ALEXANDRIA

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How are we searching? Methodological aspects of studies at the interface between Education and Technologies

Como estamos pesquisando? Aspectos metodológicos de estudos na interface entre Educação e Tecnologias

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Abstract: This article presents an analysis of methodological approaches in scientific publications that explore the intersection between science education and technologies. An integrative literature review methodology was employed, encompassing a selection of five databases (ERIC, SciELO, Web of Science, Redalyc, and Scopus). The time frame encompassed the period from 2011 to 2021. The analyzed corpus consisted of 324 articles. The findings reveal a prevalence of qualitative investigations. The methodological preferences of the majority of the scrutinized studies position them within the ambit of research rooted in the Human and Social Sciences, suggesting an understanding that technologies are socio-technical phenomena and inherently cultural and human in nature. The analysis of the corpus also discloses gaps in the precise definition of certain methodological aspects such as categorization, research objectives, and analytical procedures or viewpoints. Most studies offer clear descriptions of data collections techniques.

Keywords: science education, educational technology, reviews of the literature, educational research, research methodology.

Resumo: Este artigo apresenta uma análise das indicações metodológicas em publicações científicas cuja temática explore a interface entre educação em ciências e tecnologias. Utilizou-se a revisão integrativa de literatura. Foram escolhidas cinco bases de dados (Eric, Scielo, Web of Science, Redalyc e Scopus). O lapso temporal abarcou o período de 2011-2021. O corpus de análise resultou em 324 artigos. Os resultados mostram que há uma preponderância de estudos de natureza qualitativa. As escolhas metodológicas da maioria dos estudos analisados os posicionam como pesquisas cujos fundamentos estão nas Ciências Humanas e Sociais, o que pode indicar o entendimento de que as tecnologias são fenômenos sociotécnicos, portanto, essencialmente culturais e humanos. Os estudos do

corpus também apresentam lacunas na definição clara de alguns elementos metodológicos como tipificação, finalidade da pesquisa e procedimentos ou perspectivas analíticas. Já as técnicas de coleta de dados são claramente descritas na maioria dos estudos.

Palavras-chave: educação em ciências, tecnologia educacional, revisão de literatura, pesquisa em educação, metodologia de pesquisa.

Introduction

Research in the field of science education, like other areas, has a wide range of methodological possibilities, both in terms of analytical approaches, perspectives, and in terms of data production tools and procedures. When we incorporate the theme of Information and Communication Technologies (ICT) into this already diverse scenario, certain elements can be incorporated and/or altered due to changes in the conditions surrounding the educational contexts investigated through the mediation of these technologies. We can find, for example, the proposal of virtual ethnography or netnography (Polivanov, 2013), as well as discussions about the specificities of online focus groups for data collection (Oliveira et al., 2022).

In the specific field of science and mathematics education, Santos and Greca (2013) present a literature review focusing on "[...] research methodologies and instruments used in articles published in the main journals in the field of science education in Latin America in the period 2000-2009" (p. 15, our translation). The authors indicate, among other points, the need to expand: i) the "spectrum of methods, procedures, and instruments for data collection and analysis"; ii) the "integration between qualitative and quantitative approaches"; and iii) studies that "evaluate the proposed teaching approaches." (Santos & Greca, 2013, p. 29-30, our translation).

At the interface between education and technology, Carvalho, Rosado, and Ferreira (2019) propose, based on a bibliographic survey of articles in Portuguese published in Qualis A journals up to 2016, seven "labels" and "research approaches" in the field of Education and Technology. Although they deal with research approaches, the authors do not specifically address methodological choices for data collection and analysis. Nevertheless, they state, "The field of EduTech, at least in Portuguese, still has methodological and conceptual weaknesses." (Carvalho, Rosado & Ferreira, 2019, p. 230, our translation).

We thus highlight the need for broader and more recent studies that indicate the main theoretical and methodological choices that underpin and organize research

at the interface between Science and Technology Education, understanding this articulation as part of research in the Humanities and Social Sciences. For Coutinho (2014), supported by Bachelard (1979), in this sphere of human knowledge, the researcher's methodological choices must be centered on the search to capture the essence of the social phenomenon. This search would thus be a sine qua non condition for "[...] the existence of a true scientific spirit" (Coutinho, 2014, p. 38, our translation). We understand, therefore, in dialogue with Feenberg's (2019) critical constructivism, technologies as socio-technical constructions, and therefore locate this study in the broad field of the Humanities. We thus corroborate the ideas of Feenberg (2019, pp. 40-41), who proposes that "[...] technology can no longer be considered either as a collection of devices or, more generally, as the sum of rational means. [...] Technical objects have two hermeneutic dimensions, *their social meaning and their cultural horizon*" (emphasis added by the author).

Lemos (2021), Ramírez-Castañeda and Sepúlveda-López (2018), and Jiménez Proaño (2014) reiterate this understanding, situating it within the field of education. In this scenario, the authors reinforce the proposition that, even though they are "machines," technologies are essentially intertwined with the human, social, and cultural spheres as is education in all contexts in which it can develop. Therefore, investigating the relationship between education and technologies requires this search for the essence of the social phenomenon.

Furthermore, we seek support in Coutinho (2014) to highlight the existence of three concepts (techniques/methods/methodologies) that are important for this research and that have increasing levels of generality, but whose boundaries overlap:

> ● at the first level, very close to practice, we have the techniques used by a particular branch of knowledge or science in its scientific praxis;
> ● a set of techniques that are general enough to be common to a significant number of sciences constitutes a method;
> ● at a more general level, methodology analyzes and describes methods, distancing itself from practice to make theoretical considerations about its potential in the production of scientific knowledge;
> ● the above methodology is the paradigm, a system of principles, beliefs, and values that guides methodology and bases its conceptions on a given epistemology (Coutinho, 2014, p. 26, emphasis added, our translation).

In this study, we focus on the first two levels and, in this sense, we seek to identify, through an integrative literature review (Ercole, Melo & Alcoforado, 2014)

conducted in five international databases, the main methodological choices of studies that discuss the interface between science and technology education.

Considering their geographical and/or linguistic scope, in addition to their broad coverage of studies in the broad field of education, the databases chosen for this review were: Scientific Electronic Library Online (SciELO), Education Resources Information Center (ERIC), Red de Revistas Científicas de América Latina y el Caribe, Spain, and Portugal (REDALYC), Web of Science (WoS), and SCOPUS. It is worth mentioning that the first three databases follow the philosophy of open access to knowledge, have a tradition of publications in the field of Humanities, and are publicly funded. The Web of Science and SCOPUS platforms are private initiatives, but they were chosen for their extensive coverage of English-language publications.

We believe that these five foundations can provide the overview we seek to present in this text. We consider this important for strengthening and deepening academic and scientific discussions involving the effects, possibilities, risks, and limitations of ICT in education in general, as well as in the specific field of science education. In this regard, and concerning studies in this field, which is also often referred to as “Educational Technology” (ET), Castañeda, Salinas, and Adell (2020, p. 242, our translation) point out that:

> It seems clear that in academic ET, there is a certain feeling that the discipline needs to reflect deeply on its epistemological assumptions, its objectives, its methods of research and theory construction, and its practices. Recently, for example, there has been criticism of the excess of quantifying and experimental proposals in research (Biesta et al., 2019), the excessive partiality of views on what ET is and what it implies (Lai & Bower, 2019), the problems arising from “paradigm wars” (Jones & Kennedy, 2011; Kimmons & Johnstun, 2019), and the evident lack of pedagogical foundation in designs (Bartolomé et al., 2018; Zawacki-Richter et al., 2019). There have been calls for more holistic and critical views, with new perspectives that go beyond “what works” and also explore “how it works,” what is valuable to achieve and what responds to spurious interests, the underlying processes, and new methodological paradigms (Castañeda, 2019; Castañeda & Selwyn, 2018; Jameson, 2019; Lai & Bower, 2019; Williamson et al., 2019). In short, several authors advocate for more complex and less reductionist views that help us had better understand the relationship between education and technology (emphasis added, our translation).

Finally, we highlight, in the specific circumstances of the study's production, its relevance for the training of new researchers. The review presented here was produced collectively, at all stages, in the context of the research group Technologies and Digital Culture in Science Education (TeCDEC), formed within the Graduate Program in Science Education at the Federal University of Itajubá. The group has participants with different backgrounds and roles: university research professors,

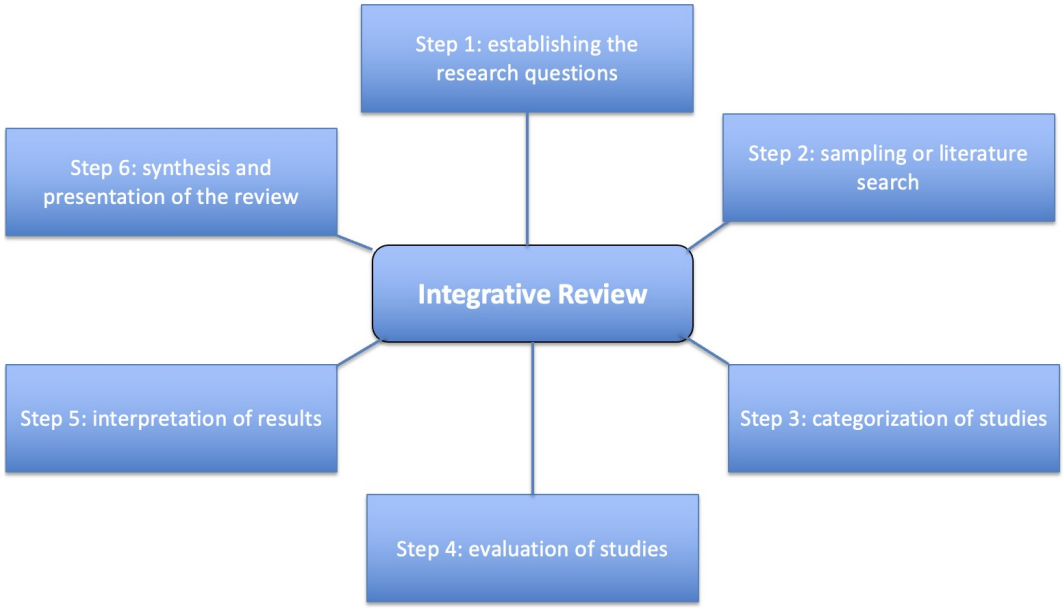
masters and doctoral students, undergraduate students, teachers, and basic education administrators.

Investigative Process

Based on the stages of integrative literature review (Ercole, Melo & Alcoforado, 2014; Mendes, Silveira & Galvão, 2008), we will now detail the process of constructing this study. Mendes, Silveira, and Galvão (2008) propose six steps for this type of review, as shown in Figure 1:

Figure 1.

Integrative Review – research steps



Source: Adapted from Mendes, Silveira, and Galvão (2008, p. 761), our translation.
Note. [Image description] This is a diagram with six rectangular boxes with blue backgrounds and no images connected to a central box (with blue background and no images) that reads “Integrative Review.” Each of the peripheral boxes presents a step in the integrative review. Thus, the image summarizes the steps, or stages, of this type of review. Namely: step 1, establishing the research questions; step 2, sampling or searching the literature; step 3, categorizing the studies; step 4, evaluating the studies; step 5, interpreting the results; and step 6, synthesizing and presenting the review. [End of description].

Following the steps proposed in Figure 1 and considering that the research began in June 2021, a period in which we were experiencing social isolation due to the COVID-19 pandemic, all meetings related to steps 1, 2, 3, and 4 were held virtually. Four general meetings (GM1, GM2, GM3, and GM4) were held during this period with all sixteen members of the research team. The team itself was quite

diverse, with more experienced researchers, beginners, undergraduate students, and graduate students. After the initial collective definitions (step 1), the researchers were divided into five working groups. These groups were organized according to the five databases chosen for review. Each group was led by a PhD researcher.

In GM1, the research objectives were defined, and decisions were made regarding the composition of the working groups. There was also a debate on the main characteristics of the databases that had been pre-selected by the most experienced researchers for this review. The meeting ended with a task for everyone to critically analyze the databases, their functions, tools, and filters for sharing and discussion at the next general meeting.

In GM2, explanations were given on how each database works in order to align future searches. As a task for GM2, each of the groups would conduct free tests on their respective platforms for the alignment and final definition of search terms, inclusion and exclusion criteria, filters, etc. (step 2).

In GM3, each group presented its initial results, adjustments were discussed so that searches would be similar across different databases, and a shared spreadsheet was created so that each group could begin its data collection activities and keep a record of the characteristics of the database and the respective searches (step 2). The results of this first stage are presented in Table 1 as “Free Quantitative.” At the end of the first three general meetings, we defined the following for data collection: a) SEARCH TERMS – Technology (ies) and Science Education / Technology (ies) and Science Teaching; b) TIME INTERVAL – 2011 to 2021; c) LANGUAGES – Portuguese, English, and Spanish[1]; d) OBJECT – Title, Keywords, and Abstract. These definitions took into account the collective reflections produced from the “Free Quantitative” and, after the new searches, each group arrived at the results presented in Table 1 as “Initial Quantitative.”

[1] In Portuguese, the terms used were: Tecnologia(s) e Educação em Ciências / Tecnologia(s) e Ensino de Ciências. In English, the terms were: Technology and Science Education / Technologies and Science Education / Technology and science teaching / Technologies and science teaching. Finally, in Spanish, the terms searched for were: Tecnología(s) y enseñanza de la(s) ciencia(s) / Tecnología(s) y educación en ciencia(s).

Table 1.

Description of the working groups and initial research findings

Group identification	Base	Number of analysts	Free Quantitative	Initial Quantitative
G1	SCIELO	3	2692	314
G2	SCOPUS	3	626	462
G3	ERIC	3	22566	452
G4	REDALYC	3	453	287
G5	WoC	4	2375	2375

The numerical variation between the quantities is due to structural and usability differences between the databases. In free searches, the groups had no limitations related, for example, to period, languages, and/or keywords. After adjustments, all groups worked on the repositories according to the collection criteria already described.

Based on these initial results, the groups were reorganized to begin forming the analysis corpus (steps 2 and 3), guided by the elimination of duplicate studies in different databases and the inclusion and exclusion criteria (which will be presented below). These actions consisted of five refinement stages (R1, R2, R3, R4, and R5), the quantitative results of which are summarized in Table 2. Due to the numerical difference between the initial distribution of the studies and the result after refinements, the groups were restructured so that, in the next phase (step 4), the work would be equitable among the groups.

Table 2.

Initial quantity and the five successive phases of data refinement

Base	Initial	R1	R2	R3	R4	R5	Groups
SCIEO	314	310	301	212	28	24	G1
SCOPUS	462	440	279	206	69	49	G1
ERIC	452	410	377	265	64	53	G2
REDALYC	287	208	204	160	44	7	G2
WoS	2375	1684	1682	1124	405	191	G3/G4/G5
TOTALS	3890	3052	2843	1967	610	324	

For the quantity indicated in Refinement 1 (R1), the automatic duplicate detection tool in Excel spreadsheets was used, considering the titles of the papers. However, many duplicate lines remained, mainly since this type of automatic refinement is more effective when all characters in the field are identical. In this case,

the data was extracted from different platforms, and there were differences in punctuation, spaces, symbols, etc., which compromised our automatic selection and generated rework. Thus, Refinement 2 (R2) was performed, in which each line was checked to extract duplicate titles that, for some technical/operational reason, had not been extracted in the first refinement (R1). We emphasize that R2 was performed by only one researcher who, at that moment, made random choices to define on what basis the duplicate paper would be kept for later analysis.

After verifying the existence of several articles that, even after applying the database filters, were not relevant to our study, we read all the titles in R2 to exclude these works. The quantitative result of this stage is presented in R3. Starting with R3, each group sought to access all texts in their entirety, but many works could not be accessed due to the unavailability of access to journals, the need to pay to read them, etc. Thus, they were also excluded from the research, and the remaining studies are quantified in R4. The final refinement followed qualitative inclusion and exclusion criteria defined by the group in GM4, namely: a) REGARDING THE FOCUS – focused on the broad area of Education and/or Humanities with a focus on Science Education or Science Teaching; b) REGARDING THE CONTEXT – Higher Education, Secondary Education, Primary Education, Technical and Technological Education, Non-formal contexts; c) REGARDING RESEARCH SUBJECTS – students, teachers, managers; d) REGARDING TEXTUAL GENRE/PLACE OF PUBLICATION – only articles in journals (theoretical or empirical); e) EXCLUSION – works published at events and preprints, literature reviews, experience/practice reports; f) EXCEPTIONS – require review by the group or another team.

Once the research corpus had been compiled, summarized in column R5 of Table 2, the groups began the analytical process of the 324 selected works (step 4). In a collective spreadsheet, each group sought to identify, first in the abstracts, the explicit elements of the methodological construction of the selected works, without making any value judgments about any inconsistencies or mistakes, nor making any kind of inference that was interpretive or extrapolated what had been explicitly proposed by the authors. Due to the limited number of lines for abstracts in journals, it was agreed that, if elements were not identified in the abstracts, the groups would also continue their search in the section dedicated to the methodological aspects of the selected works.

The collective spreadsheet was organized into eight columns and sought to identify the elements presented in Table 3. The “preliminary indications” in the

spreadsheet were defined by the most experienced researchers on the team, based on Gil (2008) and Gerhardt and Silveira (2009), and shared with the other researchers participating in this study as a guide for filtering the corpus data.

Table 3.

Elements of the spreadsheet used for data analysis

Id.	Grouping	Prior indications
DB	DATABASE	Eric / Scielo / WoS / Redalyc / Scopus
WK	WORK	Article title
DC	DATA COLLECTION TOOLS AND PROCEDURES	Interview / Questionnaire / Focus Group / Discussion Group / Observation / Application / Document Analysis / Others
CL	CLASSIFICATION	Action research / Participatory research / Case study / Narrative / Phenomenological / Ethnographic / Experimental / Quasi-experimental / Historical / Survey / Ex-post-facto / Others
AP	APPROACH	Qualitative / Quantitative / Quali-Quanti / Other
PP	ANALYSIS PERSPECTIVES AND PROCEDURES	Content Analysis / Discourse Analysis / Discursive Textual Analysis / Documentary Analysis / Grounded Theory / Narrative Analysis / Others
PU	PURPOSE	Exploratory / Descriptive / Explanatory / Comparative / Other
GR	GENERAL REMARKS	To enter comments or questions from researchers about the classification of articles

Steps 5 and 6 of the study were carried out in the first half of 2022. The final results and summary of the review were shared at face-to-face meetings of the research group in June 2022. Thus, the actions of this literature review that involved data collection and analysis lasted one year. It should be noted that the time frame was directly related to the training process developed with the novice researchers of the TeCDEC research group, as already mentioned.

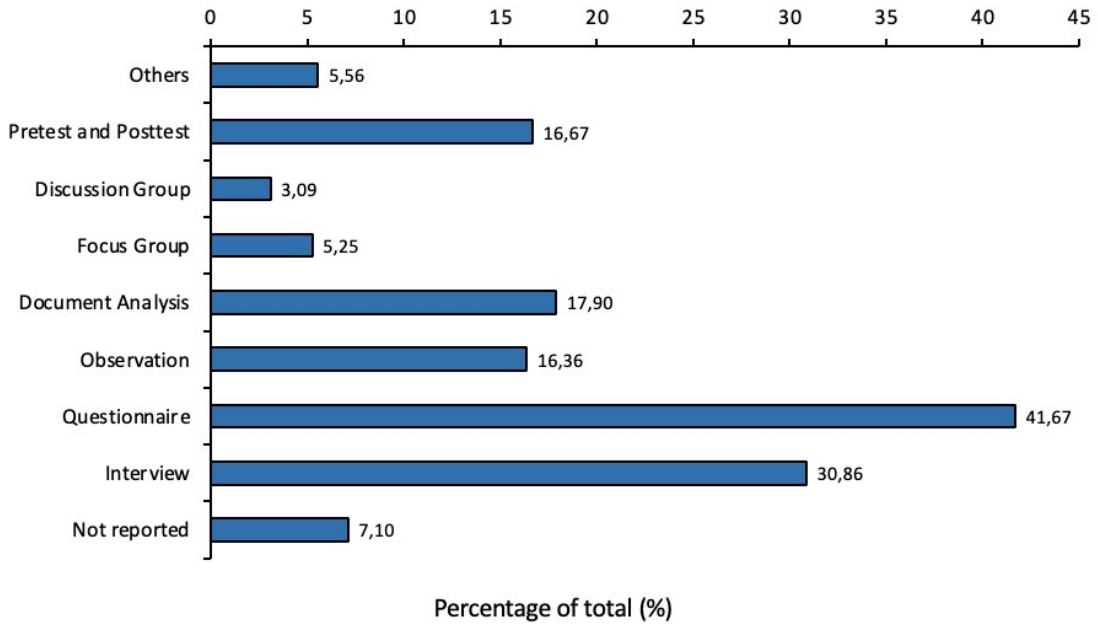
Although the groups' work was guided by databases, the analyses in the next section will not be segmented by databases due to the random choices that were made to eliminate duplicates, as already described in the second refinement (R2). The groups (DC, CL, AP, PP, and PU) in Table 3 will present the results and discussions.

Results and Discussion

Regarding the grouping of data collection instruments and procedures ("DC"), this was the most frequently mentioned methodological element in the analyzed corpus. Only 7.10% of the studies did not explicitly mention how the data for their respective research were collected, as shown in Figure 2. On this topic, there are also 49 studies (15.10%) that report two or more DCs used together in their investigations. We also observed that there are 445 mentions of at least one DC in the 301 articles, which amounts to an average of 1.48 DC/articles. This indication shows that, on average, studies in the field use more than a single technique for data production. This mixture also seems to reflect the complexity of research in the Humanities in general and in Education in particular. In this context, Coutinho (2014) echoes other authors and argues that, in research in the field of Humanities and Social Sciences, researchers should use the methodological strategies that best suit the questions raised in the research.

Figure 2.

Quantity of data collection instruments and procedures



Among the DCs, Questionnaires stand out (41.67%), followed by Interviews (30.86%). However, a more refined analysis indicates that these percentages, already significant, tend to increase, since 88.88% of the papers that report having used Pre-Tests and Post-Tests as DC also use questionnaires and/or interviews. The contributions of Gil (2008) and Gerhardt, Riquinho, and Santos (2009) can help us

understand the choices for these DCs. For the latter, “The technical instruments developed by the researcher for recording and measuring data must meet the following requirements: validity, reliability, and accuracy” (Gerhardt, Riquinho & Santos, 2009, pp. 68-69). According to Gil (2008), the main advantages of questionnaires are: direct knowledge of reality; economy and speed in data collection; and the possibility of quantification. Regarding interviews, the author states that they are a technique.

> [...] quite suitable for obtaining information about what people know, believe, hope, feel, or desire, intend to do, do, or have done, as well as about their explanations or reasons for the foregoing (Selltiz et al., 1967, p. 273). Many authors consider the interview to be the technique par excellence in social research [...] (Gil, 2008, p. 128, our translation).

In absolute and relative terms, focus groups and discussion groups were mentioned in 27 articles (8.97%). Thus, they are the least used DCs in studies. A possible explanation for this low use could lie in the characteristics of both procedures (Gil, 2008; Gondim, 2002) and which may involve some additional difficulties: from an operational point of view, due to the need to bring a group of people together at the same time and place (albeit virtually); from a technical point of view, due to the necessary skill of the researcher to act as a moderator. Gatti (2012, p. 35) argues that the moderator “[...] needs to be experienced, skilled, clear in their expression, sensitive, flexible, and capable of leading the group with confidence” (our translation).

Furthermore, among the studies that use focus groups or discussion groups, it is noteworthy that 22 (81.80%) use these procedures as the sole data collection technique for their research. In the case of focus groups, this occurs in 88.23% of the articles, and in the case of discussion groups, in 70.00%. We understand that this may indicate, even with the difficulties already highlighted, that these techniques are also understood by researchers as potentially rich in data production for research in the field of Science Education in its interface with Technologies. Perhaps because they tend to generate many contextual, experiential, and reflective data, since they are research techniques that favor data collection through interactions between subjects in a given social group, as suggested by Gondim (2002) about focus groups, but whose argument also applies to discussion groups. Being characterized as resources “[...] to understand the process of constructing perceptions, attitudes, and social representations of human groups” (Gondim, 2002, p. 151, our translation), the

use of these techniques in research seems to us to confirm the link between studies on technologies in the field of education and the humanities and social sciences. Thus, on the one hand, studies seem to approach the understanding of technologies as socio-technical constructions and, on the other hand, they distance themselves from the "[...] view of most engineers and managers; they quickly grasp the concept of 'function', but find no use for the [concept] of 'meaning'" (Feenberg, 2019, p. 41). In other words, the main methodological choices for data collection provide us with evidence that the research is based on the principle that "[...] technology and society are not domains alien to each other [...]" (Feenberg, 2019, p. 111) and the investigative focus, therefore, does not fall on the function of the technological apparatus *per si.*

In contrast, in 78.38% of all studies reported in articles with the Observation and Document Analysis groupings, at least one other DC followed these. We can justify this percentage by the fact that observation, according to Diehl and Tatim (2004, p. 72, our translation), "[...] provides direct and satisfactory means to study a wide variety of phenomena" and "[...] allows for the evidence of data not included in the interview script or questionnaires." Thus, it is possible to deduce that, on the one hand, observation is seen as an efficient procedure; on the other hand, it is a DC that can, in an understandable and seminal way, complement or be complemented by another DC.

In the analysis of the classification (CL) of the studies, most of the studies analyzed (52.47%), representing a total of 170 works, do not explicitly mention the type of research conducted. The data in Figure 3 show that, of the 154 studies that do so, 50 mentions that they conducted a case study (32.47%). According to Meirinhos and Osório (2010), the use of case studies in Education and Social Sciences research has grown in prominence, based on perspectives that "[...] have sought to deepen, systematize, and lend credibility to case studies in the field of research methodology" (p. 49, our translation). For Alves-Mazzotti (2006), however, there is a difficulty among researchers in explaining the characteristics of a case study, which leads to the erroneous use of this term to classify research.

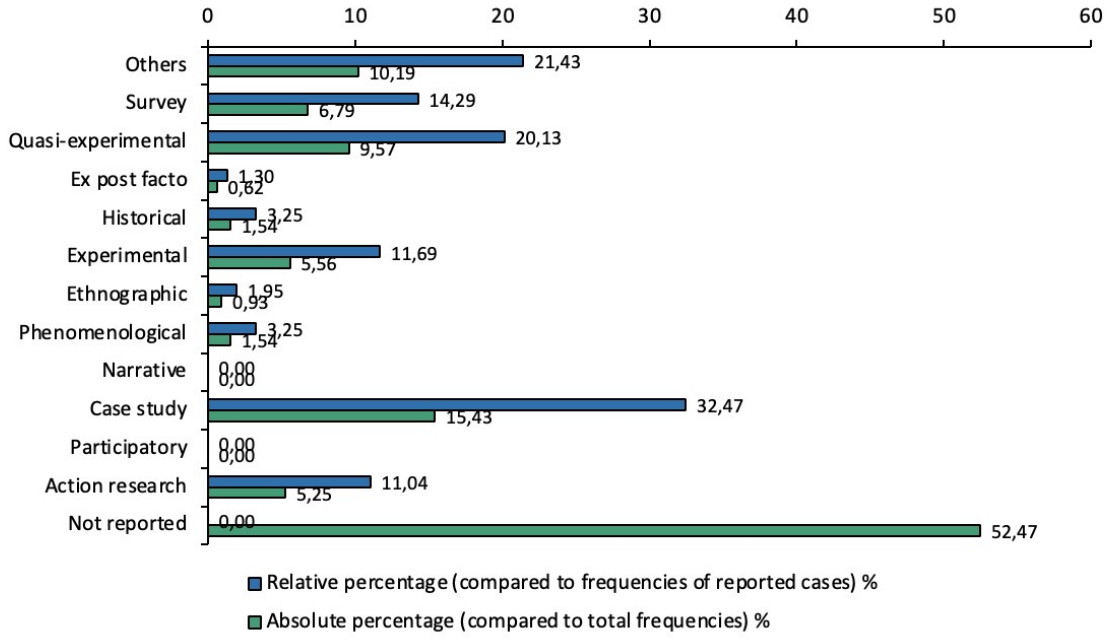
> [...] The biggest problem with most of the works presented as case studies is that they are not characterized as such. Reflecting a mistaken view of the nature of this type of research, these studies are so-called by their authors simply because they are developed in only one unit (a school, a class) or because they include a very small number of subjects (Alves-Mazzotti, 2006, p. 639, our translation).

The author considers that the case is extremely complex and original due to various aspects (such as nature, history, context, relationship with other cases, informants, etc.). The originality of the case requires its inclusion in a previous discussion that will allow for the continuity of scientific production, incorporating possible contributions. In line with this argument and considering aspects of selection, characterization, validation, and generalization, "[...] the case must be critical, extreme, or unique, or else revealing; and in any of these situations, it must focus on complex social phenomena, retaining the holistic characteristics of real-life events" (Alves-Mazzotti, 2006, p. 649, our translation).

This high number of works, characterized by their authors as case studies, may, on the one hand, reflect the difficulty these authors have in characterizing their research. On the other hand, it also seems to indicate the localized, concrete, and contextual nature of the research in the field investigated in this study.

Figure 3.

Quantitative data on the research classification



Secondly, studies classified as quasi-experimental (20.13%) appeared, followed by surveys (14.29%), experimental studies (11.69%), and action research (11.04%). Figure 3 shows that research classified as phenomenological, ethnographic, historical, and ex-post-facto together account for only 9.75% of the analysis corpus. In 21.43% of the studies, other CLs not previously listed in our study appeared, such as cross-sectional studies and relational screening, among others.

However, no CL stands out in the “Others” group to the extent that it would justify a separate analysis. Two CLs that were previously predicted, participatory research and narratives, were not cited in any of the studies analyzed. Regarding the former, one explanation may lie in the terminology and references adopted by the authors of the studies, since participatory research is often considered synonymous with action research.

Regarding the significant presence of experimental and quasi-experimental research, accounting for 31.82% of the studies, we emphasize that this may be the result of a more recent and criticized movement, for example, due to the excess of quantifying and experimental proposals in the field of Education and Technology research, according to Biesta et al. (2019) and Castañeda, Salinas, and Adell (2020). This movement may have different genealogies (ranging from the epistemological choices of researchers to the positivist stances of some high-impact international journals), but Castañeda, Salinas, and Adell (2020, pp. 259-260) warn that

> Educational Technology is the field of knowledge that formulates questions and seeks educational answers about the complex relationship between people and technology in all areas of education. [...] It is essential to use a broader concept of technology in ET, one that goes beyond its instrumental value. [...] ET is a field of study that must maintain a deep, fluid, and constant dialogue with other disciplines in the educational sciences to complement them and be complemented appropriately (emphasis added, our translation).

The representative number of survey-type studies (14.29%) could be associated, for example, with distance learning contexts, which tend to involve numerous students, teachers, and tutors, that is, a large number of actors in the ICT, mediated educational scene. In addition, they rely on virtual environments that can facilitate both the application of questionnaires, which are the instruments for collecting this type of research, according to Silveira and Córdova (2009), and access to people who directly form a “[...] group of interest regarding the data to be obtained (Silveira & Córdova, 2009, p. 39, our translation).

Finally, regarding CL, we infer that action research (11.04%) may feature prominently in studies due, on the one hand, to the concrete and localized nature that we have identified in the works in the corpus of this review; on the other hand, due to a certain adherence of the research (also identified in the data) to the broader field of the Humanities and Social Sciences. For Gil (2008, p. 31, our translation),

> Both action research and participatory research are characterized by the involvement of researchers and the researched in the process of this study. [...] Thus, the relationship between the researcher and the researched is not merely one of

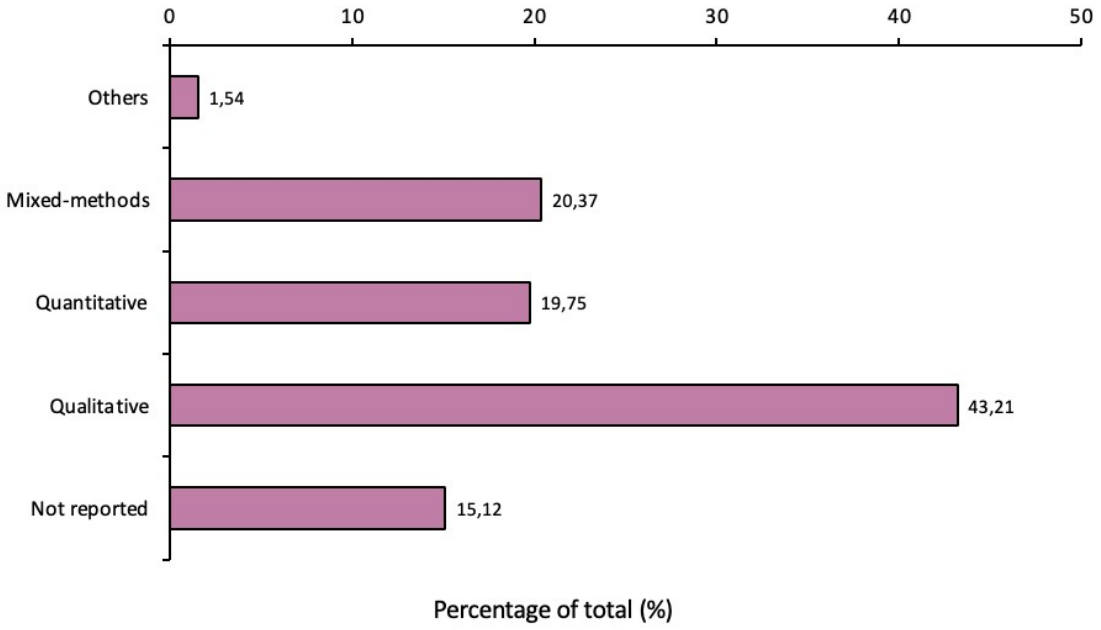
> observation by the former of the latter, but rather both “end up identifying with each other, especially when the objects are also social subjects, which allows us to dispel the idea of the object as something that belongs only in the natural sciences” (Demo, 1984, p. 115, our translation).

Due to these characteristics and their relationship with educational reality, Silveira and Córdova (2009, p. 40) highlight that this is a controversial type of research. However, they stress that, “Despite the criticism, this type of research has been used by researchers identified with reformist and participatory ideologies” (Silveira & Córdova, 2009, p. 40, our translation).

Unlike the other methodological elements listed in Table 3, the approaches (AP) were clearly indicated in most studies, with 275 (84.88%) indicating them, compared to 49 (15.12%) that did not. Of these 275, 140 state that they follow the qualitative research paradigm, 64 are associated with quantitative research, and 66 are referred to as qualitative-quantitative research. In “Others,” there are studies whose authors used compound terms, such as qualitative-interpretive and quantitative-descriptive. Figure 4 shows the percentages found in the groupings.

Figure 4.

Quantitative research approaches



According to Chizzotti (2003, p. 224, our translation), qualitative research emerged in the late 19th century, when some studies “[...] sought to describe the precarious conditions of urban and rural workers in the era of industrialization, using records and documentation of the adverse living conditions of workers.” In the

context investigated, this type of approach refers to an investigative perspective that considers the concrete conditions of the contexts and subjects of the research, once again placing ICTs as socio-technical phenomena.

Quantitative research, in turn, is based on the more positivist tradition, resorting to

> [...] quantification as the only way to ensure the validity of a generalization, assuming a single research model derived from the natural sciences, which starts from a guiding hypothesis, only admits external observations follows an inductive path to establish laws through objective verifications supported by statistical frequencies (Chizzotti, 2003, p. 222, our translation).

In a study on the joint application of these approaches in educational research, Souza and Kerbauy (2017) reinforce the predominance of qualitative studies, corroborating the data in Figure 4, and point out, in the broader scenario, the trend also identified in our data, of the emergence of "quali-quanti" studies (20.37%). In conclusion, the authors highlight that:

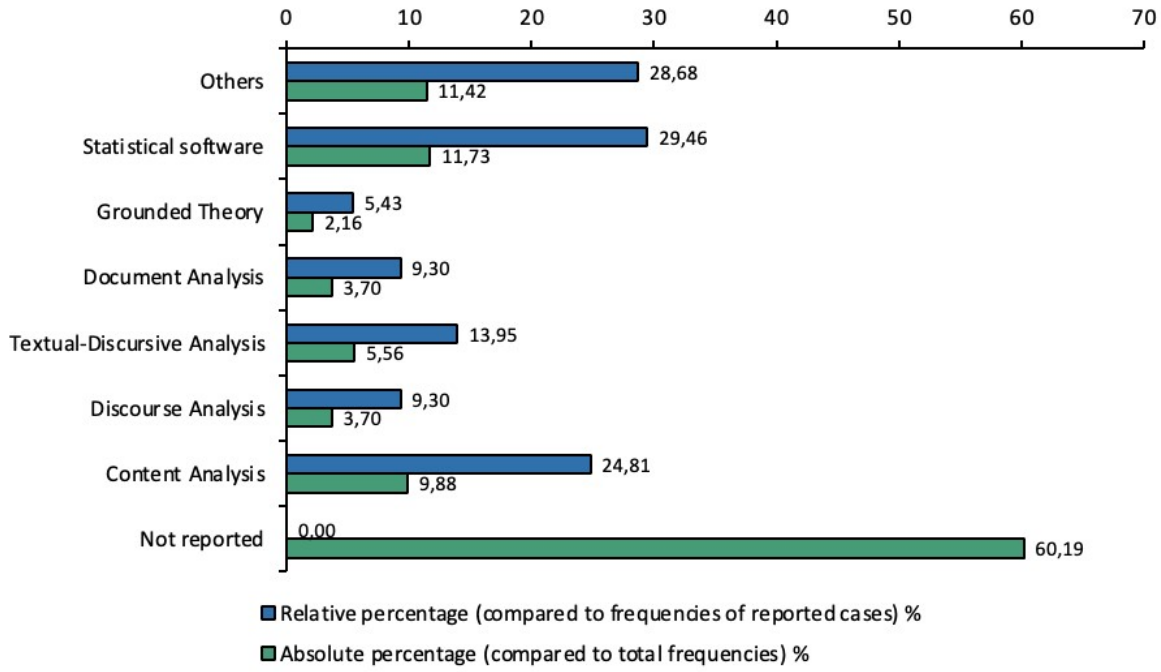
> Qualitative and quantitative approaches are necessary, but when used separately, they may be insufficient to understand the entire reality under investigation. In such circumstances, they should be used as complementary tools. Therefore, the literature in this field clearly demonstrates that quantitative-qualitative/qualitative-quantitative and/or mixed research is a trend that indicates the emergence of a new methodological approach. An approach that provides more elements to uncover the multiple facets of the phenomenon under investigation, meeting the research objectives. It is characterized as a scientific movement that opposes the historical quantitative-qualitative dichotomy (Souza & Kerbauy, 2017, p. 40, our translation).

From an inferential perspective, the number of quantitative studies, whose representation of 19.75% cannot be overlooked, could be associated with the presence, also significant in the corpus, of experimental and quasi-experimental studies (31.82%), which tend to perform primarily quantitative analyses.

With regard to perspectives and data analysis procedures (PP), 195 studies do not specify a particular analytical technique, representing 60.19% of publications. Of the remaining 129 publications, there are 156 mentions of PP, indicating more than one methodological choice per article concerning analytical procedures and perspectives. In these cases, when more than one technique was stated, the papers were credited in more than one category, and as a result, the sum of the individual percentages of the categories may exceed 100% of the studies, as shown in Figure 5.

Figure 5.

Quantitative outlook and analysis procedures



From the data in Figure 5, we can see that content analysis is the most commonly used explicit technique in studies that reported on PP (24.81%). For Triviños (1987), content analysis is a PP that is suitable for both quantitative and qualitative research. Bardin (1977) highlights the versatility of this technique by also pointing out that it can be used with any collection procedure (here referred to as DC), as it allows working with data from verbal or nonverbal communication materials. This could explain the significant presence of this analytical procedure in the studies in the corpus. Still on the subject of content analysis as a technique for data analysis, we highlight the warning by Sampaio and Lycarião (2018, p. 31), when the authors state that “Content analysis has been normatively defined based on three fundamental principles: validity, replicability, and reliability” and that “[...] empirical studies in Brazil and abroad have neglected these principles, especially the last one (reliability)”. (our translation)

It is also worth mentioning the significant number of studies that use statistical analysis software (29.46%). This grouping was emergent and not defined a priori, like the others. On the one hand, although these mentions may indicate a trend toward the use of these resources to support analysis, on the other hand, they do not necessarily indicate the specific categorization of a PP.

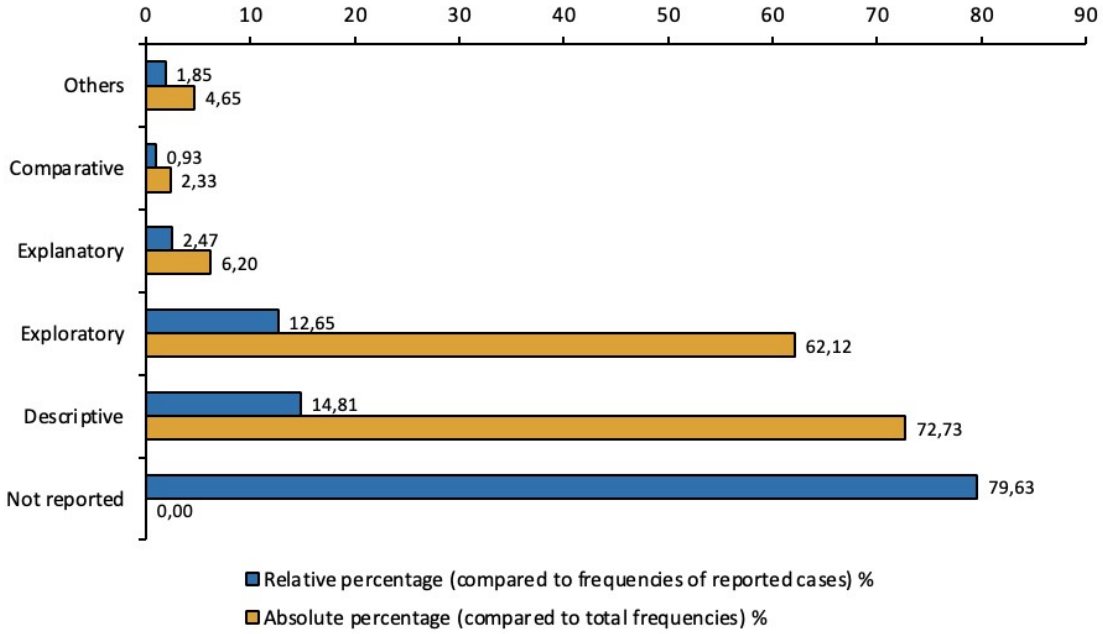
We also highlight, in the “Others” group (28.68%), mentions of procedures that, individually, were not statistically significant for the composition of a category,

but together indicate a significant percentage of the total. In this group, for example, the following were identified: selective coding technique, discourse psychology, multiple correspondence analysis, triangulation, etc.

Regarding the levels and purposes (PU) of the research, we selected, based on Gil (2008), five previous groupings: Descriptive, Exploratory, Explanatory, Comparative, and others. Figure 6 presents the results:

Figure 6.

Quantitative data relating to research purposes



From these data, we highlight that most studies (79.63%) do not clearly state their PU in terms of methodological perspective. However, in the overall calculation, there are 106 explicit mentions of some PU in the remaining 66 studies. In 20 of these articles, there is more than one explicit purpose, for example, “Descriptive-Exploratory.” In these cases, the mentions were counted twice, once in each classification (which explains why the sum of the individual percentages, excluding studies that do not mention an FP, is greater than 100%).

Among the articles that provide this type of information, descriptive and exploratory approaches stand out (72.73% and 62.12%, respectively), in contrast to explanatory and comparative approaches, which together account for only 8.53% of the total number of PUs declared. A possible explanation for the predominance of descriptive and exploratory research could lie in the fact that these two purposes, according to Gil (2008, p. 28, our translation), are “[...] those usually carried out by

social researchers concerned with practical action. They are also the most requested by organizations such as educational institutions [...]". Thus, the data could, in a way, indicate the social and specific nature of studies at the interface between Science and Technology Education.

We also note that, in the "Other" classification, there are studies classified as: design, non-parametric, informative, etc., and, in most cases, we infer that these are terminological variations, given that authors such as Diehl and Tatim (2004), for example, make a distinction between the aim and purpose of the study. The authors rely on Gil (2002) to classify research as exploratory and descriptive, based on its general objectives, and present a possibility of characterization based on the peculiarities of the studies in view of the purpose to be achieved (diagnostic research, evaluation of results, etc.). We understand, in line with Freixa (2013), that this terminological variation is a process resulting from linguistic variation, an inherent characteristic of communicative situations, which involve lexical differences related to discursive, stylistic, historical, geographical, and sociocultural aspects. We emphasize that linguistic variation does not always presuppose a relationship of synonymy and that, given the specificities of research in the humanities and social sciences, linguistic choices are yet another of the phenomena they portray.

Final Considerations

We begin this section by reminding the reader that the data in this study were produced based on information provided by the authors of the articles and, therefore, even though reading the article could lead to conclusions about its methodological characteristics, these were not inferred by us. No analyses were performed to verify whether the authors were theoretically aligned with the cited source or with the literature in the field. Based on this observation, we consider it pertinent to conduct in-depth and comparative studies on what the authors state in relation to what is presented in the literature and in relation to what was actually carried out in the research.

That said, we present the main conclusions of this review:

a) the preponderance of qualitative studies (43.21%), which shows that research on technologies related to science education tends to consider the elements of the realities and concrete contexts in which the studies are conducted. We also found a significant percentage of studies declared as qualitative-quantitative

(20.27%), surpassing, albeit by a small margin, purely quantitative studies. The emergence of qualitative-quantitative studies may be a trend to be confirmed in future reviews.

b) Concerning the definition, characterization, and specification of a broader methodological nature, the articles analyzed tend to explicitly present information on research approaches (84.88%) and data collection procedures (92.90%). In contrast, information on study classification (47.53%), analytical procedures or perspectives (39.81%), and research purpose (20.37%) is less explicit.

c) Regarding classification, we highlight that the high number of works (32.47%) declared as “case studies” may reflect both a difficulty in characterizing the specificities of the research and indicate the localized, concrete, and contextual nature of these investigations. Regarding the purposes of the research, descriptive and exploratory studies prevail, although 4/5 of our corpus does not make explicit reference to this methodological delimitation.

d) Among the data collection instruments, questionnaires (41.67%) and interviews (30.86%) stand out. When added to the articles that state they use pre-tests and post-tests, this percentage increases to 87.34% of the total. Regarding perspectives and analysis procedures, 60.19% of the studies in the corpus do not indicate a specific data analysis technique. Among the studies that do so, the use of content analysis stands out (24.81%). The use of statistical software (29.46%) is also noteworthy and may be associated with the emergence of quali-quanti studies and the exploration of ICT by researchers as a tool to support scientific research in the field of Humanities and Education.

e) The methodological choices of most of the studies analyzed seem to position research on Science and Technology Education as studies whose foundations lie in the Humanities and Social Sciences. This may indicate the researchers' understanding that technologies are socio-technical phenomena; therefore, essentially cultural and human. Review studies dedicated to understanding the theoretical foundations and insights of research in this field may confirm or refute this inference, which in this study stems from methodological perspectives.

Finally, we highlight two general aspects related to this literature review: i) the contribution of this research to the training of new researchers, as well as the importance of this type of training work developed within research groups. In this sense, we confirm that the collective choices made throughout this study were the result of discussions and reflections related to the field of Science Education and its

dialogue with technologies. However, we emphasize that, in itself, this area cannot support the analyses and in-depth studies necessary for research and must therefore seek support in the Humanities and Social Sciences, especially in the broad field of Education, which is also evident in the results of this research; ii) the potential of ICT as tools to support scientific research in terms of data collection and analysis through digital resources. This last aspect may be the subject of further studies with a view to new contributions to methodological constructions.

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