Longitudinal multivariate profile of Brazilian journals on Science Education from 2013 to 2019

Eric Batista Ferreira
Frederico Augusto Toti

Abstract. Scientific findings travel in the light speed in the information revolution century. Particularly, scientific journals spread research on Science and Physics education worldwide. Brazilian journals play an important role in the scientific international scenario and can be monitored by bibliometric and scientometric evaluations. This paper analysed 3557 papers from thirteen Brazilian electronic journals focused on Science education and/or Physics education. We use impact and bibliometric metrics and Qualis Journals for multivariate profiling Brazilian journals, as well as evaluating their temporal course from 2013 to 2018. Journals could be classified in four clusters fairly distinct in terms of impact and individual temporal path could be identified.

1. Introduction

Scientific findings travel in the light speed in the information revolution century. Particularly, scientific journals spread research on science education worldwide. Dozens and dozens of journals nowadays are specialized in Science, Physics, Biology and Math Education and research on it, which are monitored through qualitative and quantitative metrics in order to drive researchers and management decisions (Hadimani; Mulla; Kumar, 2015; Abramo; D'Angelo, 2015; Kellner, 2017; Schulz, 2019; Santos et al., 2018).

At the end of 1940, some isolated actions promoted the creation of the firsts research groups on Physics and Science educations in Brazil. After, in the decade of 1970, the firsts journals were created and the firsts meetings on Physics education was held in Brazil (Nardi, 2005). Nowadays, Brazilian researches and researchers are well known and influent in the international scientific scenario. In this context, current Brazilian journals on Science and Physics education look for high quality papers as well as readers, downloads and citations.

Impact based metrics can be used to screen journals practices and drive management decisions. Some indices are well known and used by the researchers on Bibliometrics and Scientometrics, like the impact factor (citations per paper in a two-year period), Hirsch's h-index (Hirsch, 2005) and its alternatives, such as the g-index (Egghe, 2006), h-index normalized by individual (hinorm – Harzing; Alakangas; Adams, 2014) and the h-index normalized by year (hiannual – Batista et al., 2006). Several other metrics can be used for the goal of screening journals, stablishing

profiles and estimating journal impact such as the number of papers published, views, downloads, citations and so on (Carpenter; Cone; Sarli, 2014).

CAPES – acronym that stands in Portuguese for Coordination for the Advancement of Graduate Education – is a Brazilian government agency linked to the Ministry of Education. Since 1976 CAPES is responsible evaluating postgraduate programs in Brazil. CAPES' assessment system consists of a number of tools (Marenco, 2015) where Qualis Journals is one of them. Its role is to assist the evaluation committees in the process of qualification of the bibliographic production of the teachers and students of Capes accredited graduate programs (Barata, 2016).

Briefly, Qualis is a categorical variable created to label journals which would reflect the quality of the postgraduate programs whose professors and students publish in. During the quadrennium 2013-2016, Qualis was formed by 8 strata (Table 1), where A1 stands for the highest level (1st stratum) and C the lowest (8th stratum). As it was conceived, there were one Qualis for each area of knowledge, what was quite hard to understand and can be deleterious for periodicals with broad scopes, since one single journal can be labelled with different Qualis categories (Kellner, 2017). For instance, the *Latin-American Journal of Physics Education* (http://www.lajpe.org/) was labelled A2 for *Teaching*, B1 for *Interdisciplinary*, B5 for *Material* and C for *Astronomy/Physics*[1].

Even though Barata (2016, p.5) says clearly that "Qualis Journals should not be considered as an adequate source for the quality rating of scientific journals for purposes other than the evaluation of graduate programs", Marenco (2015) notes what is very natural and intuitive: Qualis drives researcher submission. Therefore, indirectly, Qualis says something about the quality of the journal. If so, how can a journal have several quality levels at once? Of course it has not! So, the explanation goes back to its conceptual origin and Barata's statement.

In July 18th 2019 CAPES has announced an enhancement to its rating system, in particular Qualis Journals. The improvement need of Qualis had been previously speculated in the literature (Trzesniak, 2016). The idea is to use unique criteria based on bibliometric indicators – Scopus (CiteScore), Web of Science (JCR) and Google Scholar (h5 index) – yielding a single classification for each journal (Capes, 2019a). The day after, the same agency published that a list of journals and unique Qualis had been sent to programs coordinators, highlighting that such list is temporary (Capes, 2019b). The unique Qualis is now formed by 9 strata rather than 8 (Table 1). However, since they are different metrics, their categories are not promptly equivalent, i.e., the highest stratum of the old metric must be carefully compared with the highest stratum of the new one.

[1] Such classification can be found for periods 2010-2012 and 2013-2016 in shorturl.at/jwCW2.

Table 1. Multiple and unique Qualis categories.

Strata	Multiple	Unique
1st	A1	A1
2nd	A2	A2
3rd	B1	A3
4th	B2	A4
5th	B3	B1
6th	B4	B2
7th	B5	B3
8th	C	B4
9th		C

Source: Author.

Several respected and valuable databases such as Scielo, Scopus and Web of Science house scientific articles and can be consulted to get the number of citations for papers of a specific journal during a period. However, as highlights Schulz (2019), a paper can impact researches, professors, lectures and students in several ways, such as influencing their monographies, dissertations, thesis, abstract for meetings and conferences and so on. That's where the Google Scholar plays an important role, accounting for citations on all kinds of scientific documents.

In this context, the aim of the paper is to profile Brazilian journals on Science and Physics education in a multivariate approach, considering impact and bibliometric metrics and Qualis Journals, as well as evaluating the temporal course made by the journals from 2013 to 2018.

2. Material and Methods

It is a retrospective longitudinal quantitative and observational study on Brazilian journals on Science education, with particular focus on Physics education. We aim to access the profile by their main features and publications impact through several metrics.

The object of the study are 3557 papers from thirteen Brazilian electronic journals focused on Science education and/or Physics education, with editorial board, International Standard Serial Number (ISSN) and own website. Full names in Portuguese, acronyms and websites are given in Table 2.

Data were collected from December 1st to 25th of 2019. We visit the websites for acquiring some information but obtained most data through the software Publish or Perish (PoP) version 7.15.2643.7260 (Harzing, 2007). PoP searched in Google Scholar database for finding the articles, citations and calculating impact metrics. We used the ISSN and the full name of the journal for searching for its articles year by year from 2013 to 2019.

Table 2. Journals, acronyms and respective websites.

#	Journal	Acronym	Website
1	Revista Brasileira de Ensino de Física	RBEF	https://bit.ly/2QvdPGR
2	Caderno Brasileiro de Ensino de Física	CBEF	https://bit.ly/2F5h3vD
3	Ciência & Educação	CE	https://bit.ly/2MEMAIX
4	Ensaio: Pesquisa em Educação em Ciências	EPEC	https://bit.ly/2F56gkV
5	Revista Brasileira de Pesquisa em Educação em Ciências	RBPEC	https://bit.ly/37g9L4f
6	Alexandria	A	https://bit.ly/2EZxTMr
7	Investigações em Ensino de Ciências	IEC	https://bit.ly/3553Q0j
8	Experiências em Ensino de Ciências	EEC	https://bit.ly/2Q7Cm5Y
9	Amazônia – Revista de Educação em Ciências e Matemáticas	ARECM	https://bit.ly/2MFEjo3
10	Revista Brasileira de Ensino de Ciência e Tecnologia	RBECT	https://bit.ly/2QsLYY6
11	Ensino de Ciências e Tecnologia em Revista	RCTR	https://bit.ly/2ZDap9s
12	Ciência & Ensino	Cens	https://bit.ly/2ZGeLN2
13	A Física na escola	AFE	https://bit.ly/39l25zq

Source: Author.

The publishing period of the articles of this study is from 2013 to 2019. Such period binds the quadrennium (2013-2016) for evaluating the publications of Brazilian postgraduate programs with the period up to the present day (2017-2019), when circulates the preliminary unique Qualis index.

We have observed fourteen variables, some of them referring to journal features such as number of papers publish per year, journal's lifetime, number of authors per paper (app) and the percentage of papers that mention the word Physics (%phy). Other considered metrics indicate impact such as h-index, g-index, normalized and annual h-indices, cites per paper and four variations of Qualis index, namely Teaching, Education, Astronomy/Physics and preliminary unique Qualis (teaQ, eduQ, aphQ, uniQ).

Statistical analysis was performed in software R version 3.6.2 (R Core Team, 2019) through R Studio version 1.2.5033 (RStudio Team, 2019). Descriptive statistics was used as proportion, mean and correlation estimation as well as principal component analysis (PCA) with supplementary qualitative variable (Husson; Le; Pages, 2010) and hierarchical cluster analysis (HCA).

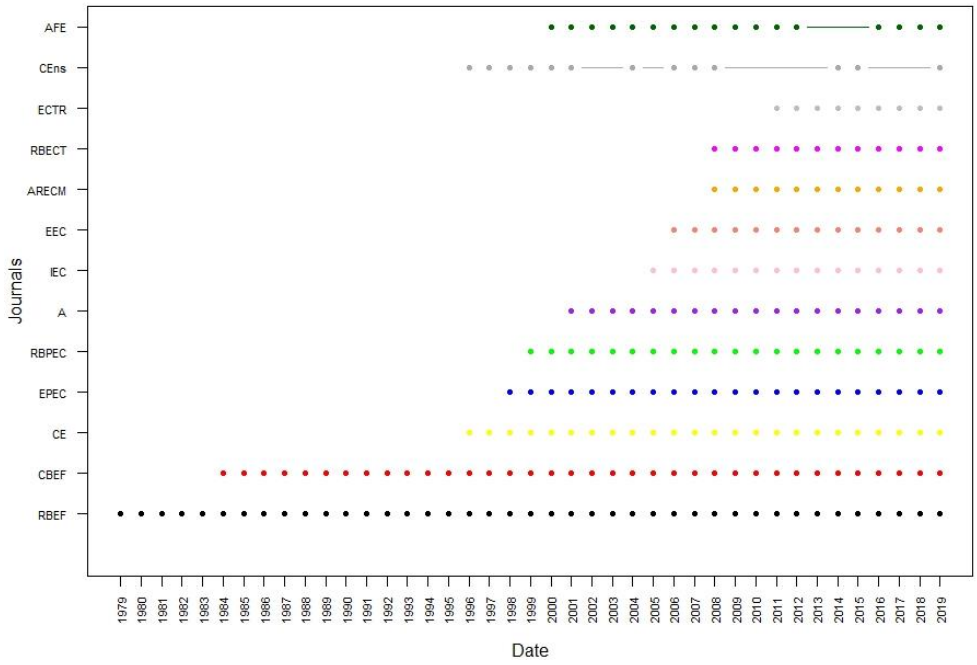
3. Results and discussion

At first, we selected 13 Brazilian electronic journals based on their focus and scope. As can be seen in Figure 1, some of them are traditional journals, with decades of expertise and others are quite recent ones. On the top of Figure 1 we highlight two journals for missing issues. Coincidentally, both journals were removed from this study because their metadata are not available the way Google Scholar - and consequently PoP - needs. It causes empty returns in PoP for searches about these journals, making them impossible to be considered in this research.

Science education journals in Brazil are 9 to 41 years old what make them recent journals among other of the same area worldwide. Although the International Journal of Science Education (Taylor & Francis) is exactly 41, and the Journal of Science Education and Technology (Springer

Verlag) is 28 years old, the American Journal of Physics publisher papers about education since 1934 and the journal Physics Education since 1966.

Figure 1. Lifetime of Brazilian electronic journals of Science education.

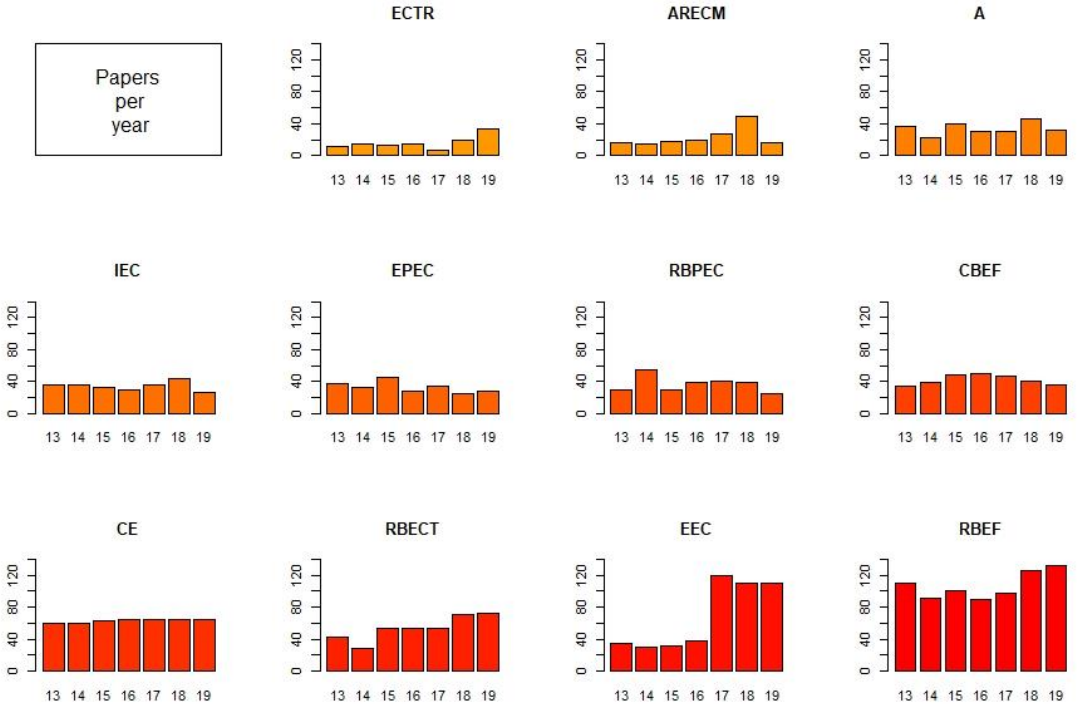


Source: Author.

Another feature related to the history of a journal as well as its flow is the number of papers published per year (ppy). Publishing a large number of articles a year is not a sign of quality per se. However, this may indicate a more popular and more proclaiming journal by researchers. Figure 2 brings an overview of how the number of papers published per year change from 2013 to 2019 for the Brazilian journals. Most journals use to publish up to 40 papers a year in 2 to 4 issues. They also tend to maintain a similar number of papers along the years but EEC, that shows a clear increase from 2017 on.

Catches the eye the journal RBEF that publish around 120 papers a year in the last seven years and is the more traditional journal on Physics education in Brazil. In this case, many papers and a long life reflect a respected journal. Schulz (2019) states that the documents published by RBEF impact beyond citations. The author had analysed data from three databases (Scopus, Web of Science and Google citations) and, regardless of the database, the impact of RBEF is increasing, in both citations and access, nationally and internationally.

Figure 2. Number of papers published per year between 2013 and 2019 in eleven Brazilian journals

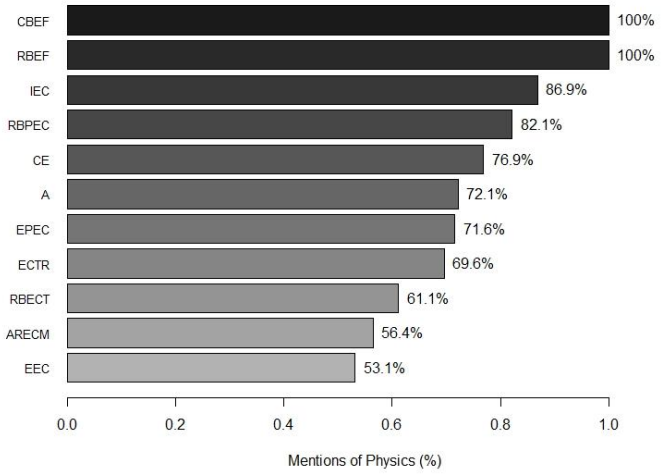


Source: Author.

As the focus of this work is on Physics education and some of the investigated journals are interested specifically in Physics, the percentage of papers mentioning the word Physics was computed (Figure 3). The aim was to check the coherence between the scope of the journal and this metric. Such word was searched in title, abstract, keywords and in the text body.

Indeed, the only two journals that are specifically interested in Physics education (CBEF and RBEF) presented the word Physics in all papers published from 2013 and 2019 and there was no journal with less than 50% of the papers containing that word. Even the journal devoted to experiences in science education – that has no word Physics in its objectives - presented more than 53%. Such behaviour is in line with expectations since science is hardly detached from Physics. Feynman, Leighton and Sands (1963) write “Physics is the most fundamental and all-inclusive of the sciences, and has had a profound effect on all scientific development”.

Figure 3. Percentage of papers that mention the word Physics somewhere.

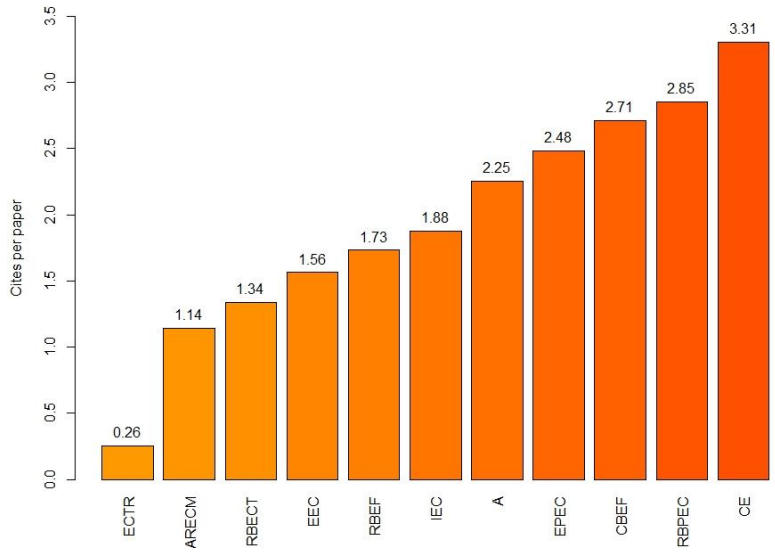


Source: Author.

In order to evaluate the impact of publications on science and Physics education – and consequently journal impact – several metrics were considered. The first one computed was the overall number of citations over the overall number of published papers per journal, along the whole period (2013-2019). That metric can be understood as a kind of impact factor. The usual impact factor over a database – just like the proprietary JCR® – is computed over a two-year period (Garfiel, 1999). In this case, the same metric is computed over a seven-year period.

Figure 4 shows the ordered citations per paper (cpp) and reveals that journal CE holds the highest score. CE journal is indexed in Scielo and Google Scholar, presenting h5 index equal to 17 and h5 median to 23. Also catches the eye the journal ECTR with less than one cite per paper far from the second smaller, ARECM. The ECTR journal is the youngest Brazilian journal on science education (9 years old) and presents the smallest number of papers per year (Figure 2) although a light increase in the last couple of years.

Figure 4. Citations per paper (cpp) published during the period 2013-2014 according to Google Scholar, for eleven Brazilian journals.

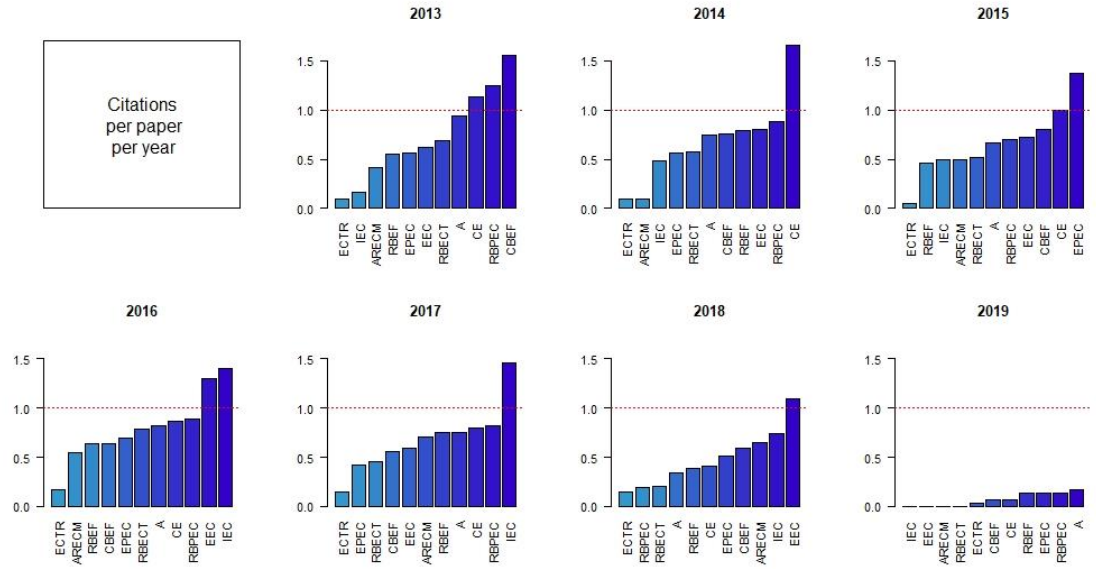


Source: Author.

In order to evaluate the longitudinal evolution of the impact factor we computed the citations per paper in each year from 2013 to 2019, weighted by how many years they have been cited. Figure 5 brings that information highlighting the cote of one citation per paper per years (cpppy) as a reference.

It seems that papers published in 2019 did not have had time to be cited yet, since for all journals, the citation accounts are very low. Apart from that, 2016 seems to be a year of well-cited publications for all journals but ECTR. Specifically, catches the eye the evolution of ICE. It was in the last positions in 2013-2015 but increased to the first positons in 2016-2018. ECTR and ARECM keep low impact factors along the entire period as well as CE, CBEF, RBPEC, EPEC, RBEF and A shuffle in the higher positons.

Figure 5. Citations per paper weighted by how many years they have been cited (cpppy).



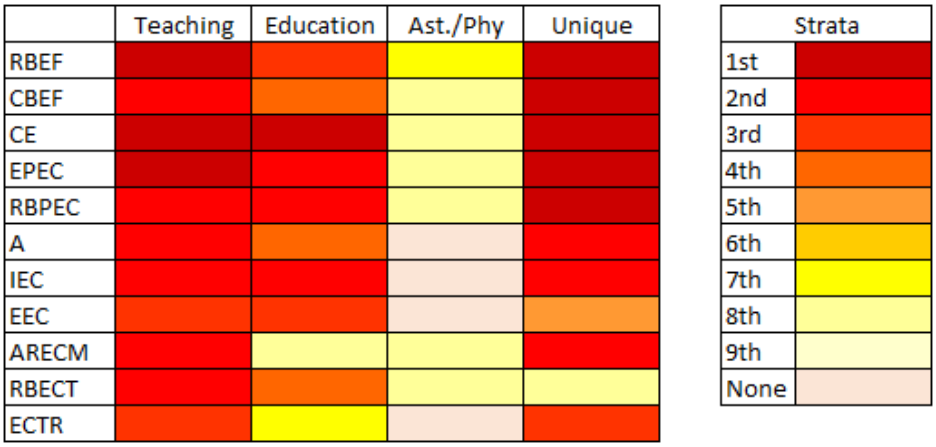
Source: Author.

As discussed in the first section, the Brazilian metric Qualis Journals was not built to be an impact metric however, it drives author's choice and associates indirectly a label of quality to each journal. Figure 6 brings the Qualis Journals for each journal evaluated in this work, where colour intensities refer to different strata. First three columns refer to the multiple Qualis for *Teaching*, *Education* and *Astronomy/Physics* areas. Fourth column stands for the recent preliminary unique Qualis.

In spite of been correlated areas, the eleven journals on Science and Physics education are poorly classified in *Astronomy/Physics*, since there are specific areas and committees to manage them. We can also note that most of the unique Qualis match the highest level among the three areas, for a journal. It has to be clear that the preliminary unique Qualis follows a specific classification algorithm that inputs impact metrics like CiteScore (Scopus), JCR (Web of Science) and h5 index (Google Scholar) and what we noted is nothing but coincidence. By the way, a couple of journals present a lower unique than multiple Qualis, namely RBECT and EEC.

Finally, we can note that journals RBEF, CBEF, CE, EPEC and RBPEC – that present the highest unique Qualis – in general, also present the longest lifetimes, mentions of the word Physics, cpp and cpppy (figures 1 to 5). Since Qualis Journals uses impact metrics in some extent to classify journals (Barata, 2016; Capes, 2019a) it is not a surprise suggesting a positive association between them (Santos et al., 2018; Marenco, 2015).

Figure 6. Qualis classification for evaluated journals in *Teaching*, *Education* and *Astronomy/Physics* areas; and unique Qualis.



Source: Author.

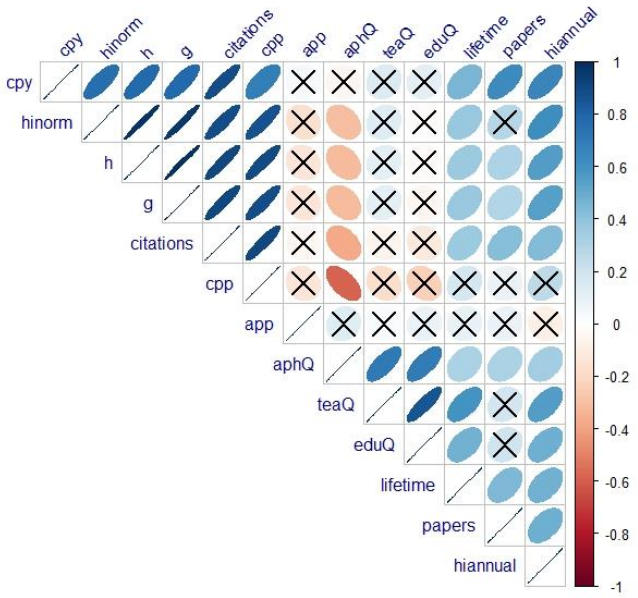
Checking for correlation, Spearman correlation coefficient was computed and tested for all pair of variables. In Figure 7, the colour scale indicates the strength while the crossed ellipses represent non-significant correlations, at 5%.

In Figure 7 we see that Qualis indices are correlated among themselves – as suggested in Figure 6 – but the positive association between Qualis and impact metrics are not significant at 5%, as expected. It is also worth noting that negative significant correlations were found between Qualis in *Astronomy/Physics* and the impact metrics. The journals we are interested in this study are not devoted to Astronomy or Physics but teaching and education as well as research in education. That is probably the reason why Qualis present such anomalous behaviour here.

As expected, we found that the impact factor (cpp) is strongly correlated with h, g and hinorm indices besides the number of citations and citations per year in the journal, but surprisingly it is not correlated with hiannual. The individual, average annual increase of the h-index (hiannual) was proposed by Harzing, Alakangas and Adams (2014). The hiannual is useful for the following reasons: *i.* it removes to a considerable extent any discipline-specific publication and citation patterns that otherwise distort the h-index; *ii.* It reduces the effect of career length; *iii.* it is meant be an indicator of an individual's average annual research impact. Rather than being correlated with citations per paper, in this work hiannual was found to be correlated with citations per citations per year.

Finally, the variable authors per paper (app) showed no correlation with the other metrics, what contradicts Fox, Paine and Sauterey (2016) that found that the number of citations increase with the number of authors, manuscript length and references cited in ecological journals; and Abramo and D'Angelo (2015) that found positive correlation in papers of some knowledge areas in Italy.

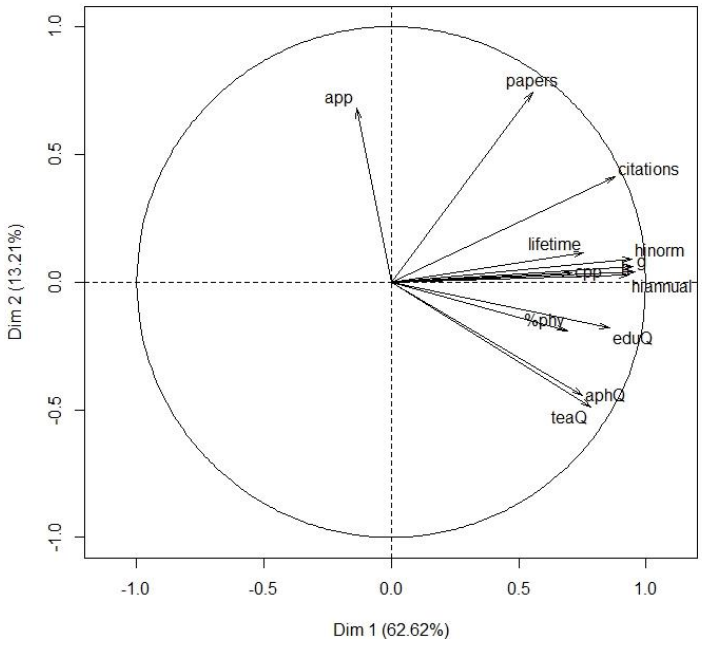
Figure 7. Spearman correlation coefficient between impact metrics, authors per paper and lifetime for eleven Brazilian journals.



Source: Author.

Now, in a multivariate approach, we performed the Principal Component Analysis (PCA) in average and longitudinal data, as well as Hierarquical Clustering Analysis (HCA) for finding groups. Figure 7 brings the variable space, i.e., the first two components where the variables are represented. That plan explains 75,83% of the total variance. We can see that impact increases to the positive direction of the first component, where the impact metrics stand together. Qualis indices are also together, indication correlation while the number of authors per paper, pointing to the positive side of the second component, positions orthogonally to the impact metrics. That confirms the impendence found in the correlation analysis.

Figure 7. Variable space representation.



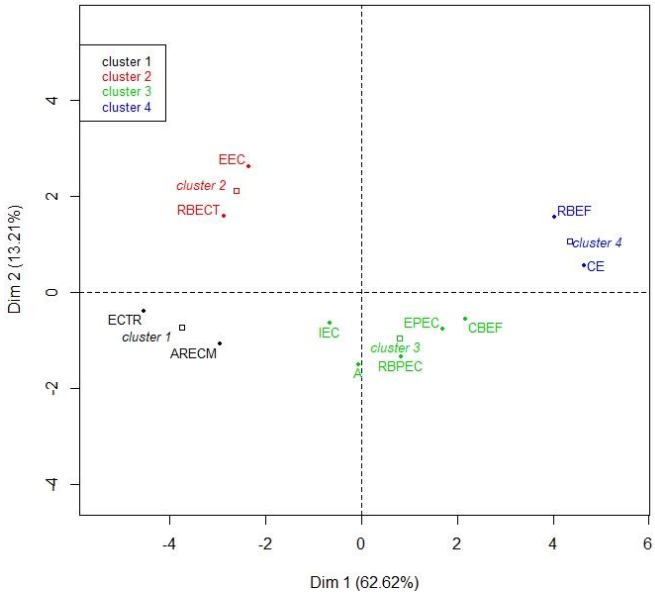
Source: Author.

In association with the variables space, the sample space (Figure 8) present where journals position among each other. Figure 8(a) also brings four clusters where journals can be placed together by multivariate similarity. Figure 8(b) shows are the clustering tree where we see the similarity level. For instance, we note that cluster 1 and 2 are more similar to each other than to any one else.

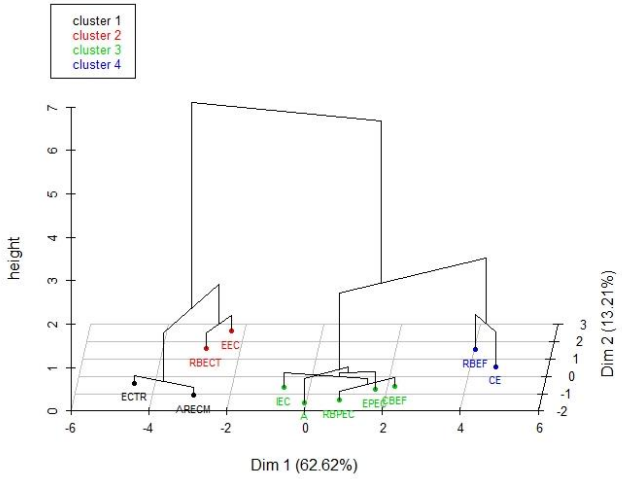
RBEF and CE are characterized by high impact metrics. IEC, EPEC, CBEF, A and RBPEC present average numbers. On the other hand, lower impact characterizes EEC, RBECT, ECTR and ARECM. However, cluster 1 present a little higher Qualis and cluster 2 more authors per paper. Hadimani, Mulla and Kumar (2015) also used impact metrics for evaluating 76 journals and profiling the publications of Indian Institute of Science Education and Research from 2008 to 2013.

Schulz (2019) analysed the impact and influence of the RBEF through citations to documents published in the journal retrieved from the Web of Science and Scopus databases and Google Citations. The author states that RBEF publish high impact papers not only due to citations but also due to the increasing number of accesses in Brazil and abroad.

Figure 8. Sample space representation of the eleven Brazilian journals.



(A)



(B)

Source: Author.

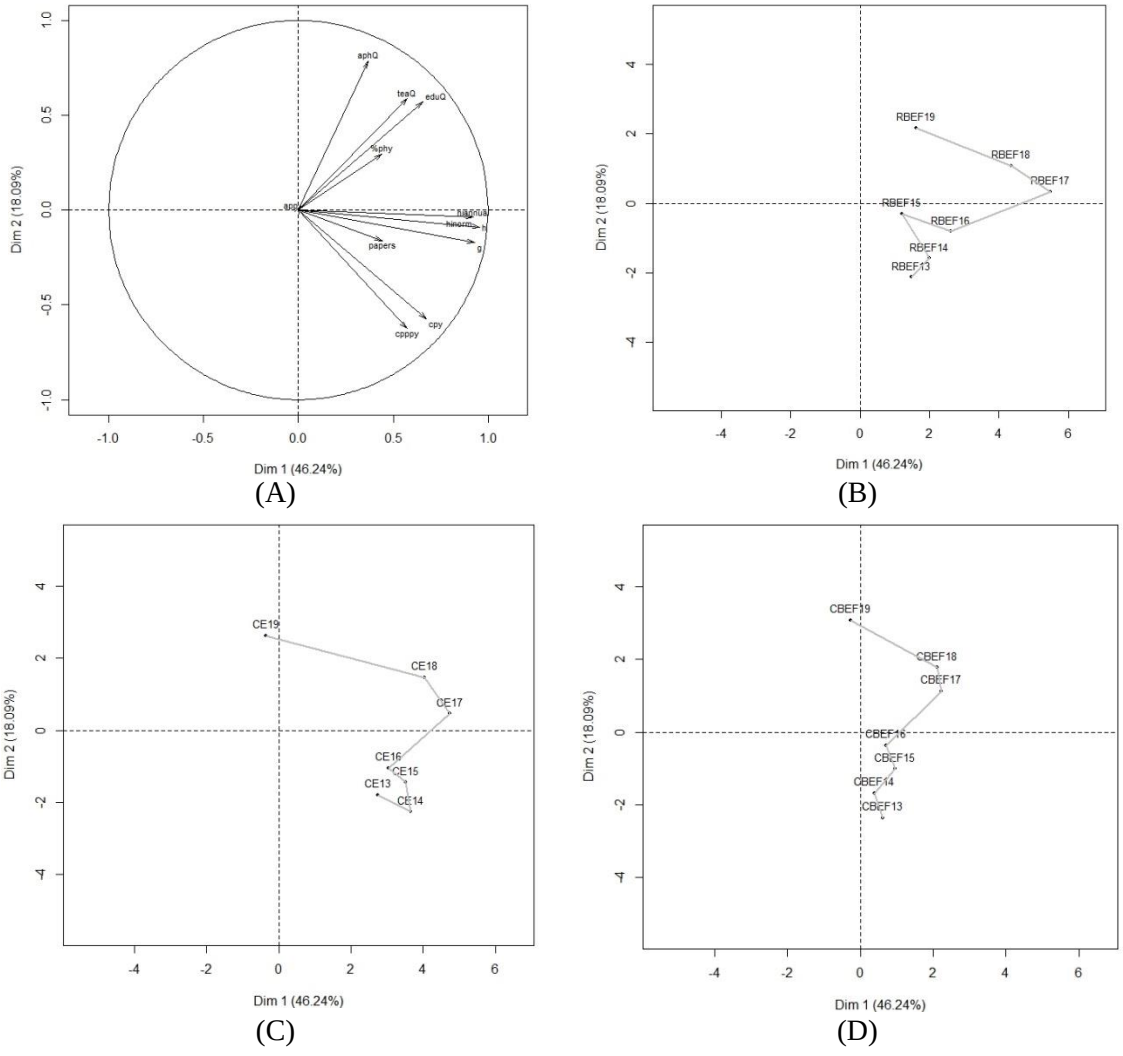
In a longitudinal multivariate approach, Figure 9 brings the first two principal components for the whole dataset, which account for 64.33% of total variation. In this approach, in addition to the variables previously used, we consider the number of articles per article per year (cpppy).

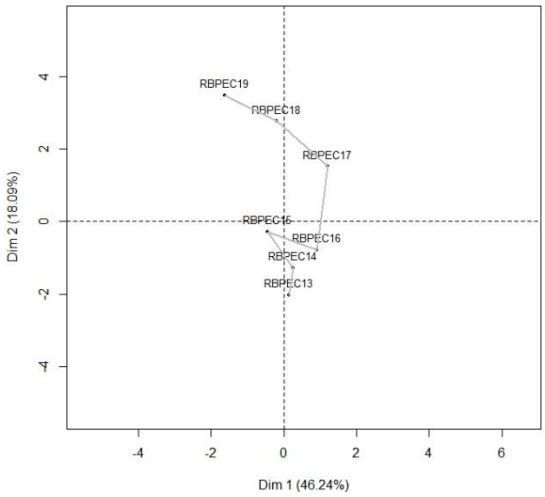
We can see in Figure 9(a) that the number of authors per paper (app) is placed at the origin, what means it does not figure in the first two dimensions. However, we detected before that it seems not to be important for expressing impact in our database. The right hand side of the plots – quadrants 1 and 4 – represent the direction where the impact increases. Specifically, the positive direction of X axis represents g, h, hinorm and hiannual indices (proper impact metrics) while quadrant 1 represents

Qualis and the percentage of mentions of the word Physics in the paper. The quadrant 4 stands for the number of published papers, citations per year and citations per paper per year.

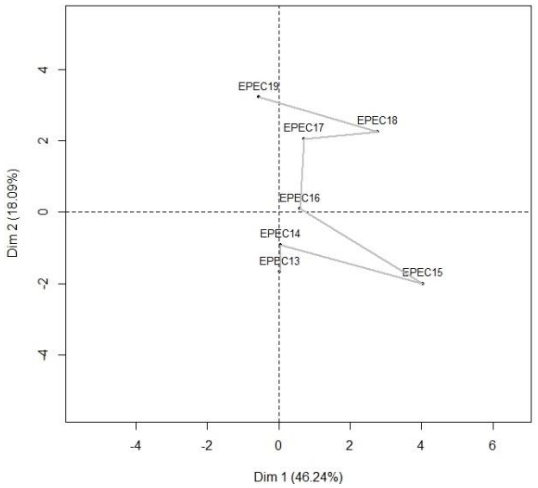
Figures 9(b) to 9(l) bring the time course of the journals from 2013 to 2019. In each plot, the journal acronym is followed by 13 to 19 indicating the year. In general, the more to the right the journal/year is, the more impact it has/had. The ideal course would be always to the right, however, recent years do not provide good numbers since the papers had not time to be read and cited yet. That is why 2019 usually goes to left.

Figure 9. Variable space and sample space as principal components output for eleven Brazilian journals.

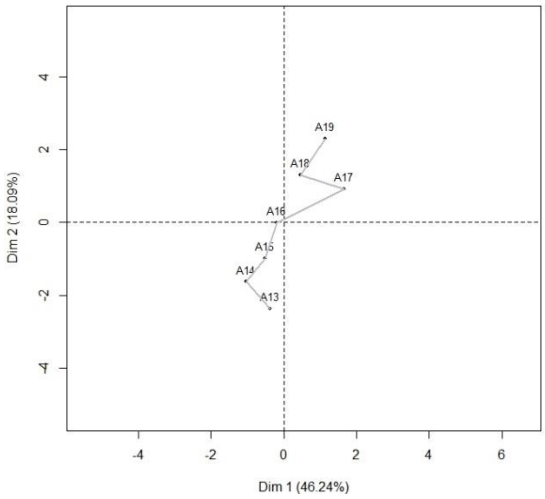



RBPEC19
RBPEC18
RBPEC17
RBPEC15
RBPEC16
RBPEC14
RBPEC13
Dim 2 (18.09%)
Dim 1 (46.24%)

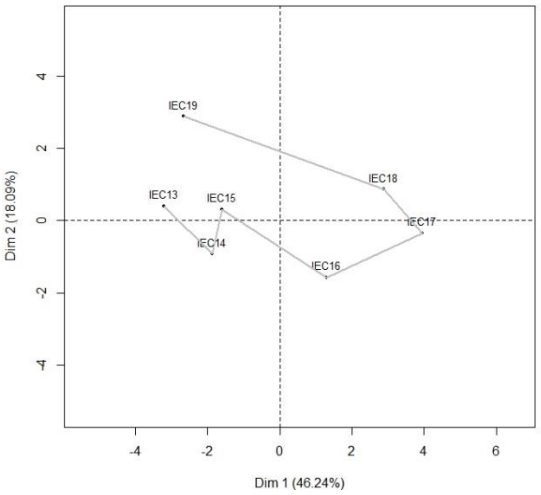
(E)


EPEC19
EPEC18
EPEC17
EPEC16
EPEC14
EPEC13
EPEC15
Dim 2 (18.09%)
Dim 1 (46.24%)

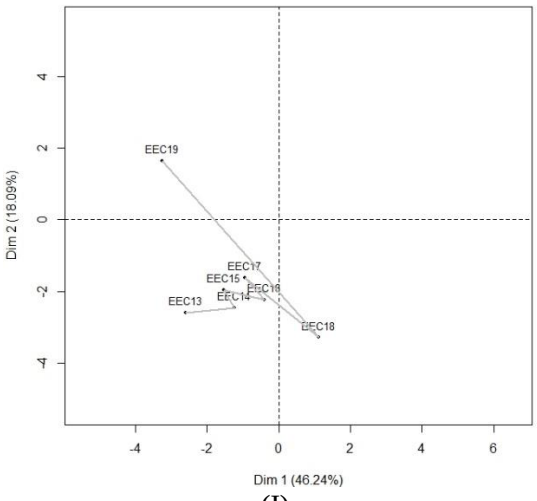
(F)


A19
A18
A17
A16
A15
A14
A13
Dim 2 (18.09%)
Dim 1 (46.24%)

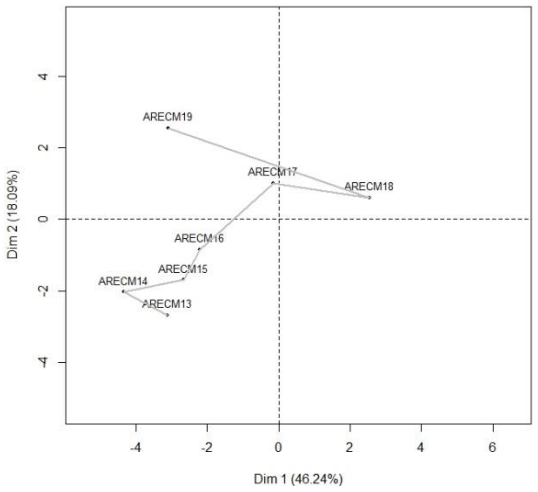
(G)


IEC19
IEC18
IEC13
IEC15
IEC17
IEC14
IEC16
Dim 2 (18.09%)
Dim 1 (46.24%)

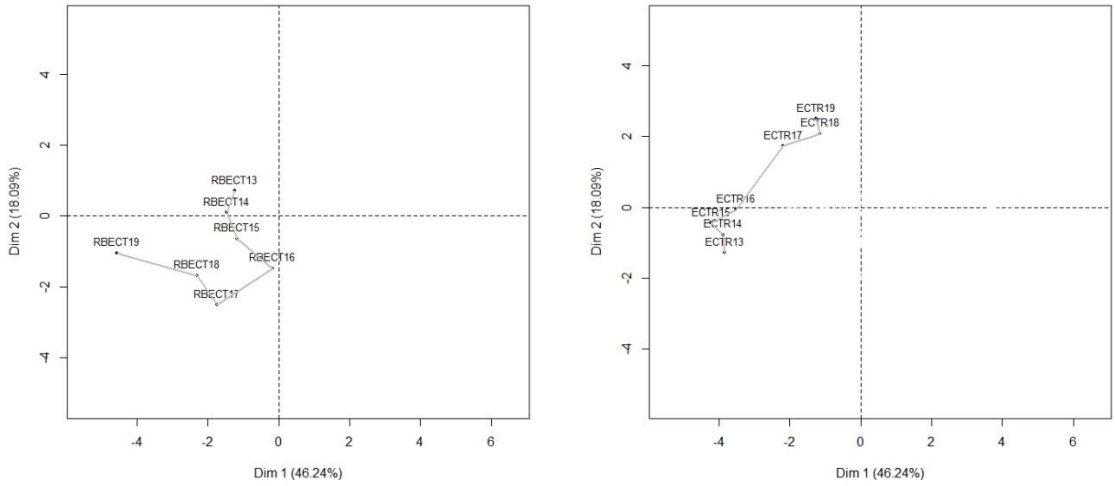
(H)


EEC19
EEC17
EEC15
EEC16
EEC13
EEC14
EEC18
Dim 2 (18.09%)
Dim 1 (46.24%)

(I)


ARECM19
ARECM17
ARECM18
ARECM16
ARECM15
ARECM14
ARECM13
Dim 2 (18.09%)
Dim 1 (46.24%)

(J)



(K) (L)

Source: Author.

For instance, RBEF course seems to be the path more to the right, indicating the highest impact journal. In RBEF course, 2017 is the year which papers had more impact. Schulz (2019), studying impact metrics from 2015 to 2018 found that RBEF presented an increasing impact overall. An overview reveals that most journals published the more important papers in 2017 and 2018 (RBEF, CE, CBEF, RBPEC, A, IEC and EEC, ARECM, ECTR, respectively).

Regardless of the position in respect to the X axis, it seems to be a temporal movement upwards, generally contraclockwise. It can be interpreted as an increase of Qualis over cpy and cpppy. RBECT is the only journal that moves downwards and to the left. Its more important publication year was 2016 and its cpy and cpppy are increasing over the Qualis. Note that, in Figure 6 the unique Qualis attributed to RBECT is the minimum among the previous Qualis for Education, Teaching and Astronomy/Physics. That is the only journal whose unique Qualis is the minimum amongst the others, i.e., the Qualis index decreased over time.

4. Main conclusions

Thirteen Brazilian journals on Science and Physics education were considered in this paper. Unfortunately, two of them were discarded since the metadata were not in a suitable format for Google Scholar search.

From eleven journals considered, in general, journals with more impact – cites per paper, h and g indices and so on – usually present many papers that mention Physics, publish many papers per year, have high Qualis Journals index and have long lifetime. The number of authors per paper was uncorrelated with every metric considered.

Along time, Brazilian journals had the best (more impact) papers between 2017 and 2018 and are receiving higher Qualis index, overall. Such longitudinal multivariate analysis is able to detect

patterns and be used as a management tool for driving journals to the desired position in the scientific scenario.

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