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EXCEL-BASED QUALITATIVE DATA ANALYSIS: METHODOLOGICAL GUIDELINES FOR SYSTEMATIC ORGANIZATION, ITERATIVE CODING, AND THEMATIC VISUALIZATION

(Research article)

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Abstract

This paper addresses the need for a systematic, cost-effective methodology for qualitative analysis by detailing how Excel's spreadsheet environment can support transparent coding, thematic synthesis, and visual interpretation. Particularly for small-scale projects, mixed-methods designs, or researchers new to qualitative tools. Therefore, it presents the available opportunities for integrating manual coding rigor with Excel's spreadsheet logic, offering the transparency of paper-based analysis with digital scalability for arranging, categorizing, and displaying qualitative data. Although more sophisticated tools are available in specialized qualitative analysis programs such as NVivo, ATLAS.ti, and MAXQDA, Excel offers researchers a more accessible, adaptable, and user-friendly option. This paper shows how systematic coding, data management, and visual aids in Excel can handle and evaluate qualitative data efficiently. The results demonstrate Excel's usefulness in qualitative research, especially for those seeking an affordable and comfortable platform without sacrificing analytical rigor, providing insights on the benefits and drawbacks of using Excel for qualitative data analysis.

Keywords: Excel, qualitative data analysis, methodological guidance, thematic visualization

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1. **Introduction**

1.1 Background to the study

Qualitative data (QD) refers to non-numerical information that captures the complexity, richness, and depth of human experiences and social phenomena. The primary purpose of QD is to explore underlying meanings, patterns, and relationships within a particular context, making it inherently subjective and interpretative (Creswell & Creswell, 2018). QD are typically collected through interviews, focus groups, observations, and open-ended surveys, where the data form is textual or visual rather than numerical (Denzin & Lincoln, 2017; Patton, 2014). Qualitative data (QD) analysis involves identifying outcomes such as themes, categories, and patterns using methods such as thematic analysis, coding, and narrative analysis, among other QD analytic approaches (Braun & Clarke, 2019). This exploratory nature allows researchers to develop a deep contextual understanding of the phenomena under study, acknowledging the significance of context in shaping the data (Patton, 2014). QD's richness lies in its ability to provide detailed insights into participants' perspectives, motivations, and social interactions, offering a holistic view of the research subject (Miles et al., 2014).

Qualitative data analysis (QDA) is a critical component of research across various disciplines that provides deep insight into complex phenomena that cannot be captured through quantitative methods alone. Traditionally, specialized software, such as NVivo, MAXQDA, and ATLAS, have been used. They have been the go-to tools for qualitative analysis because of their robust features tailored for coding, categorizing, and visualizing non-numerical data (Braun & Clarke, 2019). However, these tools often have steep learning curves and financial costs, making them less accessible to researchers with constrained budgets or limited technological infrastructure.

Microsoft Excel, a widely available and user-friendly tool, is a viable alternative to the QDA. Although primarily designed for numerical data, Excel’s flexibility and powerful features can be adapted to organize, code, and visualize qualitative data. This paper explored the best practices for leveraging Excel in qualitative research, focusing on structuring data, implementing coding techniques, and creating visual representations that facilitate in-depth analysis. Bree and Gallagher (2016) laid an essential foundation by demonstrating how Excel can be effectively utilized for basic qualitative analysis tasks, particularly in contexts where specialized software such as NVivo and ATLAS.ti may be unavailable or too costly. Their work emphasized Excel’s potential for organizing, coding, and thematically analyzing qualitative data, making it an invaluable tool for researchers in resource-limited environments.

Expanding on this foundational work, Ose (2016) examined Excel’s utility in her study "Using Excel and Word to Structure Qualitative Data," which is tailored for large-scale applied social science projects. Ose’s methodology is particularly beneficial for managing extensive qualitative datasets, such as interview transcripts, where she highlights the simplicity and efficiency of using Excel and Word to structure and categorize data into manageable units. Her work is handy for projects that require straightforward data management without the complexity of more advanced Computer-Assisted Qualitative Data Analysis Software (CAQDAS).

However, both Bree and Gallagher (2016) and Ose (2016) primarily focused on the basic functionalities of Excel, such as data organization and simple coding, which, while effective for foundational analysis, still need to exploit its advanced capabilities fully. This limitation is addressed in the current paper, which builds on earlier works by illustrating how Excel's more sophisticated features, such as PivotTables, Conditional Formatting, and Macros, can be leveraged for more complex QDA tasks. For instance, this paper demonstrates how these advanced features can enhance the visualization of patterns, facilitate data summarization, and automate repetitive tasks, thereby enabling a more in-depth analysis of qualitative data.

In addition to these works, Meyer and Avery (2009) also explored using Excel for qualitative data analysis, highlighting its potential as a cost-effective alternative for organizing and analyzing data. Their study provides a practical guide for using Excel for coding and thematic analysis, reinforcing that Excel can be a reliable tool for qualitative researchers, particularly in educational settings. However, similar to Bree and Gallagher, Ose, Meyer, and Avery's focus remains on the fundamental uses of Excel without delving into its more advanced functionalities.

Moreover, (Eliot (2011), in her article "Using Excel for Qualitative Data Analysis," discusses Excel's utility as a middle ground between manual analysis and the use of expensive software. She emphasized Excel's capacity to manage and organize textual data effectively, particularly for small-scale projects where the data volume does not necessitate specialized software. Eliot's work provided practical steps for setting up Excel templates for qualitative analysis, highlighting how the tool can be adapted to various qualitative research needs.

Finally, Garrett (2015), in his examination of Excel textbooks, critiques Excel as a superficial tool, often focusing on button-pushing rather than deep analytical skills. His findings underscore the importance of teaching Excel as a powerful tool for data analysis in quantitative contexts and qualitative research. Garrett's work suggests that Excel can achieve a much more sophisticated analysis with proper training and understanding than is typically realized in standard education or business settings.

Bree & Gallagher (2016). Eliot (2011), Garrett (2015), Meyer & Avery (2009), and Ose (2016) have all made significant contributions to understanding how Excel can be used for qualitative data analysis; the current study extends this foundation by exploring Excel's advanced features and their application in more complex QDA tasks. The current paper provides practical, step-by-step guidance through a detailed case study, demonstrating how Excel can be leveraged for basic data organization, coding, and more intricate data analysis processes. This confirms Excel's utility in resource-limited settings and positions it as a robust tool for qualitative researchers seeking to maximize the capabilities of widely available software.

By presenting a methodological paper on using Excel for qualitative data analysis, we aim to provide practical guidance for researchers seeking to optimize their data management and analysis processes. This paper outlines step-by-step procedures for organizing qualitative data in Excel, discusses approaches to coding and categorization, and highlights techniques for visualizing non-numerical data. Additionally, it addresses the challenges and limitations inherent in using Excel for qualitative research and offers strategies to ensure the reliability and validity of the analysis. Ethical considerations, such as data privacy and responsible coding practices, were also examined to ensure the analysis was conducted with integrity.

This paper contributes to the broader discourse on qualitative research methodologies by examining these best practices in detail and demonstrating, through a practical example, how Excel can effectively support rigorous and insightful qualitative analysis, with data collection and transcription conducted via separate tools.

1.2 Problem Statement

Qualitative research ideally relies on specialized software such as NVivo and ATLAS.ti, which offer advanced features for organizing, coding, and analyzing non-numerical data (Bazeley, 2007). However, these tools can be expensive and require specialized training, making them less accessible to researchers in resource-constrained settings. Previous studies have explored Microsoft Excel as an accessible and cost-effective alternative for qualitative data analysis. These studies have demonstrated that Excel can be a viable tool for organizing and coding qualitative data, particularly for small-scale projects (Bree & Gallagher, 2016; Eliot, 2011; Garrett, 2015; Meyer & Avery, 2009). Despite the existing research, most studies have focused on Excel's basic functionalities in qualitative analysis, often overlooking its more advanced capabilities for complex qualitative data management and visualization. Additionally, these studies focus on specific aspects of qualitative analysis, such as coding, without providing a comprehensive guide that includes best practices for data structuring, automation, and ethical considerations (Meyer & Avery, 2009). This study aims to fill these gaps by offering a more comprehensive exploration of Excel’s potential for qualitative data analysis. It builds on existing research by demonstrating basic coding techniques and introducing more advanced uses of Excel, such as automating parts of the coding process, creating pivot tables for qualitative analysis, and addressing the challenges of maintaining data integrity and ethical standards in Excel.

The study provides a detailed methodology that equips researchers with practical strategies to conduct rigorous qualitative research using Excel, even without specialized software, and aims to;

1. To demonstrate how Excel organizes and codes qualitative data using a structured approach.
2. To illustrate Excel's capabilities in visualizing qualitative data using charts and tables.
3. To develop practical guidelines and evaluate the advantages and challenges of using Excel for qualitative data analyses.

2. Methodology

2.1 Research Design

This explains how Excel was used during qualitative data analysis of a quasi-experimental research project conducted at six secondary schools in Uganda. The primary aim of the original study was to investigate the effectiveness of two instructional strategies, Van Hiele Phased Instruction (VHPI) and Technology-Enhanced Van Hiele Phased Instruction (TVHPI), with GeoGebra in teaching Transformation Geometry to S.3 (third-year secondary school learners aged from 14 to 18) students. This methodological paper focused on documenting how Microsoft Excel was used to organize, code, and visualize the qualitative data derived from the project, specifically student interview transcripts.

TVHPI is an instructional method that incorporates digital tools, such as GeoGebra, to facilitate learning geometric concepts through visual and interactive means. In contrast, VHPI is a traditional pedagogical approach that guides students through structured phases of geometric understanding without using technology. Both methods are based on the Van Hiele theory of geometric thought, which emphasizes sequential progression through levels of geometric reasoning (Senk et al., 2022; Tamam & Dasari, 2021; Uwurukundo et al., 2021; Vágová & Kmetová, 2019).

2.2 Data Source and Interview Process

This methodological paper used data from a survey that involved open-ended interviews with 48 students from six secondary schools, selected based on specific criteria, including functional computer labs for TVHPI and multiple streams in S.3 (students in the 3rd year of secondary education aged between 14 to 18) Two classes or streams per school were randomly chosen, with interviews targeting higher and lower achievers from each instructional method (VHPI and TVHPI). The interviews, lasting 30–45 minutes, explored learning experiences, instructional impacts, teaching effectiveness, and encountered challenges. Responses were recorded, verified with participants, and anonymized using a unique identifier system that reflected gender, achievement level, school location, and the instructional method.

2.3 Interview Process

The interviews were structured to explore four key areas: (1) Learning Experience: The students' engagement with instructional strategies and their understanding of geometry. (2) Instructional Impact: The effect of instructional strategies on students' learning. (3) Teaching Effectiveness: Insights into which parts of the instruction were the clearest and most beneficial. (4) Difficulties encountered: challenges or perspectives that arise during the learning process.

The interviews were conducted outside regular lesson hours, typically in the morning or evening, to minimize disruption. Each interview lasted 30–45 min, and student responses were recorded verbatim. The responses were read to students for confirmation and revision to ensure accuracy. The resulting transcripts were anonymized using a unique identifier system that accounted for students' gender, achievement level, school location, and instructional method (e.g., MHA/TVHPI/R1 for a male higher achiever from a rural school taught using TVHPI).

2.4 Data Preparation, Organization, and Analysis

In this study, 48 interview transcripts were broken down into 438 distinct data units/segments, each representing a unique concept related to the research question. These data units were systematically organized in Excel, with rows representing individual units and columns capturing attributes such as participant ID and thematic categories. The coding process involved open coding to assign themes such as "engagement" and "challenges," followed by categorization into broader themes such as "Learning Experience." Excel features, including conditional formatting, filtering, and sorting, were used to organize and analyze the data. The pivot tables and charts provide visual summaries and cross-analyses of themes, offering valuable insights into the impact of instructional strategies (VHPI and TVHPI) on student learning and engagement in Transformation Geometry.

2.5 Ethical Considerations

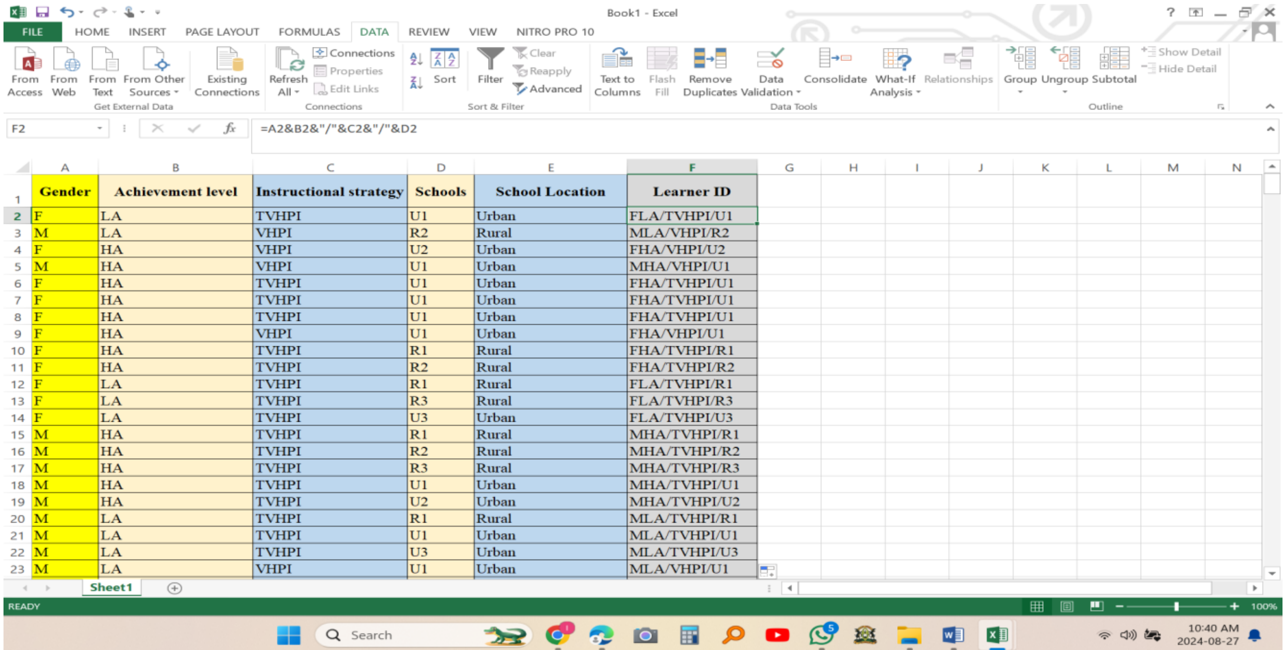
The original study was approved by the Uganda National Council for Science and Technology (UNCST) under the clearance code SS2857ES and the Research Ethics Committee (REC) of the Mbarara University of Science and Technology (MUST) under the code MUST-2024-1519. Informed consent was obtained from all participants, and their identities were anonymized to protect their privacy. No new data collection was undertaken in this methodological paper, and the analysis adhered to all ethical standards set by the original research.

3. Results

This section presents the results of the methodological paper, demonstrating how Microsoft Excel was used for organizing, coding, categorizing, and visualizing qualitative data. The steps followed in the analysis process are outlined below, with the accompanying insights and practical guidelines derived from each step.

3.1 Data Anonymization

Anonymization involves organizing key variables in Excel and generating unique learner IDs using a ***concatenation*** function. This ensures confidentiality while enabling efficient tracking and categorization for further analysis. Figure 1 shows an Excel spreadsheet depicting anonymizing and generating students' unique identifiers.



Gender	Achievement level	Instructional strategy	Schools	School Location	Learner ID
F	LA	TVHPI	U1	Urban	FLA/TVHPI/U1
M	LA	VHPI	R2	Rural	MLA/VHPI/R2
F	HA	VHPI	U2	Urban	FHA/VHPI/U2
M	HA	VHPI	U1	Urban	MHA/VHPI/U1
F	HA	TVHPI	U1	Urban	FHA/TVHPI/U1
F	HA	TVHPI	U1	Urban	FHA/TVHPI/U1
F	HA	TVHPI	U1	Urban	FHA/TVHPI/U1
F	HA	VHPI	U1	Urban	FHA/VHPI/U1
F	HA	TVHPI	R1	Rural	FHA/TVHPI/R1
F	HA	TVHPI	R2	Rural	FHA/TVHPI/R2
F	LA	TVHPI	R1	Rural	FLA/TVHPI/R1
F	LA	TVHPI	R3	Rural	FLA/TVHPI/R3
F	LA	TVHPI	U3	Urban	FLA/TVHPI/U3
M	HA	TVHPI	R1	Rural	MHA/TVHPI/R1
M	HA	TVHPI	R2	Rural	MHA/TVHPI/R2
M	HA	TVHPI	R3	Rural	MHA/TVHPI/R3
M	HA	TVHPI	U1	Urban	MHA/TVHPI/U1
M	HA	TVHPI	U2	Urban	MHA/TVHPI/U2
M	LA	TVHPI	R1	Rural	MLA/TVHPI/R1
M	LA	TVHPI	U1	Urban	MLA/TVHPI/U1
M	LA	TVHPI	U3	Urban	MLA/TVHPI/U3
M	LA	VHPI	U1	Urban	MLA/VHPI/U1

Figure 1: Extract of the Excel sheet depicting the anonymization and generation of students' unique identifiers.

The anonymization process, as illustrated in Figure 1, was effectively done by using separate columns for contextual variables such as "Gender," "Achievement Level," "Instructional Strategy," "Schools," and "School Location." A unique student ID is generated by concatenating the values from these columns into a single string in the "Learner ID" column. This was achieved using Excel's concatenation function (and), as shown in formulas ***=A2&B2&"/"&C2&"/"&D2***. Each transcript was labeled with the student's identification before data segmentation. This method ensured that each student's identity was anonymized while retaining the essential data needed for the analysis, organized in a structured and systematic manner.

3.2 Data Segmentation

Each transcript was broken down into smaller meaningful units, with each segment representing a specific theme, idea, or experience relevant to the research question. This segmentation allowed for a more detailed and granular analysis, as each unique dataset captured a distinct aspect of the participants' responses, such as their experiences with instructional strategies or challenges in learning geometry. This approach is common in qualitative research to ensure that all relevant insights are thoroughly analyzed. This resulted in 438 data segments subjected to the coding process. Table 1 lists the fragment extracts of the original and segmented transcripts.

Table 1: Showing the difference between segmented text from the original text of a transcript

Original Transcript (Extract)	**Segmented transcript (extract)**
Qn1: How was your experience learning geometry, and how did you improve over time? **Student ID- MHA/TVHPI/U1** At first, I did not know how to rotate shapes. The rotation order confused me, but I got better at finding the right angles after more practice. Reflections were easy for me because I could see the symmetry in the shapes. I struggled a bit with applying the transformations in the Cartesian plane, but after some time, it got easier.	*Qn1: How was your experience learning geometry, and how did you improve over time?* **Student ID- MHA/TVHPI/U1** 1. At first, I did not know how to rotate shapes. 2. The rotation order confused me, but I got better at finding the right angles after more practice. 3. Reflections were easy for me because I could see the symmetry in the shapes. 4. I struggled to apply the Cartesian plane transformations, but it got easier after some time.

This table illustrates the segmentation process that breaks down a continuous narrative from the original transcript into manageable units. The original transcript presented the participant's response as a cohesive passage, whereas the segmented transcript isolated specific ideas, numbered for clarity. This segmentation facilitated more precise coding by allowing each thought to be analyzed individually, such as distinguishing struggles with rotation from ease with symmetry. This approach enhanced thematic analysis, improved accuracy, and made identifying patterns and trends across the data more accessible, leading to more precise insights into the participants' experiences.

3.3 Data Transfer into Excel

The segmented data units were then transferred to Microsoft Excel. Each row represents an individual data unit, while columns are created to capture various attributes such as participant ID, instructional strategy, and specific category (e.g., Learning Experience, Instructional Impact). Table 2 briefly describes the Excel headings used to capture segmented data.

Table 2: Columns of the Excel sheet for organizing qualitative data

Variables	**Description**
1. Gender	Categorizes students as male or female for analyzing gender-based differences.
2. Achievement Level	Classifies students as higher or lower achievers based on post-test scores.
3. School Location	Differentiates between urban and rural schools, impacting student experiences.
4. Instructional Strategy	Specifies the teaching method used (VHPI or TVHPI) for comparative analysis.
5. Student Identifier	Unique code ensuring anonymity and enabling tracking of responses.
6. Transcript Segment	Extracted portions of interviews for detailed analysis.
7. Analytical Memos	The researcher's notes reflect thoughts and emerging patterns during analysis.
8. Codes	Labels are assigned to transcript segments to identify key ideas or concepts.
9. Categories	Broader groups of related codes represent significant concepts.
10. Subtheme	**Optional**: Specific ideas emerging from categories for deeper analysis.
11. Main Themes	Overarching ideas derived from categories (or subthemes) representing the study's key findings.
12. Illustrative quote	An illustrative quote is a direct, word-for-word excerpt from a participant's response that exemplifies a specific idea or concept.

Variables 1–4 are specific to the case study used and vary from case to case, whereas variables 5–12 are generic and can be adapted for every case. These variables were organized in Excel columns, as illustrated in Figure 2.

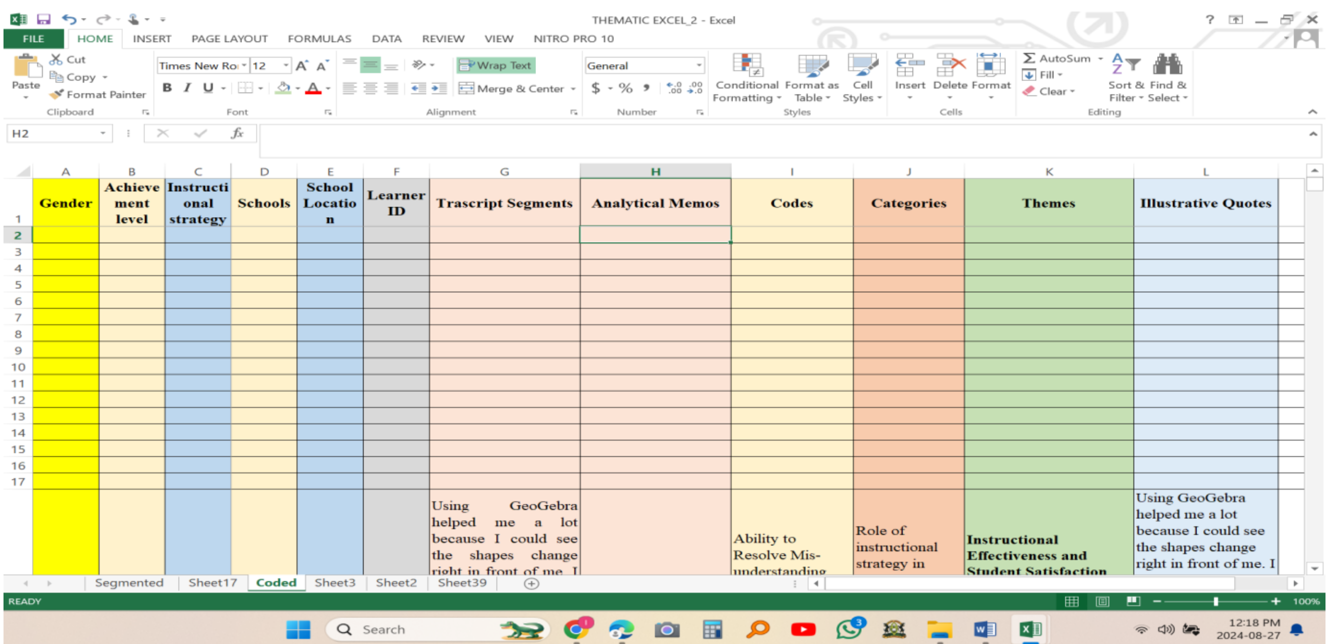


Figure 2: Excel extract showing column headings for organizing qualitative data.

Color coding and the specific arrangement of columns in the Excel sheet were strategically designed to improve clarity and efficiency during data analysis. Demographic variables such as "Gender" and "Achievement Level are highlighted in yellow, while contextual variables such as "Instructional Strategy" and "School Location are marked in blue for quick identification. The logical arrangement began with demographic and contextual data, followed by anonymized "Learner IDs" in grey, ensuring participant confidentiality. "Transcript Segments" and "Analytical Memos" were next, leading into the final columns for "Codes," "Categories," "Sub-themes," and "Themes," which supported a systematic and coherent flow through the stages of qualitative analysis.

3.4 Data Coding

The coding process was systematic and iterative, ensuring that the insights derived from student responses were accurately categorized and reflected in the final analysis. This section outlines the approach taken during the coding process, highlighting the key stages, methodological decisions, and the structure of the final coding framework.

The coding process involved several systematic phases to analyze qualitative data. Initially, an open coding phase was conducted in which transcript segments were analyzed without predefined categories, resulting in granular codes that closely reflected students' language and experiences. Examples include codes like “difficulty following steps” and “enhanced visual learning.” After this stage, a codebook consisting of 20 final codes was generated.

Axial coding was then employed to group similar codes into broader provisional categories. For example, codes related to learning difficulties were grouped under "Learning Challenges and Obstacles," while those supporting learning strategies were categorized under "Instructional Support and Guidance."

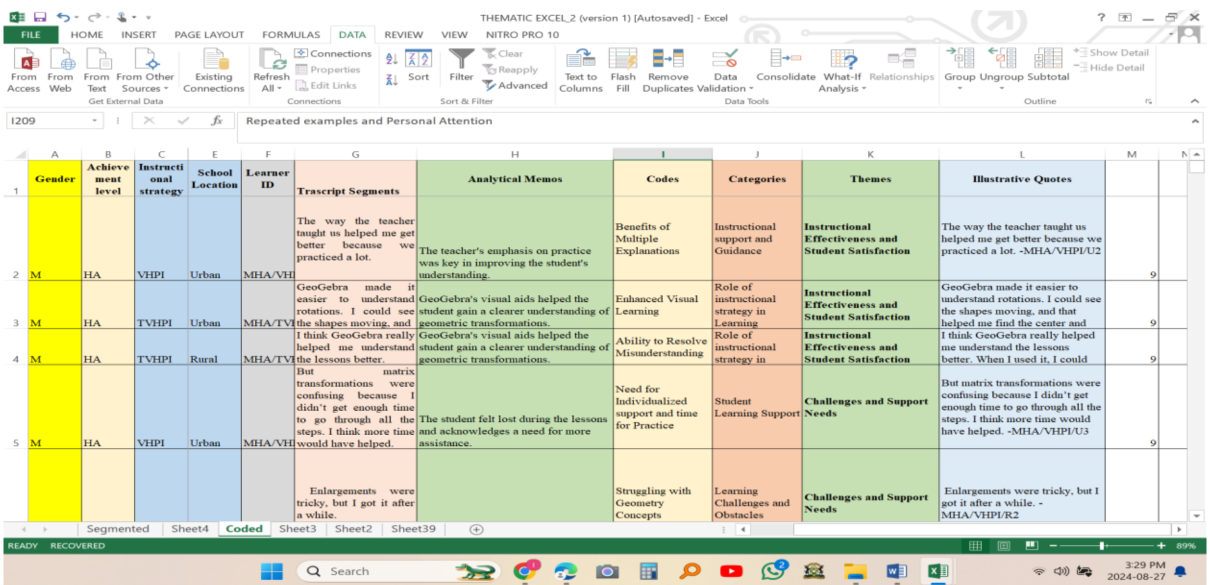
As the analysis progressed, categories were refined to clarify boundaries and ensure accurate data representation. This led to new categories, such as "Metacognition and Self-Regulated Learning," which capture students' reflective practices.

Subsequently, these refined categories were organized into hierarchical structures, grouping related categories under broader themes like "Challenges and Support Needs" and "Instructional Effectiveness and Student Satisfaction."

Finally, through iterative refinement, categories are continuously revised to ensure consistency and meaningful distinctions. This iterative process led to the finalization of categories, where some were merged, split, or reassigned to reflect the data better. This ultimately provided a comprehensive understanding of students' experiences and the effectiveness of instructional strategies. Table 2 shows an extract of the codebook, Figure 3 shows the extract of the final code structure, and Figure 4 summarizes the coding process.

Table 3: **Extract of the code book.**

Codes	Definition	Illustrative Quotes
Desire for More Time with GeoGebra	Transcript sections where students wish extended periods to practice using GeoGebra to enhance their geometry learning.	*More time on that with GeoGebra would have helped me a lot.*
Difficulty Following Steps	There are parts of the transcripts where students describe challenges in keeping up with or understanding the sequential steps in learning or using tools like GeoGebra.	*However, I struggled with matrix transformations because I could not keep up with all the steps.*



	Gender	Achievement level	Instructional strategy	School Location	Learner ID	Trascript Segments	Analytical Memos	Codes	Categories	Themes	Illustrative Quotes	
2	M	HA	VHPI	Urban	MHA/VHI	The way the teacher taught us helped me get better because we practiced a lot.	The teacher's emphasis on practice was key in improving the student's understanding.	Benefits of Multiple Explanations	Instructional support and Guidance	Instructional Effectiveness and Student Satisfaction	The way the teacher taught us helped me get better because we practiced a lot. -MHA/VHPI/U2	9
3	M	HA	TVHPI	Urban	MHA/TVI	GeoGebra made it easier to understand rotations. I could see the shapes moving, and	GeoGebra's visual aids helped the student gain a clearer understanding of geometric transformations.	Enhanced Visual Learning	Role of instructional strategy in Learning	Instructional Effectiveness and Student Satisfaction	GeoGebra made it easier to understand rotations. I could see the shapes moving, and that helped me find the center and	9
4	M	HA	TVHPI	Rural	MHA/TVI	I think GeoGebra really helped me understand the lessons better.	GeoGebra's visual aids helped the student gain a clearer understanding of geometric transformations.	Ability to Resolve Misunderstanding	Role of instructional strategy in	Instructional Effectiveness and Student Satisfaction	I think GeoGebra really helped me understand the lessons better. When I used it, I could	9
5	M	HA	VHPI	Urban	MHA/VHI	But matrix transformations were confusing because I didn't get enough time to go through all the steps. I think more time would have helped.	The student felt lost during the lessons and acknowledges a need for more assistance.	Need for Individualized support and time for Practice	Student Learning Support	Challenges and Support Needs	But matrix transformations were confusing because I didn't get enough time to go through all the steps. I think more time would have helped. -MHA/VHPI/U3	9
						Enlargements were tricky, but I got it after a while.		Struggling with Geometry Concepts	Learning Challenges and Obstacles	Challenges and Support Needs	Enlargements were tricky, but I got it after a while. - MHA/VHPI/R2	

Figure 3: *Illustrating a section on the final code structure.*

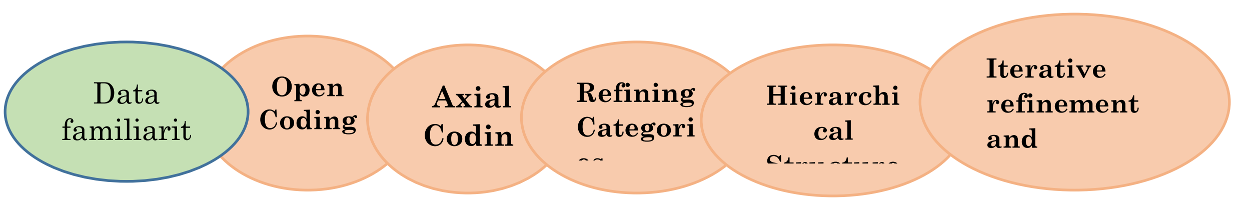


Figure 4: Summary of the qualitative data coding process

3.5 Data Analysis and Visualization

Pivot Tables and Pivot Charts enhanced the qualitative data analysis process by allowing for dynamic organization and visual representation of complex datasets. PivotTables were employed to summarize and categorize the qualitative data, revealing patterns and relationships between variables, such as themes and participant responses. This facilitated the identification of critical trends and the comparison of various categories within the data. Pivot Charts were used to visually depict these findings, providing clear and accessible insights supporting qualitative results' interpretation and communication.

> *A PivotTable is a data tool in Excel and Google Sheets that helps organize and summarize large datasets by grouping values, calculating totals, and filtering categories. It enables users to categorize and count data elements, making it ideal for simplifying complex data sets. A Pivot Table can categorize and count recurring themes or codes in qualitative analysis, helping researchers quickly identify common responses or patterns across groups.*

In addition to using PivotTables and Pivot Charts to visualize qualitative data, this study employed a variety of other Excel tools to enhance the analysis and interpretation process. Conditional Formatting was utilized to highlight key themes and patterns by applying color codes, making the data more visually distinguishable. This study also leveraged various Charts and Graphs, such as bar and pie charts, to represent trends and relationships within the data. Heat Maps were created using Conditional Formatting to visualize the intensity of themes across the dataset, while Sparkline provided a quick visual summary of trends over time.

> *A PivotChart visually represents data from a Pivot Table, providing an intuitive way to analyze and compare information across categories. It updates dynamically with the PivotTable, instantly reflecting any changes in the dataset. When applied to qualitative data, PivotCharts can highlight patterns, such as the frequency of themes by demographic group, making insights more accessible to understand at a glance.*

For instance, bar charts were generated to compare the frequency of different experiences and understandings reported by the students in the VHPI and TVHPI groups. Visualization of the data made it easier to interpret the complex patterns and relationships between instructional strategies and students' experiences. Pivot tables were handy for cross-analyzing themes against demographic variables such as gender and achievement level.

> *To obtain a PivotTable and PivotChart in Excel, select your data range, go to the "Insert" tab, and click on "PivotTable." Choose the location for your Pivot Table. Once created, drag fields into the appropriate areas (Rows, Columns, Values) to organize your data. For a PivotChart, go to "Insert" > "PivotChart," and select the desired chart type.*

Figure 5 shows a pivot table and chart comparing the distribution of categories and themes between students taught using the VHPI and TVHPI across school locations.

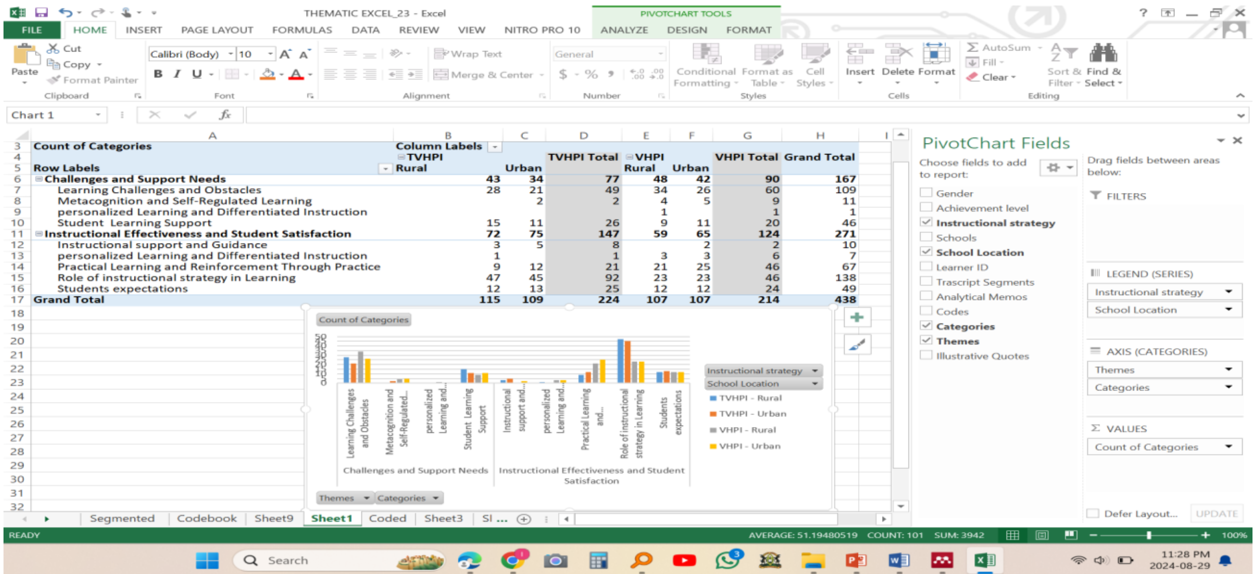


Figure 5: A pivot table and chart comparing the distribution of the categories and themes between students taught using VHPI and TVHPI across school locations.

3.6 Data Extraction into Word Document

After the data analysis and visualization were completed, key findings and visual outputs were extracted from Excel and organized into Word documents. This step was essential for structuring the final report and for ensuring that the analysis was presented in a coherent and readable format. Data extraction into Word allowed for seamless integration of charts, tables, and textual analysis in the report. Here, Excel content was sorted according to theme, Category, and Code, and then the codes, categories, themes, and illustrative quotes' columns were exported to a Word document. It appears in table form, which is converted to text, and the writing begins. An organized transcript, arranged according to themes, categories, and codes, was created to guide the writing process. The appropriate steps to perform this extraction have been outlined by Ose (2016).

3.7 Limitations of the Method

In this study, Excel proved to be an accessible and flexible tool for analyzing qualitative data from 48 student interviews across six schools, focusing on their experiences with VHPI and TVHPI. However, the method revealed limitations, particularly in scalability and manual coding, where the potential for human error increased as we categorized differences in student experiences. The lack of advanced qualitative tools, such as integrated memoing and sophisticated visualization options, has constrained our ability to map complex relationships between themes, such as instructional clarity and engagement. Additionally, the time-intensive nature of manual coding and analysis in Excel, while manageable for this dataset, may hinder large-scale studies. Despite these limitations, Excel effectively facilitated the exploration of critical insights into how technology-enhanced learning through GeoGebra impacted student understanding, making it a practical choice for moderate-sized qualitative research. However, specialized software may be more appropriate for more extensive or complex analyses.

4 Discussion

This methodological paper presents the use of Excel as a tool for qualitative data analysis, focusing on two primary objectives: assessing its practicality and limitations in manual coding and data organization and exploring its effectiveness in visualizing qualitative data to highlight key patterns and themes. This discussion interrogates the claims supported by this study and the relevant literature by examining the potential and limitations of using Excel for qualitative research.

4.1 Assessing the Practicality of Using Excel for Manual Coding and Organizing Qualitative Data

This study demonstrated that Excel can be a practical tool for organizing and manually coding qualitative data, particularly for smaller datasets. The structure and flexibility of Excel allowed for the efficient organization of interview transcripts, with columns dedicated to themes, subthemes, and memos. This finding is consistent with Silver and Lewins (2017), who emphasized that Excel can be adapted for qualitative analysis if the data are carefully structured. Similarly, Ose (2016) highlighted Excel’s accessibility and ease of use, particularly in resource-limited settings where specialized software might not be available.

However, the approach presents significant limitations. Manual coding in Excel was time intensive, requiring significant attention to ensure consistency and accuracy across the dataset. This aligns with critiques from Miles et al. (2014), who argued that manual coding increases the potential for human error and inefficiency, particularly in larger datasets. These authors advocate the use of specialized qualitative software, such as NVivo or Atlas.ti, which offers automated coding features that streamline the analysis process and reduce the likelihood of coding inconsistencies.

Another significant limitation of this approach is Excel's scalability. Although Excel worked well for the 48 interview transcripts used in this study, larger datasets would likely overwhelm its capabilities. Jackson et al. (2019) argued that Excel lacks the advanced organizational and analytical tools necessary for handling more complex qualitative datasets. Specialized qualitative software is better equipped to manage the intricate coding and organizational needs of larger studies, offering hierarchical coding structures and linked data that Excel cannot easily accommodate.

Conversely, some studies have shown that Excel suits smaller qualitative research projects. Woods et al. (2015) found that Excel provides a viable alternative for researchers with limited resources, particularly for studies that do not require complex coding or large datasets. This study supports this claim but adds the caveat that Excel's utility diminishes as the dataset grows in size or complexity.

4.2 Exploring How Excel's Visualization Tools Can Effectively Represent Qualitative Data and Highlight Key Patterns and Themes

Excel's built-in visualization tools, such as pivot tables, bar charts, and bubble charts, have proven helpful in representing qualitative data and identifying key patterns and themes. These tools enabled us to compare how different instructional strategies impacted students' understanding of geometric transformations and explored differences across variables such as gender and achievement level. This finding aligns with Woods et al. (2015), who argued that Excel's visual tools, while basic, can be practical for small-scale qualitative studies, particularly in visually representing the frequency and distribution of themes.

However, this study also identified significant limitations in Excel visualization capabilities. While pivot tables and charts provide valuable insights, Excel lacks the more advanced visualization features in software such as NVivo, MAXQDA, and ATLAS.ti. For instance, these specialized programs offer thematic maps, network diagrams, and other sophisticated visualizations that allow researchers to explore deeper relationships between themes and subthemes (Jackson et al., 2019; Miles et al., 2014). The inability of Excel to generate such advanced visualizations limits the depth of the qualitative analysis that can be conducted, mainly when the research requires more exploration of complex data relationships.

Braun and Clarke (2006) argued that advanced visualizations, such as thematic maps, are crucial for deepening the understanding of qualitative research by illustrating connections and hierarchies between themes. These visualizations enable researchers to identify subtle patterns that may not be immediately apparent using simpler visual tools such as those available in Excel. Although Excel's basic charts were adequate for illustrating high-level trends, they were insufficient for delving into the more intricate relationships between data points, often critical in qualitative research.

Despite these limitations, Excel's visualization tools are still praised in some parts of the literature for their simplicity and accessibility. Ose (2016) suggested that for researchers with limited access to advanced software, Excel's ability to generate straightforward charts and graphs is sufficient to provide a clear visual summary of qualitative data. In this study, Excel's visualizations helped communicate broad trends and make comparisons across groups, particularly in analyzing students' experiences with different instructional strategies.

The findings of this study suggest that Excel can serve as a viable option for qualitative data analysis, particularly in settings where access to specialized software is limited or when working with smaller datasets. This aligns with Braun and Clarke's (2006) argument that flexibility in qualitative research methods is vital and that researchers should adapt their tools to fit the needs of their specific research context. Excel offers a familiar and widely available platform for researchers who may not have the resources to invest in an expensive qualitative analysis software.

However, the trade-offs between accessibility and analytical depth must be carefully considered. Although Excel provides a straightforward and accessible means of organizing, coding, and visualizing data, it lacks the advanced features that are often necessary for more complex qualitative research. For studies that require deeper thematic analysis or involve larger datasets, specialized qualitative software offers significant advantages in terms of efficiency, accuracy, and the ability to explore more complex relationships within the data.

5 Conclusions and Recommendations

In conclusion, this study supports the idea that Excel can be effectively leveraged for qualitative data analysis, particularly in small-scale studies and resource-limited settings. However, the limitations of Excel, particularly in terms of manual coding and advanced visualization capabilities, suggest that it may not be the best tool for more complex qualitative research. Although Excel offers an accessible entry point for qualitative analysis, researchers should consider transitioning to specialized software as their datasets grow or analytical needs become more sophisticated. This balance between accessibility and complexity reflects the broader consensus in the literature that while generalist tools such as Excel can be adapted for qualitative research, specialized software remains essential for in-depth qualitative analysis in larger or more complex studies.

Based on these findings, it is recommended that Excel be utilized because of its strengths in performing fundamental qualitative analyses, particularly in the initial stages of research. Before transitioning to more advanced tools such as NVivo or ATLAS. ti, it should be considered a valuable starting point. Excel offers a practical alternative to conducting meaningful qualitative analyses in resource-limited settings. Additionally, its effectiveness in organizing and storing qualitative data makes it an essential tool for systematically arranging data for future analysis. Researchers should maximize Excel's potential, especially in contexts where traditional qualitative tools are inaccessible.

Data Availability: The data used in this methodological paper can be provided upon request.

Conflict of Interest and Ethics: On behalf of all authors, the corresponding author states that there are no conflicts of interest. The ethical committee approval was obtained from the Research Ethics Committee (REC) of the Mbarara University of Science and Technology (MUST) under the code MUST-2024-1519.

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