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Science Education Research Trends in Latin America

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Abstract The purpose of this study was to survey and report on the empirical literature at the intersection of science education research in Latin American and previous studies addressing international research trends in this field. Reports on international trends in science education research indicate that authors from English-speaking countries are major contributors of publications. Despite the internationalization of the science education community, as represented by the publication of the work generated in non-English-speaking countries, research trends in science education in Latin America are uncommon in the literature. Therefore, it was deemed important to explore the scholarly productivity of science education researchers from Latin America to learn about the research orientations pursued by scholars from this region. Collective review findings are presented with respect to author's nationality, publication volume generated in each country, research type and topic, collaborative research, and areas for future research. Of the ten countries represented in this study, Brazilian authors were the most research active scholars followed by their colleagues from Venezuela, Mexico, and Argentina. The History, Philosophy and the Nature of Science (HPNOS) was the topic that most attracted the interest of Latin American science education researchers, and the Empirical Qualitative studies was the most frequent research type combination in the analyzed publications. Findings in this study suggest a relationship between investment power in Research and Development (R&D) and the scholarly productivity not only in science education but also in the scientific field in the countries of the region.

Keywords Latin America · Research trends · Science education · Survey

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Introduction

The scholarly contributions of Latin American science education researchers to the international community have been small throughout the years. Interestingly, this finding corresponds with the participation of researchers in the scientific disciplines at the international level as well (Ayala, 1995; Estrada-Mejía & Forero-Pineda, 2010; UNESCO Science Report, 2010). Existing reports in the literature provide comprehensive reviews of the scientific productivity in Latin America (Coutinho, Davila, dos Santos, Rocha, Souza, Folmer & Puntel, 2012; Wagner & Wong, 2012). However, similar studies dealing with the research activity of science education scholars from Latin America are scarce. Therefore, it was considered important to explore the magnitude of the scholarly activity in science education in Latin America in parallel with the work done in the rest of the international science education community. Findings in this study will provide Latin American science education researchers and educators with important insights that may inform their current and future research and instructional practices. This type of studies is also relevant and needed because of the globalization of education and the challenges imposed by socioeconomic and political disparities affecting school communities in each nation. Thus, this study seeks to explore the participation of Latin American science education scholars in a globalized community and with it contribute to a dialogue on the science education research tradition in this region.

Studies addressing the quality of science education across nations and over time have several benefits: they reveal alternative ways of teaching science (Hiebert, Morris & Glass, 2003) and help identify subtleties of science teaching that deserve analysis (Stigler & Hiebert, 1999). Science education research can also be viewed as an indicator of a country's development capacity and productivity in the education sector. The latter is of paramount interest because of the role science plays in the preparation of a scientifically literate citizenry and "in promoting and sustaining the scientific and technological capacity of the workforce" (Chang, Chang & Tseng, 2010, p. 315). Furthermore, the examination of research trends in science education across the globe is a worthwhile line of research because it reflects the interests of authors (Barrow, Settlage & Germann, 2008), supports the "validation of research related ideas and outcomes" (Milne, Siry & Mueller, 2015, p. 1064), and assists scholars in identifying the type of research conducted in the past and in planning their current and future investigations (Chang et al., 2010). It is also important to highlight the cultural nature of reviews of this sort because they "speak directly not only to issues of economics, sustainability, and inclusion, but also address theoretical and empirical gaps in our understanding of science education in its context" (Brandt & Carlone, 2012, p. 144).

Publications addressing science education research trends in Latin American countries (LAC) are absent in the literature. As a Latino science teacher educator, I am curious about publications appearing in major science education journals that deal with studies originated in this part of the globe. An inspection of these publications indicates that the science education research activity being generated in Latin America has been small throughout the years, has appeared mostly in a few international journals, and is limited to the participation of a few countries. This study contributes to the science education literature in relation to the underrepresentation of science education scholars from Latin America in international journals with English as the language of

publication. Understanding the nature and magnitude of science education research in LAC is also important for government agencies, policy makers, and members of the education sector because of the opportunities for social and economic development that can be generated with the preparation of practitioners in science-related fields. This article seeks to address this gap by surveying the empirical literature at the intersection of science education research in Latin America and previous studies documenting global science education research trends during the 1998–2015 period. The rationale for this time frame relates to a major purpose of this article which was to document the science education research activity in Latin America during the period covered in previous studies (1998–2012). This article also offers an updated analysis of publications by Latin American authors by expanding the review period to 2015.

Review of the Literature

Latin America as a Region

Although in this article the term Latin America is used in reference to countries with Spanish and Portuguese as the main spoken language, it is important to acknowledge the presence of countries with Anglophone origin. "It is difficult to consider Latin America as a whole, since one of the most prominent characteristics of the region is its heterogeneity, both between and within countries" (Albornoz, Matos Macedo & Alfaraz, 2010, p. 77). Latin America covers a vast range of territories with varying geographical features and distinctive socioeconomic, cultural, and political systems. Brazil is one of the most populated countries in the world (198 million people). Other countries like Argentina, Brazil, and Venezuela have a diverse ethnic composition including African, European, Japanese, and Indigenous origins. In other countries like Guatemala, Mexico, Peru, Paraguay, and Bolivia, a significant portion of the population has been identified as Spanish and Indigenous language speaking. The distribution of the country's population as rural or urban varies with El Salvador and Guatemala where 60% of the people live in rural areas and Uruguay, Chile, and Argentina with 90% of the population residing in urban settings (Avalos, 2007). Latin America is frequently referred to as a region with high rates of inequalities (Cofré, González-Weil & Vergara, 2015; Marchesi, Tedesco & Coll, 2012). Likewise, it has been argued that in addition to the gap between the rich and the poor, the main feature characterizing these diverse societies is their Hispanic cultural heritage (Inglehart & Carballo, 2008). In 2007, only five countries (Brazil, Mexico, Argentina, Venezuela, and Colombia) accumulated 80% of the regional GDP (Albornoz et al., 2010; Vessuri, 2003). The survey described in this study includes articles published by authors from ten Latin American countries (LAC) with varying Indexes of Human Development (HDI). Table 1 below shows the HD rankings for countries represented in the reviewed publications.

The Research Tradition in Latin America

Investment in science and technology in Latin America is a critical issue. Although expenditures in these areas grew in the 1990s reaching a figure of 3400 million of dollars, it continues to be low as compared to the resources invested by most

Table 1 Human development indexes of the countries represented in this review

Rank	Country	Human development index 2013	Research and development expenditure (% of GDP 2005–2010)	Population (Millions 2012)
Very high human development				
1	Norway	0.955	1.8	5.0
2	Australia	0.938	2.3	22.9
3	USA	0.937	2.8	315.8
40	Chile	0.819	0.4	17.4
45	Argentina	0.811	0.5	41.1
High human development				
59	Cuba	0.780	0.5	11.2
61	Mexico	0.775	0.4	116.1
62	Costa Rica	0.773	0.4	4.8
71	Venezuela	0748	N/A	29.9
77	Peru	0.741	N/A	29.7
85	Brazil	0.730	1.1	198.4
91	Colombia	0.719	0.2	47.6
Medium human development				
133	Guatemala	0.581	0.1	15.1

Adapted from the United Nations Development Programme (UNDP) (2013). Human Development Report 2013. The Rise of the South: Human Progress in a Diverse World. New York, NY: UNDP

industrialized nations in these areas (2.0–3.0% of their GDP) (Salas-Madriz 2007). Perhaps this feature explains the overreliance on government funding which determines, to a great extent, the lines of research being pursued in each country (Wagner & Wong, 2012). This feature correlates with the selective dissemination of scientific research in that publishing in certain journals and databases is taken as a qualifying condition for state funding and academic evaluation purposes (Estrada-Mejía & Forero-Pineda, 2010). Although both publication output and the number of researchers in science in Latin America grew at the same pace in the last decade, this growth did not translate into solutions to the structural needs related to innovation, technology, and development in the countries from this region (Marin, Petralia & Stubrin, 2015). The same trend has been observed in the science education field (Castaño-Rodriguez, 2015). This lack of articulation between the volume of scientific research and socio-economic development is by far a major weakness in the research tradition in Latin America (Marchesi et al., 2012).

Science education in Latin America, like its geographical and ethnic composition, is highly diverse. Poverty and literacy levels, especially in rural areas, and the structure of national education systems vary greatly across the region. Consequently, the influence that science education may have on each country is in concomitance with the variability of the national economics and Research and Development (R&D) programs each country can put forward. From a historical standpoint, science has had a positive influence in higher education in LAC. According to Tewolde (1997), the practice of science went from being focused on a teaching in the 1950s, to the replication of pre-

existing technologies in the 1960s, to an increase in the rates of productivity of goods and services in the 1980s. In the 1990s, both economic and managerial aspects were integrated into the higher education system of the region while still maintaining an emphasis on productivity. Although there is evidence that LAC have reached satisfactory levels of the scientific enterprise, the impact of these developments has fallen short in producing the needed impacts in the national economies (Marin et al., 2015).

In his review of science in Latin America, Ayala (1995) offers an examination of the research activity in higher education institutions in the region. His report highlights the model of the modern [research] university imported from Europe in the early 19th and implemented after World War II. The emphasis of this model was on promoting and financing scientific research through the newly created national institutions to support development in research. Although this boost in investment in research supported the creation of specialized centers and institutions, the scope of these initiatives failed to reach the education sector as one would have expected. In some countries, the research tradition was not even implemented at the inception of these initiatives which may have contributed to the gap between the countries engaged in research and those in the initial stages of a research program. Perhaps a reason for these disparities can be found in the socioeconomic inequalities that characterize the region since the foundation of each nation; a fragmentation that has worsened as a result of the economic globalization (Marchesi et al., 2012). Likewise, the alterations in the national economies, first in the 1950s and 1960s and later in the early 1990s affected in different ways the R&D programs in each country. Furthermore, the political unrests that took place in the mid-1980s in some LAC caused a large number of researchers and other scholars to migrate. These are crucial issues that have been identified in connection with the status of R&D in several Latin American nations which have thus kept them from moving towards a more competitive and cohesive research infrastructure (Glanzel, Leta & Thijs, 2006).

An examination of the amount of researchers in Latin America reveals that the number of practitioners in each nation replicates the diversity of the region. In 2007, the number of scientists and engineers in Latin America was estimated to be around 252,000 Full-Time Equivalents (FTE). That is 3.5% of the global share. Four countries (Argentina, Brazil, Chile, and Mexico) are home to more than 90% of scientists and engineers with Brazil accounting for almost half of the researchers in the region. These are the LAC with high expenditures in research and development (Table 1). At the beginning of the twenty-first century, Latin America experienced a significant growth in the number of researchers; this number doubled by 2010, however this growth continues to be small when placed in a global context.

The research productivity of Latin American scientists, as listed in the Thomson Reuter's Science Citation Index (SCI) doubled from 1997 to 2007. This growth in the share of publications corresponds to 1.8% in 1997 and 3.4% in 2007 (Coutinho et al., 2012). Within the region, Brazilian scientists contributed 47% of the publications, followed by their counterparts from Argentina, Chile, and Mexico. As pointed out by Nicolaci da Costa (1995), "understanding the reasons for the small contribution to science and technology from Latin America is not only of academic interest but essential for promoting the economic and social development of the region" (p. 827).

The reason behind this overview of the scientific research tradition in the region is to propose that the scholarly productivity of Latin American science education researchers mirrors that of their counterparts in the scientific disciplines, which in turns reflects the

impact of sociopolitical and economical factors on the research activity in each community and in the region as a whole. The assumption is that countries with a long history of scientific research have been able to sustain and advance their research programs; it is also proposed that the research culture in the scientific disciplines served as an exemplary research practice adopted in the science education community.

Research Trends in International Science Education

Reviews of science education research trends at the global level have been published periodically in the literature over the last 15 years (Chang et al., 2010; Eybe & Schmidt, 2001; Lee, Wu & Tsai, 2009; Lin, Lin & Tsai, 2014; Tsai & Wen, 2005). Although findings in these studies indicate that the majority of science education publications have been contributed by researchers from English-speaking countries, they also acknowledge the increasing participation of researchers from non-English-speaking nations. Table 2 highlights the science education research trend studies conducted at five time intervals during the 1998–2012 period. While the first review study (Eybe & Schmidt, 2001) was on chemistry education publications, the other four included the review of science education articles and expanded the number of target journals. The purpose of these studies was to investigate the type of science education research conducted around the globe and thus reveal possible trends in the field.

The outcomes of these studies encourage the exploration of research patterns in science education in Latin America in an attempt to present a depiction of the research activity in this field in relation to the research trends in the international community. The focus of the proposed study was on the authors' contributions to eight science education journals, author's nationality, research type, and research topic. It is important to note that science education researches from LAC disseminate their work regionally in their native languages, and through a wide range of journals, including some that outside the science education domain. In addition to the socioeconomic variables of each nation, it is also worth considering the demands of "existing in English" in the academic world being placed on scholars from non-English-speaking countries and regions (Buckingham, 2008; Lee et al., 2009; Lee, 2015). This is a factor that may account for the rarity of science education publications authored by Latin American researchers in international English-medium journals.

A set of articles focused on the hegemony of English in science education journals appeared in the 10th issue of the *Cultural Studies of Science Education* journal in 2015. In these papers, the authors discuss the underrepresentation of diverse cultures and languages in international journals with English as the language of publication (Castaño-Rodriguez, 2015). The authors point out that "valuing difference can create educational value and allows one's science teaching to be interrogated, evolve, and maintain its relevance" (Lee, 2015, p. 1051); they also highlight the role of journals as agentic tools (Brandt & Carlone, 2012) for cultural exchange, especially in non-English-speaking countries where the research done at the local and regional levels is also relevant in global contexts (Milne et al., 2015). Among the proposed measures to counteract the contemporary challenges of publishing in a globalized science education community, the authors advocate the implementation of a "pluringual and multicultural model for science education research journals" as well as the use of "new writing genres in digital forms" (Espinet, Inquierdo & Garcia-Pujol, 2015, p. 1029).

Table 2 Review of science education research trends between 1998 and 2012

Study	Time frame	Target journals	Purpose
Eybe and Schmidt (2001)	1991–1997	• *International Journal of Science Education (IJSE)* • *Journal of Research in Science Teaching (JRST)*	To examine the quality criteria of research in chemistry education
Tsai and Wen (2005)	1998–2002	• *International Journal of Science Education* • *Journal of Research in Science Teaching* • *Science Education (SE)*	To investigate the type of research in publications by authors from different countries in three major journals from 1998 to 2002
Lee et al. (2009)	2003–2007	• *International Journal of Science Education* • *Journal of Research in Science Teaching* • *Science Education*	To present a follow-up study on the work done by Tsai and Wen (2005)
Chang et al. (2010)	1990–2007	• *International Journal of Science Education* • *Journal of Research in Science Teaching* • *Science Education* • *Research in Science Education (RISE)*	To conduct a development trend analysis of science education research
Lin et al. (2014)	2008–2012	• *International Journal of Science Education* • *Journal of Research in Science Teaching* • *Science Education*	To reveal the status of science education research during the period 2008–2012 and to compare the findings with those of Tsai and Wen (2005)

Science Education Research in Latin America

The only report in the literature dealing with science education research in Latin America appeared in a paper published by Lorenz (1978) in the *Science Education* journal. This publication was produced as a report on the First Annual Symposium of the Latin American Science Teachers Association (APCAL). In that year, the symposium was held in Brazil and included participants from 14 LAC (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, The Dominican Republic, Ecuador, Honduras, Mexico, Nicaragua, Panama, Peru, and Uruguay). The purpose of the symposium was twofold: to discuss the status of science teaching in the participating countries and to identify future trends in science education pertinent to the countries of the region. Lorenz (1978) highlights that only six studies presented in the 1-day event were of diversified nature and that "their lack of theoretical underpinnings discouraged any comprehensive summary statement to be made about the symposium and how it met its objectives" (p. 250).

Given the increasing participation of science education researchers from non-English-speaking countries in international science education publications, it is conjectured that the science education research productivity of Latin American authors has also increased over the years as measured by publications in international science education journals. A cautionary note should be included here in relation to the nature of this review. Perhaps when embarking on this kind of task, there is a chance to ignite controversies due to the nature of these investigations which deal with the ranking of countries and institutions measured by research productivity (Barrow, Settlage & Germann, 2008; Jenkins, 2000). Likewise, it is important to acknowledge that the "multilingual, multiethnic, multicultural, and the politically diverse nature of Latin America" account for the unique realities experienced in each nation (Torres & Puiggrós, 1995, p. 5). These conditions may explain the difficulty in producing a comparative analysis at both national and regional levels and in times of globalization of science education when standardization and other accountability measures are key features (DeBoer, 2011).

In an attempt to contribute to the dialogue around the participation of diverse science education research groups in the international community, in particular from Latin America, the proposed study aimed at answering the following research questions:

1. How did authors from Latin America contribute to publications in eight major science education journals during the 1998–2015 period?
2. What were the research topics most commonly investigated in the contributions of Latin American science education researchers from 1998 to 2015?
3. What types of research characterized the publication contributions of Latin American authors?

Method

This review targeted eight science education journals (Table 3). The first four journals correspond to those included in previous studies investigating international research trends. Four more journals (*St Sc Ed*, *J Sc Ed Tech*, *Sc & Ed*, & *Rsch Sc Tech Ed*) were

Table 3 Volumes and impact factor of the journals used in this study

Journal	Impact factor	Total issues	Total articles
1. *Journal of Research in Science Teaching*	3.162	179	915
2. *Science Education*	2.825	109	758
3. *International Journal of Science Education*	1.132	271	1672
4. *Research in Science Education*	0.806	84	166
5. *Studies in Science Education*	2.083	26	99
6. *Journal of Science Education and Technology*	1.214	94	845
7. *Science & Education*	0.634	126	933
8. *Research in Science and Technological Education*	0.278	45	303

added to the search process in order to capture a number of publications that was representative of the work produced by Latin American science education scholars. Scores and rankings in the Social Sciences Citation Index (SSCI) of the 2014 Journal Citation Report were the criteria used in the selection of the four additional journals.

The standardization of the search procedure included the following criteria: empirical science education studies published by Latin American authors in the identified journals between 1998 and 2015; the authors were affiliated to a Latin American education institution at the time of the study; and the article was produced in collaboration with researchers from neighboring countries or from other regions (non-LAC) and on topics pertaining to educational settings in Latin America. This review discarded editorials, letters to the editor, acknowledgements, book reviews, interviews, and book analyses. The data processing followed the work done by the authors of previous studies, including the formula used in the calculation of author's contribution (Lee et al., 2009; Lin et al., 2014; Tsai & Wen, 2005). For each identified article meeting the above-mentioned criteria, the following information was entered in a data base: title of publication, authors, year, nationality, research type, research topic, collaborative research, and number of issues per year per journal.

Authors' Nationality

This information was of great significance because the major purpose of the paper was to document the research productivity generated in LAC. Articles published by Latin American authors or by Latin American authors in collaboration with researchers from other countries or regions were subject to a calculation to determine each author's contribution to the publication. This calculation employed Howard, Cole and Maxwell's (1987) formula which takes into account the number of authors and authorship order. In the calculation procedure, each article is assigned one point. In the case of multi-authored articles representing different countries, the calculation of the score for each author uses the formula shown below where the values "n" (total number of authors) and "i" (order of the specific author) are entered for each case. Although different methods to calculate scholarly productivity exist (Hanish, Horan, Ken & Clark, 1998), this reviewed of the articles included in this surveyed used the formula of Howard et al. (1987) in order to maintain the same procedures employed in previous studies.

$$\text{Score} = \frac{\left(1.5^{n-1}\right)}{\sum_{i=1}^{n} 1.5^{n-1}} \quad (1)$$

For instance, in the paper published by de Lima Tavares, Jiménez Aleixandre and Mortimer (2010) in *Science & Education*, the calculated scores were 0.47, 0.32, and 0.21, respectively. In this case, the first and third authors contributed a score of 0.68 to Brazil. Additionally, a review of publications by authors from non-Latin American countries in the eight journals, and in the 1998–2015 period, was also conducted for comparison purposes. This additional review was conducted to place the science education research activity in LAC in an international context.

Research Type

The analysis of each article for this feature employed the research type categories used in previous studies. These categories include the following: (1) empirical research article (quantitative or qualitative); (2) position paper, which conveyed the position of the author/s regarding a certain issue in the science education field; (3) theoretical paper in which the authors propose a new science education theory; (4) review paper in which the authors summarize the science education literature without putting forward a strong position; and (5) other (e.g., a description of a curricular or reform program of a specific country).

Research Topic

The analysis of this feature used Tsai and Wen's (2005) categorization which was adapted from the research strands of the National Association for Research in Science Teaching (NARST). The research topics consist of nine categories: (1) Teacher Education; (2) Teaching; (3) Learning-students' conceptions and conceptual change (Learning-Conceptions); (4) Learning-Classroom Contexts and Learning Characteristics (Learning-Context); (5) Goals and Policy, Curriculum, Evaluation, and Assessment; (6) Culture, Social, and Gender Issues; (7) History, Philosophy, Epistemology, and Nature of Science; (8) Educational Technology; and (9) Informal Learning. These categories were maintained in this study because of the purpose of this review was to investigate the research productivity of Latin American authors during the time period covered in previous studies where these categories were employed.

Results and Discussion

Research Productivity by Author's Nationality

Ten LAC were represented in the 159 reviewed articles published during the 1998–2015 period in the eight selected journals (Table 4). The most research productive country was Brazil (75.64), followed by Venezuela (20.29), Mexico (17.58), and Argentina (15.01). Countries with low scores include Colombia (2.91), Chile (2.47), Costa Rica (1.0), Guatemala (1.0), Peru (0.60), and Cuba (0.119). Of the ten countries

Table 4 Research productivity scores by country during the 1998–2015 period

Journal Country	*Sc&Ed*	*IJSE*	*ScEd*	*JScEdTch*	*JRST*	*RISE*	*RScTchEd*	*StScEd*	Score
Brazil	35.63	23.80	5.45	2	1.97	2.68	3.79	0.32	75.64
Venezuela	6.26	4	2.42	5.61	2	0	0	0	20.29
Mexico	9.6	3.93	1.77	0.28	1	1	0	0	17.58
Argentina	13.83	0.18	0	0	1	0	0	0	15.01
Colombia	0.0025	0.32	0	0.59	1	1	0	0	2.91
Chile	1	1.47	0	0	0	0	0	0	2.47
Costa Rica	0	0	0	1	0	0	0	0	1.00
Guatemala	0	1	0	0	0	0	0	0	1.00
Peru	0	0	0.6	0	0	0	0	0	0.60
Cuba	0.119	0	0	0	0	0	0	0	0.11

listed in Table 4, the top five ranked countries (Brazil, Venezuela, Mexico, Argentina, and Colombia) are also the countries that accounted for 80% of the regional GDP in 2007. Furthermore, three of these research dynamic countries (Brazil, Mexico, and Argentina) are home to the majority of scientists in the region (Albornoz et al., 2010). Likewise, the productivity of Brazilian and Mexican science education scholars in this study corresponds to that of their counterparts in the scientific disciplines. It is important to highlight that the most research active countries in this review, with the exception of Venezuela, and as shown in Table 1, are also the countries from the region with high investment capacity in R&D. It is also worth noting that in the 2016 ranking of the top 20 universities, eight higher education institutions are from Brazil, two from Chile, and two from Argentina (Quacquarelli Symonds, 2016).

It is important to highlight a relationship between productivity ratings in the selected journals and institutional reform initiatives implemented in the mid-1990s in support of scientific research. These reform efforts were put into effect in Argentina, Brazil, Chile, Colombia, Mexico, and Venezuela with the purpose of streamlining the resource distribution process and in turn, bringing more transparency and efficiency to the work conducted in universities and research centers (Albornoz et al., 2010). It should be noted that the implementation of this policies targeted research and development programs in general, not specific areas like science education research. Therefore, it can be argued that although this policy shift was intended to improve the national research and development systems, the circumstances characterizing each locality may have determined, to a certain degree, the effectiveness of those well-intended measures. In other words, and based on the outcomes of this review, it is submitted that a relationship between investment in R&D and indexes of socioeconomic development—which reflect historical inequalities in Latin America, can be associated with the research patterns in science education observed in this review. The same research trends have been observed in the scientific field in the countries with high research activity in science education (Marin et al., 2015). Additionally, the longevity of research programs in each nation is to be brought into consideration as well. For instance, in Brazil research in science education began in the 1960s as a consequence

of a renovation in the field and prompted by sociopolitical circumstances taking place during that time (Villani, Silva-Dias & Melgaco-Valadares, 2010). The science education research initiatives established in Brazil around that period included the funding of research groups and journals, and the creation of training programs for new researchers.

One more distinctive feature is the difference between the productivity levels of Brazilian science education scholars and their neighboring counterparts. Being a member of the BRIC countries (Brazil, Russia, India, and China) sets Brazil apart from the other LAC in terms of the investment capacity in R&D, which has been greater than that of their neighboring countries (Table 1). Brazil is the only country of the region that reached high levels of investment in R&D in the first decade of the twenty-first century. Mexico has maintained minimal but stable levels of investment, and Argentina incremented its R&D expenditures in 2007 after recovering from the economic crisis in 2001 (Albornoz et al., 2010). Therefore, it is suggested that the outcomes observed in science education research productivity reflect the access to and availability of resources for research in each LAC. Accessibility to resources, including information generated from research, is an essential factor in the infrastructure of national research systems. This accessibility is only possible in countries like Brazil, Mexico, Argentina, Chile, and Colombia with established national centers of science and technology (ONCYTs, from its name in Spanish). Perhaps this assumption could be used in explaining the absence of over half of the LAC in the reviewed publications. Regarding the paucity of science education research in some countries of this region, it can be proposed that researchers from the countries not represented in this survey or with low research activity are disseminating their work at regional and national levels, and in their native languages (Spanish and Portuguese). According to Vega Montiel (2014), this issue could be related to the conditions governing the academic production of Latin American researchers. In her view, the research output of "Southern scholars is subject to the rules defined in other latitudes of the world where different research conditions exist" (p. 1). It is important to point out that a good number of education journals, for the most part in South America, publishing in Spanish and Portuguese (e.g., *Diálogos Educativos*, *Ciência em Tela*), are known to serve as publication outlets of the multidisciplinary research work conducted in the region.

When looking at the number of science education researchers, this study identified a total of 166 researchers from ten countries who authored or co-authored 159 papers published in the eight selected journals. The majority of the authors (89.7%) are from three countries (Brazil, Argentina, and Mexico) (Fig. 1). These are the same countries accounting for the majority of scientists in the region; they are also the LAC that have historically concentrated the volume of scientific publications (Estrada-Mejía & Forero-Pineda, 2010). Similarly, the majority of the publications (89.8%) were contributed by authors from four LAC (Brazil, Argentina, Mexico, and Venezuela). This finding corresponds with the distribution of researchers in scientific disciplines in the region. Special attention deserves the case of Venezuela, represented by nine authors who participated in 20 of the 159 publications.

The high research activity of Brazilian science education scholars, as compared to that of their Latin American counterparts, signals the performance of authors from this country in the international science education community. Previous research addressing international research trends in science education cite three studies in reference to the participation of Latin American authors, in particular those from Brazil and Venezuela;

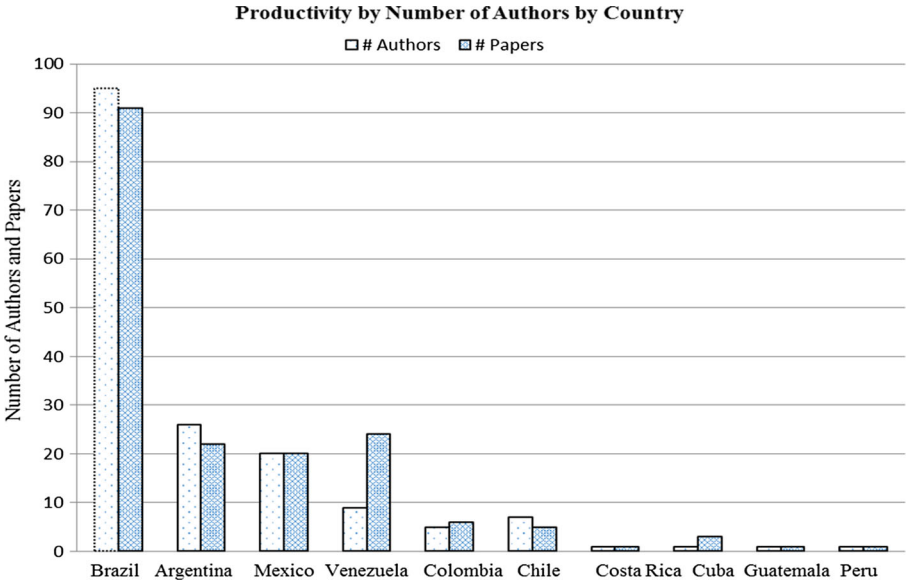

Fig. 1 Number of researchers and publications per country

two of the most research active countries identified in this survey. Tsai and Wen (2005) reported Brazil as the 9th most productive country in their review of publications in the 1998–2002 period; Chang et al. (2010) also included in their findings publications by Brazilian and Venezuelan authors in two of the nine publication categories; and Lin et al. (2014) included Brazil as the 10th most productive country in their study of research trends between 2008 and 2012.

Although the research activity of Brazilian (75.64), Venezuelan (20.29), Mexican (17.58), and Argentine (15.01) science education researchers was consistent throughout the reviewed period, their performance as the most active-research groups from Latin America is still small when compared to the productivity at the global level (Table 5). Again this trend correlates with the scientific research productivity in the last decade in Latin America. The review of publications by country in the eight selected journals, for non-LAC, reveals that authors from English-speaking nations continue to be major contributors of publications. This finding confirms what previous reports on international research trends in science education (Chang et al., 2010; Lee et al., 2009; Lin

Table 5 Science education research productivity by Latin American and non-Latin American countries between 1998 and 2015 in the eight selected journals

	Latin American countries		Non-Latin American countries	
Rank	Country	Score	Country	Score
1	Brazil	75.64	USA	2518.06
2	Venezuela	20.29	UK	524.59
3	Mexico	17.58	Australia	463.97
4	Argentina	15.01	Canada	249.60

et al., 2014) have indicated, that authors from the USA, Australia, the UK, and Canada are major contributors of international science education journal articles.

Research Productivity by Journal

According to the productivity scores by journal, Brazilian authors received two of the three highest scores (35.63 in *Science & Education* and 23.80 in the *IJSE*). The third highest score was for Argentine authors (13.83 in the *Science & Education*) (Table 4). It was also observed that Brazilian authors contributed most of the publications to all of the journals included in this review, except to the *Journal of Science Education and Technology* and *Journal of Research in Science Teaching* in which Venezuelan researchers contributed the majority of the publications.

Seventy-one percent of the reviewed papers were published in two of the eight journals used in this review (*Science & Education* (45.2%) and *the International Journal of Science Education* (25.7%)). Unlike the publication patterns at the global level, in which the majority of authors published their work in the *IJSE*, most of the papers by Latin American scholars reported in this study appeared in the *Science & Education* journal. This trend may be related to the research orientations pursued in the region, particularly in the topic of HNOS, especially by authors from Brazil, Venezuela, and Argentina. *Studies in Science Education* was the journal with the lowest number of publications contributed by Latin American authors (0.62%). Here it is important to take into consideration both the number of issues and the publication frequency of this journal. Brazilian researchers were the only group of authors publishing their work in all of the journals included in this survey; Venezuelan, Mexican, and Colombian authors published their papers in five different journals; and Argentine authors in three of the eight selected journals.

Collaborative Research

The analysis of this indicator included articles published by science education researchers from any two or more LAC or in collaboration with scholars from other regions, including non-LAC. Collaborated papers were more frequent in the *IJSE* and in the *Science & Education* journals. Authors from Brazil, Argentina, and Mexico outperformed their counterparts from the region in this area. This finding corresponds with the 2016 Ranking of Universities in Latin America in the international research network area. This ranking reports Brazilian, Mexican, and Argentine universities in the top three places in international collaborative research. While Brazilian researchers collaborated in 27 papers, mostly with authors from the UK, Argentine researchers participated as coauthors in 11 publications, six of them with colleagues from Spain. Mexican authors collaborated in eight publications with authors predominantly from Spain and the UK. The majority of the collaborated publications appeared in the *Science & Education* and the *IJSE* journals. It is important to note that only 2 of the 159 surveyed papers resulted from collaborative work among authors from LAC. These authors are from the most research active countries and included researchers from Mexico and Argentina, and Brazil and Venezuela. The two articles were published in the *IJSE* and in the *Journal of Science Education and Technology*. The topics addressed in these publications were teaching and learning student contexts. This finding differs

from the intra-regional studies conducted in scientific research which has consistently shown high levels of collaboration among mid- and low science research active countries.

Another trend related to the proportion of collaborated papers authored by groups of researchers from the same country. In the case of Brazil, authors from this country collaborated in about half of the produced papers (46.9%). The number of collaborated papers generated in the other LAC did not reach comparable figures. While both Mexican and Venezuelan authors collaborated in 33.3% of their published papers, Argentine authors collaborated in 28.5% of their articles. The authors from the other Latin American countries represented in this study did not engage in collaborative research with colleagues from their own country. Generating collaborative research initiatives that convene authors from different LAC to pursue research projects reflecting the interests and expertise of Latin American scholars may contribute to strengthen the already existing research groups and encourage the participation of researchers from countries with scarce research productivity.

Productivity by Research Type

As shown in Tables 6 and 7, Empirical studies was the most common type of research endeavored by Latin American authors. Fifty-seven percent of the articles (91 papers) submitted by authors from this region used this research type. The majority of the Empirical papers were qualitative. The next most common research types were Review (33 papers) and Position (23 papers). Other research types identified in the submitted papers included Theoretical Position and Other.

Results in this area correlate with findings reported in previous studies. Latin American authors, like their counterparts from other regions, published primarily Empirical papers. While 90.7% of papers published in the *IJSE, JRST*, and *SE* during the 1998–2012 period were identified as Empirical (Lin et al., 2014), over half of the papers (57.23%) authored by Latin American researchers in this review fall into this

Table 6 Research type by nationality

Type Country	Empirical	Position	Review	Theoretical	Other	Percentage of total articles
Brazil	51	11	14	3	4	52.2
Mexico	11	4	4		2	13.2
Venezuela	10	3	4	1	2	12.5
Argentina	8	3	8			11.9
Colombia	5	1				3.77
Chile	4	1				3.14
Cuba			2			1.25
Costa Rica	1					0.62
Guatemala			1			0.62
Peru	1					0.62
Total	91	23	33	2	8	

Table 7 Research type by journal

Type	*Sc & Ed*	*IJSE*	*Sc Ed*	*J Sc Ed Tech*	*JRST*	*RISE*	*Rsch Sc Tech Ed*	*St Sc Ed*	# articles
Empirical	22 (30.55%)	34 (82.92%)	10 (71.42%)	9 (69.23%)	6 (75.00%)	6 (100%)	4 (100%)	0	91
Position	17(23.61%)	1 (2.43%)	2 (14.28%)	1 (7.69%)	2 (25.00%)	0	0	0	23
Theory	1 (1.38%)	1 (2.43%)	2 (14.28%)	0	0	0	0	0	4
Review	29 (40.27%)	2 (4.87%)	0	1 (7.69%)	0	0	0	1 (100%)	33
Other	3 (4.16%)	3 (7.31%)	0	2 (15.38%)	0	0	0	0	8
Total	72	41	14	13	8	6	4	1	159

research type. The second most common research type pursued by international science education researchers during this period was Theory (31%), followed by Review (3.0%), and Position (2.6%). For Latin American authors, Review (20.7%) and Position (14.4%) papers were the second and third most common research types. In both groups (Latin America and International), the most common research type was published in the *IJSE*. While the other journal choices for international science education researchers were *JRST* and SE, for Latin American authors their next journal choices were *S&E* and *SE*.

Productivity by Research Topic

According to Table 8, submissions by Latin American researchers were focused on topics that ranged from History, Philosophy and Nature of Science (HPNOS) (30.8%) to Learning Student Conceptions (22.0%) and Teaching (18.8%). These findings can be correlated with an increase in the last decade, in the number of science educators in the region interested in conducting research in science teacher instruction (Cofré et al., 2015). The *Science & Education* journal published the majority of papers dealing with the HPNOS; the other two research topics (Teaching and Learning Student Conceptions) appeared in publications in the *IJSE*. Other topics studied in papers authored by Latin American researchers included Teacher Education (8.17%), Policy and Curriculum (7.54%), Goals, Culture, Social and Gender (4.40%), and Educational Technology (2.51%).

A major trend in this survey was the prevalence of the HPNOS as the most explored topic, especially by authors from Brazil, Argentina, and Venezuela—three high research productive countries identified in this study. The topic of choice for international science education researchers was Learning-Context, followed by Teaching, and Learning-Conception. *Science & Education*, a journal that specializes on HPNOS served as the publication outlet for the majority of the papers analyzed in this review. The prevalence of HPNOS publications by authors from LAC can be related to the international figuration of these scholars. For instance, 8 of the 40 members of the Editorial Board of the *Science & Education* journal are from LAC. Likewise, the fact that the 2015 International History, Philosophy in Science Teaching (IHPST) Biennial Conference took place in Rio de Janeiro, Brazil, speaks of the alliances involving Latin American scholars and members of international science education organizations. Outcomes of these partnerships might explain the research trajectories in countries like Brazil where it is argued that "the history and philosophy of science seems to have played a decisive role in developing science education research in Brazil" (Villani et al., 2010, p. 918).

Conclusions

The survey described in this study examined the scholarly productivity of Latin American science education researchers as reflected by publications in eight selected journals during the 1998–2015 period. The research productivity of Brazilian authors was exceedingly higher than that of their counterparts in the region. A major finding in this survey was the performance difference among researchers from the identified

Table 8 Research topic by journal

Topic	*Sc & Ed*	*IJSE*	*ScEd*	*JScEdTech*	*JRST*	*RISE*	*RschScTechEd*	*StScEd*	# Articles
Educational tech.	1 (1.63%)	0	0	3 (23.07%)	0	0	0	0	4
Culture, social, and gender	0	4 (11.42)	2 (14.28%)	0	0	1(16.66%)	0	0	7
Goals, policy, and curriculum	5 (6.94%)	2 (2.85%)	1 (7.14%)	1(7.69%)	2 (25.00%)	0	1 (25.0%)	0	12
Informal learning	0	1 (2.85%)	0	0	0	0	0	0	1
Learning conceptions	4 (6.55%)	15 (36.58%)	7 (50.0%)	5 (38.46%)	0	2 (33.3%)	2 (50.0%)	0	35
Learning contexts	5 (8.19%)	0	1 (7.14%)	1(7.69%)	1 (12.50%)	0	0	0	8
Philosophy, history and NOS	40 (55.55%)	4 (11.42%)	0	2 (15.38%)	3 (37.50%)	0	0	0	49
Teacher education	6 (8.33%)	2 (4.87%)	1 (7.14%)	0	1 (12.50%)	3 (50.0%)	0	0	13
Teaching	11 (15.27%)	13(31.70%)	2 (14.28%)	1 (7.69%)	1 (12.50%)	0	1 (25.0%)	1 (100%)	30
Total	72	41	14	13	8	6	4	1	159

countries. There is a notable gap between countries engaged in science education research and those with low or no research output. Although countries like Mexico, Argentina, Venezuela, and Brazil have achieved institutional stability (Villani et al., 2010) and maintained research productivity over the last 15 years, their research productivity, when compared to their counterparts in the international science education community, reveals a notable difference in the productivity of the region as a whole.

A revealing finding in this study is the lack of collaboration among science education researchers as demonstrated by only two publications produced by coauthors from different LAC. It is important to point out that the volume of collaborative work between Latin American and non-Latin American authors is higher than the collaboration among Latin American researchers. Likewise, it should be noted that there is no collaboration among authors from high- and low research productive Latin American countries.

The internationalization of the science education community is evident by the increasing participation of researchers from non-English-speaking countries (Lee et al., 2009; Tsai & Wen, 2005). This turning point presents researchers from Latin America with a formidable opportunity to overhaul their research programs, especially in terms of translating research outcomes into possible solutions to inequality issues endemic to the research and education systems in each nation. It is reasonable to propose that concerted efforts should be put forward in each nation and through the region in identifying the so called *intermediary* factors (persons, institutions, programs) that could contribute to a reduction in "the distance between the results of research and its application in the classroom" (Villani et al., 2010, p. 930) and in the wide community, especially when dealing with sociopolitical tensions and challenges characteristic of each locality.

The UNESCO's 2010 Science Report indicates that scientific research in developing countries continued to depend on national investments. This fact leads us to believe that if the research and education provisions in science, engineering, and technology are tied to the investment capacity of each nation, then there is a great chance that the R&D divide in Latin America continue to persist. This is a critical issue because as indicated in this review, the most dynamic science education research countries are those with strong R&D programs. Being aware of the social, political, and economic limitations faced by researchers from this part of the globe would allow us to suggest that collaborative programs between countries with high and low science education research activity should be established. Efforts of this sort might be implemented in an attempt to instigate the needed changes against low levels of investment in R&D which directly affects educational research in the region. "Education, including science education, is argued to be one of the mechanisms by which the economic gap may be bridged through increasing equal opportunities and providing social mobility" (Cofré et al., 2015, p. 46).

The results of this review are significant in different ways. First, they reveal for the first time, a depiction of the science education research orientations being practiced by Latin American scholars over the last 15 years. Second, this review provides Latin American science education researchers with a depiction of the research landscape that may be informative in their current and future research endeavors which in turn may contribute to the optimization of the research opportunities and resources in each nation. Third, this review ascertains the need for more collaborative research practices

that welcome the interests, needs, and expertise of researchers from all the corners of the Latin American region, especially from countries with little or no participation in science education research.

Finally, it is important to point out that this review was limited to publications available in English in major international science education journals. Therefore, and for the reasons expressed in previous sections, the findings presented in this study are not intended to serve as an exhaustive depiction of the science education research activity in Latin America. In order to produce a more comprehensive examination of this issue, it is proposed that future studies on science education research trends in Latin America be conducted periodically to keep the field in check and also include publications in Spanish and Portuguese to take a broader approach to the science education research activity in this region. This type of studies would be useful in determining if the same science education research types and topics revealed in this study are also reported in studies published in Spanish and Portuguese, or if different research trends are more common in the native languages. Future studies might also address research trends in the region in light of the research and education infrastructure in each country and across the region to add merit and value to the efforts being made in this field in each nation.

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