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A multi-methodological framework combining text mining and causal mapping to engage experts, policymakers and stakeholders in policy design

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Abstract

Views of experts in a particular field of knowledge are pivotal in shaping the outcomes of effective public policies. When designing policies, policymakers and stakeholders often struggle to incorporate the views of both, experts and those affected by the policy implementation. The complexity and volume of good quality data stored from public interviews with experts make it difficult for policymakers to structure their thoughts into themes that could be fully understood and translated into public policy design and implementation. This paper addresses this problem and advances a multi-methodology framework to facilitate the dialogue between high level experts, on one hand, and stakeholders and policymakers, on the other hand. By combining *text mining* and *causal mapping,* two (quantitative and qualitative) methods from different paradigms, the proposed methodology aims to overcome the challenge of translating experts' views into clear themes and patterns that can be embedded into policies. Using a set of media interviews concerning literacy problems in Brazil, the paper demonstrates the framework's value in linking experts and policymakers when a large volume of qualitative data is available. Findings suggest that policymakers could be guided by a list of key themes to bring into focus the main concerns of those potentially affected by the policies. By proposing a novel framework and illustrating it with a real-world case, we aim to contribute to the practicalities of improving public policy design and to the increasing debate about multi-methodological practice in Operational Research.

Keywords: text mining; causal mapping; clustering; public policy; media data; multi-methodology; Brazil; education

1. Introduction

According to Mingers and Brocklesby, multi-methodological practice in Operational Research (OR) can be seen as the practice in which, the researchers '*utilize more than one methodology, or part thereof, possibly from different paradigms, within a single intervention*' (1997, p. 491). Multi-methodological practice in OR has been widely used to combine hard and soft approaches in different settings around the world. Some examples include Franco, Cushman, & Rosenhead (2004), Hindle & Franco (2009), Pollack (2009), Paucar-Caceres, Hart, Vergés, & Sierra-Lozano (2016), Paucar-Caceres & Jerardino-Wiesenborn (2020), Paucar-Caceres & Rodriguez-Ulloa (2007); Henao & Franco (2016); Abuabara, Paucar-Caceres, Belderrain, & Burrowes-Cromwell (2018); Castellini & Paucar-Caceres (2019); Paucar-Caceres, Santos, Wright, & Belderrain (2020); Duran-Encalada & Paucar-Caceres (2007), and Paucar-Cáceres & Abuabara (2024), amongst others.

Over time OR has made advancements to accommodate methods emerging from other research fields, with recent additions of techniques from *business analytics* and *data science* (Amundson, 1998; Romero-Silva & Leeuw, 2021). This incorporation permitted OR to extend its scope, thus potentially reducing the gap between academic research and practice (Liberatore & Luo, 2010; Ranyard, Fildes, & Hu, 2015; Mortenson, Doherty, & Robinson, 2015; Vidgen, Shaw, & Grant, 2017; Hindle, Kunc, Mortensen, & Vidgen, 2020). Indeed, Sodhi & Tang (2008) recognize the ability to assimilate methods from different research areas as one of the strengths of the OR field.

We further contribute to this type of OR practice by combining *causal mapping*, a method widely used in Soft OR methodologies, with *text mining* techniques from data science, to facilitate the decision-making process of policymakers in the presence of a large amount of media data that can inform this process.

Cognitive map is a diagrammatic structure used to reflect the perspective of an individual while the term *causal map* is used when representing the perspective of a group. The group itself can construct a map in a group dynamic (or a workshop) assisted by a facilitator, or the map can be produced from merging several cognitive maps by a facilitator as well (Pidd, 2003).

A useful way to analyse a map is to partition it into clusters, where each cluster deals with a specific subject or theme. *Clusters* are identified by interconnected constructs that focus on the same theme, or an 'island' of themes (Eden, 2004). A map can be constituted by several clusters, that is, a system of interrelated themes. The intention of assessing clusters is to identify the "system of problems" that compose the "issue" being addressed.

Interviews, debates, magazine articles and other publicly available media materials are a rich source of information on various issues of concern to societies nowadays. They generally deal with political, historical, educational, economic and health issues, amongst many others. This ample material can be of high-quality (technically- and contentwise) as it entails the contributions from members of the industry, consultants, experts, academics, and governments engaged in these issues. However, such a large volume of data might be of little use in guiding policymakers without a method for effectively analysing it.

Hence, this research aims to improve policy design by combining text mining and causal mapping, a Soft Operational Research (OR) tool, using discussion of issues documented

through secondary media data stored for public domain. The use of publicly available data and information engages experts and citizens in the decision-making process in a deliberative way (Habermas, 2012). We believe that this cannot be disregarded in the *social and policy decision-making contexts* and warrants further investigation. Therefore, in this research we exploit information in the form of secondary data from stakeholders' sources within problem structuring process towards policy-making. Proposing a methodology that enriches the decision-making process through the use of media data can also be an opportunity to prove this data meaningfulness (Meinard, et al., 2021), making it a rich and useful source of information.

The media data used to exemplify our methodological approach entails debates and discussions concerning literacy during the 2018 pre-election period in Brazil. The information arising from these discussions can support the (re-)design of public policies, but its volume makes it difficult to analyse it effectively. Thus, in this paper clusters are created first via text mining processes, and then maps focusing on the identified themes are built via causal mapping, offering a multi-methodological approach to further understand the literacy problem in Brazilian education. This combination of techniques from different disciplines can be considered a particular case of *Smart OR* (Burger, White, & Yearworth, 2019) where 'data-driven decision support and context-specific (human) resources' are gathered, creating new opportunities for enhancements of decision-making. The proposed framework is tested in a pilot study using a set of three 20-minute televised interviews about literacy problems in Brazilian education. Figure 1, in the form of a Rich Picture, captures the general approach followed in this paper.

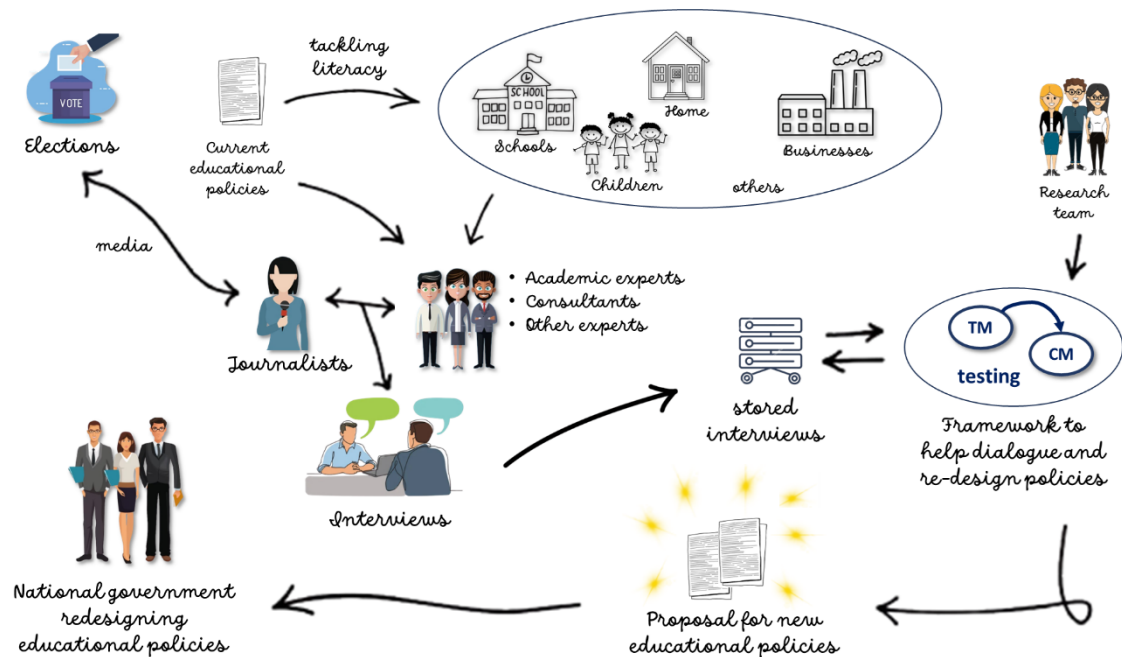*Figure 1. Rich Picture depicting the general approach and study purpose.*

The methodological framework we propose can be useful and propitious to explore societal issues in strategic and government plans. This multi-methodological framework is purposively named *M3*, the initials of (text) *mining*, (causal) *mapping* and *media* (data). To address our aim, we pose the following research questions (RQ):

RQ1: How to combine the analytical tool *text mining* with a Soft OR tool *causal mapping* in a multi-methodological framework to explore large sets of data?

RQ2: How to engage experts, policymakers and stakeholders in (re-)designing public policy by using the multi-methodological framework?

Further details of our approach, which also explain our input into the relevant literature will address RQ1, whilst the application using a data set of three recent interviews will answer RQ2.

After this introduction, Section 2 outlines our contribution to the literature, where we review how our multi-methodology fits with other OR studies utilizing media data (Section 2.1) and how the proposed framework advances the OR and analytics disciplines (Section 2.2). In Section 3, we provide a detailed overview of the proposed framework. In Section 4, we test the framework in a pilot study using a set of media interviews about literacy problems in Brazilian education. In Section 5, we present and discuss the results of the practical application. Finally, in Section 6, conclusions together with some limitations of the proposed multi-methodological framework are drawn and some avenues for future research are advanced.

2. Literature Review

This section of the paper details a review of two distinct but related areas underpinning the conceptual themes of the study: (1) media data and causal mapping, and (2) Operational Research and Analytics. These are discussed next.

2.1 Media data and causal mapping

The exploration of features of causal mapping in media data is not a novelty and has been performed by various authors. In Georgiou (2009), causal mapping is applied to learn about the complex situation of the Brazilian railways. The content analyzed in his study is taken from a prime magazine of the Brazilian railway industry, which provides a rich source of quality information with contributions from members of the industry, consultants, and the government.

A different type of media data is employed by Shaw, Smith, & Scully (2019), who use televised debates on the context of Britain exiting the European Union (Brexit) to construct cognitive maps. Although there is the technological apparatus to support the design of cognitive maps, the process is laborious and requires from the analyst a careful elaboration of the maps. This involves, amongst other things, the active listening process to identify the main ideas debated, turning the ideas into constructs, making the linkage of causality and consequences between constructs, as well as merging the maps.

Similar demands characterise a different research study by Shaw, Smith, & Scully (2017), who use criteria to select debates concerning Brexit from a major set to be analysed through cognitive mapping. In this case, the authors listen to the debates several times to identify the themes and to construct the maps based on those themes (rather than the debaters). Whilst building and analysing maps from a large group of participants is highly commended, it is an exceedingly resource-demanding process.

Whilst the present paper also applies causal mapping to the analysis of media data, this step is preceded by the use of text mining techniques. Hindle (2007) also proposes a methodology that links textual analysis and Soft OR. Specifically, his framework balances objective and subjective aspects of the process of textual analysis using a systemic concept and a modified version of the systems modelling language from Soft Systems Methodology (another Soft OR approach).

The present framework utilizes text mining to help group large amounts of media data into clusters, which subsequently enables the construction of causal maps focusing on the themes within clusters. This is important, since, as engaged social processes, Problem Structuring Methods are not designed for large groups (White, 2002). Facilitated working groups are usually composed by a small number of people, which may vary between 2 to 6 (an 'intimate' group), 7 to 15 (a 'small' group), or can be a 'large group' of more than 15 people (Phillips & Phillips, 1993). These groups are not any sort of openly adversarial work groups, and their purpose is not the communication (Phillips & Phillips, 1993). These are facilitated groups for negotiation and reaching a consensus. In the proposed framework, we do not require facilitated group processes. This is considered as an advantage as access to experts and relevant stakeholders is frequently limited. Rather, we focus our attention on the available qualitative data.

In this research, whilst we refer to small/large groups, it is not their size that matters but the amount of information they generate. Hence, even a small (large) group can generate a large (small) volume of data. In this model, we are able to accommodate the significant amount of data that organizations (including media) make available because of a wide range of sophisticated analytical tools we currently have available for processing such large volumes of data (Ormerod, 2021; Liberatore & Luo, 2010). Media data contains the main components of the so-called Big Data, which includes *volume*, *velocity* and *variety* (later, also *value* and *veracity*) (Gewirtz, 2018; Mortenson, Doherty, & Robinson, 2015). However, we also recognise that the power of data is not just in its volume, but in its quality and applicability. Our research focuses on *secondary media data*, but it can also integrate primary produced data, thus providing an opportunity for the widest possible range of individuals in an organization to work in a participative intervention process (White, 2002).

Thus, the present framework legitimizes the use of media data to faciltate the decision-making process of policymakers, in the sense of gaining relevant information through a transparent and accountable process that is ensured by the companies publishing and broadcasting the media data and information. These are mainly specialized TV channels, the public TV (Shaw, Smith, & Scully, 2017), and specialized magazines (Georgiou, 2009). The information made publicly available includes factual information, as well as scientific and expert knowledge, which are all presented in a purposely constructive approach to surfacing, modelling and understanding the opinions, values and judgments of the range of relevant participating stakeholders (Meinard, et al., 2021). This leads to a multi-methodological framework that can facilitate the decision-making process of stakeholders in the presence of a large volume of relevant media data.

2.2 Operational Research and Analytics

The purpose of this section is to explain how the proposed multi-methodological framework connects broadly understood *analytics* and Operational Research (OR). Indeed, Mortenson, Doherty & Robinson (2015) have highlighted the importance of the

analytics movement to the OR discipline. They identified a significant lack of research into analytics in operational research orientated publications arguing that the literature entailing the use of different analytical techniques in OR is growing rather slowly. This seems the case despite the increased multi-disciplinarity of the OR field instigated through the introduction of the soft OR and Problem Structuring Methods (PSMs) (Paucar-Caceres, 2010). To explain how the present study addresses this gap we first reflect on the relationship between the field of analytics and Operational Research (PSMs in particular).

According to Mortenson, Doherty & Robinson (2015), *Analytics* or *Business Analytics* (BA) is an interdisciplinary field that encompasses a number of traditional and emergent academic disciplines which can be located into one or more of three categories:

> '**Technological**: incorporating the various tools used such as hardware, software, and networks, which together support the efficient processing of data.
>
> **Quantitative methods**: the applied quantitative approaches to analysing business data, such as statistics, machine learning, econometrics and *OR/MS*.
>
> **Decision-making**: representing the tools, theories, and practices used to support and understand the decision-making process. This inherently interdisciplinary area is incorporated into many academic traditions, most obviously in psychology and behavioural science, but also in many of the other disciplines of the paradigm (e.g. studies into human–computer interaction and visualisation in information systems, or *Problem Structuring Methods in OR/MS*)' (Mortenson, Doherty, & Robinson, 2015, p. 585, our italics).

Thus, it can be deduced that Operational Research (OR) contributes to the Analytics field in the *quantitative methods* and *decision-making* categories. Indeed, this paper offers an OR multi-methodological approach to decision-making, highlighting how causal mapping (a PSM) can enhance Business Analytics, in particular text mining, capabilities. This further supports the idea of Hindle & Vidgen (2018), who develop a four-stage Business Analytics Methodology which hinges on the structuring and mapping activities borrowed from the soft OR approach. In addition, this aligns with the conceptual framework of analytics defined by Rose (2016), where the latter is seen as the union of data science and OR, where text mining and causal mapping are their respective techniques. Thus, the multi-methodology proposed in this research not only bridges the gap between analytics and OR but enriches both disciplines by enabling a focus on both data and problem at hand. This methodology is discussed next.

3. A multi-methodological framework to combine text mining and causal mapping using media data

An overview of *M3* conceptual model is illustrated in Figure 2. The model is named *M3* as it combines visual text *mining* and causal *mapping* to be used with a large amount of textual *media* data. Modeling through the *M3* framework enables to bring together two types of stakeholders whose actions are determined by different interests and who do not necessarily (or usually) interact with each other. The former are experts in a specific area of knowledge which is of interest to society, such as education, sustainability, health, economics, law, and so on. The second are social decision-makers, such as legislators and

governors at various local, state or federal levels. In between, we have the proposed framework where experts are interviewed in the media and these interviews undergo the process of transcription with the aim of generating a *textual corpus* that is subjected to text mining techniques followed by causal mapping.
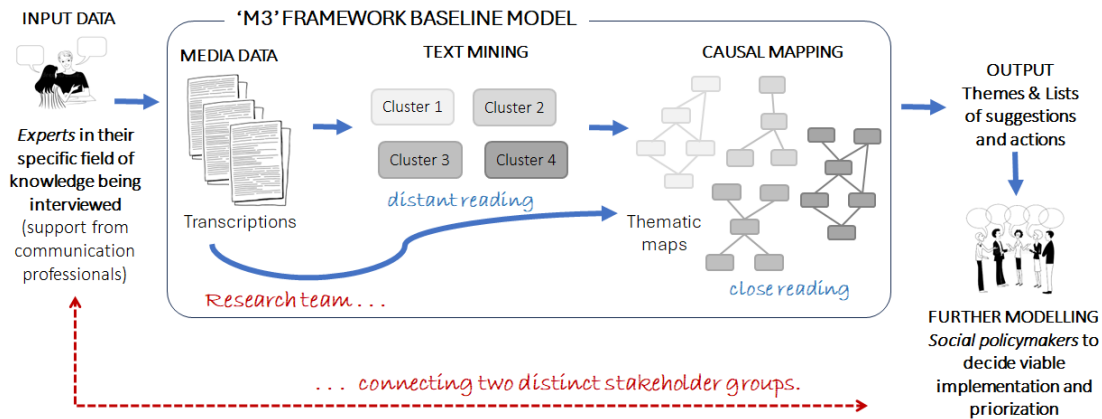

Figure 2. Overview of the conceptual framework of the 'M3' model.

Once the media data has been generated through interviews with experts, this data is subsequently transcribed and analyzed by the research team. The first stage of the analysis entails text mining. Text mining techniques involve the use of algorithms that identify patterns within transcribed texts based on the language's logic (the logic of words, sentences and paragraphs), its frequency and the relation to co-occurrence in the text, amongst other statistics (Jackson & Moulinier, 2002). In the present research, we explore hierarchical clustering, which groups important words and terms according to the Reinert method (Reinert, 1990). Conforming to this method, the corpus is divided into *text segments,* extracts of a few (1 to 3) lines, respecting punctuation breaks whenever possible. Each *text segment* is designated as an *'elementary context unit'*. This method further enables text segments to be grouped into *lexical classes*. Each class constitutes a *'linguistic context'* (not to be confused with *'situational context'*), which gives us a sense of language use and its collective representation. This clustering process is known as *Descending Hierarchical Classification* (DHC) which is hierarchically organized according to the relevance of the term in each *class* (also called a 'cluster') (Reinert, 1990). We attribute a label to each cluster. Subsequently, the interpretation of the clusters can be done by understanding the most representative *text segments* of each cluster.

Text mining has recently become standard in digital humanities, where it provides a "distant reading" of a situation (Moretti, 2013). In that sense, in addition to being a quick way to have an overview of the data, mining textual data is a means of grouping data when a vast amount of media data is available, like in the present framework. The complementary "close reading" is then provided by causal mapping.

The analysis proceeds with a production of 'thematic maps' focusing on certain themes emerging from the collection of interviews and based on the grouped words and terms, which were generated through text mining. Thematic maps, usually causal maps, represent the arguments presented by interviewees as networks in a causal relationship. The set of thematic maps supports modeling and structuring the system of problems. The themes and the lists of suggested actions generated from the analysis of these maps shall feed and guide the discussion and future decisions of the relevant policymakers. Thus,

combining causal (cognitive) mapping and text mining, two techniques from different paradigms with their distinctive features (see Table 1), facilitates and enriches the process of decision-making in the context of media data.

Table 2. Features of text mining and causal mapping techniques.

Item	Text mining (TM)	Casual Mapping (CM)
1	TM is suitable for processing large amounts of textual data.	CM is applied within small (at least manageable) groups and the information they produce.
2	TM simplifies information (e.g. texts are seen as 'bag of words' or 'vector of words', or 'matrices') ignoring any syntax or semantics, remaining only lexical analysis.	CM allows for actively and carefully listening to the participants.
3	TM does not deal with synonymy and polysemy (a same word with a different meaning).	CM makes use of the bipolarity to address the ambiguity inherent in the language.
4	TM depends on the context to have insights identified and interpreted (since it is not possible to model the context itself).	CM allows to work directly with participants cognition, this way the context is easily identified.
5	In TM, *language*, converted into texts and then into a set of words, is considered an *unstructured* data.	In CM, *language* is a way of expression and argumentation, including subjectivity and different interpretations.
6	One of the outcomes of TM is a *visual* graphical representation of *quantitative* information (e.g. dendrogram, word cloud)	CM is per se a *visual* diagrammatic representation of *qualitative* information.

4. Testing the Mining, Mapping and Media (*M3*) framework

Although the advantages of automatic textual analysis are greater with larger (compared to smaller) textual data volumes, we produced an illustrative example with only three interviews. This number of interviews was sufficient to enable us to detail the content of each interview and the list of words in each cluster, whilst simultaneously allowing us to work with manageable causal maps as well as to include our own comments and evaluation within the application of the framework. Figure 3 illustrates the process we underwent. Activities inside the framework are those conducted by the research team. Activities outside the framework invoke the direct or indirect participation of certain stakeholders that we specify below.
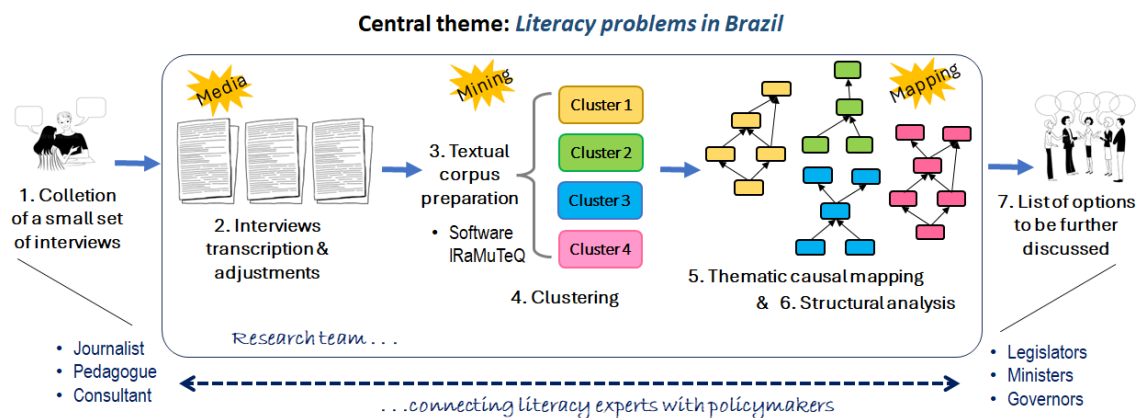

Figure 3. Process of testing the multi-methodology.

Figure 3 includes a title which identifies the central theme of the application, which is *'Literacy problems in Brazil'*. When we talk about literacy, we immediately think of children in the early years of school life. However, we shall also consider *illiterate* and *functionally illiterate adults*.

In the next paragraphs, we briefly describe the steps that follow:

[1] Collection of data from a small set of interviews: This entails the *material* (or *input data*) of the case study. We used three interviews which are video recorded and were arranged as well as produced by a public Brazilian TV, hence they are in Portuguese. These interviews are part of a larger set of interviews that follow the same pattern of elaboration (time, recording features, interviewer, studio site, and so on). The use of a limited number of interviews makes it possible to evaluate the processes in each step including the identification of potential limitations and difficulties. However, it is worth emphasizing that in practice, the proposed multi-methodology is designed for large volumes of textual data. We also recall that this research is developed for the use of secondary source material, but the methodology also allows for the use of primary data.

The interviews were conducted by the TV station in 2018, an election year in Brazil, and aimed to inform the candidates' public policy plans. Literacy in Brazil is a challenge that has been exacerbated by the COVID-19 pandemic, affirming that these interviews are not outdated. Indeed, the literacy problem still exists in Brazil with the Brazilian Ministry of Education reporting the proportion of literate students in the context of the entire student population to be 55% in 2019, 36% in 2021, and 56% in 2023 (MEC, 2023). Table 2 captures the information about the interviews and the interviewees (stakeholders who are experts in education). Other sources of input material, in addition to the televised interviews used here, may include social and traditional media such as podcasts, news articles, as well as academic sources such as article reviews and scientific publications. Other issues of social interest, such as climate change and tax reforms, are discussed with the population in public hearings. It is a true myriad of speeches that deserve attention and consideration and can be explored by the proposed framework.

Table 2. Set of interviews that compose the textual corpus

Item (text)	Title and Topic discussed	Interview duration	Interviewee information
Interview 1:	Literacy in Brazil: what can be improved?[1]	*18'41''*	*Journalist* specialized in Education and twice the winner of the 'Journalism in Education' award.
Interview 2:	Are there many functional illiterates in Brazil?[2]	*18'35''*	*Pedagogue* and *professor* in the faculty of Education at University of São Paulo/Brazil
Interview 3	What is literacy?[3]	*22'36''*	Educational *consultant*

In general terms, *quality* of data is a crucial feature for the text mining process. Depending on the source and topic, text data can be 'noisy', ambiguous, subjective, and may include many technical terms, which can affect the accuracy and validity of the results if not

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[1] Video available at: https://www.youtube.com/watch?v=-VHEGpbNxIY
[2] Video available at: https://www.youtube.com/watch?v=xYbtJFXoRnw
[3] Video available at: https://www.youtube.com/watch?v=A2PA7nvJt8E

preprocessed appropriately. Additionally, in current times, social media users' interactions create an extensive field of research in language. In these cases we refer to an intermediate and contemporary language that is an informal spoken language, but which is presented in a written and compressed form (e.g. microblogging systems such as X, former Twitter) (Basari, Hussin, Ananta, & Zeniarja, 2013). In environments as these, interpretation might be difficult due to the use of a non-literal language, such as sarcasm, critique, dialect, or praise (Garcia, Turcan, Howman, & Filik, 2022), quite distant from any formality. Moreover, we do not recommend mixing sources of data which usually have different charactristics (e.g. social media and news articles) and can be even more problematic for analysis, ultimately skewing the results.

The main content of each interview is described as follows:

Interview #1: It discusses the difficulties and future consequences of (not) teaching children to read and write at the appropriate age. It mentions Brazilian education guidelines on children's entry into primary education. Furthermore, it addresses some current problems that can harm the cognitive and social development of children, such as the lack of preschool places.

Interview #2: The routine of a functionally illiterate person is discussed, such as the search for a job. Some Brazilian statistics on functional illiteracy are presented. The inefficiency and quality of teaching are discussed, including mechanistic practices. The need for policies that provide access to culture and the practice of language and communication inside and outside school is addressed. The origin and social heritage of functional illiteracy are further explained.

Interview #3: Literacy concepts and processes used in Brazil are discussed and compared to those in developed countries. Statistics from the National Literacy Assessment are reported. Other topics discussed include vocabulary acquisition, history of literacy in Brazil, literacy at home and at school, as well as teaching conditions.

[2] Interviews transcriptions & adjustments: We employed a free web application called DownSub (https://downsub.com/) to automatically download the subtitles of the videos in text (*.txt) format. For that, we entered the URL (Uniform Resource Locator) address which is the location of the webpage (link) of each interview. The accuracy of the transcription was checked by watching the interviews at a reduced speed. When necessary, adjustments were made manually, such as correction of a word or removal of any irrelevant data (e.g. sticks, songs). Indeed, ensuring quality data entry was the research team's priority. As the interviews were professionally conducted and recorded, their automatic transcription was a smooth process. Generally, for data originally in text format, such as scientific and news articles, this step is simplified. In contrast, texts originating from verbal language, as in the case of interviews, involve the expressions of ideas, feelings, intentions and emotions with a significant number of contextual terms, slang, nuances, associations of ideas, and expressions of emotions and values, which make this stage more laborious.

[3] Textual corpus preparation: Once transcribed, we made some adjustments to the text to adapt it to the software used. We: (i) rewrote each interview in a single paragraph; (ii) removed all signs (e.g., question marks, hyphens, dashes and so on) except for periods and commas; (iii) retrieved the questions in the answer; (iv) removed interjections and filling words (e.g., *so*, *like*, *I think that*, *ah*, *well*, *perhaps*, *isn't it?*); and (v) underscored expressions, central terms and concepts of interest (e.g., *primary_school*, *high_school*).

Data preparation and adjustments helped meet the requirements of the analytical tool chosen by researchers for text mining. The tool chosen by the researchers is specified in the following activity. For illustrative purposes, we include a short excerpt duly translated from the beginning of one of the interviews, in the form of a dialogue as it originally occurred, and then with the necessary adjustments to become the textual corpus:

Original interview dialogue

[Interviewer] - *Do you think literacy is Brazil's Achilles heel?*

[Interviewed] - *It is an Achilles heel whenever literacy instruction does not follow the necessary steps for children to become literate at the ideal age.*

Textual corpus after preparation

Literacy is an Achilles_heel in Brazil whenever it does not follow the necessary steps to ensure that children become literate at the ideal age.

[4] Clustering: We explored basic and multivariate lexicographical analysis of IRaMuTeQ (*Interface de **R** pour les Analyses **MU**ltidimensionnelles de **T**exts **E**t de **Q**uestionnaires*), an open-source software for lexicographic textual analysis (www.iramuteq.org) which allows statistical analysis of textual corpus that is anchored in R software (www.r-project.org). We were positive (software options) for lemmatization and selected as active forms (i) adjectives, (ii) verbs, (iii) nouns, and (iv) unrecognized forms (the ones underscored). Moreover, Portuguese was established as a standard dictionary and the corresponding idiom.

*[5] Thematic causal mapping***:** The number of clusters defines the number of thematic maps to be built. Information from the interviews is used to construct the thematic maps which essentially follow the rules of causal maps with bipolar constructs from Kelly's Personal Construct Theory (Kelly, 1955). *The dichotomous constructs consider two polarities for the purpose of contrast or alternativeness* (Georgiou, 2010; Eden, Ackermann, & Cropper, 1992). Three dots separate the two poles of the construct and can be read as *rather than*. For example, we transcribed one of the constructs ([3.1]) that is part of the research results: *"Literacy (reading and writing) at the right age and within a standard ... Not a commitment"*. We can read it like this: *"Providing children with literacy (including reading and writing) at the right age and within a learning standard, rather than having no commitment"*.

*[6] Structural analysis***:** This activity was carried out on the thematic causal maps and is based on principles of graph theory. The key principle is *centrality*, which is based on degree of the node/construct (total number of constructs leading into and leading out of it) (Harary, Norman, & Cartwright, 1965). Another crucial principle is the construct structural categorization according to certain basic types such as tails (prime causes), heads (objectives or consequences), strategic options (construct just below a head), implosions (major effects), explosions (major causes), and dominants (central influence) (Georgiou, 2011; Abuabara, Paucar-Caceres, Werner-Masters, & Boas, 2023). Figure 4 highlights the positions of each type of construct within a causal map (in principle, a directed graph). This process results in a set of objectives and actions that feed a likely plan.
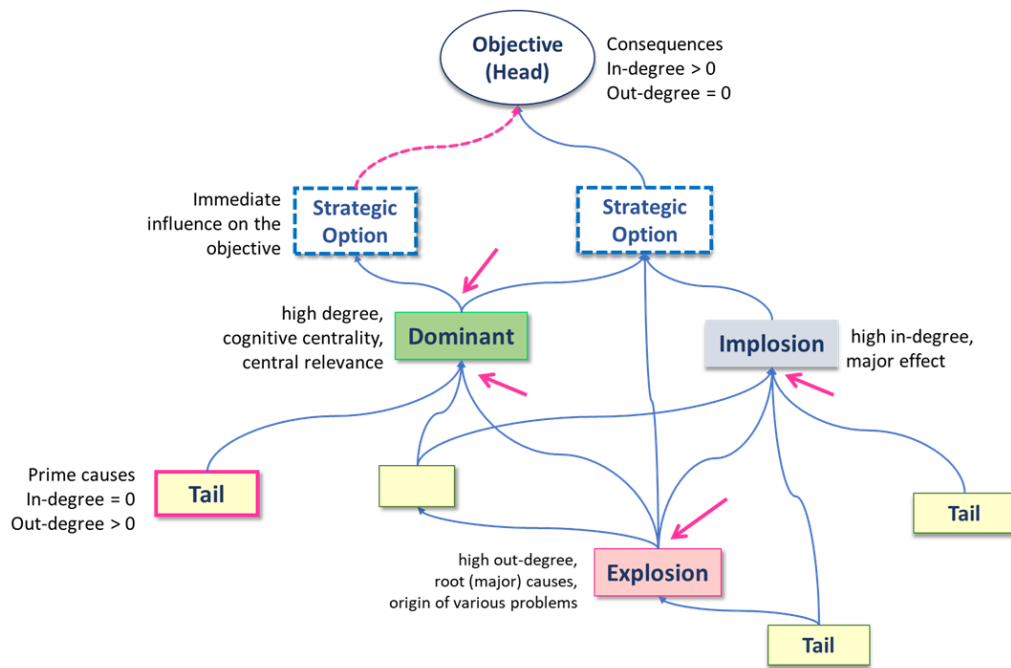
Figure 4. Types of constructs within a causal map.

[7] List of decision options to be further discussed: This activity is not covered in this study but might be a crucial part of the entire process. The idea is to use the result of the previous step which is a set of decision options to be part of the discussion by policymakers which can also include society and/or experts and consultants. In this discussion, feasibility shall be verified, and prioritization shall be considered. Additional methods and techniques, particularly in Decision Analysis (Goodwin & Wright, 2004), can be incorporated into the model and explored in this phase. Each application has its own policymakers, here we enumerate three possible such as legislators, ministry of education, and governors.

Finally, we can say here that steps 1 and 7 have been connected. In other words, the demands of the stakeholder group represented in step 1 reached the stakeholder group represented in step 7.

5. Discussion of the results

After running the software with the textual corpus (transcribed interviews properly adjusted and pre-processed), a set of outcomes is returned. As the input material is originally in Portuguese, the results presented here were duly and carefully translated into English by the Brazilian-native first author.

Table 3 shows the textual corpus information, descriptive statistics and some outcomes after the implementation of the analytical software, IRaMuTeQ. In addition to the frequency, the statistical information in the second column can be used to quickly scan whether the software is reading the corpus correctly and if the latter is considered coherent from a linguistic perspective. The third column contains a brief explanation of each piece of information.

Table 3. Textual corpus information and relevant statistics.

Software information		Interpretation
Number of texts	3	Number of interviews (items) in the textual corpus.
Number of Occurrences	6,842	Total number of words in the textual corpus.
Average occurrence per text	2,281	Average number of words per interview.
Number of forms	1,531	Number of unique words.
Number of lemmas	1,113	Number of lemmas heading a set of words with the same stem.
Number of active forms	980	Number of words classified as adjectives, verbs, nouns, or unrecognized forms.
Number of supplementary forms	127	Words classified as other than adjectives, verbs, nouns, or unrecognized forms, that means adverbs, articles, pronouns, conjunctions, prepositions and so on.
Number of text segments	194	Sequence of words of one to three lines, scaled automatically by the software, respecting punctuation breaks whenever possible.
Average of forms per segment	35	Average number of unique words per text segment (TS).
Number of clusters	4	Number of semantic classes generated from the text segments (TSs).
Retention rate	74.74% (145 segments classified on 194)	Number of TSs appropriate for the cluster building process. (Note: A figure of 75% or above provides evidence of the corpus being suitable for the analysis by the clustering technique offered by IRaMuTeQ (Camargo & Justo, 2018).

The process continues by presenting the content of the textual corpus grouped into four lexical classes (the clusters) resulted from the analytical analysis. Hierarchical classification is represented by a dendrogram, which is a tree-like structure that displays the dataset's relationships, organized in a branching pattern. First, in Figure 5, the entire corpus, entitled "Literacy problems in Brazil" is branched into 2 sub-corpora (**A** and **B**). Subcorpus **A** is further divided into two other sub-subcorpora: **A1** which contains class 4 labelled "The process of becoming fluent in a language"; and **A2**, which contains class 1 (**A21**) labelled "Teaching conditions" and class 3 (**A22**) labelled "Illiterate adults". Subcorpus **B** includes class 2 named "Consequences of low literacy". From a broader perspective, we can say that subcorpus **A** refers to the literacy process for children or adults, and the means to facilitate it, while subcorpus **B** deals with the consequences of low literacy for the future of society. The boxes in Figure 5 also include the number of text segments (TS) that made up each lexical class, as well as the corresponding percentage. For example, in sub-subcorpus A1 there are 40 TSs and they constitute 27.6% of the total TSs in this lexical class. Furthermore, the figure indicates the interview at which the specific theme is predominantly discussed, and which is then used to build the thematic map. Since only three interviews were used, there is only one interview per cluster, with a number indicating the interviewee. Finally, Figure 5 also specifies the p-value of the algorithm test criterion.
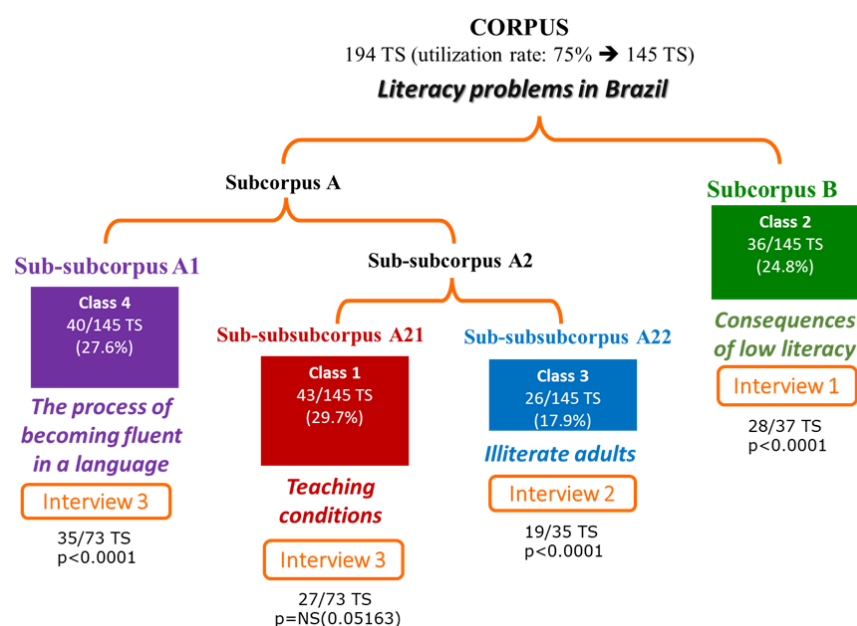
Figure 5. Lexical clustering.

The lexical classification is then expanded in Figure 6, which presents the list of words (ordered in descending manner) belonging to each cluster. The number of words in each cluster varied between 20 and 24. As previously mentioned, the corpus and consequently the results offered by the software are in Portuguese. In this way, the list of words herein contained was translated one by one by the first author. We report that in some translations, there were doubts about the meaning of the word to be translated and we had to resort to the text where it was inserted. This happens because the same word can have several meanings and therefore different translations. An important feature is that the same word rarely appears in two (or more) different clusters. We abide by this rule in the translation process. The percentage to the right of each word in Figure 6 indicates how much that word is part of the cluster in relation to the entire corpus.

The title assigned to each class is in some way an interpretation and summary of the problem and is initially based on the set of words contained in it. In some cases, just the set of words is not enough to understand or define a problem well. In such cases, causal mapping is essential to understand the problem in depth. In this way, the title is assigned or revised following the mapping process. For example, class 4 labelled "The process of becoming fluent in a language", is based on expressions that we can form from words like 'the *process* of becoming *fluent*', '*measures* of *fluency*', and '*number* of *words*' (words in italics are part of the class 4 set as shown in Figure 6).

CORPUS
Literacy problems in Brazil

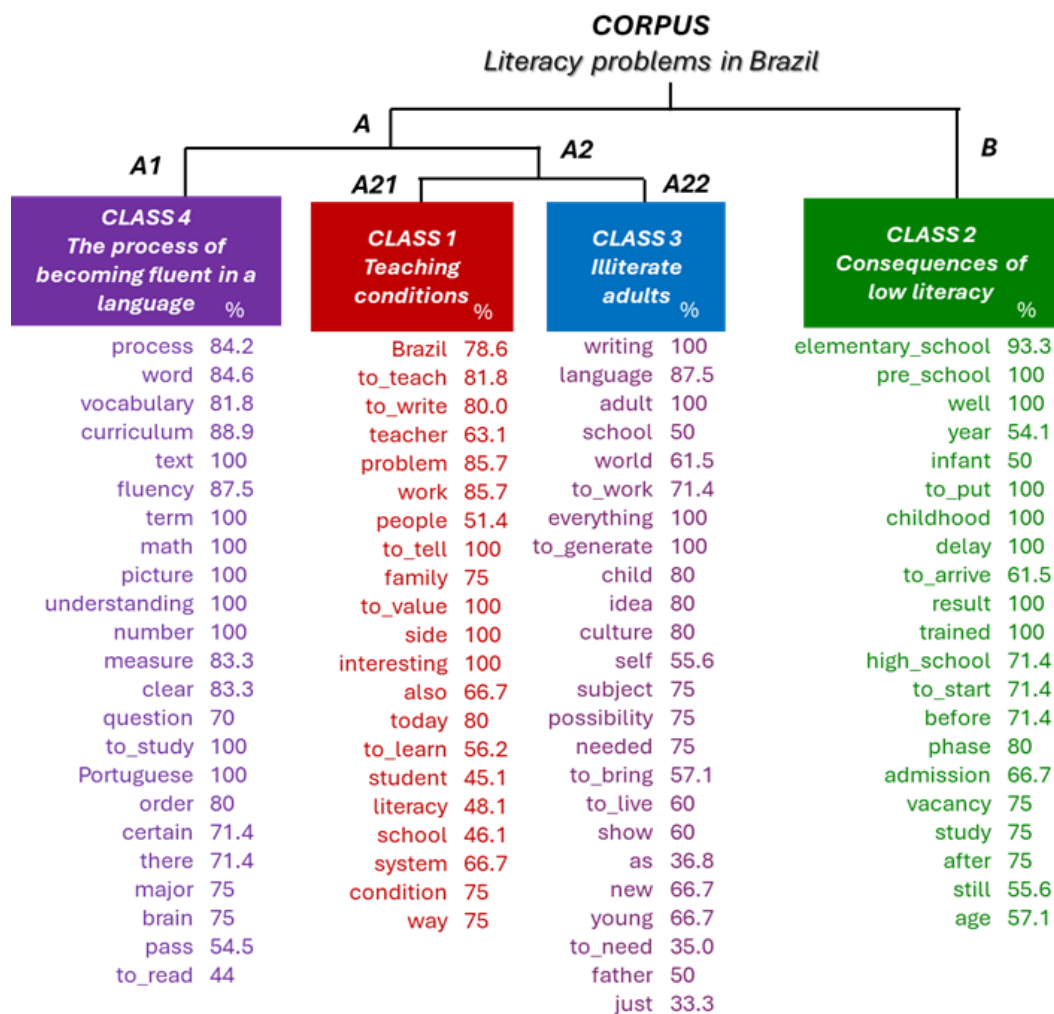| CLASS 4 The process of becoming fluent in a language %	CLASS 1 Teaching conditions %	CLASS 3 Illiterate adults %	CLASS 2 Consequences of low literacy %
process 84.2	Brazil 78.6	writing 100	elementary_school 93.3
word 84.6	to_teach 81.8	language 87.5	pre_school 100
vocabulary 81.8	to_write 80.0	adult 100	well 100
curriculum 88.9	teacher 63.1	school 50	year 54.1
text 100	problem 85.7	world 61.5	infant 50
fluency 87.5	work 85.7	to_work 71.4	to_put 100
term 100	people 51.4	everything 100	childhood 100
math 100	to_tell 100	to_generate 100	delay 100
picture 100	family 75	child 80	to_arrive 61.5
understanding 100	to_value 100	idea 80	result 100
number 100	side 100	culture 80	trained 100
measure 83.3	interesting 100	self 55.6	high_school 71.4
clear 83.3	also 66.7	subject 75	to_start 71.4
question 70	today 80	possibility 75	before 71.4
to_study 100	to_learn 56.2	needed 75	phase 80
Portuguese 100	student 45.1	to_bring 57.1	admission 66.7
order 80	literacy 48.1	to_live 60	vacancy 75
certain 71.4	school 46.1	show 60	study 75
there 71.4	system 66.7	as 36.8	after 75
major 75	condition 75	new 66.7	still 55.6
brain 75	way 75	young 66.7	age 57.1
pass 54.5		to_need 35.0	
to_read 44		father 50	
		just 33.3	

Figure 6. Dendrogram including the main terms of each cluster.

At this stage, many studies using text mining propose to raise and discuss insights based on each group of words and terms. This requires some knowledge in the area and of the context of the problem being addressed, which might not be on hand. Indeed, gaining insights into emerging trends and patterns is important and relevant when working with large amounts of data. However, we know that inherently associated with this approach is the fact that high frequency of occurrence of a term means its high relevance for the topic. This can be considered a limitation of this method. Hence, unlike those studies, we will unravel the interviews by building the thematic maps.

We follow presenting the thematic maps in Figures 7, 8 and 9. We build four thematic maps, as this is the number of clusters. However, two thematic maps (1 and 2) derive from the same interview (#3). As this interview has a single objective, thematic maps 1 and 2 are presented together, differentiating them only by the colours (purple and red) of the constructs.

Before we begin analyzing the maps, we make a few considerations. The texts of the constructs were expanded for better understanding. The number in brackets is the construct number. The number before the dot indicates the interview (or item) of origin and can vary from 1 to 3. The decimal number indicates the number assigned to the construct in each thematic map. The thematic maps 1 and 2 are presented in Figure 7.
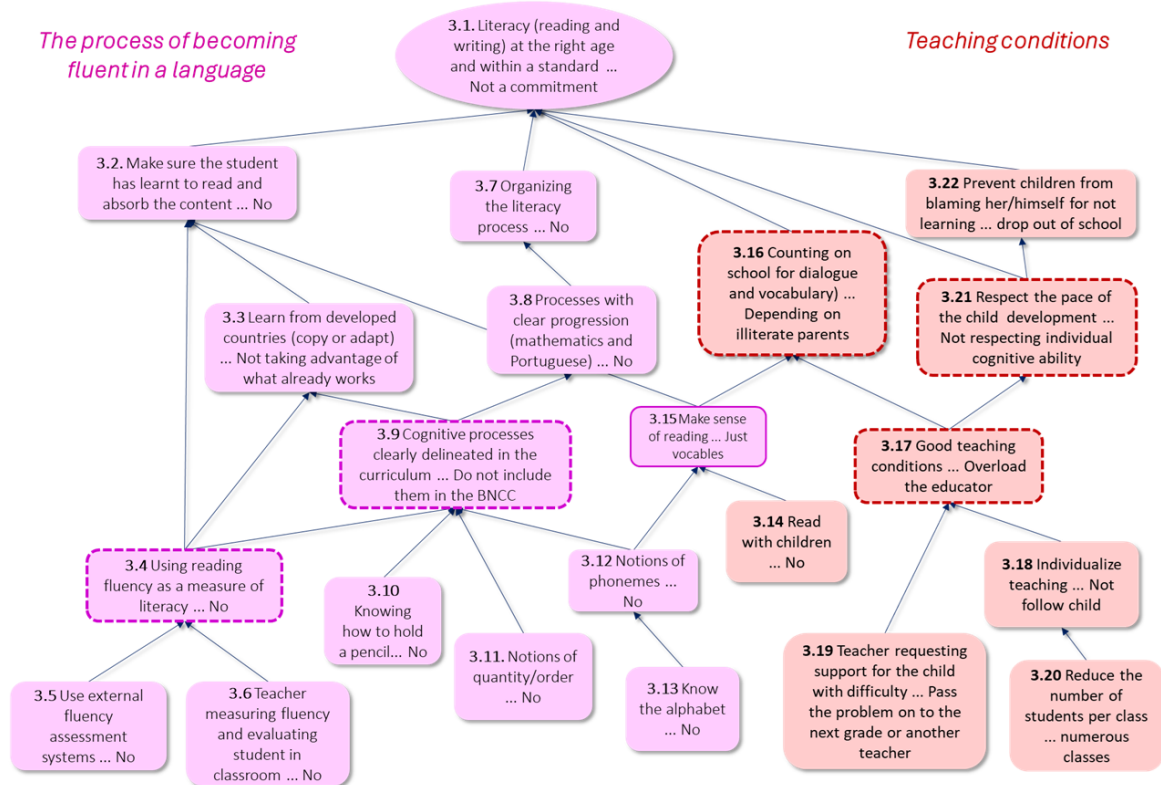
Figure 7. Thematic maps 1 and 2.

Thematic maps 1 and 2 share the same objective that refers to the **literacy process**:

> **[3.1]** Providing children with literacy (including reading and writing) at the right age and within a learning standard, *rather than* having no commitment.

Thematic map 1 (left hand side of Figure 7, in purple) refers specifically to the literacy process of young children in primary education, which includes particular learning techniques, assessment and monitoring measures. The dominant constructs of this map are:

> **[3.4]** Educators using the fluency measure to assess children's literacy effectiveness *rather than not* using it.

This assessment involves reading aloud an age-appropriate text. Reading speed is measured (number of words per minute). Children are then asked questions verifying their understanding of the content. The map also points to:

> **[3.9]** Having children's cognitive processes and progress clearly outlined in the curriculum, *rather than* not including them in the National Common Curriculum Base (BNCC).

Cognitive processes need to have a clear progression. Education is a cumulative process for any discipline (language, mathematics, science, music and so on). The educational process is individualized, as it involves the retention of knowledge and cognitive skills by each child. Each child develops at a different speed or using a different process. This process and progress shall be clear in the curriculum that educators follow. Furthermore, this construct also means ensuring that all children in any primary school in the country

should have the same literacy process and, therefore, the same opportunities for development.

Thematic map 2 (right hand side of Figure 7, in red) refers to some teaching conditions that might inhibit gaining literacy competence. This could include a family with illiterate parents who do not value school education, sometimes sharing a life without books or culture. This may be even more explicit in the working conditions of educators teaching excessively large classes and not being able to pay attention to individual pupils. The dominant constructs of this map are:

[3.16] Children counting on schools to learn a language through the dialogue and a rich vocabulary, *rather* than relying on illiterate parents.

[3.17] Providing the educator with good teaching conditions (e.g.: a reduced number of children in the classroom) *rather than* overloading them.

[3.21] Children having the pace of their development respected *rather than* not respecting their individual cognitive ability.

One of the consequences of not learning to read and write in childhood is dropping out of school and, therefore, the potential for a marginalized adult life. This is the central topic of thematic map 3 shown in Figure 8.
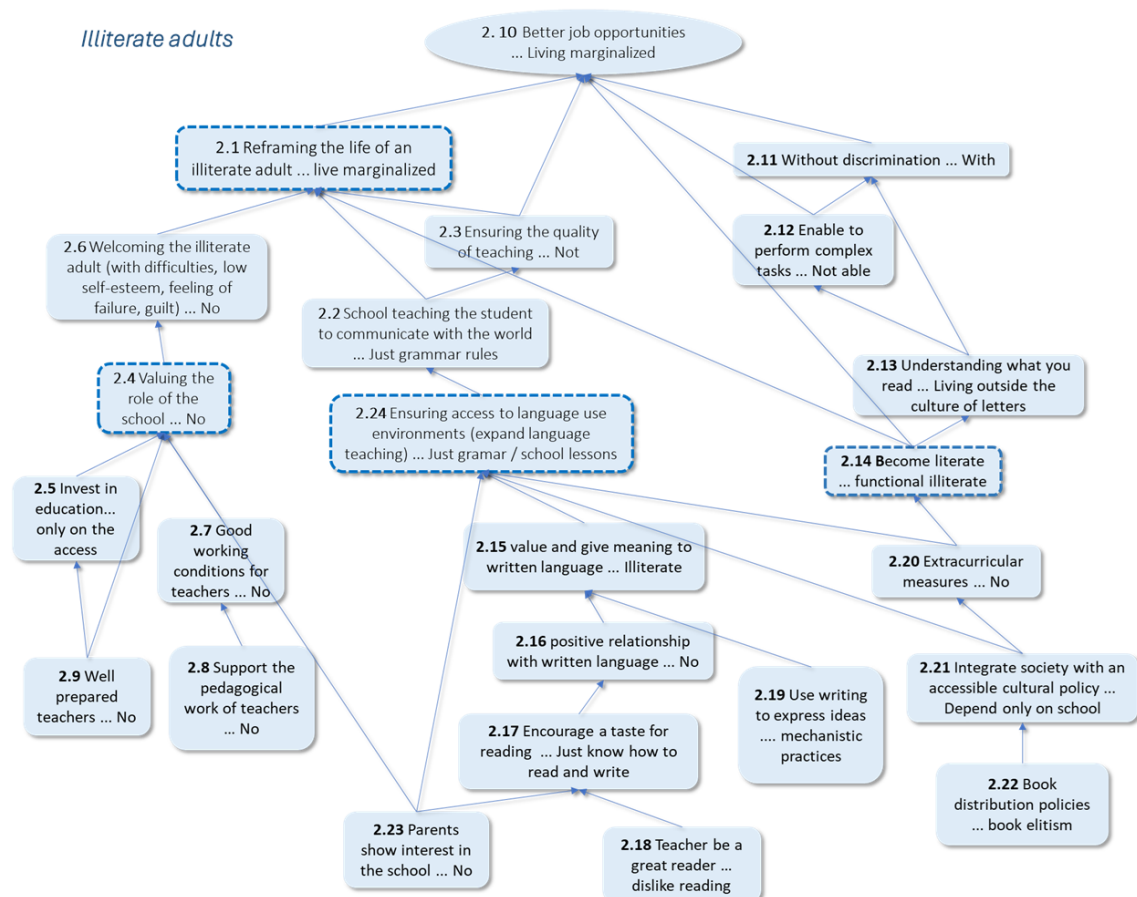

Figure 8. Thematic map 3.

Our job (or occupation) is often what defines our position within society. Illiteracy takes away our opportunities for professional development and fulfillment. Here we are referring not only to illiterate adults, but also to functional illiterates, who despite

knowing how to read and write, have difficulty interpreting texts and suffer from the same social consequences. In addition to the social impact of being illiterate, there is also an economic impact, as education and income are positively correlated (MEC, 2023). The objective in thematic map 3 (Figure 8) is related to these opportunities:

[2.10] Through literacy, (adults) having better job opportunities *rather than* not having them and living marginalized.

We highlight four dominant constructs in thematic map 3. The first one ([2.1]) is also a *strategic option* (just below an objective) and deserves more attention. The other constructs call for actions that also appear in the context of children's literacy, showing the relevance of these actions.

[2.1] Giving a new meaning to the life of illiterate adults *rather than* living on the margins of a literary culture, suffering from prejudice, discrimination as well as from feelings of low self-esteem, guilt, and a sense of failure.

[2.4] Valuing the role of the school by providing good working conditions for teachers *rather than* not valuing it.

[2.14] Becoming literate *rather than* functionally illiterate.

[2.24] Ensuring students' access to language use environments (inside and outside of school, with public policies such as access to books) *rather than* just grammar and school classes (mechanized practices).

Learning to read and write is one of the first accomplishments a child celebrates in the early years of education. In contrast, low literacy has consequences for educational and professional trajectory and results in fewer opportunities in life. More broadly, low literacy has consequences for the whole: the society, which will not have qualified professionals; and the economy struggling to develop and grow, amongst other things. This introduces the last thematic map in Figure 9.
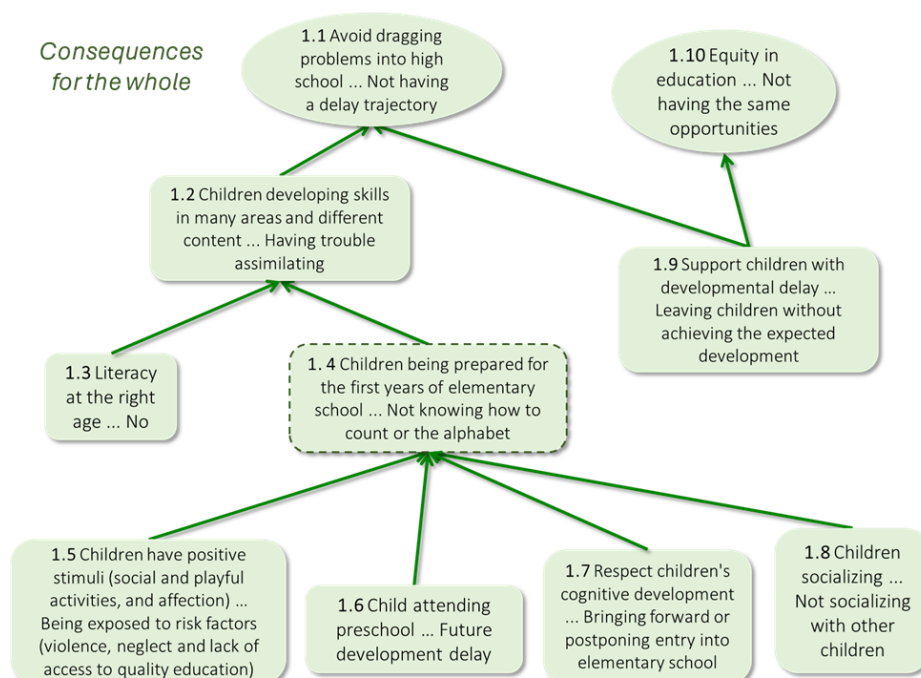

Figure 9. Thematic map 4.

This map points to two objectives:

[1.1] Prevent the child from carrying over their learning problems into high school, *rather than* having a delay in learning.

[1.10] All Brazilian children having equity in education (regardless of social class or region they live in), *rather than* not having the same opportunities.

The *dominant construct* in this thematic map is quite direct and has four prime causes linked to it, meaning many opportunities to meet the objective [1.1]:

[1.4] Children being well prepared for the first years of primary school *rather than* reaching that stage without knowing the alphabet or numbers.

Table 4 condenses the themes and the corresponding list of actions. The intention of this table is to guide policymakers in their discussion by accounting for feasibility, implementation costs and deadlines of the suggested actions, among other constraints.

Table 4. Themes and suggested actions for future evaluation.

Themes & Suggested Actions			
The process of becoming fluent in a language	**Teaching conditions**	**Illiterate adults**	**Consequences for the whole**
• Commit to a literacy project (reading and writing) for children at the right age and within recognized learning standards. • Use fluency measures (e.g. number of words per minute) to assess the effectiveness of the literacy process. • Have the cognitive processes of literacy, including expected progress, clearly outlined in the school curriculum.	• Teach language in the school environment through dialogue and a rich vocabulary. • Provide the educators with good learning conditions (e.g.: reduced number of children in the classroom) so as not to overload them. • Respect the pace of development and individual cognitive capacity of each child.	• Through literacy, give adults better job opportunities avoiding the marginalization of their lives. • Bring new meaning to the lives of illiterate adults, preventing them from living on the margins of literary culture, suffering prejudice, discrimination, as well as feelings of low self-esteem, guilt and a sense of failure. • Value the role of the school. • Teach adults to read and write, avoiding functional illiteracy. • Ensure students access to language use environments (inside and outside of school, with public policies such as access to books) avoiding just mechanized practices in school classes.	• Prevent each child from carrying over their learning problems into high school, which means having a learning delay from an early age. • Provide all children with the same educational opportunities, regardless of their social class or region of origin. • Prepare preschool child well for the first years of primary education, including knowledge of the alphabet and numbers.

6. Conclusions

In this research, we developed a multi-methodological framework that combined text mining through a clustering process with causal mapping from Soft Operational Research for application to cases where a large volume of qualitative data is available. The use of media data is timely as it is often available in abundant quantities. Moreover, many issues of social interest are covered by the media, which gives access to experts, producing quality information, both technical- and contentwise. Thus, different problematic situations in a variety of contexts can be explored within the proposal framework, thus expanding the possibilities of Soft OR practice and inspiring new applications.

This article aimed to answer two research questions. First, RQ1, refers to a likely combination of techniques from different paradigms, one analytical, the other a Soft OR approach. In this regard, we proposed a methodological framework, named *M3*, the initials of (text) *mining*, (causal) *mapping* and *media* (data). We believe the paper enhances the operational research practice and reflection, when using a multi-methodological strategy in systemic interventions. In this way, the framework proposed and the way it is applied will certainly increase the repository of multi-methodological operational research and for management science in general. Moreover, we emphasize that the *M3* framework proposed bridges the gap between OR and Business Analytics, leading to the enrichment of analytical capabilities too.

The second research question, RQ2, concerns the application of the framework to cases of policy re-design. Thus, we tested the multi-methodological framework in a pilot study using a limited set of media interviews concerning literacy problems in Brazilian education. Through this application we were able to verify how the methodology works in practice. Altought we explored ways of using the proposed framework in a case study by making use of stored data from important interviews with experts, the *M3* framework provides an important connection between two distinct stakeholder groups: experts and policymakers. On the one side, experts provide information based on their knowledge of the subject and the problems in the area in question. This information will feed the methodology. On the other side, policymakers have the opportunity, through the methodology, to have a list of condensed decision actions within the themes in question.

Although the proposed framework was designed as a way to facilitate cases where there is a large amount of data, there are other relevant advantages in the results it provides. Thematic maps are designed to provide dedicated and detailed action plans. This is because the problem is seen in parts, the 'system of problems' that compose the issue was seen from a more thorough perspective.

Limitations and Future Research

The conceptual and empirical results reported should be considered in the light of some limitations.

First, in relation to the ***media data***, the practical example used a limited number of three interviews of approximately 20 minutes. Possible continuation of this study includes the implementation of the methodological framework using the full set of interviews in which it originated. In principle, the interviews were produced for a specific demand. Using the same available data in our research was a way of giving it a new purpose. We emphasize that the quality of media material, which includes the credibility of those who produced it, as well as that of experts or information providers, shall be carefully assessed by researchers.

In relation to **text mining**, there is a range of tools and techniques beyond the one used in this research: topic modelling, clustering, text classification, sentiment analysis, just to mention a few. Other techniques and software can be explored remembering that, in general, some textual corpus preparation activity is necessary before implementing the software. Although it is sometimes somewhat manual and mechanical work, it is above all an opportunity to familiarize yourself with the material and the subject in question.

We shall also keep in mind that clustering through text mining has its limitations in the sense that it provides a linguistic context that is very different from the context of the situation. However, it can still be a very useful methodology in many situations, particularly when summarizing textual data.

In relation to the **causal mapping**, as stated earlier, exactly the same interviews used in text mining were also used in causal mapping. There may be occasions when the volume of interview data is such that it is difficult to use it in causal mapping in its entirety. In these cases, we shall adopt some strategy to select the most relevant interviews or parts of them that will be used in the mapping phase, running the risk of leaving something behind.

In relation to the **framework**, it would be useful to add a technique that brings together common actions and prioritizes the most important ones.

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Disclosure of interest

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