

Brazilian scientific production in science education

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Received: 18 November 2011 / Published online: 9 February 2012
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Abstract In the present study we analyzed the Brazilian scientific production in the area of science education. The study was structured on: data by research groups registered in Conselho Nacional de Desenvolvimento Científico e Tecnológico; analysis of the post-graduate strictu sensu programs; analysis of theses and dissertations linked to post-graduate programs; and papers in international databases. Our research was conducted strictly via world wide web, from December 2009 to September 2010. It was found that both number of research groups, researchers, post-graduate programs, thesis, dissertations and papers presented a marked increase, especially in the last decade (from 2000 onwards). The major research centers were found to be located in public universities from Brazilian southeast and south regions. However, it was observed a tendency of decentralization, due to a recent investment in new public universities in the other Brazilian regions. So, this study sought to present an overview of the scientific production about science education and we expect that this information can help to expand the vision about the development of this research area in Brazil.

Keywords Scientometrics · Science education · Scientific production · Brazil

Introduction

Brazil, as a developing country, has crossed a process of growth in several areas, including the development of scientific research, especially when compared to developed countries in

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Europe and the United States. According to Filgueiras (1990) the practice of science in Brazil, as an organized activity and regular, has a very recent history and is strongly linked to higher education institutions.

According to De Meis et al. (2007) modern science in Europe began to develop around the seventeenth century and gradually spread through the world. However in Brazil, due to the fact it was a Portuguese colony, this process took longer to arrive because the Portuguese kings, at the time, had no interest in developing scientific studies in Portugal and much less in Brazil.

Taking into account, De Meis et al. (2007) pointed that only in 1951 through the creation of agencies Coordenação de Aperfeiçoamento de Pessoal de Ensino Superior (CAPES) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), which were the initial milestones of public investment in science, by the financial support, sending researchers abroad and incentive to Brazilian post-graduate. So, according to Hermes-Lima et al. (2008) government investments were critical to the development of scientific research in Brazil.

Currently, scientific research in the country is intrinsically linked to post-graduate programs *strictu sensu* located in universities. As Santos (2003), the first steps of post-graduate courses in Brazil were given in the early 1930, through the proposal of the Statute of the Brazilian Universities, with the idea of a post-graduate in the European format.

Souza and Pereira (2002) studied the evolution of post-graduate in Brazil at the level of master's and doctoral and they found in the period 1960 to 1964 the existence of 29 programs. Still, they observed that in the period between 1960 and 1997, the majority of master's courses was created in the decade of 1970, with 521, and doctoral degrees in the period from 1990 to 1994, with 176.

In relation to the Brazilian researchers, Marchelli (2005) in his study showed that until 1985, more than 40% of them had obtained his title in foreign institutions. More recently, due to the policy of expansion and decentralization of post-graduation courses in the 1990, there was a significant growth in the number of titles issued in the country. This policy which gave priority to training of researchers in the country achieved its objectives, so that in the 90, only one out of five titles of doctorates was obtained abroad.

Regarding the Brazilian publications, Adams and King (2009), show that Brazil increased its scientific production of about 8,000 to more than 17,500 documents from 1998–2007 in relation to the scientific world. Hermes-Lima et al. (2008) describes that the number of Latin American publications (in Pascal database) increased from 6,994 in 1990 to 17,919 in 2004, reaching a 3.4% share of scientific publications in the world, compared with only 1.8% in 1990. Which demonstrate the increase in scientific research in the country.

Gomes (2007) states that the main research centers are located in Brazil's public universities. De Meis et al. (2007) complement this information pointing that the two-thirds of Brazilian students do their graduate course in private universities, while 90% of scientific production of Brazilian scientific production is derived from public universities.

The Brazilian research related to education, according to Campos and Fávero (1994), came to be made more regularly towards the end of the 1930 decade, through the creation of the National Institute of Pedagogical Studies (INEP) and its developments, from 1938 at the Centre for Educational Research and in the regional centers, because until this time the research in education field were made in isolated way by some teachers.

According to Campos and Fávero (1994), the first post-graduate courses in education in Brazil are those of the Catholic University of Rio de Janeiro (1965) and Catholic University of São Paulo (1969). Between 1971 and 1975 were created 16 graduate courses in

Brazil, and the first doctoral program began in 1976. Recently, De Meis et al. (2007) pointed that the post-graduate courses from the fields of multi-disciplinary and education together held 189 master's and 44 doctoral programs.

The increasing number of post-graduate courses in Brazil, in public and private universities, generates several developments, due to the strengthening of some sub-areas of these courses are created new post-graduate programs. So, stand out in this context the programs related to the area of science education, which according to Campos and Fávero (1994), they had great incentive in the 1990 decade featuring a specific funding line, making the programs in this area increase in recent years. Moreover, most of these courses are independent from the education centers of the universities and are largely composed by the researchers from called hard sciences field.

Thus, research on science education in Brazil started to receive more attention from the mid-twentieth century and this increase is identified through the creation of post-graduate courses specific to the area, scientific and educational events, and papers in scientific journals (Dias et al. 2009). However, there are few studies (Delizoicov 2004; Fernandes and Megid Neto 2007a; Slongo and Delizoicov 2006) that seek to evaluate the Brazilian scientific knowledge production focused on science education. Therefore, analyzing them is very important, because this kind of research permit to view what has been done and can also show trends and paths to follow in the future. In fact, scientometrics studies are growing in Brazil, which according to Araújo and Alvarenga (2011) is a study area of information science, which has an important role in the analysis of scientific production of a country, and its indicators depict the degree of development of an area of knowledge of a scientific field or know.

So, considering the exposed above, the aim of this study was to analyze the Brazilian scientific production in science education related to the school context. Specifically, our main objectives in this study were: (a) evaluate the concentration areas of the Brazilian strictu sensu post-graduate programs; (b) examine the theses and dissertations linked to the Brazilian post-graduate programs; (c) analyze the Brazilian research groups registered in the CNPq; and (d) investigate the Brazilian papers in international databases of the area of teaching of sciences and mathematics.

Methods

In order to investigate the production of knowledge in the area of science education our research was structured on: search by research groups registered in the CNPq (2010); post-graduate programs strictu sensu, recommended by CAPES (2010a); analysis of theses and dissertations in the bank of CAPES (2010b); and the Brazilian papers published in international databases. CAPES and CNPq are the main agencies of public financing of research in Brazil. So, these data are related to area correspondent to the science education.

The information about research groups were collected in the directory of CNPq groups, which contains information about the research groups currently working in Brazil. The information contained in database, that were collected and used in this paper, were related to human resources constituent of the groups (researchers, students and technicians), research lines, region and affiliation (institution in which the researchers were located).

The search for the data of the post-graduate strictu sensu programs of science education recommended by CAPES (2010a), were made through visits in theirs own websites. Additionally we used the theses bank of the CAPES (2010b) to collect information with respect to the theses and dissertations.

All the research was carried out using as keywords “science education”. These keywords were chosen after testing several words related to the school context, since they showed the greater number of occurrences of results, with lower rate of false positives, and these words contemplate the area of natural and exact sciences, in which are located the school disciplines of science (chemistry, physics and biology), and mathematics. We collected all available data from 1980 onwards, because this was the period that has available information in the web.

The analyses were done by use of an array of analytical data, as indicated by Faria Junior (1992), in which the collected data were placed according to their contents, region of origin, number of students and researchers.

The research for the Brazilian articles in scientific journals, related to science education was made in the following databases: ISI Web of Knowledge, National Library of Medicine—PubMed, Science Direct, SCIRUS and SCOPUS. For this purpose, it was added the word “Brazil” to the keywords “science education”. Taking into account that scientific papers production is very dynamics and growing fast, it is possible that some studies could not be considered in our research.

The entire data collection was exclusively made by electronic way, via the World Wide Web during December 2009 and September 2010, using different ways of measurement of the production of knowledge. Vanti (2002) points bibliometrics, scientometrics, and informetrics, and the youngest of them, webometrics as possible forms to the data collection. The latter makes the quantitative analysis easier, and at the same time brings new and exciting fields.

Results and discussion

Brazilian research groups related to science education

In order to examine the CNPq registered groups related to science education in Brazil, we analyze the available data in the website from CNPq, concerning these groups since 2000 until 2010. As shown in the Fig. 1, it was found a great increase in research groups working to science education subscribed in CNPq. In fact, 2000 it was found only 38 groups, whereas in 2010, 364 groups were found (corresponding to 960% of increase in the last decade; Fig. 1). Regarding to the period previously 2000, the CNPq website presented only general data of the groups earlier than 1993, a condition that do not allows a precise analyze.

Previous papers have been shown that this increase in registered groups was not restricted to sciences education (Prado and Sayd 2004; Menezes 2006; Parreiras et al. 2006; De Meis et al. 2007; Hermes-lima et al. 2007; Coutinho et al. 2009). Furthermore, Barbosa et al. (2009), points that the possible reasons for the evident increase in the number of registered groups, could be due to the changes in the registration system in CNPq, and also due to an increase in the participation of researchers in the groups.

An analysis of the research groups revealed that 220 of them (60%) presented lines of research particular on the subject area of this study. Additionally, it was found 904 lines of research among the 364 groups, being 517 (57%) specific to the sciences education. Moreover, it was found 1,715 professors and 1,696 students in the groups, being that 25 (1.45%) leaders of the groups are receiving a productivity fellowship from CNPq (57.7% men and 42.3% women).

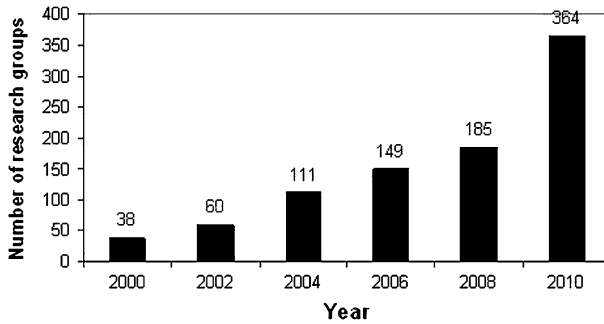


Fig. 1 Research groups working to Science Education registered in CNPq from 2000 to 2010

Our results are in accordance to the CNPq data, in which in 2000 a total of 11,760 research groups and 48,781 researchers were found; whereas in 2008 22,797 groups and 104,018 researchers were recorded, indicating an increase of 94 and 113%, respectively. The evident growth in the analyzed parameters could be attributed to an expansion of higher education in the last years, and mostly due to the increase in the financial incentives for the research in Brazil. In fact, while CAPES invested in 2000 US\$214,409.20, in 2008 the same foment agency was responsible for US\$462,261.23 in investments in order to promote the research in Brazil, representing an increase of 115% of magnitude.

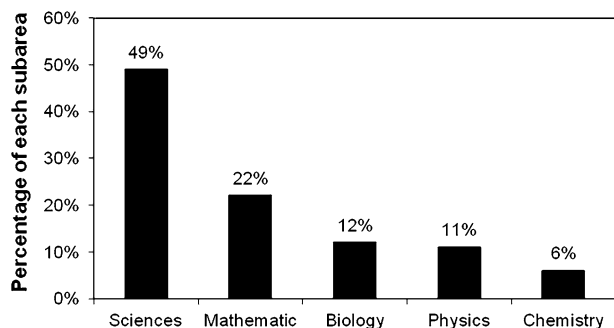
The oldest research group registered in CNPq was “Ensino de Física” from the Federal University of Santa Catarina, since 1981. Nevertheless, Sao Paulo presented the greatest number of registered groups (50 groups), compared to other Brazilian states.

Figure 2 shows that the research groups focused the studies predominantly on the discipline of sciences, followed by mathematics, biology, physic and in less extension on chemistry. The disciplines classification was done based on the currently Brazilian model of school disciplines. However it is interesting to consider that science could be understand as a discipline that take into account the chemistry, biology and physics contents.

Brazilian post graduate programs on science education

Our search about Brazilian post-graduate programs in the field of science education revealed two types of post-graduate strictu sensu programs: professional and academic. Both of them were considered in our study, being 31 professional masters, 28 academics masters and 16 doctoral.

Fig. 2 Focuses of the research groups considering the Brazilian model of scholar disciplines



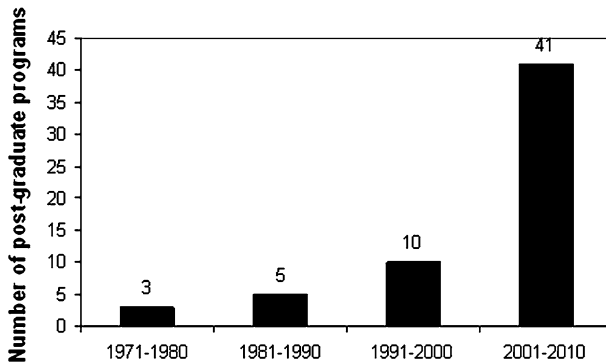


Fig. 3 Progress in the Brazilian post graduation programs related to science education

Silva (2009) pointed that Brazil experienced a long period of stagnation, where there was no significant investment on higher education. In contrast, recently it has been occurred a dramatic change through the expansion of post-graduate and graduate courses in public universities. According to CAPES database, the number of post-graduation programs increased from 1,259 in 1998 to 2,568 in 2008, corresponding to an increase of about 104%.

Figure 3 shows the increase of the post-graduate programs related to the science education, since 1971 onwards. The more evident progress in the last decade (310%) is in accordance with the above mentioned growing in the registered research groups in the CNPq database (see Fig. 1). However, 32 post graduate programs were not included in the present data (Fig. 3) since that did not have website working, or do not have any relevant information.

The southeast with 28 (47.46%) possesses the greatest number of post graduate programs related to science education, followed by the southern region with 15 (25.42%), northeast with 8 (13.56%), midwest with 5 (8.48%) and northern with 3 (5.08%) programs. Our data are in accordance to Amadio (2003), which reported the majority of master (62%) and doctorate (79%) programs, and almost 80% of students involved in post-graduate courses concentrated in the Brazilian southeast states, especially in Sao Paulo.

Moreover, 64% of master degrees are considered from grade 3, 22% from grade 4 and 14% from grade 5, whereas 69% of the doctoral programs are from grade 4 and 31% from grade 5. These concepts (that range from the minimum 3 to maximum 7) given to the post-graduate courses are reviewed periodically by the CAPES (each 3 years).

The oldest program found in the database of the CAPES was the “Ensino de Ciências”, from University of São Paulo (USP) since 1973, focused on the modalities chemistry, physics and biology. However, the highest number of post graduate programs related to science education was found in Sao Paulo and Rio de Janeiro with 12 each.

Table 1 show that the teaching of physics was predominant as concentration area linked to the analyzed programs, followed by science and mathematics, teaching of mathematics, and in less extent others. These data are in accordance with Delizoicov (2004) findings.

Theses and dissertations linked to post graduate programs in science education

A preliminary examination on the CAPES database revealed a total of 2,768 dissertations and 665 theses related to the theme sciences education. However, a more detailed analysis

Table 1 Concentration areas of post-graduate programs

Concentration area	Percent
Physics teaching	15
Science and mathematics	10
Teaching mathematics	10
Health sciences	8
Science education	6
Science education and technology	6
Teaching biology	3
Teaching chemistry	3
Not identified	39

established that solely 521 dissertations and 42 theses were developed in post-graduate programs specific to the field of science education.

Figure 4 shows the number of theses and dissertations produced in the last decade linked to science education. Accompanying the tendency pointed to both to registered research groups (Fig. 1) and to the post-graduate programs (Fig. 3), the number of thesis and dissertations increased more than 900% from 2000 onwards. Likewise, Slongo and Delizoicov (2006) reported that from 1997 to 2000 there was a marked increase in the number of theses and dissertations, supporting our data.

The southeast presented the greatest number of thesis and dissertations (285 corresponding to 50.6%), followed by the south with 178 (31.6%), northeastern 63 (11.2%), and northern 37 (6.6%), whereas midwest did not presented thesis and dissertations linked to science education until September 2010. Our findings are further supported by Leal (2008), which points that southeast and south of Brazil concentrates the majority of the post graduate programs. Besides that, the Brazilian southeast and south possess the best economic and social indices, which could be, at least in part, due to the investment in the production of scientific and technological knowledge in these regions.

Table 2 shows the main institutions responsible for the Brazilian production of theses and dissertations on science education. It was found that the Paulista State University campus Bauri presented the greatest number of thesis and dissertations (19.5%) linked to

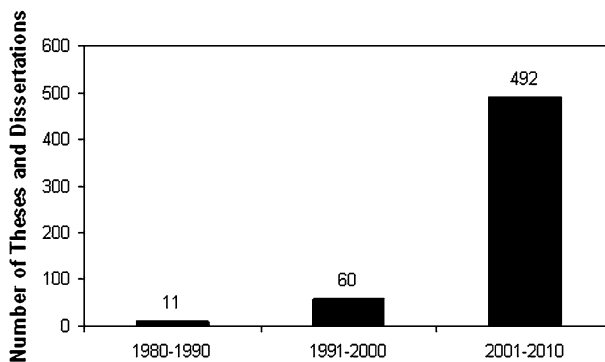


Fig. 4 Number of theses and dissertations produced from 1985 onwards in post graduate programs related to science education

Table 2 Distribution of theses and dissertations considering the institution

Institution	Dissertations	Thesis	Total
Paulista State University Campus Bauru	93	17	110
Federal University of Santa Catarina	33	12	45
Oswaldo Cruz Foundation	20	05	25
University of Campinas	04	05	09
Paulista State University Campus Rio Claro	10	03	13
University of Sao Paulo	101	–	101
University of Pará	37	–	37
Federal Rural University of Pernambuco	33	–	33
Northwest Regional University of Rio Grande do Sul	32	–	32
Federal University of Bahia	30	–	30
Pontifical Catholic University—RS	28	–	28
State University of Londrina	28	–	28
Lutheran University of Brazil	26	–	26
Federal University of Rio de Janeiro	17	–	17
State University of Maringá	14	–	14
Santa Ursula University	06	–	06
Federal University of Rio Grande do Sul	04	–	04
Pontifical Catholic University—SP	03	–	03
Pontifical Catholic University—RJ	01	–	01
Federal University of Paraná	01	–	01
Total	521	42	563

science education, whereas the earliest dissertations found in the CAPES database were from the University of Sao Paulo in 1987.

The analysis of the thesis and dissertations revealed a predominance of qualitative studies (82.1%), followed by quantitative (9.1%) and both qualitative and quantitative (8.8%). Taking into account, Lüdke and Cruz (2005) suggest that there is a great appeal to qualitative research in education due to the great complexity of the studies, since the quantitative methods are not sufficient for the analysis of the entire phenomenon. So, it has been noted that both techniques are necessary to improve the research related to education (Lüdke and Cruz 2005).

Considering the knowledge area, Table 3 shows that almost 90% of the thesis and dissertations concern science education or sciences (physics, mathematics, chemistry, biology), followed by physical education, geography, history, and higher education.

Table 3 Knowledge area of the theses and dissertations

Area	Total (%)
Science education	46.9
Physics	18.8
Mathematics	10.7
Chemistry	7.8
Biology	5.0
Physics, chemistry and biology	4.1
Others	6.7

Table 4 Content of theses and dissertations

Theme	Percent
Teacher education	25
Teaching-learning process	19
Analysis and alternative to the textbook	14
Conceptions of science	12
Transversal themes	11
Interdisciplinarity	7
Others	12

The marked increase in Brazilian production of scientific knowledge linked to science education, has been also accompanied by a diversification in the themes of the thesis and dissertations, as previously described (Slongo and Delizoicov 2006; Goldbach et al. 2009). This phenomenon is due to a large critical mass of researchers involved in this area of knowledge, which generate good and new expectative regarding the science education in Brazil.

When considered the content of the thesis and dissertations (Table 4), it was found a prevalence of studies in teacher education, followed by those related to teaching-learning process, those concern in offer alternatives to textbooks, some that did mention to the views of teachers and students on certain scientific contents, and those that demonstrate different ways of implementing the school transversal subjects (ethics, environment, health, cultural diversity and sexual orientation) that are set by the Ministério da Educação (Brasil 1997) through the national curriculum.

Figure 5 shows that public universities dominates as the major centers of production of knowledge, when compared to private institutions. Our findings are in accordance with previously reported by Gomes (2007) and De Meis et al. (2007), which points that 66% of undergraduate students are from private institutions, whereas 90% from the Brazilian scientific production derived from public institutions. Additionally, De Meis et al. (2007) have been shown that among the 25 major Brazilian centers of knowledge production 96% of them are public, supporting our data (Fig. 5).

One of the reasons for the observed discrepancy among the public and private universities considering the scientific production could be due to distinct characteristics of both. So, while public universities give attention to the production of knowledge, private institutions guided by economic vision, are restricted to a reproduction of knowledge, given attention primarily to undergraduate courses. However, when basic education is taking into account, the private institutions have optimum performance at the national level as compared to public (Sousa 2009). Figure 6 shows a comparison among the Brazilian regions concern the parameters included in our study. As pointed above, southeast and south predominate over other regions as the major centers of scientific production on science education field. These findings are further supported by previous studies (Megid apud Delizoicov 2004; Schnetzler 2002; Fernandes and Megid Neto 2007b). Indeed Megid apud Delizoicov (2004) reported that from 1972 to 1995 almost 50% of the production of scientific knowledge was linked to institutions from southeast: mainly in University of São Paulo (USP), University of Campinas (UNICAMP) and Federal University of Rio de Janeiro (UFRJ).

Additionally, Schnetzler (2002) have been shown that up to 53% of the papers, related to the theme chemistry education, comes from the southeast universities, while Fernandes and Megid Neto (2007a) reported that still 85% of the dissertations and thesis, related to the teaching of biology, derived from universities from south and southeast regions.

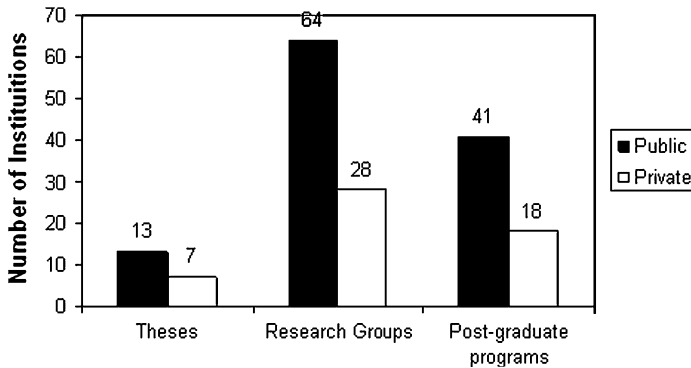


Fig. 5 Comparison among public and private universities concern to Brazilian scientific production on science education and mathematics area

Although the southeast and south are still the major knowledge production centers, we have seen an academic decentralization process in Brazil, because start to appear new centers of scientific production in other regions (see Fig. 6). This process is taking place through public investment in construction and installation of research centers in universities in the poorest regions. It would be expected that through this expansion a parallel increase in post graduate programs and scientific production could occur. Conversely future studies, in science education must take care with the transmission and applicability of their data, in order to its knowledge makes sense and really be used in the school context.

Brazilian papers production on science education

Table 5 shows the number of papers available in the different on line databases. As shown in Table 5, Brazil is responsible for up to 0.57% of total scientific production linked to science education. Since De Meis et al. (2007) reported that Brazil was responsible for 1.75% of the world scientific production, our findings are bellow of them. However, the

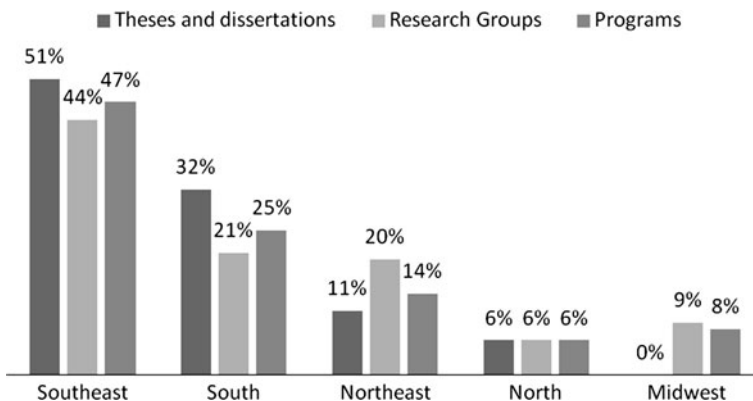


Fig. 6 Regional distribution of scientific production considering both the parameters included in this study

Table 5 The Brazilian papers production about teaching of science and mathematic

Font	World	Brazil
ISI Web of Knowledge	13,754	94
SCOPUS	7,755	21
SCIRUS	1,103	18
Science Direct	1,896	9
PubMed	498	2
Total	25,006	144

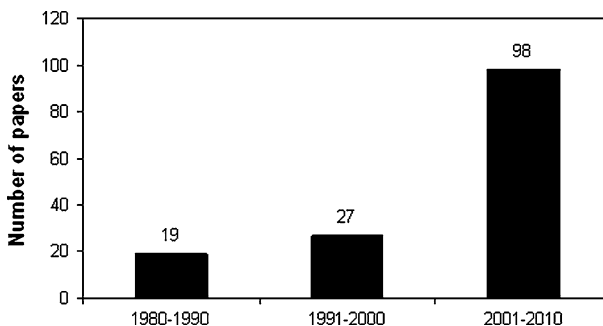
Research performed on
September 2010

Brazilian participation in the international databases must be underestimated, once that a lot of papers are published in national journals on Portuguese language, does not being considered when the search is performed in international database.

Figure 7 shows that the Brazilian papers production was more evident from 2000 onwards. In fact, in the last decade the Brazilian scientific production increased more than three times, accompanying the growth in the other analyzed parameters. Moreover, Rezende (2010) says that the growth of Brazilian scientific production in the period 1982–2010 has been around 10.5% per year, while world production has been three times smaller. According to previous studies, the expansion in scientific knowledge production it is expected to occur naturally when a country increase the investments on higher education (Hermes-lima et al. 2007; Zenteno-Savín et al. 2007; Adams and King 2009; Helene and Ribeiro 2011). Our consideration is further supported by De Meis et al. (2007) study, in which was reported that the key for the growth of scientific research is through the expansion of the post-graduate programs.

Figure 8 shows that there was a balance in the number of papers, when the content of them were taking into account. Actually, it was found that independent on the discipline related to the area of natural and exact sciences (biology, chemistry, physics and mathematics) the percentage of paper focused on each one was very identical (20–30%). This balance between the disciplines focused is very important, since Fensham (2008) reported that the knowledge of science refers to the knowledge of the natural world and its perception is essential for the student insertion in society. So, the understanding of the entirely natural phenomenon it is indispensable for the students learn about science.

The increase in the number of researchers involved, and the consequent increase in the scientific production in the education field, creates new and good expectation for the improvement of the teaching on school. However, even with the evident increase in

**Fig. 7** The Brazilian papers production on science education in international database

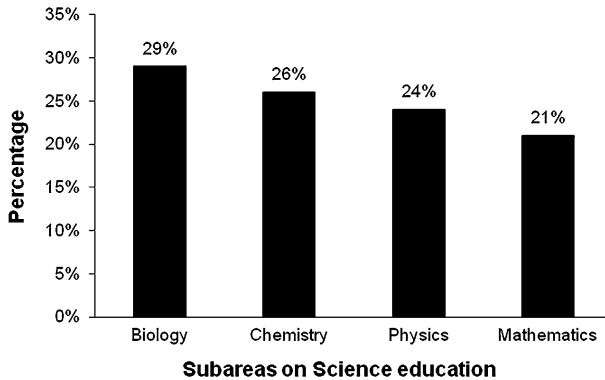


Fig. 8 Distribution of scientific papers by considering the content approach

the Brazilian scientific knowledge production linked to science education, still there was no improvement in the performance of our students on international assessments. Accordingly INEP (2008), the Brazilian student performance remains practically the same obtained in 2000.

Therefore, while Brazil produces a lot of knowledge there was no improvement on the teaching of science in school, leading to a detachment among scientific knowledge production and teach of science. This assertion is supported by the PISA results (INEP 2011), which show that the performance of Brazilian students in the basic institutions of education is lower than many Latin American countries like Chile, Uruguay and Mexico. However, when analyzing the scientific production of Brazilian higher education institutions there is the opposite, with the country being well ahead of other Latin American neighbors (Glänzel et al. 2006; Wainer et al. 2009; Wagner and Wong 2011). So based on the exposed, we conclude that the current knowledge generated in higher institutions is in practice ineffective and a small part of this knowledge comes to schools.

Conclusions

Our results clearly show the Brazilian expansion in the production of scientific knowledge linked to teaching of sciences and mathematic, considering all the analyzed parameters. Moreover, it was found that the major centers of research are located mainly in the Brazilian southeast followed by south, despite a slight tendency of decentralization through the public investments in new universities and research centers in poorest regions. Of particular importance, this fact would be expected to lead advancement and dissemination of knowledge for all regions, contributing for the economic development of them.

About Brazil's participation in worldwide research, our study found that it has increased in recent years in science education, especially after 2000. However, we emphasize that much of the Brazilian scientific production is published in Portuguese making it difficult the spread of this knowledge in international databases. Additionally we can also observe that the improvement of Brazilian scientific production about these contents is not accompanied by the basic education (Coutinho 2010; INEP 2011). So, we believe that is necessary to investigate if the teachers in schools are using this scientific knowledge about science education, and how they are using it. Finally, this study sought to present an

overview of the Brazilian scientific production related to science education and we expect that these information can help to expand the vision about the development of this research area in Brazil.

Acknowledgments The financial support by Fundação de Amparo à Pesquisa do Rio Grande do Sul (FAPERGS), Financiadora de Estudos e Projetos (FINEP), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Pró-reitoria de Pós-graduação (PRPGP) UFSM and Conselho Nacional de Pesquisa (CNPq) is gratefully acknowledged.

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