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Trends and priorities in inquiry-based science teaching: a study comparing the most cited articles from Brazil and South Africa

H. V. C. Corrêa[a], M. S. Shimada[b], S. W. Locatelli[c] , L. A. Testoni [d], A. A. James[e]

[a]Higor Vinícius Camargo Corrêa (higorviniciuscamargocorrea@gmail.com)

[b]Marcella Seika Shimada (marcella.shimada@ufabc.edu.br)

[c]Solange Wagner Locatelli (solange.locatelli@ufabc.edu.br)

[d]Leonardo André Testoni (leonardo.testoni@unifesp.br)

eAngela Antoinette James (jamesa1@ukzn.ac.za)

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E-mail:
higorviniciuscamargocorrea@gmail.com
marcella.shimada@ufabc.edu.br
solange.locatelli@ufabc.edu.br
leonardo.testoni@unifesp.br
jamesa1@ukzn.ac.za

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ABSTRACT

The articles were selected from the Web of Science database and the Coordination for the Improvement of Higher Education Personnel (CAPES) portal. The following criteria were used to filter the articles: i) contain "inquiry-based teaching"; ii) country: Brazil or South Africa; iii) period: from 2013 to 2024; iv) citation: 5 most cited studies. The initial results indicated the difference in focus in the context of the countries; while South Africa still suffers consequences due to the recent history of apartheid, in Brazil, ethnic issues also exist, but the historical context of slavery is socially silenced. The similarities highlight the advantages of the inquiry teaching approach, the approval of teachers, and the gaps in their training.

Este artigo tem como objetivo destacar os pontos de convergência e divergência entre os artigos mais citados no Brasil e na África do Sul, que tratam do Ensino de Ciências por Investigação. Os artigos foram selecionados a partir da base de dados Web of Science e do portal da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). Para tanto, foram utilizados filtros com os seguintes critérios: i) conter "inquiry-based teaching"; ii) país: Brasil ou África do Sul; iii) período: a partir de 2013; iv) citação: 5 estudos mais citados. Os resultados indicaram a diferença de foco entre os países: enquanto a África do Sul ainda sofre consequências devido à história recente do apartheid, no Brasil, as questões étnicas também existem, mas o contexto histórico da escravidão é socialmente silenciado. As semelhanças destacam as vantagens da abordagem do ensino investigativo, a aprovação dos professores e a lacuna na sua formação.

I. INTRODUCTION

Inquiry-based science teaching (IBST) is a methodology and an approach that focuses on the student's role in their learning, as it encourages the construction of knowledge and intellectual freedom (Carvalho, 2018). In a complementary way, IBST allows emphasis to be placed on the development of scientific skills and competencies, such as observation, hypothesizing, data collection, testing and analysis, argumentation, and evidence-based decision-making (Barrow, 2006).

Therefore, this development of the scientific skills approach allows students to better understand scientific concepts, construct knowledge meaningfully, and actively participate in the learning process (Carvalho, 2018). According to Carvalho (2018), the methodology awakens interest in science and makes learning more interesting and motivating.

Students, adopting a more autonomous stance through IBST, may consider both the learning product and the investigative process and the argumentative and critical potential in decision-making situations (Bueno & Sedano, 2021; Sherin, 2004).

This study aims to understand IBST in different contexts of application, specifically in Brazil and South Africa. These countries were chosen because they have political and economic relationships and leaders in their regions, which are BRICS members (Ribeiro & Morais, 2015). Furthermore, these countries face the difficult task of guaranteeing their macroeconomic objectives in the long term and establishing higher standards of living in the short term (Vizentini & Pereira, 2010), and they are regarded as developing countries in the world.

To this end, it is necessary to consider new approaches to social policy and, as an alternative, the transformative social approach. According to Phiri (2017), the policy approach can be incorporated into intellectual debates to address the conceptual crisis and dialogue with an emphasis on contextual applications in both South Africa and Brazil, as the two countries offer a compelling comparison through shared histories of colonial domination, slavery, and anti-black racism.

As racism permeates social and economic evolution, colonialist logic has worked to discredit the humanity of the colonized through land dispossession, reduced opportunities, social mobility, and systemic violence.

> Any attempt to understand the trajectory of poverty and inequality in South Africa and Brazil needs to be historicized since both countries have developed distinct notions of exclusion and inclusion in the evolution of their political and social histories. Progressive social policies must, therefore, go beyond the master-slave relationship that shaped patterns of redistribution and opportunity for both countries (Phiri, 2017, p. 97, authors *translation*)

Consequently, there is a need to recognize the school's current reality and then take advantage of existing strengths when implementing a curricular innovation. In view of this, this research responds to the following question: What are the characteristics of inquiry-based science teaching addressed, in a comparative study of the most cited articles, in the Brazilian and South African contexts?

II. METHODOLOGY

The research strategy is a systematic review that "is a means of identifying, evaluating and interpreting all available research relevant to a particular research question (...) "(Kitchenham, 2004, p. 1) of a qualitative and interpretative nature.

The search was for references in the field of education. Therefore, the searches were initially carried out using the following databases: Education Resources Information Center (ERIC), Web of Science, and the CAPES Periodicals Portal. After an exploratory search, it was found that the last two databases had numerous results and were better aligned with the aim of this study. The databases chosen to search the documentary corpus were the Web of Science and the CAPES Periodicals Portal.

Variations of the keyword "inquiry-based teaching" in English and Portuguese were tested to identify the most appropriate version for the review, i.e., those that best answered the research question. Therefore, it was determined that the keyword "inquiry-based teaching" was suitable for searching South African and Brazilian articles in the Web of Science and CAPES (Portal de Periódicos) databases.

When searching for South African articles using the keyword established in the Web of Science database, the "country or region" filter was used, selecting "South Africa". The search was then refined with a second filter called "period", limiting the data from 2013 to 2024. From the total number of articles found, the 5 most cited were selected. This was done by analyzing the citations for each of the articles and then selecting the five with the highest number.

The search for articles considering the country of Brazil was carried out in the same way as the sequence of filters mentioned above. Starting with the keyword "inquiry-based teaching", the filter "country or region" was used to refine the data, selecting "Brazil". Finally, the time filter was also applied to results from 2013 to 2024. From the total

number of articles found, the 5 most cited were selected. The methodological approach to searching for articles on South Africa and Brazil can be seen in Figure 1 below:

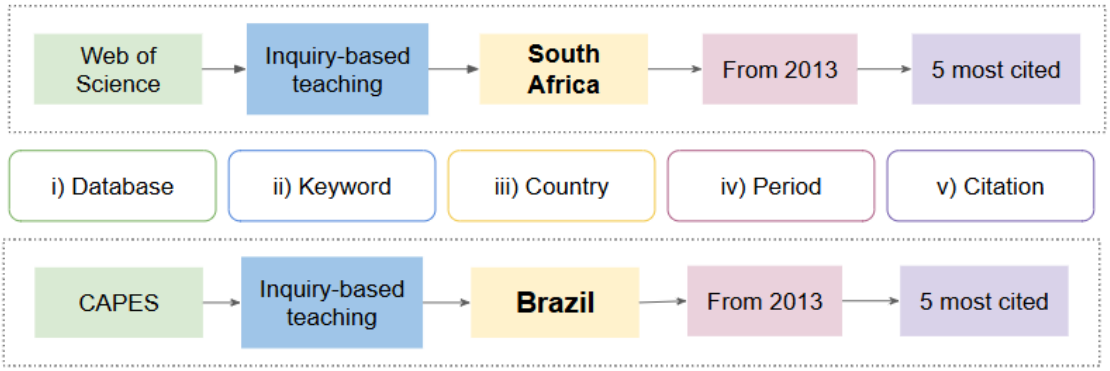

FIGURE 1. Search scheme for South African and Brazilian articles.

Therefore, the documentary *corpus* of this review comprised 10 of the most cited articles since 2013, 5 of which were South African (A) and 5 Brazilian (B), within the scope of this research. This data was collected in September 2023. These documents were read and analyzed for similarities and differences.

III. RESULTS AND DISCUSSION

Here we present the list (Table 1) of the 10 articles selected for this research according to country, with South Africa having the acronym A and Brazil the acronym B, title of the articles, authors, year of publication, and in descending order of number of citations (n), considering first those from South Africa, then those from Brazil.

TABLE I. Tamanho médio de partículas como função de uma trituração.

Acronym	Title	Authors and year	n
A	The pedagogical orientations of South African physical sciences teachers towards inquiry or direct instructional approaches	Ramnarain & Schuster (2014)	35
A	Teachers' perceptions of inquiry-based learning in urban, suburban, township and rural high schools: The context-specificity of science curriculum implementation in South Africa	Ramnarain (2013)	25
A	Teacher beliefs and attitudes about inquiry-based learning in a rural school district in South Africa	Ramnarain & Hlatswayo (2018)	19
A	A systematic review characterizing and clarifying intrinsic teaching challenges linked to inquiry-based practical work	Akuma (2018)	16
A	Understanding the influence of intrinsic and extrinsic factors on inquiry-based science education at township schools in South Africa	Ramnarain (2018)	15
B	Alfabetização científica, ensino por investigação e argumentação. Relações entre ciências da natureza e escola	Sasseron (2015)	562
B	Ensino de ciências por investigação: oportunidades de interação social e sua importância para a construção da autonomia moral.	Sedano & Carvalho (2017)	71
B	Ensino de ciências por investigação: uma estratégia pedagógica para promoção da alfabetização científica nos primeiros anos do ensino fundamental	Brito & Fireman (2016)	64
B	Competências e formação de docentes dos anos iniciais para a educação científica	Briccia & Carvalho (2016)	44
B	O ensino de ciências por investigação: vivências e práticas reflexivas de professores em formação inicial e continuada	Oliveira & Obara (2018)	34

The following is a brief description of the articles published I) in South Africa, II) in Brazil, and finally, III) the comparison of the 10 articles.

III.1 Description of South African articles

The articles selected show Professor Umesh Ramnarain's great influence, as four of the articles are his own. His research focuses on inquiry-based teaching and learning and its use in South African classrooms, which are characterized by diversity and complexity in terms of intrinsic (personal attributes of the teacher) and extrinsic (environmental) factors.

With 35 citations, the study by Ramnarain and Schuster (2014) reports that there is a great disparity in school demographics in South Africa, which can also affect teaching practices. The authors also state that teacher support is lacking, as it is difficult to accompany students throughout the application of activities and the inquiry teaching approach. Furthermore, for these authors, many teachers remain poorly qualified to teach, a problem that is compounded by a lack of resources, which is considered a legacy of the post-Apartheid education system.

In another study with 25 citations, Ramnarain (2014) addresses the issues of a) the benefits of inquiry-based learning, b) student autonomy, c) learning, d) inquiry-based assessment, and e) teacher competence. The main results show that teachers positively perceive inquiry-based learning, which benefits students by developing experimental skills and making science more enjoyable.

In the rural context with school teachers, Ramnarain and Hlatswayo (2018), in their article with 19 citations, stated that although inquiry-based teaching is geared towards the student as the protagonist, it is essential to emphasize that the teacher must still be the mediator and believe in the method. The belief and training for these teachers is the key to the issue.

Furthermore, when comparing implementation in different contexts, it seems that the presence of extrinsic factors strongly mediates the realization of inquiry. In South Africa, these factors are pronounced, and although teachers respond favorably to inquiry, they subvert an inquiry-based curriculum.

The systematic literature review of Akuma and Callaghan’s (2018) article with 16 citations, indicates that it aimed to characterize and clarify intrinsic challenges linked to design and implementation of IBST, in the sciences. According to the authors, researchers and professional development providers need to make efforts to improve science teachers' IBST practices in relation to the various intrinsic challenges they might encounter in the context of design and implementation.

Finally, Ramnarain's (2016) article with 15 citations, highlights teachers' perceptions of intrinsic and extrinsic factors that influence the implementation of IBST in (under-resourced) secondary schools in South Africa. The author highlights the need for increased scientific knowledge of the content, pedagogy, learners, educational contexts, and curriculum, contributing to the teachers' uncertainty of how to implement IBST. In addition, extrinsic factors constitute a significant gap in implementing inquiry-based education in schools.

III.2 Description of the Brazilian articles

The most cited Brazilian articles, highlight the importance of social interactions, teacher training, and the influence of their skills and practices as mediators in developing the learning process, and are concerned with effectiveness and the extent to which these complex intersections affect teaching practices.

Sasseron (2015) with the most citations of 562, reflects on the role of students and the teacher in training students. The author indicates that with this didactic approach, interactions between teachers, students, materials, and information are necessary. Thus, the role of students is in engagement, which generates learning. This author also discusses argumentation in teaching situations, which involves learning epistemological aspects. The development of

argumentation in science is already configured as an approach that goes beyond the straightforward content of a discipline, also allowing for the possibility of developing epistemic authority among students.

The study by Sedano (2017), with 71 citations, analyzed a group investigative proposal for elementary school students in a public school in São Paulo, to evaluate social interactions and the construction of moral autonomy. These authors defend group work in investigative science activities because of the opportunity for interaction, participation, construction, and conflict, the chance for students to experience a diversity of attitudes, and the consequent formation of moral autonomy.

Brito and Fireman (2016), with 64 citations, point out that IBST has established itself as an effective methodology for promoting scientific literacy. The study indicated that the students showed empathy for the proposed problem and driven by curiosity, developed skills such as manipulating variables, questioning evidence, investigating controversial situations, organizing data, and clearly communicating methods. The students also created their conceptual knowledge comprehensively, which was achieved through the following skills: critical thinking, development of reasoning, flexibility, argumentation skills, problem-solving, and synthesis skills.

Briccia and Carvalho (2016), in their article with 44 citations, analyze the training, practice, and reflections of a group of teachers to observe the main factors for teachers' inclusion in science education. There is evidence of the need to develop their own knowledge since scientific didactics has both methodological and conceptual understanding that is essential for teachers to enter this universe. In addition, they conclude that a teacher's involvement with a new subject is not based on specific knowledge but on a series of competencies present in training and practice.

Oliveira and Obara (2018), in their article with 34 citations, emphasize that effective education must be aligned with students' social reality and the role of teachers in mediating scientific concepts. Thus, they propose a new approach to teacher training that integrates teaching and research and promotes a reflective teacher profile in their professional practice.

III.3 Correlating discussions

Regardless of the country, Brazil or South Africa, region of the country, or social class, teachers and students had a favorable view of the benefits of IBST, in the research cited. In fact, in addition to actively appropriating knowledge, the IBST approach provides students with the development of various cognitive skills simply by bringing them closer to scientific practice (Akuma & Callaghan, 2018; Briccia & Carvalho, 2016; Brito & Fireman, 2016; Ramnarain, 2014; Sasseron, 2015).

Reflecting on the socio-economic and racial aspects, it is constantly said that just over 130 years after the Aurea Law[1] is a short time to eradicate racism and everything that involves the consequences of slavery in Brazilian society. It should be noted here that the end of apartheid is only 30 years with the introduction of the democratic government in 1994, in South Africa.

If Brazil's social policies are moving slowly to reduce the gap between social classes and undo the results of centuries of post-slavery restrictions, South Africa is still in its post-apartheid infancy. According to Bhorat (2013), Francis and Webster (2019), even with government policies, inequality has increased for most of the post-apartheid period, and progress in reducing poverty requires a redress of social, economic and political power, it is limiting.

Education, which should be a right, is unfortunately still a privilege in many places, especially in South Africa. Freire (1984) argues that it is naïve to expect the dominant classes to promote an education that allows the dominant classes to understand social injustices critically.

Before measuring the practice's efficiency, one must consider teachers' contact with IBST as a pedagogical approach. South African research reports problems associated with managing students' experiences in large classes (Ramnarain & Schuster, 2014) and in schools in disadvantaged communities, where classes are overcrowded and

[1] Aurea Law declared slavery extinct in Brazil, having been sanctioned on May 13, 1888 by Princess Isabel.

equipment inadequate for practical work, further highlights how school factors, experienced by teachers exert a considerable influence on the implementation of curriculum reform (Ramnarain, 2016).

According to Ramnarain and Schuster (2014), teachers' orientation is compromised by the degree of competence due to their training and, consequently, their confidence in redefining the teaching role, transitioning from a centralizing bias in the educational process to a role that facilitates learning. The analysis of productions from both countries shows that many remain poorly qualified to teach despite professional development initiatives.

A comparison of the most cited articles from the two countries also shows some differences. While the discrepancy in resources between locations was a more prominent challenge in South Africa, in Brazil, there was an emphasis on the difficulty of moving away from traditional teaching and the lack of familiarity with inquiry teaching. Therefore, teacher education emerges as a critical factor in both cases. Furthermore, all the articles unanimously list the advantages and teachers' favorable views of using IBST in their teaching practices. However, as most of them had never had direct contact with research during their training, some reactions revealed fears, even with positive indicators that highlighted good results in educational dynamics.

In Brazilian studies, Briccia and Carvalho (2016) draw on research by Machado and Sasseron (2012) and Carvalho (2007), who emphasize that the way the teacher conducts the work is decisive for the type of discussion and interaction that develops during the lesson. They also stress the need to work with teachers on methodological aspects, which are often denied in their initial and continuing training. Guided by the same concern, Oliveira and Obara (2018), when evaluating initial and continuing teacher training in a study group of scholarship students and basic education teachers, reinforced the need to review the pedagogical practices of training courses.

Sedano (2017) points out that individuals choose their attitudes consciously rather than passively accepting rules or moral concepts imposed on them. According to the author, to decide on the most appropriate action, they need to experience situations that teach them how to deliberate on them.

Along these lines, Sasseron (2015) defends the articulation between IBST and scientific literacy, focusing on the need for argumentation in the school environment because of its hybrid culture; Sedano (2017) reflects social interactions and the construction of moral autonomy in investigative classes, Brito and Fireman (2016) show that this teaching methodology contributes to the student making a coherent reading of the world; Briccia and Carvalho (2016) reinforce teacher training and the influence of their skills and practices as a mediator for development in the learning process; De Oliveira and Obara (2018) are concerned with the effectiveness of education in relation to the reality of teachers, comparing teachers in initial and continuing training; none of the Brazilian articles come close to bringing up the social contrast and how this affects teaching practices, such as Ramnarain (2014) and Akuma and Callaghan (2018) points out the need to broaden the view to limited access or fewer opportunities in school activities, a multilateral perspective, for more adequate results.

IV. CONCLUSION

The search for articles in the Web of Science databases and CAPES journal portal produced the five most cited articles of South African origin and the five most cited Brazilian ones. This research considers the central question: What are the characteristics of inquiry-based science teaching addressed in a comparative study of the most cited articles, in the Brazilian and South African contexts?

The results indicate that South African researchers are concerned about the social situation in which students and teachers are contextualized, considering post-Apartheid's legacy on the educational system. Four of the five research articles in South Africa were authored by the same author, which may explain the similarity in the investigations.

On the other hand, Brazilian research focuses on the benefits of IBST as a potential citizen-former, emphasizing the importance of interactions between students and teachers, teacher training, affection, and skills that students develop throughout their investigative practice.

In the convergence of South African and Brazilian research, both countries highlight a need for qualified teachers for IBST, which is extensively emphasized in articles from South Africa. Therefore, the study also emphasizes the importance of ongoing teacher training, which is essential for them to use investigative practices in the classroom.

In these studies, teachers demonstrate a favorable view regarding implementing IBST in the classroom, even if they had not had contact with this method in their initial training. This highlights the transformative potential of teaching that enables the development of critical thinking in educational contexts, forming more aware and active citizens in their cultural surroundings.

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