et al. (1997) evaluated the actions of the Commission on Sustainable Development. The study by Shallcross (1996), on its turn, deals with “education for sustainability” more specifically, considering that this expression is used for a new vision of the environmental education and

sustainable development following the principles of the Agenda 21. Likewise, Cawsey (1997) working with “education for sustainability” in a more specific way considers that the syllabus of the formal education should be changed to incorporate the issue of sustainability and to have it as a central focus of activities. Shallcross and Wilkinson (1998) have a more specific strategic approach considering that environmental education is one of the aspects to be taken into consideration in the “education for sustainability”. The mentioned authors evaluate constructivist strategies as being inducers of behavioral changes, which could make the principles of education with focus on sustainability more effective. Such a proposal was evaluated by Scott (1999) who comments on the lack of clarity in some proposals or approaches to environmental education or education for sustainability.

However, from the mid 2000’s it gains traction, as showed on Fig. 1. At that time, we can highlight the studies that evaluate “education for sustainability” from a more specific point of view, detaching it from the environmental education and analyzing its meaning and comprehensiveness (Jickling 2000; Haury 2001; Stables and Scott 2001; Taylor et al. 2003). As per Jickling (2000) “education for sustainability” was quickly accepted, but little attention has been paid to this expression, meanwhile Stables and Scott (2001) comment that “education for sustainability” must be inspired by pre-modern practices instead of being guided by the currently prevailing pragmatism. Taylor et al. (2003) consider the need of a more holistic approach, while Haury (2001) recommends an approach that includes a qualitative improvement to the day-to-day life. As the quantity of studies grew, a more specific focus can be seen, and more recent papers have their focus on the education of the teachers (Cebrián and Pubill 2014; Falkenberg and Babiuk 2014; Shephard and Furnari 2013), working in elementary schools (Ärlemalm-Hagsér 2013), in high-schools (Gottlieb et al. 2013), and in universities (Markley Rountree and Koernig 2015; Schweinsberg et al. 2013; Sidiropoulos 2014), or exploring didactical and syllabus strategies (Duggan et al. 2015; Jones and Galloway 2013; Medir et al. 2014).

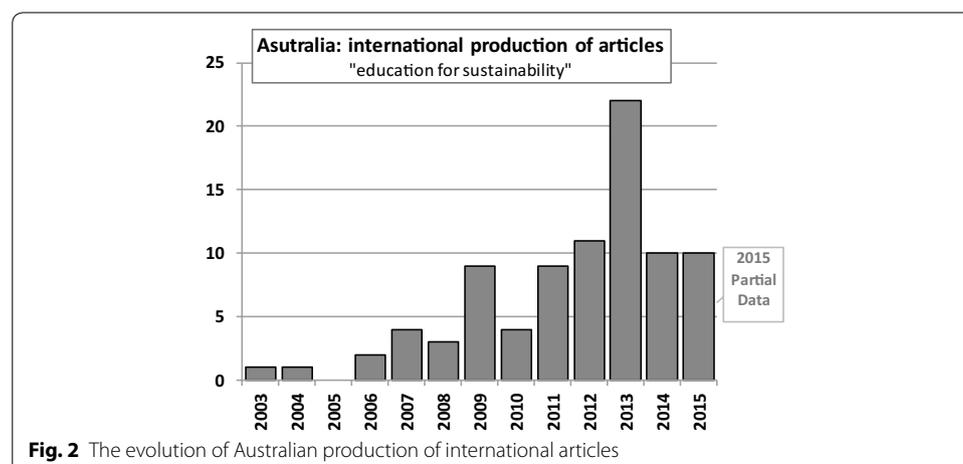
In addition, there were innovative approaches, as the one discussed by Andrews (2015) about the “circular economy” as opposed to the linear model of “take-make-use-dispose” originated from the Industrial Revolution. The afore mentioned author proposes that this new economic model, that advocates the efficiency of the processes, could reduce the quantity of waste and would incentive the reuse and recycling, having the “education

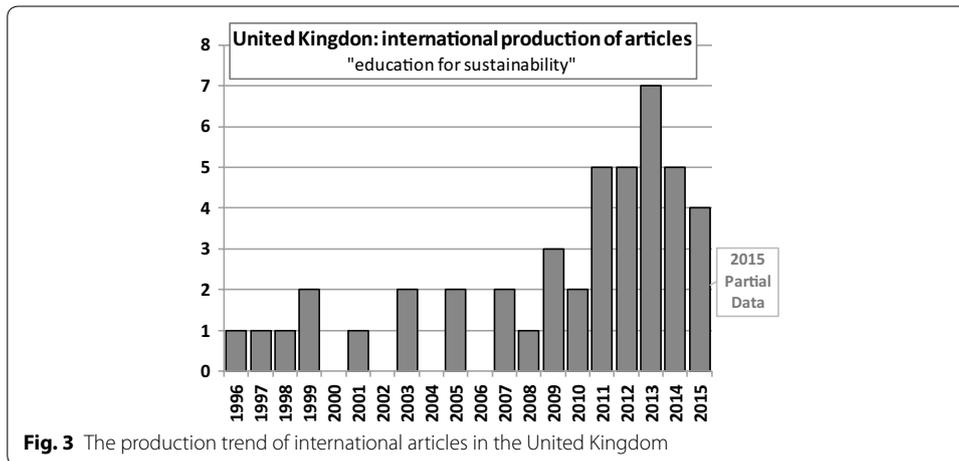


for sustainability” as an implicit part of the process. Popescu (2015) follows the same path when questioning if the current model, that recommends the growth of the Gross Domestic Product, can be supported without damaging the environment. Brantmeier (2013), on his turn, argues that an education for sustainability must consider the inherent right of both people and ecosystems to live and prosper with dignity, demanding the “education for sustainability” as a catalyst of a transforming process. In a summary of the period from the 1990’s to 2015, Wheeler et al. (2015) consider that the education for a sustainable development impacted the education in the last decade, but they question if it is enough to compensate the changes occurring all over our planet. Those authors consider that UNESCO’s focus has been on the academic realm, ignoring the actions in communities and organizations (both public and private). As educators, Wheeler et al. (2015) consider that it is necessary to establish bridges to apply academic teachings to the daily practices.

As to the production in various countries, the spotlight is on Australia that shows a growing trend in research since the 2000’s (Fig. 2), highlighting the production by Julie Margaret Davis (Queensland University of Technology QUT, School of Early Childhood) who is carrying out researches about developing “Education for Sustainability” with children (Gambino et al. 2009; Elliott and Davis 2009; Effeney and Davis 2013; Hill et al. 2014; Dymont et al. 2014). Another highlight goes to Ian G. Thomas (Royal Melbourne Institute of Technology University, School of Global, Urban and Social Studies) who has been dedicating his studies to this same theme, but in relation to the higher education (Holdsworth et al. 2008; Thomas 2009; Thomas et al. 2013; Thomas and Day 2014).

The United Kingdom (Fig. 3) is also presenting a considerable production, related to this theme, which has started in the late 1990’s (Shallcross 1996; Smyth et al. 1997; Shallcross and Wilkinson 1998; Sato and James 1999; Scott 1999) with different approaches. British production, in general, kept low rates until 2008 when it started to show a significant increase. From this more productive period one can highlight John F. Huckle (Bedford Coll of Higher Education) analyzing the education of teachers (Huckle 2012), commenting on future perspectives (Huckle 2014) or analyzing the actions from the United Nations (Huckle and Wals 2015). There are studies from Andrew Stables (University of Roehampton) either approaching pragmatic aspects of the “education for

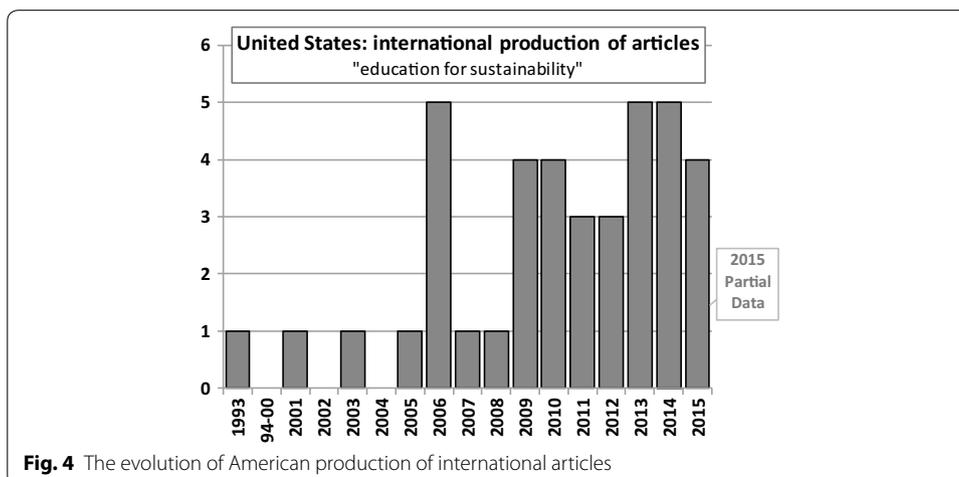


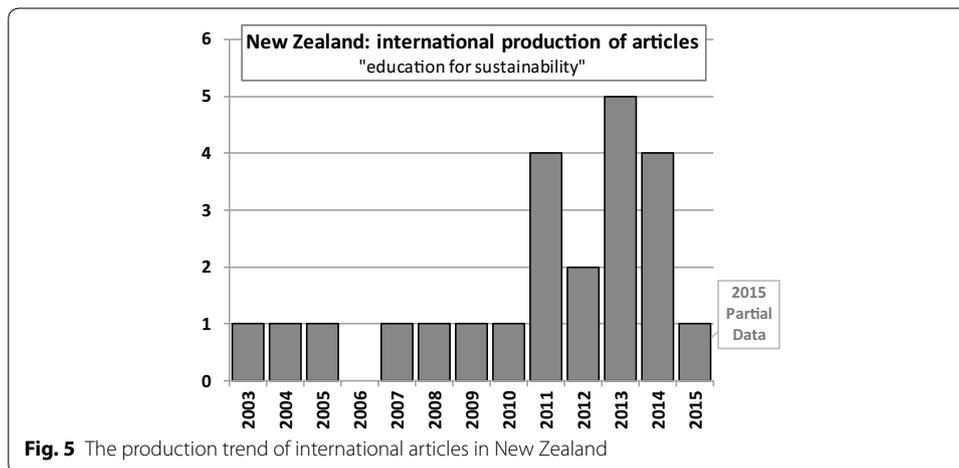


sustainability” (Stables 2010) or discussing the ontological and epistemological aspects of the “education for sustainability” (Gough and Stables 2012), retaking and reconsidering the aspects approached by Stables and Scott (2001).

Just like what happened in the United Kingdom, the production in the USA gained traction late in the first decade of the current century (Fig. 4). From this more recent period, one can cite the works by Lynnette D. Madsen e Ashley A. White (National Science Foundation) discussing the actions from the National Science Foundation, having the theme of “education for sustainability” as a background (White et al. 2013; Madsen and White 2014) and by John L. Motloch (Ball State University) about an association Brazil–USA (Motloch and Casagrande 2010).

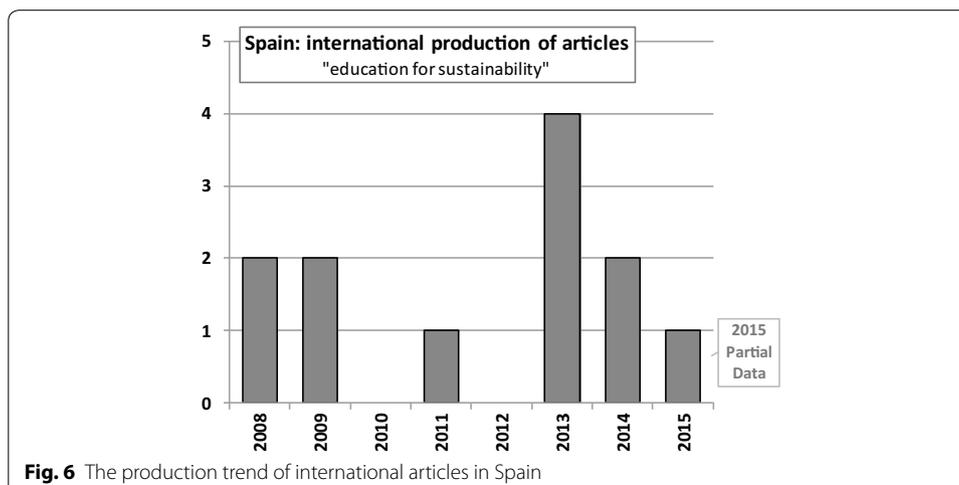
In New Zealand, the production is gaining more traction in the current decade (Fig. 5), presenting authors like Kerry Shephard, Mary Furnari e Harraway, John A. (University of Otago) and Glynne Mackey (University of Canterbury) as its most recent representation. Those studies refer to child education (Mackey 2012), analyze the possibility of incorporating sustainability into higher education syllabus (Mann et al. 2013), discuss the environmental education in open spaces (Irwin and Straker 2014) or the environmental attitudes of university students (Shephard et al. 2015).





Spain has presented a production with some oscillations from the last decade on (Fig. 6). The production has been concentrated around the “Universitat de Valencia” and the “Universitat de Girona”. There are studies discussing the higher education (Junyent and De Ciurana 2008; Minguet and Angels Ull Solís 2009), more specifically about Chemistry teaching (Vilches and Gil-Pérez 2013; Vilches and Pérez 2013) or analyzing the Spanish context (Medir et al. 2014).

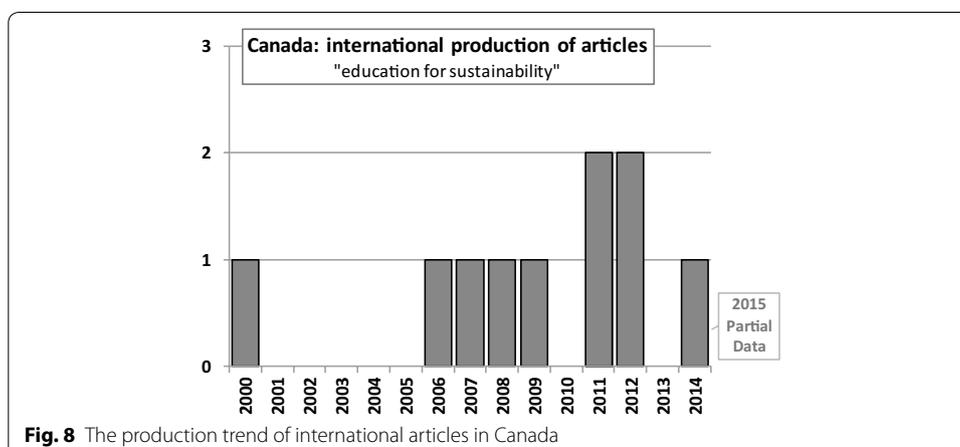
In Israel, the production started in 2004 (Fig. 7) with the study by Zoller and Scholz (2004) where the authors discuss the aspects of the “higher-order cognitive skills” focusing on learning towards sustainability. There is a gap in the Israeli production between 2005 and 2009, and the production about “education for sustainability” was resumed in 2010 with the work by Tal and Alkahrer (2010) who propose a program for “education for sustainability” for multicultural societies. It is worth noting that there are some other studies that discuss the multicultural issues related to teaching Jews and Arabs (Alkahrer and Tal 2011; Negev and Garb 2014). Just like in other countries, there also are studies about higher education (Mintz and Tal 2013, 2014).

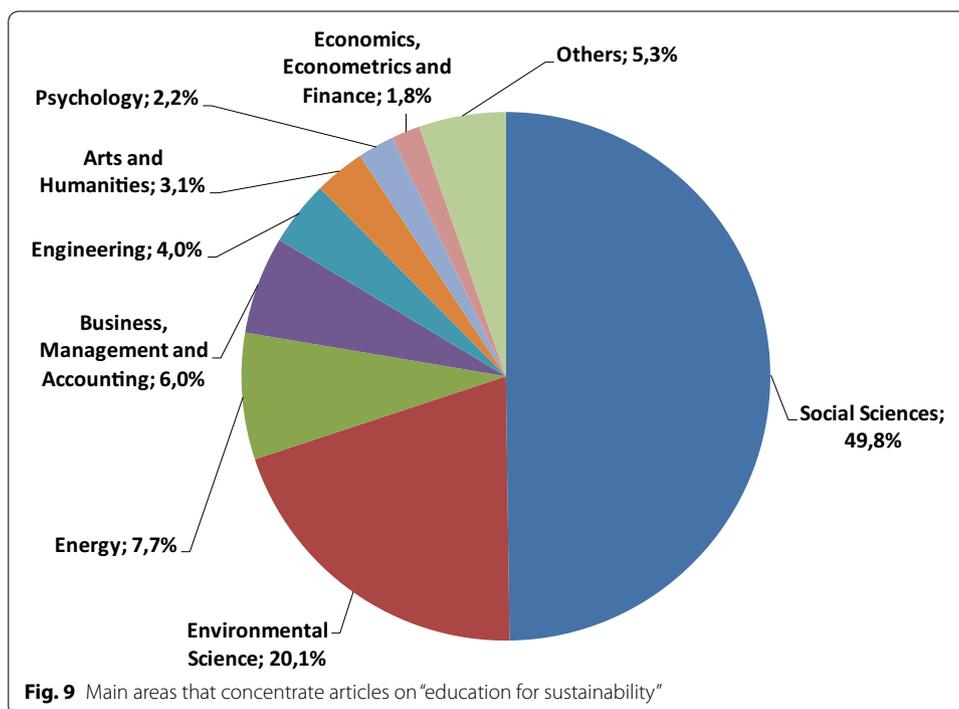




As per Fig. 8, the production in Canada is still low, but it has been featuring a trend to grow, in the years 2011 and 2012, although there are gaps in the current and the past decades. The most recent studies about “education for sustainability” discuss a variety of themes like the development of strategies and approaches to the post high school education (Buszard and Kolb 2011), proposals for the education of teachers (Falkenberg and Babiuk 2014) or educational strategies in view of the dominant economic paradigm (Lautensach and Lautensach 2011). There are researches about the role of the “education for sustainability” as a catalyst of the environmental activism among young people (Bencze et al. 2012), establishing a liaison with the considerations by Logan and Sutter (2012) as to the role of voluntarism and public programs.

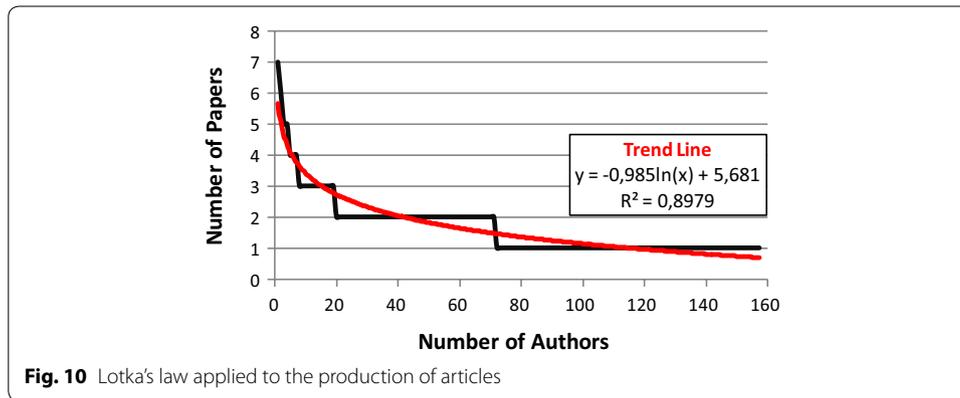
As per Fig. 9, a considerable part of the international production about “education for sustainability” happens in the field of the social sciences, followed by the environmental sciences, both featuring interdisciplinary characteristics. This aspect justifies the comprehensiveness of the themes approached in the studies that were analyzed, which is fully justifiable by the wide range of possibilities comprised by the “education for sustainability”.





The previous graphics show that, in spite the recent progress in some countries, the production of scientific articles about “education for sustainability” is still in its initial stage of growth. Applying the Law of Lotka allows us to evaluate the maturity stage of a scientific field by analyzing the number of publications by author (Urbizagastegui 2009, 2011), and can be applied to different fields (Torbati and Chakoli 2013; Pillai Sudhier 2013). In the fields that have been developed for many years, it is possible to see the high number of works produced by a small number of authors. Therefore, in those very same areas, there is a high number of researchers with a low number of published works. This fact makes an author, who wants to be prominent, to commit to the theme for long years and to produce many articles.

In themes that are more recent this phenomenon is quite reduced, with a decreasing difference between the total number of articles published by the most productive authors and the remainder of the researchers. For the articles about “education for sustainability”, the application of the Law of Lotka (Pillai Sudhier 2013; Torbati and Chakoli 2013) can be verified in Fig. 10. It is possible to verify that the most productive author is Julie Margaret Davis (7 articles), followed by Ian G. Thomas (6), Matthias Barth (5) and Tali Tali Tal (5), as per Table 1. It is evident that in the field of “education for sustainability” is in the consolidation phase and still presents a good possibility for mobility among the authors. It is possible that, in a few years, a researcher that has two or three published papers can move from right to left, increasing his/her production and climbing up to a position among the most productive authors. Nevertheless, it is necessary to consider that, due to the growth occurred in the last few years (Fig. 1), this scenario may change in a few years and there may be a higher concentration of works in an ever more restricted group of researchers, just as it happens in fields that have been developed for a longer time.



**Table 1** More productive authors and her or his affiliations

Author	No. articles	Affiliation
Davis, Julie Margaret	7	Queensland University of Technology QUT, School of Early Childhood, Brisbane, Australia
Thomas, Ian G.	6	Royal Melbourne Institute of Technology University, School of Global, Urban and Social Studies, Melbourne, Australia
Barth, Matthias	5	University of Applied Sciences Ostwestfalen-Lippe, Institute for Competence Development, Hoxter, Germany
Tal, Tali Tali	5	Michigan State University, CREATE for STEM Institute, East Lansing, United States
Baudains, Catherine	4	Murdoch University, School of Veterinary and Life Sciences, Perth, Australia
Lewis, Elaine Christopher	4	Coolbinia Primary School, Perth, Australia
Mansfield, Caroline F.	4	Murdoch University, School of Education, Perth, Australia
Ferreira, Jo Anne	3	Griffith University, Griffith School of Environment, Brisbane, Australia
Littledyke, Michael	3	University of New England Australia, School of Education, Armidale, Australia
Alkaher, Iris	3	Kibbutzim College of Education, Tel Aviv-Yafo, Israel
Hill, Allen	3	University of Tasmania, Hobart, Australia
Manolas, Evangelos I.	3	Dimokrition Panepistimion Thrakis, Department of Forestry and Management of the Environment and Natural Resources, Komotini, Greece
Zoller, Uri	3	University of Haifa, Faculty of Science, Haifa, Israel
Huckle, John F.	3	Bedford Coll of Higher Education, Bedford, United Kingdom
Shephard, Kerry	3	University of Otago, Higher Education Development Centre, Dunedin, New Zealand
Stables, Andrew	3	University of Roehampton, London, United Kingdom
Stubbs, Wendy	3	Monash University, School of Geography and Environmental Science, Melbourne, Australia
Taylor, Neil A J	3	University of New England Australia, School of Education, Armidale, Australia
Dymont, Janet E.	3	University of Tasmania, Hobart, Australia

Under this perspective, it will be interesting to follow what happens to the Australian researchers, taking into consideration that Australia is the country that presents more articles about “education for sustainability” originated in the developed researches at the Queensland University of Technology, Royal Melbourne Institute of Technology University, Murdoch University, University of New England Australia, University of

Tasmania, among others (Table 1). It will also be important to follow the development of the researches in the United Kingdom and in the USA. These two countries have also featured a strong increase in the scientific production in the last few years.

In relation to the most cited articles (Table 2), there is a variety of themes and approaches. For instance, the higher education was approached by Steiner and Posch (2006), Juárez-Nájera et al. (2006) and Fadeeva and Mochizuki (2010), showing that there is a high degree of interest in this kind of study, which characterizes an opportunity for studies. The use of innovative strategies is also the object of interest (Dieleman and Huisingh 2006) of the environmental management of university campus (Koester et al. 2006), analysis of proficiencies for the sustainable development (Mochizuki and Fadeeva 2010) that also are opportunities for studies opened to researchers studying other themes associated with the “education for sustainability”.

**Table 2 More cited papers**

Title						
Authors	Source	Year	Volume	Edition	Citations	Annual average
1. Higher education for sustainability by means of transdisciplinary case studies: an innovative approach for solving complex, real-world problems						
Steiner, G; Posch, A	Journal of Cleaner Production	2006	14	9-11	57	5.7
2. Greening of the campus: a whole-systems approach						
Koester, RJ; Eflin, J; Vann, J	Journal of Cleaner Production	2006	14	9-11	30	3
3. Games by which to learn and teach about sustainable development: exploring the relevance of games and experiential learning for sustainability						
Dieleman, H; Huisingh, D	Journal of Cleaner Production	2006	14	9-11	28	2.8
4. Management Education for Sustainability: A Web-Based Content Analysis						
Wu, Yen-Chun Jim et al.	Academy of Management Learning and Education	2010	9	3	27	4.5
5. Revealing the research ‘hole’ of early childhood education for sustainability: a preliminary survey of the literature						
Davis, Julie	Environmental Education Research	2009	15	2	26	3.71
6. Higher education for today and tomorrow: university appraisal for diversity, innovation and change towards sustainable development						
Fadeeva, Zinaida; Mochizuki, Yoko	Sustainability Science	2010	5	2	22	3.67
7. Competences for sustainable development and sustainability Significance and challenges for ESD						
Mochizuki, Yoko; Fadeeva, Zinaida	International Journal of Sustainability in Higher Education	2010	11	4	19	3.17
8. Sustainability in Mexican Higher Education: towards a new academic and professional culture						
Juarez-Najera, M; Dieleman, H; Turpin-Marion, S	Journal of Cleaner Production	2006	14	9-11	19	1.9
9. The importance of scientific literacy in fostering education for sustainability: Theoretical considerations and preliminary findings from a Brazilian experience						
Miranda Correia, Paulo Rogerio et al.	Journal of Cleaner Production	2010	18	7	18	3
10. Restructuring teacher education for sustainability: student involvement through a strengths model						
Stir, J	Journal of Cleaner Production	2006	14	9-11	14	1.4

It is important to note that, among the ten more cited articles, six of them are published by the Journal of Cleaner Production, what takes us to Table 3 showing the most used journals that are more adherent to the theme “education for sustainability”. The International Journal of Sustainability in Higher Education concentrates the highest number of articles, followed by the Environmental Education Research. Although the Journal of Cleaner Production appears more times in the roll of the more cited articles, it is in the fourth position. But the performance among the most cited works is explained by the high rate of citation (Journal Impact Factor, SJR e IPP), that is what happens with other journals, except the Sustainability Science and the Academy of Management Learning and Education that are not among the most used journals, although they have articles in the roll of the most cited.

Table 4 shows which scientific methods are more used in the analyzed studies. The analysis shows that the majority of the articles includes the analysis or evaluation of the syllabi, which is perfectly linked to the theme “Education for Sustainability”. This evaluation may be supplemented by specific document content analysis. In second place is the case studies, pointing to the particularization for further studies of specific contexts. Surveys and interviews are also reasonably used, as the “Action Research”. It is important

**Table 3 More used journals to publish articles on “education for sustainability”**

Journal	ISSN	E-ISSN	Articles	Journal impact factor	SJR	IPP
International Journal of Sustainability in Higher Education	1467-6370		32	0.889	0.661	1.582
Environmental Education Research	1469-5871	1350-4622	18	1.088	0.724	1.534
Australian Journal of Environmental Education	0814-0626		15		0.230	0.268
Journal of Cleaner Production	0959-6526		11	3.844	1.588	4.210
Journal of Teacher Education for Sustainability	1407-8724	1691-5534	7		0.217	0.222
International Journal of Sustainability Education	2325-1212	2325-1220	6		0.104	0.067
Research in Science Education	0157-244X		6	0.806	1.245	0.961
Applied Environmental Education and Communication	1533-015X	1533-0389	5		0.178	0.206

*SJR* SCImago Journal Rank, *IPP* Impact per Publication

**Table 4 The most used scientific methods**

Curriculum analysis or evaluation	62.24 %
Case study	21.09 %
Survey	13.27 %
Interview	10.88 %
Action research	10.20 %
Qualitative research	8.84 %
Delphi method	4.42 %
Content analysis	3.06 %

An article may use more than one method

to consider that the same article may mention the use of different methodological strategies, making the sum of the percentages in Table 4 exceeds 100 %.

### Conclusions

The present research was developed in order to characterize the international production of scientific articles about “education for sustainability”. Starting from 279 articles, produced by 157 different authors from 36 countries, it was possible to verify that, although being considered as incipient, the production is being developed. This fact is influencing the process of maturation of this field. Even though there is not a high concentration of papers published by a restricted group of authors, that characterizes the most consolidated areas according to Lotka’s Law, the scenario can be changed in future years. By now, as it is an area in the process of consolidation, it is susceptible to an author with a few works to be in an outstanding position (with a high production) in a short period.

In this scenario, there are countries that are highlighted by their high productivity. This is the case of Australia, which is responsible for more than 30 % of the published articles, followed by the United Kingdom (15 %), USA (14 %) and New Zealand (9 %). Australia stands out by the production of researches relating “education for sustainability” with children education, or teachers related to elementary education.

As to the journals that are used, there is a wide distribution of publications. The International Journal of Sustainability in Higher Education, with 32 articles, is responsible for 11 % of the production of the area, followed by the Environmental Education Research (6.4 %). If in one side, these data show a certain lack of publications specifically about “education for sustainability”, on the other hand it makes clear that the theme is welcome in journals that deal with the more interdisciplinary aspects of the environmental sciences. This is, at least in part, the reflection of a great quantity of articles (almost 50 %) that were originated from the Social Sciences, which have the characteristic of interdisciplinarity of themes and approaches. The fact that this area is undergoing a process of growth shows that there is a possibility of specific publications or special editions about such themes to emerge.

### Research limitations and suggestions

The present research has an important limitation that must be highlighted, because it is an opportunity for a research. The verification of the methodological techniques herein applied was automatically done by the Tropes software from the texts of the abstracts of the articles. It is important to note that, even though this method offers an overview of the main procedures used in the text, it only allows one approach. The ideal revision should include the complete text of every article, which is a suggestion for future studies.

#### Authors’ contributions

PLC: study design; data acquisition; data processing and interpretation; has been involved in drafting the manuscript and gave the final approval of the version to be published. RR: data processing and interpretation; has been involved in drafting the manuscript and gave the final approval of the version to be published. All authors read and approved the final manuscript.

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**Competing interests**

The authors declare that they have no competing interests.

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