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Systematic map and review of Google Classroom usage during the Covid-19 pandemic: an analysis by data clustering approach

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Abstract
The Covid-19 pandemic brought changes in people's lives and in various sectors of the economy, including the education sector. In this context, students and teachers were able, through digital technologies, to continue their academic activities even in these difficult times. Many of these digital technologies were used to bridge the gap between instructors and students. Thus, in this work we reviewed the literature to better understand the usage of one of the widely known tools adopted by several schools: the Google Classroom (GC). For a more conclusive analysis, we used a systematic literature review to obtain relevant articles ($N = 25$), and then, we grouped them by similarity using clustering algorithms to facilitate data analysis and summarization. The best clustering algorithm among the three compared was the k-medoids, as it generated clusters with better data separation. In our research, 56% of papers were published in 2020 and 44% of papers were published in 2021. Most of the articles reported positive reviews (72%) of using Google Classroom during the pandemic due to its good usability and the possibility of browsing through hyperlinks. Nevertheless, some weaknesses were found in 28% of papers (negative or neutral review) when teachers or students faced instability in the network. In addition, some authors have presented solutions to get around the problem about the GC usage during pandemic, such as the use of other networks to support learning and the use of tools that allow synchronous communication between teacher and student.
Keywords: *Google Classroom, Learning Management System, Machine Learning, Data Clustering, Covid-19 Pandemic, Systematic Literature Review.*

Resumo
A pandemia da Covid-19 trouxe alterações na vida das pessoas e em diversos setores da economia, incluindo o setor da educação. No entanto, mesmo distantes, alunos e professores puderam por meio de tecnologias digitais continuar suas atividades acadêmicas de forma satisfatória. Muitas tecnologias digitais foram usadas para diminuir o distanciamento entre professor e aluno, mas neste trabalho, fizemos uma revisão do Google Classroom (GC), por ser uma ferramenta amplamente difundida e muito utilizada ao redor de todo o mundo. Para uma análise mais conclusiva, utilizamos uma revisão sistemática da literatura para obter artigos relevantes e os ($N = 25$) artigos extraídos foram agrupados por similaridade por meio de algoritmos de clusterização, para facilitar a sumarização dos dados. O melhor algoritmo de clusterização dentre os três comparados foi o k-medoids, pois gerou agrupamentos com melhor separação dos dados. Em nossa pesquisa, 56% dos artigos foram publicados em 2020 e 44% dos artigos foram publicados em 2021. A maioria das análises para a ferramenta foram positivas (72%): por se tratar de uma ferramenta com boa usabilidade com possibilidade de navegação por hiperlinks. Porém algumas fraquezas em 28% dos artigos (revisão negativa ou neutra) foram encontradas quando professores ou alunos enfrentavam instabilidade nas redes. Além disso, alguns autores apresentaram soluções para contornar o problema do uso do GC durante a pandemia, tais como, o uso de outras redes para o apoio à aprendizagem e a utilização de ferramentas que permitem comunicação síncrona entre professor e estudante.
Palavras-chave: *Google Sala de Aula, Sistema de Gerenciamento da Aprendizagem, Aprendizado de Máquina, Agrupamento de Dados, Pandemia Covid-19, Revisão Sistemática da Literatura.*

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1 Introduction

The advance of the Covid-19 pandemic has changed the routine and lives of people in most countries around the world (Aristovnik et al., 2020; de Deus et al., 2020; Trinta et al., 2020). Therefore, many government officials created alternatives to contain the transmission of the disease, without affecting the economy and people's development (Fang et al., 2020). Among the sectors that suffered most changes was the education sector, as hundreds of thousands of schools were closed as a measure to face the crisis (Rundle et al., 2020). This decision meant that students had to adapt to a new reality to continue with their school activities, and investment in cell phones, tablets, computers, in addition to a good quality of internet was necessary. However, the investment was necessary not only in hardware equipment, but schools and teachers had to adopt software classified as Digital Information and Communication Technologies (DICT) for teaching and learning (T&L), more specifically tools that allowed teacher-student communication, sharing of materials and videos, realization activities and tests, with synchronous and asynchronous support (Menezes & Santos, 2021). We call these tools the Learning Management System (LMS) that support the learning process (Raza et al., 2021), allowing its planning, implementation and evaluation.

According to Raza et al. (2021), there are several LMS available, however, some are paid and can affect the budget allocated to many public institutions. That's why Google Classroom (GC) appears as an important tool for educational management in times of pandemic (de Deus et al., 2020), as it is a free, safe and easy-to-use tool, allowing an efficient management of the classroom. Furthermore, as a tool linked to Google Workspace for Education Fundamentals, it is a free suite of intuitive and easy-to-use tools that provide a flexible and secure foundation for learning, materials creation, collaboration, storage and communication[1]. Google Forms (GF) is another important tool for creating tests (de Assis Zampirolli et al., 2020), exercises and assessments, while Google Drive (GD) stores videos, notes and materials posted by the teacher and students (Shaharanee et al., 2016; Nakamura et al., 2019). It has been used by many primary and secondary schools, community colleges and universities, not only in Brazil but also around the world (Espirito Santo & Lima, 2020; Susanto et al., 2021; Sugiarto et al., 2020; Zulkefli et al., 2020; Saienko & Chugai, 2020). Therefore, this tool was chosen to be investigated in this work.

For a more analytical approach, we sought to carry out a systematic literature review (SLR) in order to find the strengths and weaknesses of the GC platform, as well as to understand some of the solutions given by researchers to overcome the obstacles. According to Machado et al. (2018), SLR is a scientific investigation that brings together important and revised studies on a formulated question, using the literature base, which objective is to carry out a critical and comprehensive literature review. We use inclusion and exclusion criteria to guide our conclusions to avoid biases that would occur in a non-systematic review. To facilitate our analysis, we sought to make a similarity grouping of the articles selected in the SLR through machine learning, more specifically, clustering algorithms Xu & Wunsch (2005). These clustering algorithms are a subgroup of unsupervised learning algorithms that make it possible to organize data by similarity in the same set, in this case, similar articles extracted from the SLR. In this way, it was possible to categorize and segment groups of articles with common information. For this, the articles were read and the main characteristics were tabulated, such as type of analysis (quali or quantitative),

[1]Google Workspace for Education is a software that includes all the Google products. It is possible to: post activities and tests, send guidelines and deadlines and students enter their activities carried out on the platform and create chats and forums. https://edu.google.com/products/workspace-for-education/education-fundamentals/.

analyzed tools and even the target audience. Subsequently, three methods were used, a hierarchical clustering method, to estimate the number of clusters, and two optimization methods: k-means and k-medoids. A comparison was made between the grouping methods and the best approach was used to draw conclusions and summarize the advantages, disadvantages and possible solutions for using GC as a LMS technology for e-learning in times of pandemic and even for distance education after returning to face-to-face teaching.

2 Methodology

The systematic literature review (SLR) is a research approach which objective is to find articles that satisfy a certain set of restrictions, so that a more in-depth analysis can be carried out on the selected articles (Dermeval et al., 2016; Tenório et al., 2016). In our work, we used the application StArt[2] to help in the systematic review of the literature, which was based on the systematic mapping pointed out in the works of Kitchenham & Charters (2007), Kandlhofer & Steinbauer (2016) and Machado et al. (2018).

In this work, the SLR was divided into three main steps: (1) planning, (2) execution and (3) summarization and into nine sub-steps, as can be seen in the diagram[3] of Figure 1. Data mining was performed on the KNIME Analytics Platform[4], a free and open source data analysis, report building and data integration platform. Scientific research for articles was carried out in August

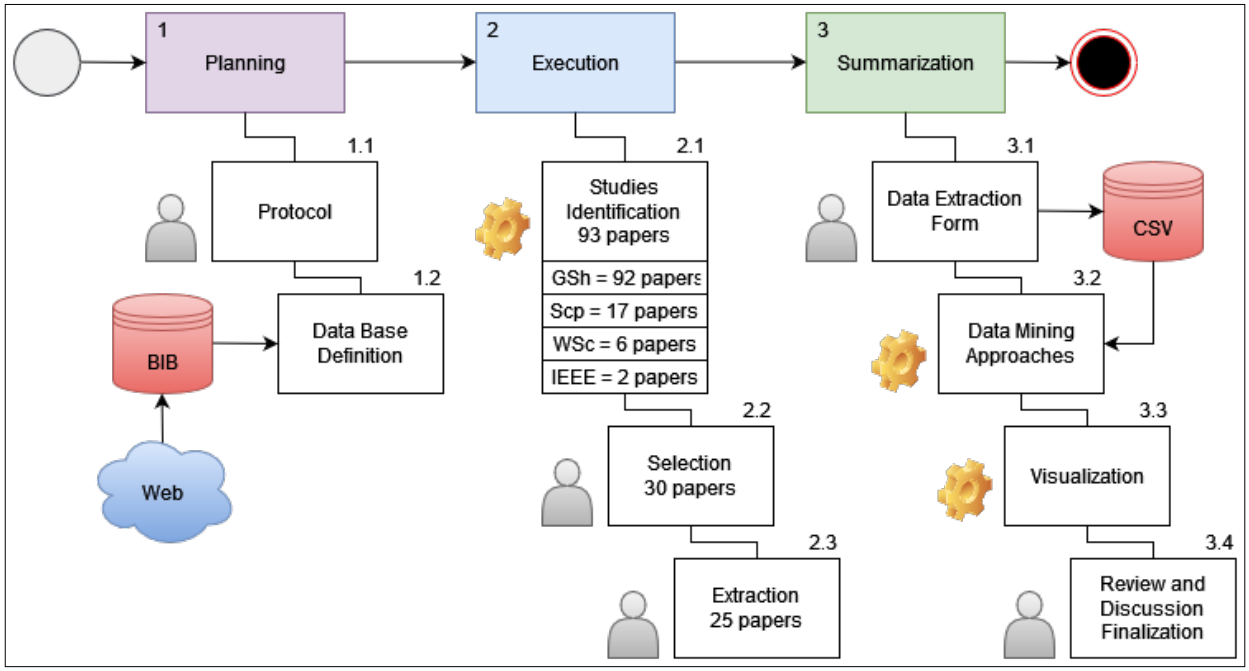


Figure 1: Process for conducting a systematic literature review, the men's drawings represent the parts performed manually, while the parts with an engine represent the parts performed automatically..

[2]Laboratory of Research in Software Engineering (LAPES) at http://lapes.dc.ufscar.br/tools/start_tool.
[3]Diagram.net, which is free online desktop and cross-platform diagramming software https://app.diagrams.net/.
[4]KNIME Analytics Platform is a software for machine learning, https://www.knime.com.

2021 in the following databases: IEEE Xplore, Web of Science, Scopus and Google Scholar with refinement by Mendeley. That is, only articles also found in Mendeley were accepted for this literature review, from articles published during the pandemic period until now.

2.1 Planning

The planning phase was divided into two main phases, the first consists of creating the research protocol manually and the second consists of extracting data in an automated way from the definition of the protocols. The databases are filled through the various articles found in the web cloud and serve to populate a `.bib` database, which was used in the next steps of the SLR process.

2.1.1 Protocol

The planning phase consists of creating the research protocol to be used to carry out the SLR. In this context, the search string was defined in order to capture all the words that correlated with the main keywords (in English and in Portuguese) which are: Google Classroom and Pandemic, thus, the final string generated was: "(Google Classroom `OR` Google Sala de Aula) `AND` (Sars-Cov-2 `OR` (Pandemic `OR` Pandemia) `OR` (Covid-19 `OR` Covid19 `OR` Covid) `OR` (Quarentena `OR` Quarantine) `OR` (Corona `OR` Coronavirus) `OR` Lockdown)", between the years 2019-2021.

In this phase, we proposed three research questions that guided the SLR process. To answer them, first, we executed data mining methods (i.e., data clustering approaches) and found the papers with the most similar characteristics:

Q1 What are the main facilities and effectiveness regarding the use of GC during pandemic times?

Q2 What are the main challenges of using the GC tool during Covid-19 pandemic time?

Q3 What are the solutions presented to overcome the challenges and the disadvantages of using the tool in the pandemic?

Furthermore, we created a data extraction form considering: (1) Paper Type = {Case Report, Evaluation Study, Trial Study, Comparative Study, Other}; (2) Analysis Type = {Quantitative, Qualitative, Mixed Approach, Other}, (3) Analyzed tools = {Classroom, Multiplatforms}, (4) Education Level = {Elementary School, High School, College, Undergraduate, Post-graduate, Other}, (5) Data Obtained = {Interview, Survey, Observation, Documentation, Other}, (6) Results = {Solutions, Challenges, Other}, (7) Audience ={Students, Teachers}, (8) Overall feedback = {positive, indifferent, negative}, (9) General purpose of the paper and (10) General summary of the paper's results. These parameters guided our studies for a subsequent analysis of summarizing the results.

2.1.2 Data base definition

The databases used to search the string were the Web of Science (WSc), Scopus (Scp), Institute of Electrical and Electronics Engineers (IEEE) and Google Scholar (GSh) databases. All articles were then refined by Mendeley (that could be found and downloaded on the engine). In addition,

in this step the inclusion and exclusion criteria are defined. Inclusion criteria (I) were: (a) article written in English or Portuguese, (b) peer-reviewed, (c) be found on Mendeley, (d) present guidelines for data analysis, (e) have been written during the pandemic (2019 - 2021) until August 2021, (f) this is a primary study. For the exclusion criteria (E) we considered: (a) article with 4 pages or less, (b) article not peer-reviewed and (c) article that cannot be downloaded using XXX Virtual Private Network (VPN).

2.2 Execution

The execution phase was divided into three distinct phases. The first step is to identify the studies. The second phase consists of the selection of studies by evaluating the inclusion and exclusion criteria. Finally, the extraction phase consists of reading the articles. Each of these phases are going to be detailed in the following subsections.

2.2.1 Studies Identification

In the identification phase of the studies, the four databases adopted were selected for data extraction. At first, a verification of the duplicated papers in the four bases was performed, as shown in Figure 2. Note that Google Scholar found all articles that were contained in the other databases,

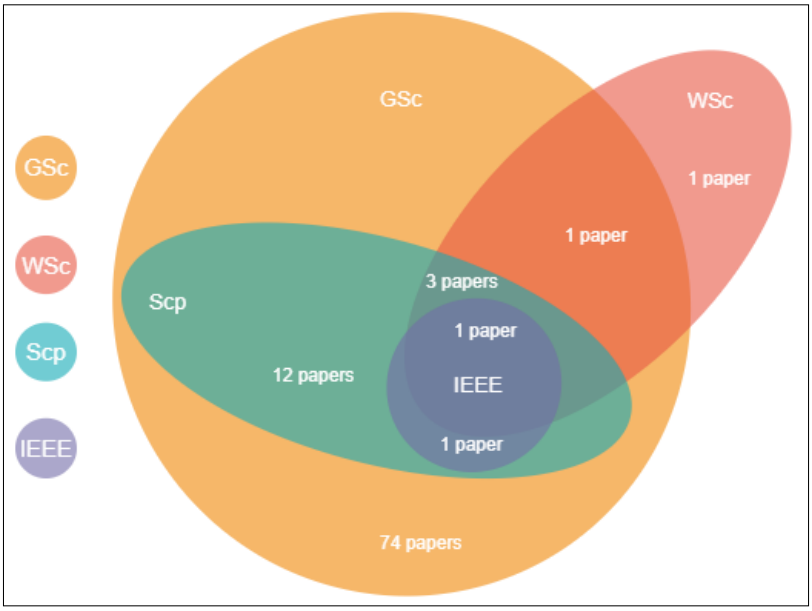


Figure 2: Venn diagram showing the intersection between the scientific databases used for the search.

except for 1 article that was in the web of Science and was not found by the first search engine. In this case, Google Scholar found 92 papers, Scopus database found 17 papers, Web of Science found 6 papers and IEEE found 2 papers. All bases found fewer papers than Google Scholar. Scopus and IEEE bases were contained in Google Scholar (IEEE $\subset$ Scp $\subset$ GSc), so the final paper count was given by Web of Science and Google Scholar (GSc $\cup$ WSc), resulting in 93 articles to be analyzed. Among the 92 articles searched, herein, in Figure 3, a world map that shows the breadth of work published about the GC usage as LMS during Covid-19 pandemic. Data map

presentation is based on the nationality of the first author of each article. A logarithmic normali-

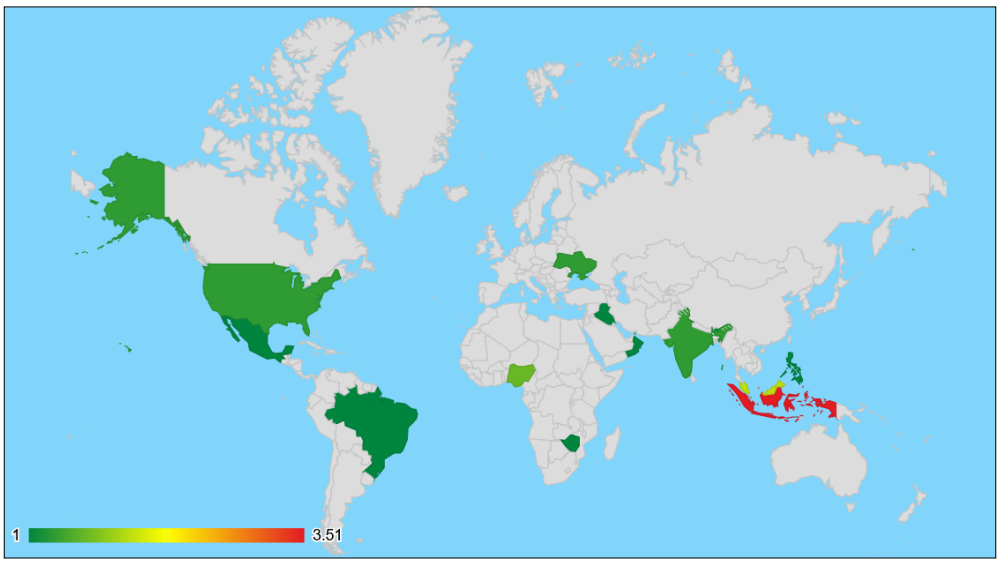


Figure 3: World map showing the amount of work on Google Classroom investigated during the pandemic by country.

zation ($2^{\log n}$) of the data was performed, where (n) is the number of occurrences of corresponding authors for each country.

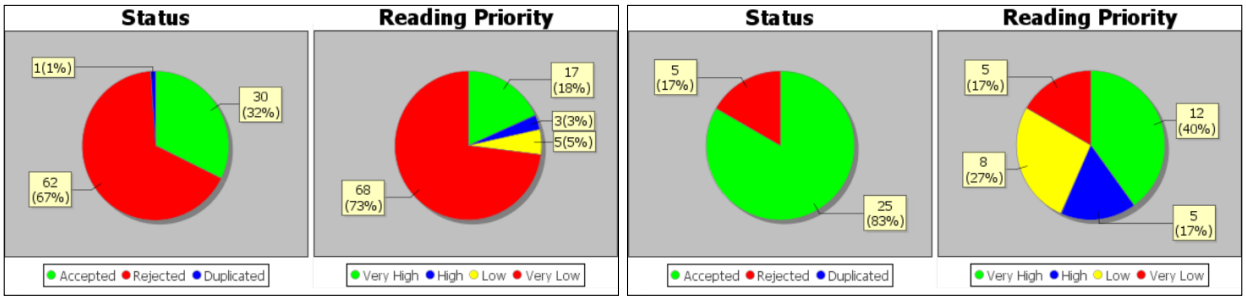
2.2.2 *Selection*

After the 93 papers are identified, the selection step is performed to further refine the screening of articles. At this stage, illustrated in Figure 4(a), 30 articles (32%) were accepted based on the inclusion criteria, 62 articles (67%) were rejected based on the exclusion criteria, and 1 article (1%) was duplicated, even though the title was different, so the duplication was detected manually. Thus, from the 30 articles selected as accepted, the reading priority was defined as follows, the 62 articles already rejected or duplicated continued with reading priority `very low`, because they did not pass any of the selection criteria. Some of the selected accepted articles were also rated `very low`, because they did not meet the decision criteria for selection in a second reading, making a total of 68 articles (73%) with reading priority order `very low`, and which were not selected for the extraction step.

For the other articles accepted, a Score was created to automatically evaluate the articles by the StArt tool. In this first moment, StArt was configured to evaluate each article with a score 0-5 for every time the search string keywords appeared in the article title. Thus, 17 articles (18%) with score 25-30 were selected with reading priority `very high`, 3 articles (3%) with score 20 were selected with reading priority `high`. Finally, 5 articles (5%) with a score of 10-15 and with a priority of `low` were selected for the extraction stage, as their inclusion criteria were accepted.

2.2.3 *Extraction*

The extraction step can be seen in Figure 4(b). In this case, 30 articles were selected for the extraction phase, among which 25 articles were extracted as accepted and were 5 rejected. For the reading priority phase, StArt values were configured so that the grade was given as follows:



(a) Selection. (b) Extraction.

Figure 4: Percentage of articles selected and rejected in the selection and extraction step and reading criteria that were manually defined.

5 points for keywords that appeared in the article title, 3 points for keywords that appear in the article abstract and 2 points for the keywords that appear in the article's own keywords. The 5 articles (17%) rejected, remained with the order of priority `very low`. The 12 articles (40%) with a score ($>$ 60) were selected with a read priority `very high`, 5 articles (17%) with a score 51-60 were selected with a read priority `high`, finally, 8 articles (27%) with a score of 30-59 and with priority `low` were selected for the extraction step, as they had accepted the inclusion criteria.

In this work phase, which consists of extracting the articles with priority `high`, `very high` and `low` in this stage they were read in full, so that the summarization could be started. In this way the data extraction form fields were filled in from the reading of each of the articles and saved in the StArt platform. At the end, we have the list of extracted authors, which can be seen in the word cloud in Figure 5, in which it is possible to notice that few authors appeared in more than 1 paper. These works are adequately summarized and explained in the following sections.

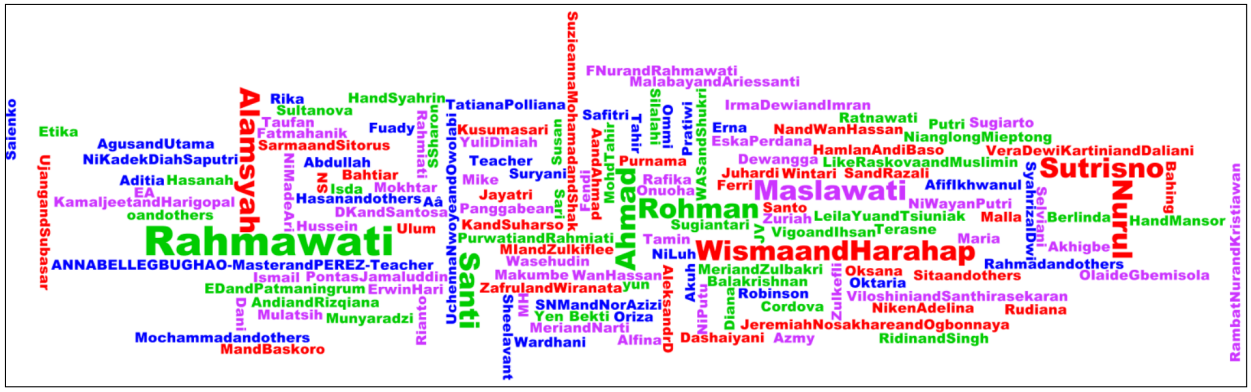


Figure 5: Word cloud representing the list of articles that were extracted.

2.3 Summarization

In the summarization step, four main steps were carried out: the first one consists of transferring and storing from the StArt platform the data extraction form file to a `.csv` database. After this data grouping and storage, data mining techniques were carried out with the focus of grouping

the works with greater similarity. Then a data preview was performed. Finally, a compilation of results was presented in a table so that the data can be discussed and the review can be completed.

2.3.1 Data Extraction Form

In the previous extraction phase, we created a database with the primary papers previously read and each of the 10 important characteristics that were presented in the protocol creation step. The grouping of all these primary features and some secondary features, derived from the primary features, were placed in a file of type `.csv`. With the data previously tabulated, data mining becomes easier, since the objective is to group the works with greater similarity to each other based on the filtered set of characteristics.

Figure 6 represents the set of characteristics previously identified in the protocol phase and the relationships of each article with all the characteristics in the form of a graph. Each item

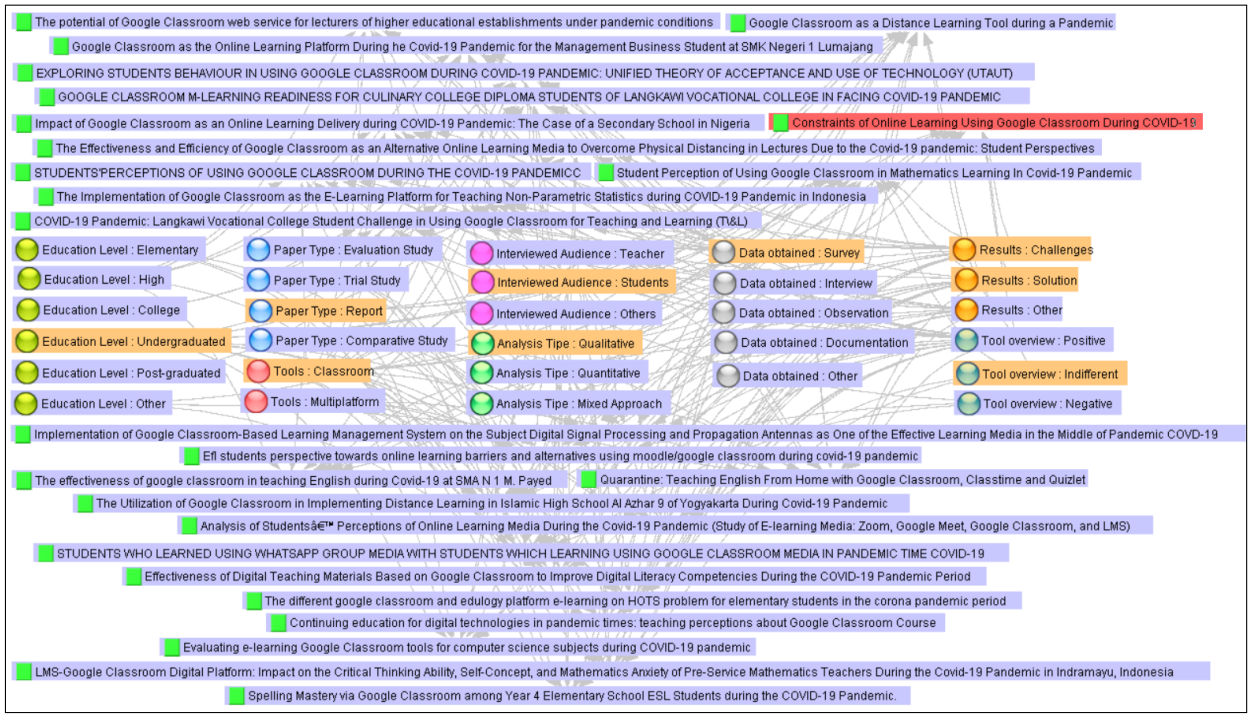


Figure 6: Graph representing the association between the article and the completed research form for each article accepted in the extraction phase.

in a green square represents each of the items selected in the extraction phase and the items in colored circles represent the characteristics observed in each of the items. In the protocol, 10 characteristics were defined to be analyzed, however, 2 of these characteristics were open to the description of the objectives of the article and the final conclusions of each one of them, thus, they are not represented in this comparison graph. As an example, the article ID 30, highlighted in Figure 6, has the following characteristics: the article observes undergraduate students using the Google Classroom platform during the pandemic period and the type of article is a report with qualitative analysis. The evaluation of the Google Classroom tool was indifferent and the results presented challenges as well as bringing some solutions. For all other articles, the same feature filling analysis was addressed to fill the database that was used herein for data mining.

2.3.2 *Clustering using machine learning approaches*

Generally data science is applied when a large number of items are found Lima et al. (2021). Although herein there is a small articles quantity, the number of features is large, and it would be difficult to find an optimal grouping for the data. Additionally, the grouping was carried out in order to find similar characteristics to explain research questions. Before we started clustering, the data had to be properly organized and transformed so that mining could take place on the KNIME Analytics Platform Ferreira et al. (2019). The workflow in Figure 7 represents the set of steps that were used for unsupervised learning data mining. First, the data is read from a file of type `.csv`, where each column contains the characteristics of each of the papers extracted from the SLR. Subsequently, the data is normalized using the "min-max" normalization approach, in which the smallest value in each column receives the value 0 and the largest value in each column receives the value 1. For normalization, the year and paper ID were disregarded. The collection of

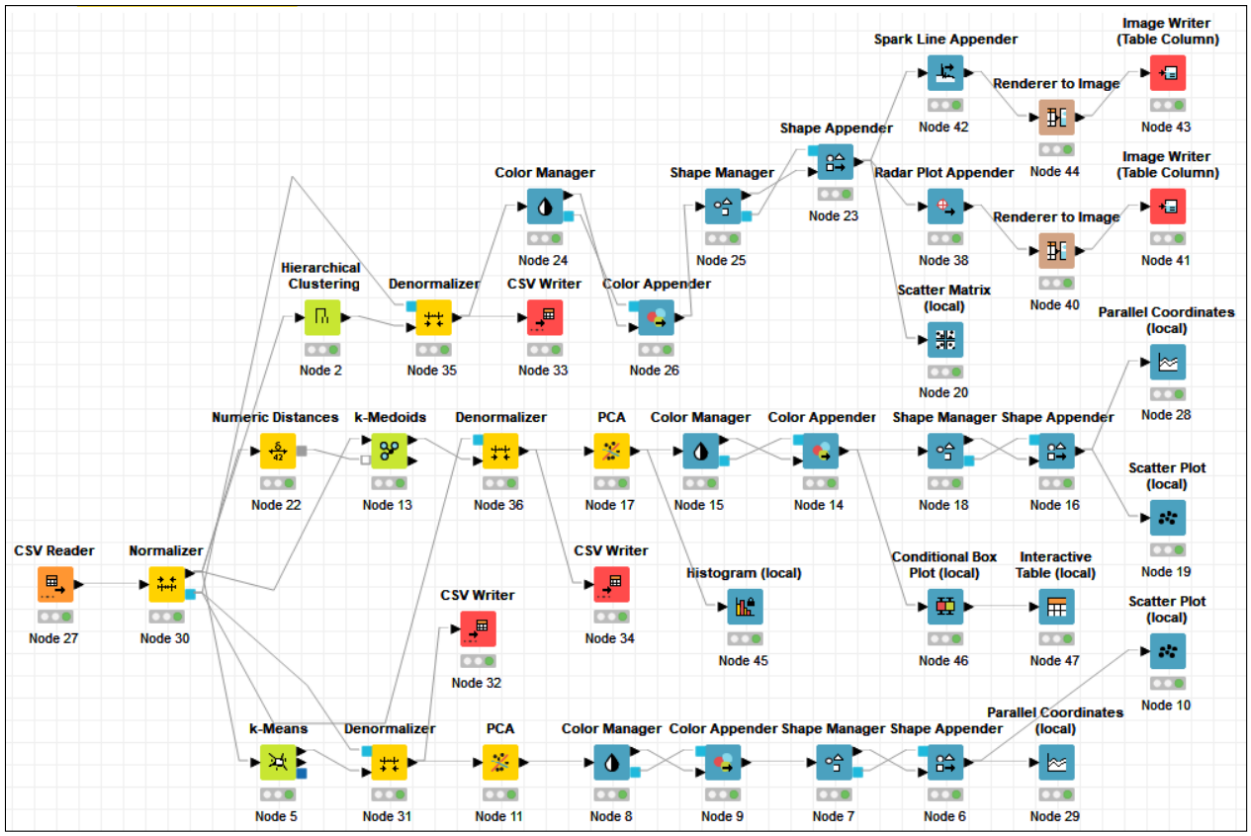


Figure 7: Workflow created in KNIME Analytics Platform to perform data mining.

interconnected nodes constitutes a workflow that is used to group the most similar articles together. In this procedure, three main algorithms were used, a hierarchical data mining algorithm and two optimization algorithms, namely: k-means and k-medoids. They were compared to understand which generated the best result. once clustering is performed, the data is denormalized. and graphics are generated for a better understanding, for that, colors and shapes of each cluster had to be configured, as can be seen in Figure 7.

The hierarchical cluster node implemented in KNIME is a bottom-up or agglomerative type

algorithm, that starts with each row of the database as a cluster and combines the most similar ones along the iterations in order to emerge a single supercluster that contains all subclusters. The distance between two clusters was defined from the complete linkage. The complete linkage defines the distance between two clusters from the maximum distance between two distinct points of each one of the clusters. The distance between two points used was the Euclidean distance. The Euclidean distance between the points of two clusters $P = (p_1, p_2, \cdots, p_n)$ and $Q = (q_1, q_2, \cdots, q_n)$ is defined according to the equation 1 in an n-dimensional Euclidean space.

$$\sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2 + \cdots + (p_n - q_n)^2} = \sqrt{\sum_{i=1}^{n} (p_i - q_i)^2} \quad (1)$$

For the k-means clustering algorithm, a node in KNIME called Numeric Distances was used, which calculates the standard Euclidean distance between the data. Subsequently, the k-means algorithm is applied and a PCA (principal component analysis) to project data from its original feature space into a space of (possibly) lower dimension with a minimum of information loss. PCA was used only because we wanted to project a 12-feature space using a two-dimensional scatter plot. Parallel Coordinates graphs were also created for a better understanding of the data.

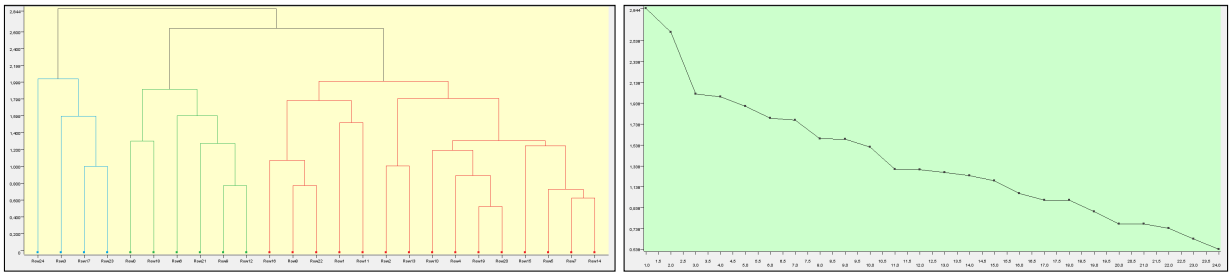
The last clustering algorithm studied was k-medoids. In this algorithm, a row is chosen and then it becomes the center of the cluster. The graphs produced for this experiment were the Parallel Coordinates, Histogram, Scatter Plot and Matrix graphs. The results of each of the groups can be seen in the next section.

2.3.3 Results Visualization

In this section data visualizations and interpretations were performed accordingly. In this case, the visualizations of three algorithms (hierarchical, k-means and k-medoids) is shown and interpreted through graphs and tables.

The first algorithm to be interpreted is the hierarchical clustering (HC) algorithm. The output for the hierarchical grouping consists of two graphs, as shown in Figure 8. The first is a dendrogram showing the whole cluster hierarchy. The closest data is connected and the connection weight displays the distance between them. No x-axis is nominal and presents each data point with their row ID and y-axis represents the distance between each cluster, which in the case of Figure 8(a) is approximately ≈ 2.0 for the height of the 3 clusters, according to the distances plot in Figure 8(b). The distance plot displays the distances between the cluster for each number of clusters. This view helps to determine a good number of clusters, for there have been sudden jumps in the similarity level as different groups are merged. The points can not be highlighted, since the distances correspond to the height of the dendrogram not to any data points. The output presents the input data with an extra column with the cluster name $\{C_a, C_b, C_c\}$ where the data point is assigned to. Each of the clusters $C_a = 6$ points, $C_b = 15$ points e $C_c = 4$ points, being chosen the value of $k = 3$ for the k-means and k-medoids groupings, which are presented next.

The next step were built other graphs for an understanding of how the data were grouped, the Figure 9 was created. The radar chart summarizes the values of a row in the database. The graph also displays a selected range, for finding values outside the given range, if necessary. Values are drawn as a green ribbon connecting the axes. The 25 articles were organized in a tabular form according to primary (protocol) and secondary (aggregated) characteristics: `ID` (paper identification), `year` (year of publication), `selectionScore` (score)



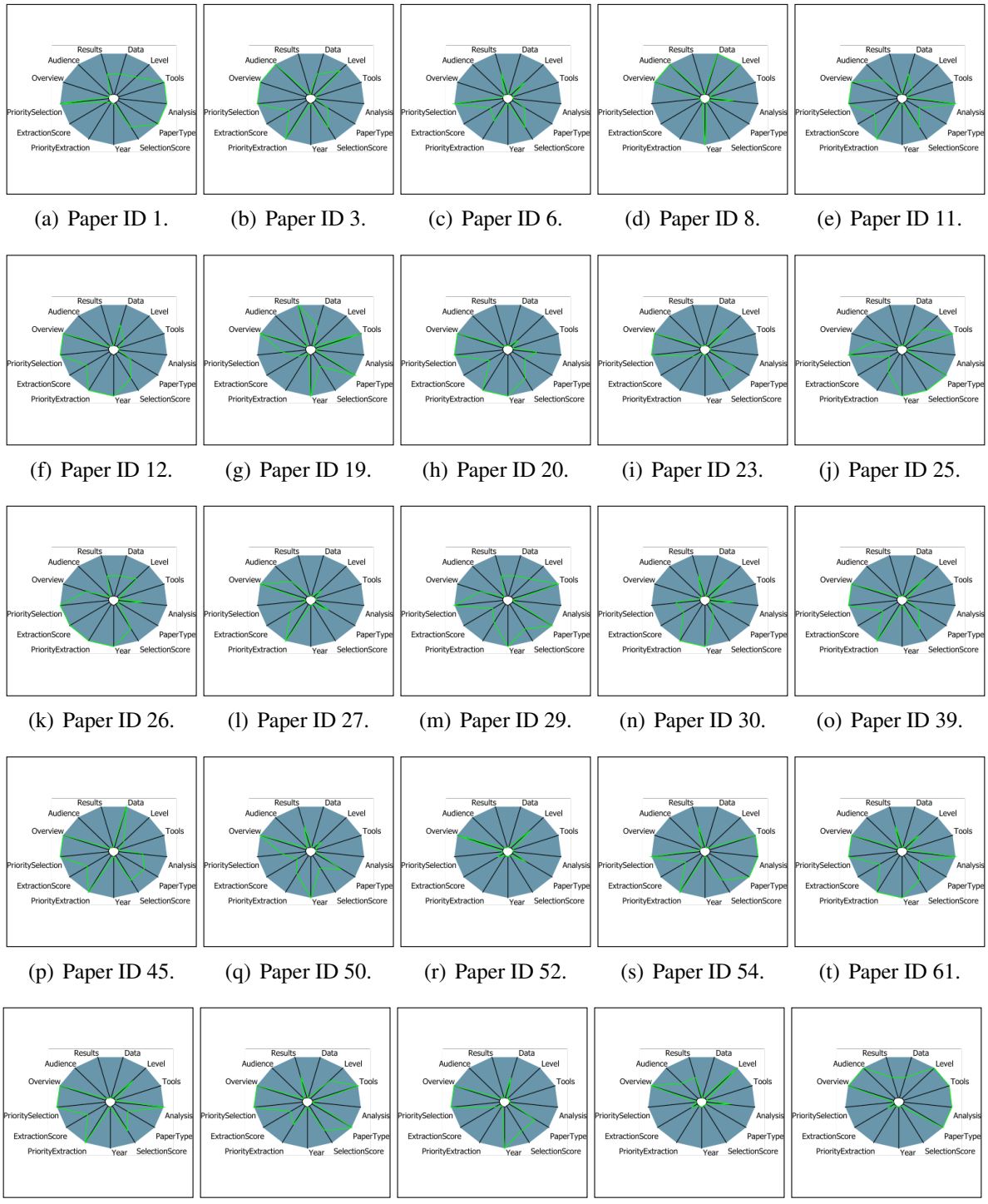
(a) Dendrogram. (b) Distances plot.

Figure 8: Views performed in KNIME Analytics Platform for Hierarchical clustering algorithm output, each color in dendrogram represents one cluster.

in the selection step grades between 15-30), `paperType` (paper type among 5 possibilities), `analysis` (quantitative, qualitative, both, others), `tools` (Google Classroom or Multiplatforms including GC), `level` (education level), `data` (how primary survey data were obtained), `results` (type of result achieved: solution, challenges, others), `audience` (teachers, students or others), `overview` (positive, indifferent, negative), `prioritySelection` (selection priority considering the title "5": low, high, very high), `extractionScore` (score in the selection step with ratings between 36-104), `priorityExtraction` (selection priority considering the title "5", abstract "3" and keywords "2"). These characteristics were taken into account for the grouping in data mining of the articles extracted in the previous step. For example, in Figure 9(a) we have paper ID 1 that was published in `year = 2020`, `selectionScore = 25` (very high), `prioritySelection = 2` (very high), `paperType = 3` (comparative study of the GC and other platform), `tools = 1` (multi-platforms comparing GC with other platform), `level = 3` (undergraduate students), `data = 2` (surveys/questionnaires and interviews), `results = 2` (solutions and challenges), `audience = 0` (students), `overview = -1` (negative), `extraction Score = 42` (low), `priorityExtraction = 0` (low). For all other 24 articles, we analyzed the same way and data are presented in the Radar Chart images.

The results for the k-means (KMe) and k-medoids (KMd) clustering algorithms were represented by means of a scatter plot, see Figure 10. The scatter plot was designed from the two dimensions created by the PCA. From these graphs it is possible to see that the k-means algorithm, Figure 10(a) presented a clustering with more mixed data than the k-medoids 10(b). In k-means the green cluster is mixed with the blue and red cluster, which does not happen with the k-medoids clusters that presented the dissimilar data further away from each other and the more similar ones closer to each other. For k-means we have the clusters $C_0 = 8$ points, $C_1 = 5$ points and $C_2 = 12$ points. For k-medoids we have the clusters $R_7 = 10$ points, $R_{12} = 7$ points and $R_{16} = 8$ points.

Table 1 presents the summary of results for the three clustering algorithms used in this work, which Google Classroom (GC) and CP (comparative platforms). The hierarchical algorithm was used to give an estimate of the number of clusters, while the optimized clustering algorithms were used for grouping the SLR data developed here. In addition, the table shows the paper ID, its respective authors and year (56% of papers published in 2020 and 44% of papers published in 2021), the type of tools and approach investigated in the paper: GC (only the Google Classroom tool) and Others (comparison between GC and other platforms). For each article, the table also presents the Extraction Score that varies in a range of 36-104, generated by the StArt tool, each of the clusters to which the paper was assigned and finally, the general overview of the paper, which



(a) Paper ID 1. (b) Paper ID 3. (c) Paper ID 6. (d) Paper ID 8. (e) Paper ID 11.

(f) Paper ID 12. (g) Paper ID 19. (h) Paper ID 20. (i) Paper ID 23. (j) Paper ID 25.

(k) Paper ID 26. (l) Paper ID 27. (m) Paper ID 29. (n) Paper ID 30. (o) Paper ID 39.

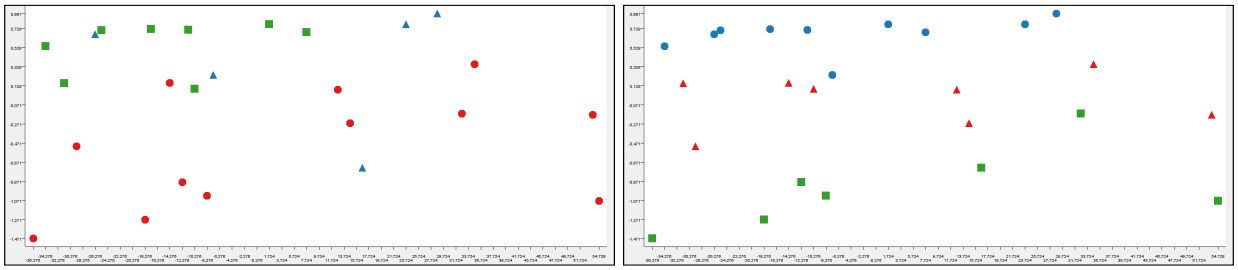
(p) Paper ID 45. (q) Paper ID 50. (r) Paper ID 52. (s) Paper ID 54. (t) Paper ID 61.

(u) Paper ID 66. (v) Paper ID 70. (w) Paper ID 72. (x) Paper ID 91. (y) Paper ID 92.

Figure 9: Radar chart for each paper selected considering all attributes (features) in extraction step, where green color represents the .

can be: positive, neutral or negative, extracted manually after reading the paper.

After reading the articles, a parallel coordinate chart was performed in order to verify which grouping among the k-means (see Figure 11) and the k-medoids (see Figure 12) is the most promising for making the final discussion of SLR articles. In this sense, for the k-means algorithm, in



(a) Algorithm k-means. (b) Algorithm k-medoids.

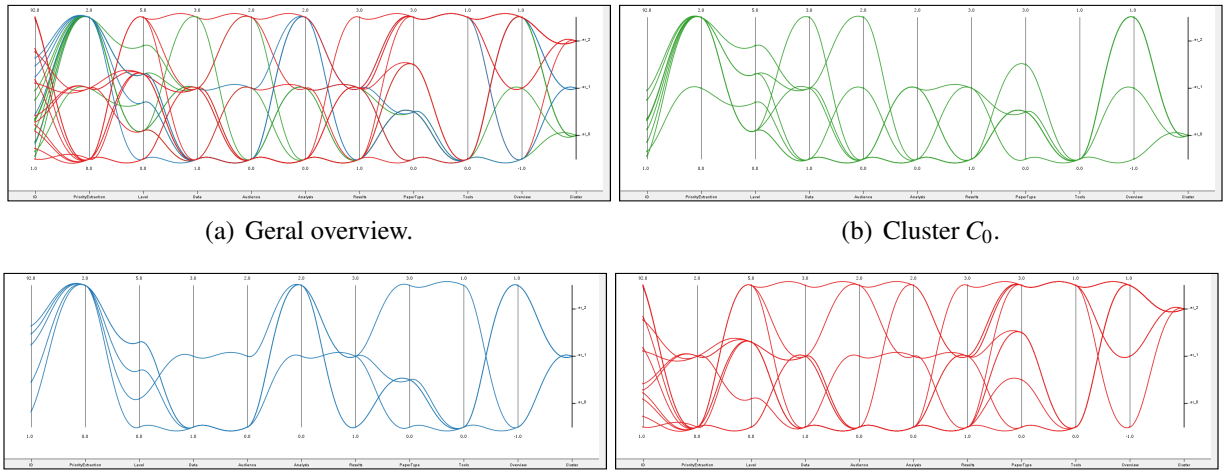
Figure 10: Views performed in KNIME Analytics Platform for k-means and k-medoids algorithm output via a scatter plot.

Tabela 1: Research results after extracting the 25 articles accepted in the summary phase.

ID	Authors	Year	Tool	Score	HC	KMe	KMd	Overview	Row
1	Octaberlina & Muslimin	2020	CP	42	C_a	C_2	R_{12}	negative	0
3	Tinungki & Nurwahyu	2020	GC	66	C_b	C_0	R_7	positive	1
6	Wan Hassan et al.	2020	GC	59	C_b	C_0	R_{16}	negative	2
8	Baharun et al.	2021	GC	36	C_c	C_2	R_{16}	positive	3
11	Oyarinde & Komolafe	2020	GC	77	C_b	C_1	R_7	positive	4
12	Oktaria & Rahmayadevi	2021	GC	76	C_b	C_0	R_7	positive	5
19	Rahmawati et al.	2021	CP	50	C_a	C_2	R_{12}	positive	6
20	A'yun et al.	2021	GC	61	C_b	C_0	R_7	positive	7
23	Hasanah et al.	2020	GC	49	C_b	C_2	R_{16}	positive	8
25	Fuady et al.	2021	CP	51	C_a	C_2	R_{12}	neutral	9
26	Fatmahanik	2021	GC	104	C_b	C_0	R_7	neutral	10
27	Sultanova et al.	2020	GC	63	C_b	C_0	R_{16}	positive	11
29	Taufan et al.	2021	CP	55	C_a	C_2	R_{12}	neutral	12
30	Susanto et al.	2021	GC	66	C_b	C_1	R_7	negative	13
39	Rohman et al.	2020	GC	62	C_b	C_0	R_7	positive	14
45	Sugiarto et al.	2020	GC	74	C_b	C_0	R_7	positive	15
50	Isda et al.	2021	GC	52	C_b	C_2	R_{16}	positive	16
52	Baskoro et al.	2020	GC	46	C_c	C_2	R_{16}	positive	17
54	Purnama	2020	CP	62	C_a	C_1	R_{12}	negative	18
61	Mokhtar & Karim	2021	GC	67	C_b	C_1	R_7	positive	19
66	Ahmad et al.	2020	GC	68	C_b	C_1	R_7	positive	20
70	Zulkefli et al.	2020	CP	59	C_a	C_2	R_{12}	positive	21
72	Yen & Mohamad	2021	GC	46	C_b	C_2	R_{16}	positive	22
91	Espirito Santo & Lima	2020	GC	46	C_c	C_2	R_{16}	positive	23
92	Saienko & Chugai	2020	CP	48	C_c	C_2	R_{12}	positive	24

Figure 11(a) an overview of the data is presented, Figure 11(b) represents the distribution of data for the cluster C_0, Figure 11(c) represents the distribution of data for cluster C_1 and Figure 11(d) represents the distribution of data for cluster C_2.

For the k-medoids algorithm, in Figure 12(a) an overview of the data is presented, Figure 12(c) represents the data distribution for the cluster R_{12}, the Figure 12(b) represents the data distribution for the R_7 cluster and Figure 12(d) represents the data distribution for the R_{16} cluster. For



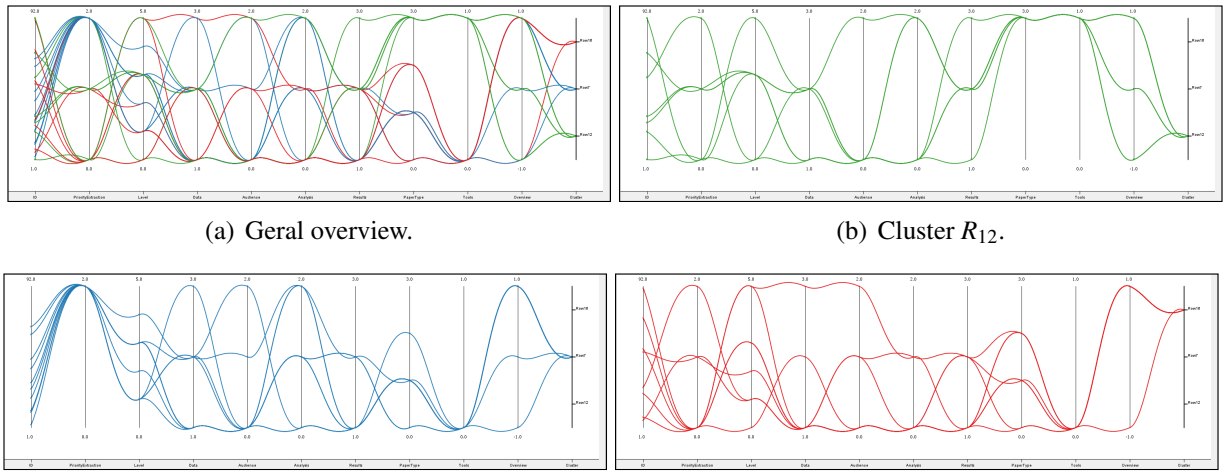
(a) Geral overview. (b) Cluster C_0.

(c) Cluster C_1. (d) Cluster C_2.

Figure 11: Parallel coordinates considering the k-means clustering.

the grouping performed by KNIME for k-medoids clusters, differently from what is observed in clusters generated by the k-means algorithm.

For k-medoids it is possible to notice a separation of the data of the columns of `tools` and `paperType` of the parallel coordinates of Figure 12, with regard to the separation data of the cluster designated R_{12}. In this sense, all articles grouped in this cluster R_{12} compare the GC with at least one other LMS, that is, the general overview in these cases was lower for the GC. In other



(a) Geral overview. (b) Cluster R_{12}.

(c) Cluster R_7. (d) Cluster R_{16}.

Figure 12: Parallel coordinates considering the k-medoids clustering.

words, it is not an article that studies only the GC tool, the same can be proven in the analysis via scatter matrix (see Figure 13) in which the attribute `paperType` and the attribute `tools` are well separated and it is possible to achieve a greater dissimilarity distance, so it is a better defined grouping. Furthermore, for this cluster R_{12} the attribute `overview` presented the highest number of negative evaluations of the GC as LMS.

Silhouette analysis measures how well a point fits into a cluster. In this method a graph is

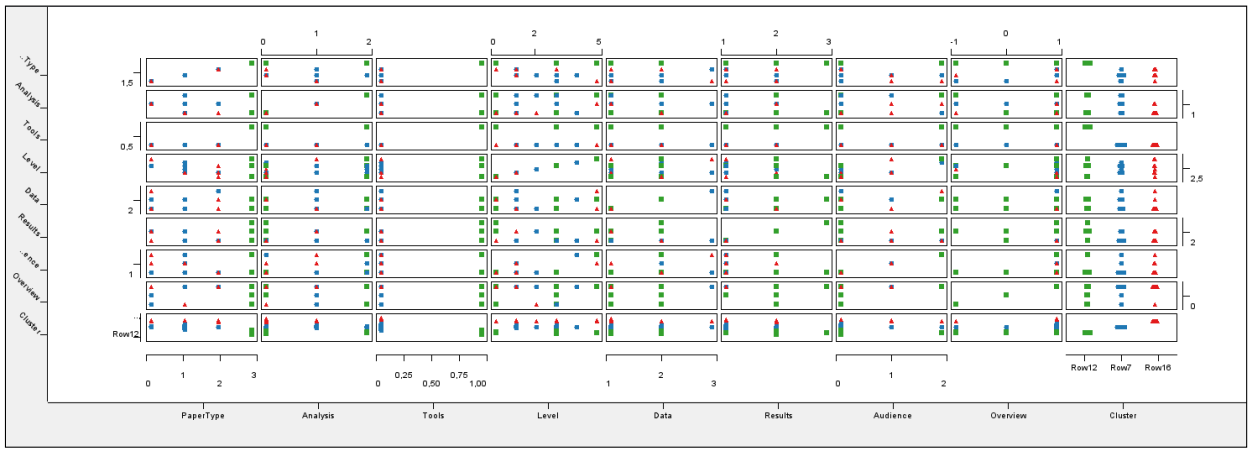
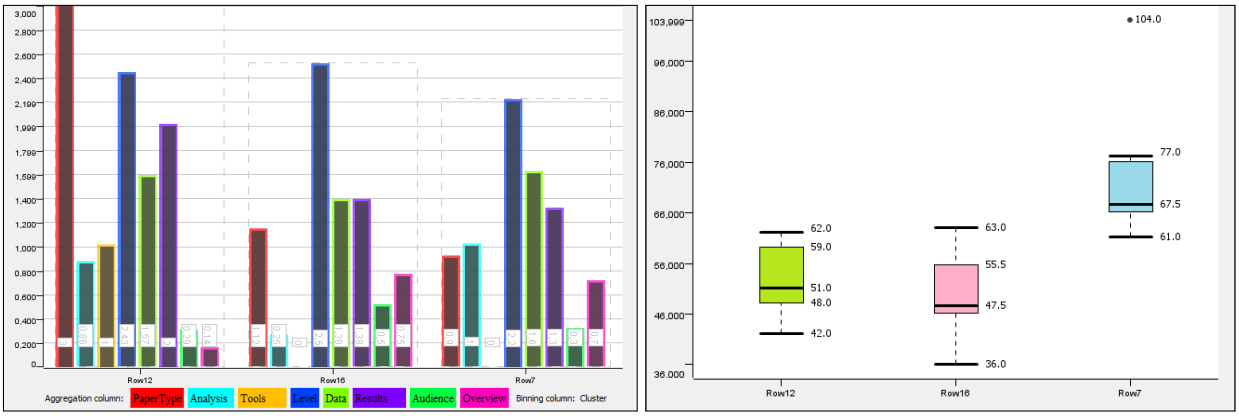


Figure 13: Data summary for each cluster for the k-medoids algorithm using a scatter matrix.

made by measuring how close the points in one cluster are to the points in the nearest cluster. The score can range from (-1) to $(+1)$. The Silhouette coefficient, when close to $(+1)$, indicates that the points are very far from the points of the other cluster, and when close to 0, it indicates that the points are very close or even intersecting with another cluster. The output is the mean Silhouette Coefficient of all samples for one method. In this case, we have the mean of 0.069 for k-means, and the mean of 0.234 for k-medoids, so the last approach was the best to cluster the samples.

In Figure 14(a) it is possible to evaluate the characteristics of each of the clusters according to a previously selected vector of attributes. For the cluster designated as R_7 where all the `analysis` are for the study involving exclusively the GC tool, with the majority of qualitative or mixed mean analysis with `data` coming from more from a source, for example, surveys and interviews. The R_{12} cluster has, in all cases, works of comparative studies, in which the GC is compared with other LMS, in addition, the papers with the education level of the respondents were close to zero, which means that the most are students and with a lower overall average of `overview`, compared to the other clusters. For the R_{16} cluster we have the highest averages for the `overview` than the R_{12} and R_7 clusters, as can be seen in Figure 14(a), in addition to having the attribute `audience` which means that the group has more teachers as the focus of interviews for the GC assessment, and the type of `analysis` was mostly qualitative with `level` of higher education among the other clusters.

Figure 14(b) shows the boxplots made in KNIME referring to extraction score data (performed automatically by the StArt tool). In this case, it is possible to see that the tool evaluated the best results for the cluster R_7. However, there was a slight inversion of automatic evaluation by StArt for the R_{12} and R_{16} clusters, in relation to the evaluation performed by the authors of this document after reading the articles, since StArt only does a syntactic analysis for the selection of each article (number of occurrences of keywords in the abstracts and title) and the authors performed a semantic analysis of each article. In the next subsection we presented the finalization of the review and then is shown the appropriate discussion for the papers analyzed and selected in the SLR carried out here.



(a) Histogram: aggregation method by average. (b) Boxplots grouped by clusters.

Figure 14: In (left) local histogram with average calculation for each of the papers clustered by the k-medoids algorithm and (right) boxplots for extraction score of articles accepted, that each cluster for k-medoids approach is represented in one different color.

2.3.4 *Review Finalization*

To complete the review, a word cloud is presented in Figure 15 and expresses the most recurrent words for the extracted articles that were discussed in the next section. Among the most found

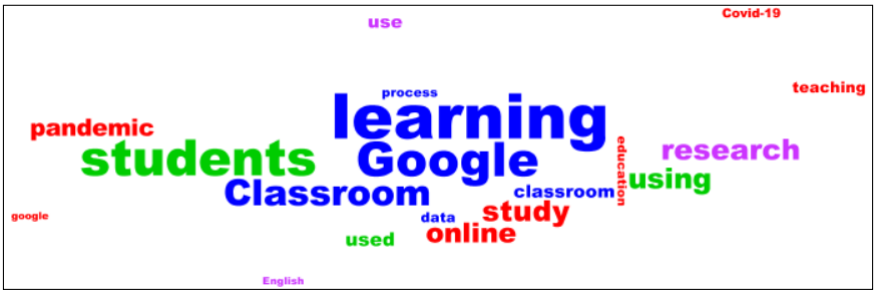


Figure 15: Word cloud for abstract of all accepted papers..

words we can mention: Google Classroom, learning, pandemic, research, online, education, teachers, study, Covid-19 and teaching. The remaining words did not reach the necessary repetition frequency to appear in the word cloud.

Regarding unsupervised learning algorithms, we performed data mining in order to better understand GC articles as LMS during the pandemic. This grouping was important for the grouping of the discussions that were carried out in the next section. In this case, the best data grouping algorithm for the articles extracted in the SLR was the k-medoids algorithm. After evaluating and defining the best method algorithm, we are going to make a semantic description of the groups. In this algorithm it was possible to find three distinct clusters: (R_{12}) cluster with articles comparing the GC tool with other LMS-type tools, (R_7) cluster with the majority of qualitative or mixed analyzes and resulting data more sources of information and the cluster (R_{16}) with selected articles with the best evaluation for the GC among all other clusters.

3 Discussion

In this section we present the articles found through the clusters in terms of their population, instruments, comparison, outcomes and context. In addition, we answered the research questions by summarizing the SLR as a whole, about the challenges, solutions, and effectiveness of using GC during the Covid-19 pandemic times.

3.1 Semantic description of the clusters

In this subsection we present the results of the findings of all the articles that were clustered. The clusters R_7, R_{12} and R_{16} found by the unsupervised learning algorithm k-medoids are presented and summarized here.

Cluster R_7: the articles have the highest average of the type of students interviewed and the highest average of the overview with the highest average of mixed or qualitative analyses.

In the work of (Tinungki & Nurwahyu, 2020), the authors collected data from 33 students majoring in Statistics through observation and investigation. In this work, the authors analyzed aspects of implementation planning as a way of using GC. Thus, the plans in the GC tool were characterized as effective, with a percentage of 79%. Adopting GC as an LMS tool allowed all teachers and students to learn from home. The use of GC was positive in terms of learning outcomes, and written tests students' responses to the implementation were also good.

In (Oyarinde & Komolafe, 2020), the authors interviewed 140 secondary school students, using questionnaires and semi-structured interviews developed by the researchers for students' perceptions on Google Classroom. The objectives were to find the impacts of distance education on secondary schools. The results presented were positive, indicating that the GC proved to be effective for the results achieved by the students. The authors also presented solutions for improvements, such as stakeholders should prepare students to use the GC platform. The tool's advantages include assisting both students and teachers to work together, connect, create assignments, post learning materials and grade students.

In the paper of (Oktaria & Rahmayadevi, 2021), 28 students have been joining GC in English Learning, and 5 students have been interviewed about their experiences using GC. The methodology is quantitative descriptive, from the result of the instrument and interviews, the researchers analyzed the data obtained to understand aspects of: usefulness, ease of use, ease of learning and satisfaction. The authors got a positive result, and the authors brought up analyzes in terms that many students had to submit their work through friends' accounts or that students had no data plan to take part in live classes. To summarise, students consider GC in school optimistic and brings good learning, because it is useful, ease of use, ease of learning, and satisfaction. GC improves students' skills, abilities, discipline, and autonomy in studies.

A total of 221 Business Management students from 3 different grades (X, XI, and XII years) were interviewed in the work of (A'yun, Suharso, & Kantun, 2021). The instrument used for the questionnaire was the Google Form, whose method is using a random sampling method 25% proportionally with descriptive-analytical analysis. The authors sought to understand how to use GC effectively, using data for interactive materials and learning. The approach was positive as the GC interface was easy and friendly to use. Students understood the content well after using GC, because the tool offers the advantages of enabling meets, videos and digital materials. From this analysis it was shown that GC is one of the best choices for the educational process during the

Covid-19 pandemic, and also a data package for students was supported monthly by the Indonesian government during the pandemic.

In the work of (Fatmahanik, 2021), 182 students majoring in primary 6th semester teacher who took Mathematics Learning in Education at Ponorogo State Institute were asked about the ease of use of GC, easy understanding and effectiveness of GC. In addition, they were asked about the obstacles experienced by students for learning mathematics by the GC. The instruments used were questionnaires and online interviews using the Google Form using a Likert scale with a choice of strongly disagree, disagree, agree, and strongly agree. The authors concluded that the GC is easy to use and understand. However, it has some obstacles faced, such as difficulty to focus, stable internet and low data quota. Despite this, the authors classified GC as effective in the process of teaching and can be used as an alternative in online learning, and suggest that it be used in combination with other face-to-face teaching-learning platforms.

In (Susanto, Sasongko, Kristiawan, et al., 2021), 40 students from the 3rd semester of Image Capturing Engineering of Computer Education of Bengkulu University were interviewed. The GF questionnaire was used as an instrument to collect data and the data were analyzed by the stages of: reduction, display and conclusion, in a descriptive and qualitative manner. Some of the criteria analyzed were: attendance menu, quiz task, essay task, download word or pdf material and download video material. The authors believe that the GC assessment is negative, because the students found some positive points that did not outweigh the negative ones during data analysis. For example, in relation to obstacles, the students found difficulties regarding attendance menu, quiz assignment menu, essay assignment menu, word or pdf download menu and video download menu. The GC usage classroom has some unexpected problems, for example, if there is a power outage, the use of GC is interrupted, the download of materials is hampered because the signal may be unstable or if the video size is too large, it may take a long time to download. As a solution to overcoming obstacles, the authors suggest that teachers learn GC to better teach their students as a way to overcome the main difficulties they face. The positive points are in relation to the essay assignment that many of the students did not have and also in relation to the quiz task, which most completed without any interference.

In the work of (Rohman, Baskoro, & Ningrum, 2020), the population considered was 120 students from the UNESA Electrical Engineering Department. The data used to analyze from the student's perspective the effectiveness and efficiency of online learning with GC through a Likert scale method for positive questions and specific questions for theoretical subjects. Online learning using Google Classroom (GC) can meet the expectations of the planned learning goals for the online teaching-learning process because the features of the tool are very simple. In the study, 88% of students declared they were efficient in online learning and 85% believed that the interface was easy to use. On the other hand, students found online learning less effective due to network or resource limitations. Only 37% of students believe they achieved the learning goals and 60% liked the GC for learning planning.

In the (Sugiarto et al., 2020) survey, 21 students were interviewed. The instruments for data collection were through observation, document analysis, and interviews. The analysis was performed using descriptive qualitative analysis, because researchers intend to describe the problem of distance learning in a history class, including teaching preparation, learning implementation, and learning evaluation. Result showed that 20 students or 95.00% completed the final grade. The average cognitive value of the final grade achieved was 77.46. The paper discussed the process of planning, implementation, evaluation of distance learning. GC was used after students submit the

assignments, which carried out directly using the assessment content in the GC application. The outcomes are positive, and the authors concluded that the planning carried out was good and sufficient, because support for students was successfully achieved. The results of this study showed that there are changes in the level of understanding of the material and the effective performance of learning in students between conventional learning and the use of GC learning in the classroom. The quality of learning was good, in the sense that educators can provide a concrete description of the materials through images, animations and videos, the assessments created by teachers through the GC were carried out successfully. Finally, the authors assessed that the tool as a whole is good, beneficial and adequate to support distance learning while the pandemic situation exists.

In the work of (Mokhtar & Karim, 2021) a population of 293 students from seven Malaysian Community colleges were evaluated using the survey methodological instrument to understand the relationship between the five predictors of student behavior for using the GC application in the learning process: (1) behavioral intention (performance expectancy, effort expectancy, social influence, student use behavior), (2) behavior condition (student use behavior). Findings from this study indicates that effort expectancy is the most significant dimension that influences behavior intention. Then are the social expectancy and the performance expectancy that influences behavior intention. The outcomes provide useful insight into the acceptance and use of GC among Malaysian students. The authors suggest as a solution that teachers use GC to create focus and strategy in their teaching method. Also, teachers should be sure that students can even use the LMS and teach them how to use the GC application.

A population of 39 culinary diploma students were participating in the Culinary Arts Program at the Langkawi Vocational College in Kedah in the work of (Ahmad et al., 2020). The methodology used was the application of an online questionnaire by the GF to collect feedback from respondents. The researchers wanted to study the degree of GC m-learning readiness among students during the online T&L process. Data were analyzed using IBM SPSS Statistics software v. 24. The objectives were to identify the GC readiness levels of Culinary Arts Diploma students and identify the readiness levels by gender. Statistical t-test analysis showed that there was no difference in the level of readiness in using GC by gender among students. The results also showed that students had no restrictions at home to enter the GC m-learning for the T&L process during the Covid-19 outbreak. The study results show that the availability of m-learning using Google Classroom among students was very high. Additionally, it can be seen that students had no knowledge restrictions in m-learning GC, thus making the experience positive.

Cluster R_{12}: the articles analyzed studies comparing the GC tool with other tools for the LMS to support teaching.

In the work of (Octaberlina & Muslimin, 2020) a population of 25 students majoring in Statistics was evaluated in order to understand the barriers and alternatives using Moodle and GC during the Covid-19 pandemic. The research instrument used for observation was through survey and interview. This research also found that there are three main barriers, namely, lack of personal contact, lack of technology and internet connectivity for students and teachers, and physical barriers for students and teachers, for example, eye strain. According to the authors, the experience for the GC was negative, being similar to the barriers found by Moodle, considering only the side of students who do homework and the barriers encountered by them when they interact during the process of e-learning learning using GC, considering one year of usage. However, there are ways to overcome obstacles, for example, to overcome the lack of personal contact, the teacher must consider the general learning objectives, consider the different learning styles of the students, of-

fer quick feedback, maintain more interactions. To overcome the lack of technology and internet connectivity, the teacher should try to convert video material into audio or even try to use reading texts. Lastly, to overcome physical barriers, the teacher must give students a break while enrolling in an e-learning activity.

A total of 38 elementary school students (grade V) were assessed on the work of Rahmawati et al. (2021) on higher order thinking skills (HOTS). The data collection instruments were interviews and test instruments in the form of problem descriptions to test the ability to do HOTS questions, with quasi-experiment post-test, using only control-group design. The comparison tools were Edulogy and GC. The results showed differences in post-test results between e-learning based on GC and e-learning based on Edulogy that affect the effectiveness of e-learning. GC features facilitate the learning process such as tasks, notes, communication, time cost, file course, privacy, and mobile apps. HOTS questions by groups of students using GC were better than students using Edulogy. The outcomes are positive, and GC is most effective in facilitating students towards HOTS skills. The GC helps the implementation of classrooms virtually, helps educators in carrying out activities in the T&L process with the blended learning method.

The study's population of (Fuady, Sutarjo, & Ernawati, 2021) was active students on the campus of Padjadjaran University and Telkom University, West Java, totaling 43,755. The research aimed to describe the perceptions of ease and usefulness that students feel about different education media such as Zoom, Google Meet, Google Classroom and LMS Platforms. The research instrument was through a survey with quantitative analysis. The results for the GC were neutral, all learning tools studied at work were easy to be used, according to the authors. However, the simplest and most useful tool, according to the students, was Zoom, followed by GC in both cases. The results also showed that Google Meet is better than other LMS Platforms. Finally, the results show that the perspective of the usefulness of media for online learning is considered to have good benefits.

The research of the work of (Taufan et al., 2021) involved the participation of 38 math teachers during the Covid-19 pandemic, where a quantitative survey uses one group pre-test and post-test design. Using the intentional sampling technique, the research sample taken is the fourth semester students of the Theory Ring Abstract Algebra course for up to 19 people. The Zoom and GC tools were used in the study to determine the effect of self-concept and mathematics anxiety on the ability to think critically pre-service with used GC. The aim is also to improve the training of future Indonesian mathematics teachers in the use of GC. The use of GC during the pandemic to improve thinking, self-concept, and anxiety skills in mathematics. Therefore, it can be concluded that there is a direct influence on self-concept and mathematical anxiety together in critical thinking skills, and the GC is therefore considered neutral in this work, since the authors did not make clear the very positive aspects of the tool. The tool can be implemented to save time by overcoming distance from campus and increasing cooperation between future math teachers. Additionally, it can be seen that it can improve communication between faculty and students, as communication is not limited by time and space. Finally, the authors concluded that the GC stores data securely and cheaply, but it must have thinking skills and knowledge of the tool at a maximum level of wisdom.

The work of (Purnama, 2020) evaluated 40 students of class VIII SMPN 1 Rawamerta, and they were divided into two classes of 20 people each. That is, 20 students to use Whatsapp and 20 students to use GC, being considered a quasi-experiment. Whatsapp Group and Google Classroom tools are widely used like T&L. The GC was considered negative by the authors, since Whatsapp

proved to be better than the GC, in the case of mathematics teaching, due to faster communication with students and parents. Despite this finding, the authors found that online learning has many weaknesses and limitations, especially in the case of poor signal and no internet quota. As solutions, the authors indicate that teachers should combine the use of GC with Whatsapp Group, thus distance learning can have more variety of tools as an effort to avoid student boredom during learning.

A population of 22 Computer Science students was investigated in (Zulkefli, Hashim, & Syahrin, 2020) at a higher learning institution in Oman enrolled in Computer Programming, Introduction to Database Management System, Network System, Web Development, Operating System, and Management Information System participated in the study. A questionnaire was applied from the previous study and the specialist's consent was maintained. For this particular investigation, Google Classroom was used in concurrence with Moodle. The research goal was to seek students' perspectives on the effectiveness of GC as a LMS tool. The evaluation was performed using inferential statistics including Pearson's correlation tests. The study sought to evaluate some parameters, such as functionality, technical mobile design, privacy, data, protection and rights data and social, teaching and cognitive presence. The assessment given for the study was neutral in relation to the use of GC by students, as there was a relationship between technical support for the operating system and social presence aspects. The challenges for the future in improving T&L for students is to increase the speed and coverage of the internet, increase the qualification of students in IT, in addition to considering other categories and aspects in the evaluation of the tool.

The (Saienko & Chugai, 2020) paper was completed by 35 learners which is 44% of the total number of Classroom Google participants at National Technical University of Ukraine. The participants were the 60 students who major in Information Technology, Mathematics or Physics, from the first to the fifth year of study; 10 students of foreign students from China, 11 students group of PhD students, and 25 students of high school students who prepare for External Independent Evaluation called ZNO in Ukraine. The research aimed to evaluate the effectiveness of the Zoom sessions, GC, Telegram and Viber tools. A mixed method research design was used in the study. A quantitative data was obtained on the basis of the survey questionnaire. A qualitative study was carried out by collecting data that was received through analyzing information from individual feedback and group discussions via Zoom sessions, Telegram and Viber. The evaluation was positive, and the authors concluded that the GC can be integrated with Classtime and Quizlet, providing a varied way of learning English. In addition, the GC allows English teachers to implement effective education for students, enabling face-to-face communication. As solutions, the authors claim that the space must be enriched with other tools.

Cluster R_{16}: that the articles analyzed in which the participants have the highest educational levels of respondents and data from more than one source, such as interviews and observation.

A total of 39 Culinary Arts Diploma students at Langkawi Vocational College were interviewed in the article by (Wan Hassan et al., 2020), using a questionnaire adapted from the previous study and had received an expert's confirmation before being used in the study. Students were taking courses in Basic Food and Cookery, Final Year Project 1 and Introduction to Hospitality Industry. The results of the paper were analyzed using descriptive statistics, and inferential statistics involved pearson correlation tests. The authors sought to understand the relationship between internet networks and motivation for using GC. With the results, the authors concluded a negative experience on the part of the students, as many challenges were encountered, such as difficulties in accessing the internet from home, difficulties in downloading and uploading schoolwork, lack of

knowledge in ICT (information and communication technology), they felt less confidence when using the tool. The authors propose as a solution that the faculty provide infrastructure for students to improve the effectiveness of e-learning.

The work of (Baharun et al., 2021) took into account interviews with various groups, such as chancellor, lecturers and students, it is a report paper with data collected through interviews, observation and documentation. Qualitative data analysis led the authors to overall positive feedback. Based on the research, the main outcomes that can be included for the use of GC is that it makes the process of T&L activities easy for teachers. In addition, it can be used to maximize the process of delivering material to students and so that assessments could be performed, every time they were made available online.

The authors (Hasanah, Dewi, Ratnaningsih, et al., 2020) used a sample of 72 fourth semester students of Elementary School Teacher Education, Jakarta State University. The methodology used was a quantitative method with pre and post-test design non-equivalent control group. The purpose of the survey was to analyze the use of GC to be significant in helping to effectively improve students' digital literacy. The results of the survey were positive, that is, the study shows that the use of materials posted on the GC help in digital literacy, students can process, access, evaluate and analyze digital information to avoid invalid information. The novelty of the research includes digital teaching materials in the GC by digitally literate researchers, such as hypertext navigation, content assessment and knowledge assembly. The authors suggest that the study can help teachers innovate materials to improve student creativity.

A study to know the theoretical level of web services, in particular the GC, was carried out with 87 teachers, from higher educational establishments, in the work of (Sultanova et al., 2020). The study was conducted on the basis of the National Aviation University (Ukraine), National Pedagogical Dragomanov University (Ukraine) and Vasyl Stefanyk Precarpathian National University (Ukraine). To show the effectiveness of the study, a pedagogical experiment was carried out through the distribution of questionnaires to understand the skills in using the GC. The authors evaluated that one of the most effective ways to solve education problems is the GC. The service has its advantages and disadvantages, and the authors claim that before the pandemic the tool was used only as a supplement to teaching methods. The authors suggest that GC should be used in conjunction with other tools in the G Suite, such as Google Meet for conducting online lectures and workshops, and applications to validate student knowledge, such as written tests. According to the results, the authors concluded that there is a positive dynamic in the levels of theoretical knowledge and practical skills in using GC, confirming the effectiveness of the results obtained.

In (Isda, Imran, Purwati, & Rahmiati, 2021), 25 eleventh grade of senior high school students were involved as well as a sample of their study. The study is quasi-experimental with a pre-experimental research design, and the researcher used a pre-test and post-test. The objective was to understand if characteristics such as grammar, vocabulary, comprehension, fluency and pronunciation were efficient as a tool for teaching the English language. Findings show that students scored an average of 71.20 in the pre-test and an average of 78.16 in the post-test. The authors concluded that the results were significant and that the GC can help students in the speaking skill, without the need to help them finish and collect the task without any time and space limitations. The implementation of GC can also improve communication between teachers and students, and is therefore a positive tool.

In the (Baskoro, Rohman, & Achmad, 2020) survey, 80 students Digital Signal Processing and Propagation Antennas were interviewed through questionnaires in 1 semester to understand

some GC criteria, such as ease and effectiveness of use, characteristics that support learning in GC, skills improvement through materials posted on the GC. The evaluation of the tool was positive according to the authors and that it was chosen as an alternative to prevent the spread of the virus in Indonesia. The results show that the GC application was very effective during the Covid-19 pandemic only with the restriction that students had to create a Google account. Among the qualities of GC, we can mention that the platform allows the student to learn in a more autonomous way, materials are distributed quickly, students and teachers can interact freely.

In (Yen & Mohamad, 2021) a survey was conducted to investigate 30 students in an English as a Second Language (ESL) class in Malaysia to master spelling. The students considered were mixed-proficiency Year 4 ESL students from a sub-urban national primary school in Selangor. Students were divided into 2 groups, the experimental (15 students who participated in the intervention) and control groups (15 students who did not participate in the intervention). The research instruments included pre and post-test results, field notes and semi-structured interviews. The authors validated the survey questions with experts for survey reliability and appropriate engagement in data collection. The case study focused on teaching spelling mastery by the GC and the results were positive, as they revealed the improvement of students and increased motivation to master spelling at an individual pace, with positive perceptions about the GC. The authors suggest that teachers should use ICTs in their language teaching classes, focusing on the student-centered approach proposed in the Malaysia Education Blueprint.

The Brazilian authors (Espirito Santo & Lima, 2020) presented a qualitative report for the evaluation of an extension course given to teachers during Covid-19 with the GC tool. Two groups were duly evaluated for this work. In class 1 there were 406 enrolled and in class 2 there were 417 enrolled, totaling 823 as the observed population. In the end, the authors managed to collect an evaluation questionnaire from 413 course participants. The objective was to evaluate participants in the Google Classroom for professors at the Federal University of Recôncavo da Bahia, in order to reflect on the context of continuing education for professors. The authors' perception was positive, that is, the course had a satisfactory level of evaluation from the course participants. The authors suggest that courses are reflective so that they promote the learning and emancipation of students in these pandemic times and have more budgetary resources for the training of teachers. Furthermore, the authors stated that the course given was not mere instrumentalization, but included in its learning path the principles of action-reflection-action as pillars of online education.

3.2 Answers to research questions

After reading, we could see that the feedbacks were very positive for the use of the GC tool during the pandemic, we had analyzes from both teachers and students, and even from educational chancellor. Additionally, it was possible to notice that some studies were conflicting, in the sense that, for example, the availability of internet quotas to all students and in some works carried out in the same country, but in other works it said that the internet has poor quality. They also had more than one paper on GC satisfaction for math, English, cooking and computer science. For each cluster found in the data mining phase, we answered each of the questions presented in Subsection 2.1.1 of Protocol. The summary of the answers to the questions is shown in Figure 16, where the advantages are represented in green, the challenges in orange and the solutions in purple.

Question Q1: the main facilities found by the study were that the GC presents a simple and easy-to-use learning experience, time savings for access, good mobile environment, usabi-

lity, privacy and security, face-to-face communication by coupled tools, ease of communication between student-teacher, archiving materials, searching and browsing through hyperlinks, easy assessment, fosters students' creativity and autonomy, skills improvement, goal-oriented learning, ease of doing homeworks.

Question Q2: for the constraints and challenges we have a lack of familiarity with the GC, connection problems (lack of signal, limited data, network instability, slow connection), physical problems (eye pain, stress or anxiety), difficulty with the interface menu: attendance menu, quiz assignment menu, essay assignment menu, digital materials menu, download menu and video download menu, and need to creating a Google account for GC product activation.

Question Q3: the main solutions found to face the obstacles were: training teachers and students, focusing not only on technical aspects of the use of GC, but also preparing using educational concepts reflection-action, for this, governments need to allocate more resources to training of teachers and devote more resources to education. Teachers should use the platform to post materials that are shorter and more innovative, yet easy to understand. Stimulate students' crea-

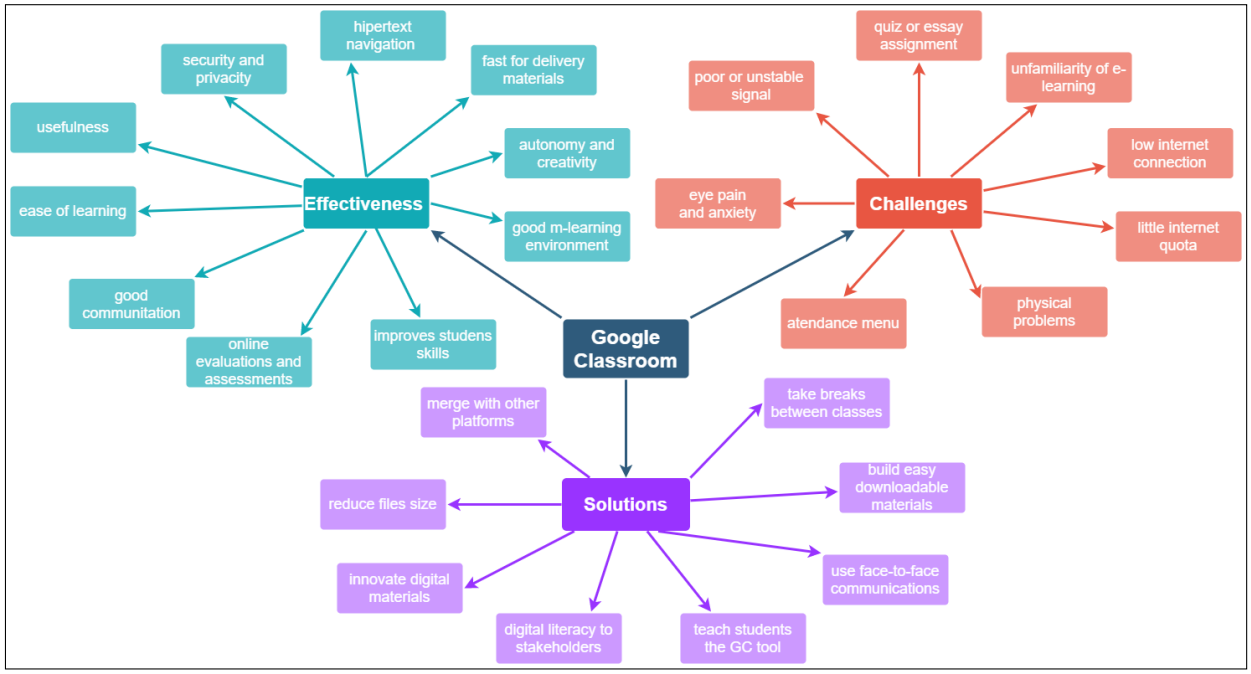


Figure 16: Graph representing the advantages and effectiveness, obstacles and solutions of using GC during the pandemic.

tivity, use tools that combined with GC to improve teaching-learning (Whatsapp, Zoom, Moodle, Teams, Google Chats, Edulogy, Google Forms), necessary to create guidelines to focus on education stakeholders, use face-to tools to give feedback to students and promote interactions with the class, check the quality of internet of students.

3.3 Limitations

In order to avoid any bias in our research, we would like to report some problems found. One aspect to be considered is that most of the extracted papers refer to works from Asian countries, which may limit some disadvantageous analyses. Although many authors criticized the GC tool as

the main responsible for the many problems presented, we could see that many of these criticized disadvantages are problems of asynchronous (or synchronous) distance classes. This means that the problem with internet instability is a problem inherent to studies online, they are an exception to the GC platform, but rather a problem likely to happen with any tool, for example, Moodle, Teams or Edulogy. Additionally, the solutions presented fit most of the tools used as LMS for online T&L, for example, training teachers and students to use GC, this would fit any platform, as it does a collective training of those involved in a platform to teaching-learning becomes essential for the quality of teaching. The last aspect to be considered is the issue that we used Google Scholar as a search tool, which can make the RSL reproducibility difficult. Although some authors Chaabna et al. (2018); Paez (2017) are already considering this search important for RSL, especially when it involves searching for strings in languages other than English or when it is a new topic that does not have many articles published yet, for example, pandemic is considered a restricted period.

4 Conclusions

The coronavirus pandemic has imposed changes in people's lives, and this transformation has impacted not only the economy, tourism, and health, but also education. In this context, teachers needed to transform their disciplines in a short period of time to the modality of distance learning. This new teaching modality caused adaptations in the homes of teachers and students who had to reserve a space completely free of noise and people's traffic so that school activities could be carried out. In addition, the pandemic changed the scenario in the forms of sociability, especially in the student-teacher relationship, in which new elements had to be inserted so that education was not interrupted, in this case we are talking about LMS.

There are several T&L tools, but in this work we use tools aimed at managing the learning environment, called LMS. In the market there are several LMS that help teachers and students to organize their school activities, and one of the most widely used and studied tools, therefore widely spread during the pandemic, was the Google Classroom, being the focus of this work. GC is part of G-Suite: a set of Google for Education applications, developed as LMS, along with other tools such as Gmail, Google Drive, for file storage, Google Forms and other text editors (Docs), spreadsheets and presentations, whiteboards (Jamboard) and chats. To enjoy so many resources, students, teachers and some governments had to invest in equipment, such as tablets, computers, cell phones and even infrastructure with internet so that school activities were not interrupted.

In this work, we seek to understand the weaknesses and obstacles, effectiveness and advantages, and the solutions presented for the use of GC during the pandemic. The analysis was performed by an SLR, in four databases, in which 93 articles were found, 1 of which was duplicated, but with a different title, from different parts of the world, proving that the tool has been studied by many researchers. Among these 30 passed the selection criteria and only 25 for the extraction. After extraction, a clustering was performed in order to group articles with greater similarity for writing the outcomes. Three unsupervised learning algorithms for clustering were used, hierarchical clustering, to drive the partitioning size k for the k-means and k-medoids algorithms, optimized clustering algorithms. Thus, $k = 3$ clusters were used, from the direction of the hierarchical grouping to the algorithms: k-means and k-medoids. Different data visualizations were carried out to make a qualitative analysis of the results and to arrive at that the best clusterer for the database which were the 25 articles was the k-medoids. The $k = 3$ clusters that divided the

articles into the following groupings: (R_{12}) cluster with articles comparing the GC tool with other tools of the LMS type, (R_7) cluster with the majority of analysis of the type qualitative or mixed and data from more information sources and the cluster (R_{16}) with selected articles with the best evaluation for the GC among all other clusters. These groupings were essential for understanding the articles studied, for example, when GC was compared to other tools, the general overview of the GC was much smaller than in articles in which only the GC was evaluated and articles with a greater source of data for collection information, had more qualitative or mixed analyses. Another finding was that articles with a higher overview had mostly more quantitative analyses.

Finally, the research questions could be answered and it was found that the GC has different advantages in relation to its use, such as ease of learning, possibility of interactive communication between teacher and student, navigation through links, adequate usability for different levels of education, portability to mobiles, real-time notifications. The main limitations were access to the platform hampered by network instability, low data limits, large files to be downloaded, physical fatigue and transactional distance between student-teacher. Finally, solutions have been presented by several authors to work around the problems in relation to GC, but not limited to these, they are: increase face-to-face encounters through other interactive platforms Google Meet or Zoom, combine other platforms such as Whatsapp, Moodle or Edulogy. Train teachers and students in the use of GC, but not only in technical aspects, but also in aspects of the reflexive-action type to understand distance education as a whole. It would be necessary for governors invest more in technologies and increase financial support for education to provide quality internet to all students.

It was also noticed that many of the advantages, problems and solutions presented are universal aspects that would be related to any LMS platform, for example, good link navigation is found in almost all types of LMS with educational purposes, but the ease of use is a advantage more focused on GC and also the ease of integration with other Google services, such as Google Meet, Google Forms, Gmail, Jamboard, Google Chat, Hangouts, YouTube, among others. Regarding the disadvantages, many were wrongly attributed to the GC, such as eyestrain or network instability. Visual fatigue is attributed to the excessive use of screens, regardless if it is only for school activities. The internet instability that in many papers was attributed to the GC is not directly related to the tool, because it does not demand a very large data traffic for its use, it was a problem found more often in Asian countries. Finally, it was possible to see that the solutions presented can be generalized for the implementation of other LMS during or outside the pandemic in different countries, for example, the posting of quality materials by teachers and prior training of students to use the tool.

As future work, we hope to build a model of guidelines so that GC can be better implemented in schools around the world. In addition, we hope to deepen our analysis using a similarity search algorithm by neighbors to find new analysis clusters and make new analyzes on this data, seeking to extract more features. When using GC, we intend to adopt some of the solutions presented in the classroom, as it was possible to see that most of the evaluations were positive in relation to the tool as e-learning.

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