

Navigating Real-World Complexity: A Guide to Multiple Case Studies in Engineering Education Research

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INTRODUCTION

The evolution of engineering education has significantly influenced the research methodologies employed by scholars in the field. Within the field, researchers use a diverse range of methodologies such as quantitative methods, qualitative methods, mixed methods, and synthesis methodologies [1]. While quantitative methods have traditionally been the most popular, there has been an increase in the adoption of qualitative methods [2].

Qualitative research is driven by a desire to explain social behavior and thinking by studying the meaning of people's lives with a priority of representing the views and perspectives of the people participating in a study [3]. Although a unified qualitative research methodology does not exist, there are specialized types of qualitative approaches or methodologies including: action research, art-based research, autoethnography, case study, discourse analysis, ethnography, grounded theory, narrative inquiry, and phenomenology [3], [4]. Given the diverse approaches to qualitative research, Case and Light [4] discuss the consequences of the absence of explicit methodological discussions in engineering education literature. The authors highlight that limited methodological discussion often leads to the acceptance of a particular methodology as a given, implicitly assuming it to be the right one [4]. Despite the acknowledgment that "there is not a right methodology or even a right set of methodologies" [p. 189], the choice of methodology is contingent upon the specific research questions one aims to address, and it is crucial to show how the theoretical framework corresponds with the research design, data analysis, and the resulting implications [5].

Specifically, the case study approach involves deep exploration of a specific individual, group, event, or phenomenon in its real-life context [6]. Meanwhile, multiple case studies, a variation of this approach, also offer several advantages as a methodology. Employing a case study is especially helpful when the researcher addresses descriptive or explanatory questions, identifies clearly defined cases with well-established boundaries and aims to deeply explore these cases or conduct a comparative analysis across multiple instances [7]. This conference manuscript aims to provide guidance on when to use this approach and summarize key methodological aspects related to the design, planning, analysis, interpretation, and reporting of case studies. Acknowledging the importance of discussing the role of epistemology, we incorporate various views from renowned scholars in case study research, including Robert Yin [8], Sharan Merriam [9], and Robert Stake [10], [11].

This paper is structured around two main sections, in the Background the paper answers two questions 1) What is a case study? and 2) What is a multiple case study? Meanwhile, the Key procedures of conducting a multiple case study describes five key procedures for conducting a multiple case study. The manuscript draws on published examples of case studies in the Journal of Engineering Education. It is through the exploration of these two sections that we hope to initiate a conversation on the application of multiple case studies in qualitative engineering education research.

BACKGROUND

What is a case study?

The literature contains various definitions and descriptions of case study research (Table 1), leading to potential confusion when trying to comprehend it [12], [13], [14], [15]. Stake [16] suggested that opting for a case study is less about selecting a methodology and more about deciding what subject matter is to be examined, while others authors describe case study as a method of inquiry, a research methodology, or a comprehensive investigative approach [8], [9]. Despite the lack of agreement in its definition, what principally differentiates case study methodology from other approaches lies primarily in its concentrated examination of a defined system, a case, which can be: an individual; a particular program; a process, an institution; or a relationship [15]. In this sense, Merriam [17] offered the following helpful example:

“a study of how older adults learn to use computers would probably be a qualitative study but not a case study, the unit of analysis would be the learners’ experiences, and an indefinite number of older adult learners and their experiences using computers could be selected for the study. For it to be a case study, *one* particular program or *one* particular classroom of learners (a bounded system), or one particular older learner selected on the basis of typicality, uniqueness, success, and so forth, would be the unit of analysis” [9, p. 41].

Qualitative case studies can be characterized by three main tenets. First, qualitative case studies are particularistic, meaning that they concentrate on a specific situation, event, program, or phenomenon. Second, qualitative case studies are descriptive, aiming to provide a comprehensive and detailed description of the phenomenon under study. Finally, qualitative case studies are heuristic, as they illuminate the reader’s understanding of the phenomenon by providing insights, lessons, or recommendations [9].

Table 1 Definitions of case study

Author	Definition
Merriam [9]	A case study is an intensive, holistic description and analysis of a single entity, phenomenon, or social unit (p. 34)
Stake [10]	Case study is the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances (p. xi)
Yin [8]	A case study is an empirical method that investigates a contemporary phenomenon (the “case”) in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident (p. 15)
Creswell [18]	A case study is an important type of ethnography (p. 465)

Three influential authors, Robert K. Yin [8], Sharan Merriam [9], and Robert E. Stake [10], [11], offer guidelines for conducting case study research, however, each of these authors presents a distinct characterization of the case study approach. Merriam characterized qualitative case studies in two groups, based on their discipline orientation (ethnographic, historical,

psychological, or sociological case study) and based on overall intent (descriptive, interpretive, or analytical, evaluative, or multiple case study). Meanwhile, Stake [10] categorizes case studies into three types, intrinsic case study, instrumental case study, and collective case study. Finally, Yin [19] categorizes it into three types, exploratory, descriptive, and explanatory. While the terminology and classifications may vary, the overarching value of case studies lies in their ability to provide rich, contextualized insights into complex phenomena within real-world settings.

Applications of case study research in education and engineering education

Case studies can be employed in educational research to enrich our comprehension of contexts, communities, and individuals [20]. According to Yin [7], case studies in education can examine various phenomena, such as the challenges faced by students; the dynamics of teachers; the effectiveness of educational programs; transformative efforts of particular schools; practical implications of policies within educational systems; and the impact of partnerships.

In the context of engineering education, case studies have been used to explore for example, how the COVID-19 pandemic impacted the academic workload perceptions of engineering instructors and students [21], the case study was developed in the School of Engineering at Pontificia Universidad Católica de Chile. Another example investigates the utilization of engineering talk by Mr. Evans, an experienced a middle school life science teacher from the Midwestern United States during an engineering design-based STEM integration unit [22]. These examples show the use of a bounded system, which provides a structured approach for conducting comprehensive analysis and acquiring understanding into complex educational phenomena.

What is a multiple case study?

Table 2 Definitions of multiple case study

Author	Definition
Merriam [9]	“...collective case studies, cross-case, multicase or multisite studies, or comparative case studies...involves collecting and analyzing data from several cases” (p. 40)
Stake [10]	Collective case studies comprise several instrumental case studies “The multicase project is a research design for closely examining several cases linked together” (p. v)
Yin [8]	A multiple-case study occurs when a study may contain more than a single-case.

Multiple case studies offer a valuable variation of the traditional case study methodology, allowing researchers to gather data from several cases and conduct comparative analyses to explore variability across different contexts (Table 2). The advantage of utilizing multiple case study is that the greater number of cases examined and the greater diversity among them, the more compelling an interpretation is likely to be [17]. According to Yin [8], there are two primary types of multiple case designs: literal replication, which aims to predict similar results, and theoretical replication, which anticipates contrasting results for foreseeable reasons. The

decision regarding the number of cases necessary depends on the type of design; Yin [8] suggests that for literal replication, two or three cases suffice, while for theoretical replication, researchers should aim for five or more cases. Stake [11] mentioned that multiple case study often have fewer than 4 cases or more than 15 cases, while Schoch [23] argues that three to four distinct cases for comparison is a more realistic approach. In sum, despite potentially necessitating more resources and time, the multiple case study design may be preferable over the single case study design [8].

Applications of multiple case study research in education and engineering education

Multiple case study methodology has been extensively employed in educational research, encompassing a diverse range of topics. For example, to study faculty members' technology adoption [24], to analyze faculty attitudes and design through course feedback [25], to explore school counselors' stress experiences in rural areas, and to investigate occupational stress with two faculty members and two administrators from a Texas University [26]. These studies demonstrate the value of this approach in providing comprehensive understandings into complex educational phenomena, enriching both theory and practice in the field.

In the context of engineering education, multiple case studies have seen limited use. Some examples have included: to examine relationships between organizations considering three specific school divisions and corresponding industry partners; focusing on integrating engineering education into middle school curriculum [27] (see Table 3 for more details) and to study the role of social capital in the experiences of Hispanic woman in engineering majors from the University of Houston [28] (see Table 4 for more details). While multiple case studies in engineering education have been employed to a limited extent, they have been applied to investigate relevant topics within the field, such as organizational dynamics, curriculum integration, social influences on underrepresented groups, and professional experiences in academia.

Table 3 Example of a multiple case study investigating interorganizational relationships focused on middle school engineering education [27]

Context: Partnerships among engineering industry, universities, and school systems to support learning appear promising, but there is still a gap in our understanding about how to establish these partnerships for mutual success.
Research question: In a public–private partnership to integrate engineering into middle school science curriculum, how do stakeholder characterizations of the collaborative process align with existing frameworks of interorganizational collaboration?
The case: The authors applied qualitative, embedded multiple case study to investigate the evolution of the first year of a multiyear collaboration involving public educational systems and science and engineering companies. Their embedded multiple case study design consisted of three cases: (1) South County and Cornerstone Industry, (2) Springfield County and EchoCorp, and (3) New County and Deltax Corporation.
Data collection: 76 semi structured interview from 49 participants.
Analysis: Within the case analysis though holistic coding techniques. Cross-case analysis to mapping similarities and differences across cases.

Table 4 Example of a multiple case study investigating the role of social capital in the experiences of Hispanic woman in engineering majors [28]

Context: A better understanding of factors influencing female and minority engineering students' academic and career decisions is particularly critical if engineering education personnel are to design and implement successful strategies to recruit, retain, and enhance the career development of underrepresented students.
Research question: For Hispanic women whose parents have limited educational attainment, what available sources of potential social capital do they identify, and by what means do they access and activate these resources in their decisions to select and persist in engineering as a college major?
The case: The authors employed a multiple case study research methodology with the individual as the unit of analysis. Four engineering students from the University of Houston, who possessed several common characteristics: female, Hispanic background, and children of immigrants.
Data collection: Semi-structured interviews.
Analysis: Within the case analysis through thematic coding, and cross-case analysis to determine major findings.

The importance of research epistemology in case study research

Understanding the epistemological differences among authors in case study research, which is the philosophical assumptions about what constitutes knowledge [15], is crucial. Epistemology influences their methodological approaches, making it essential to consider when evaluating and applying their work and ensures alignment with your own epistemological beliefs. To illustrate, let's examine the epistemological beliefs of three main methodologies within case study research.

Robert K. Yin [8]:

Yin's epistemology was described as realist—postpositivist [13] or with a positivistic orientation [14]. Although Yin did not explicitly articulate his epistemological orientation in his book [8], he acknowledges the existence of a single reality and emphasizes understanding this reality through case study research [8]. Consequently, he notes that his book might not provide comprehensive guidance for adopting a relativist or constructivist approach in case study research [19].

Sharan Merriam [9]:

Merriam's epistemology has been labeled as pragmatic constructivist [13] or constructivism [14]. In her book, Merriam states that research focuses on discovery, insight, and understanding from the perspective of those being studied [9]. From her perspective, qualitative researchers are interested in understanding the meaning people have constructed, how they make sense of their world and the experiences they have in the world. She clearly states that "reality is not an objective entity; rather, there are multiple interpretations of reality" [10, p. 22]. This perspective suggests a rejection of the notion of an objective reality, advocating instead for multiple interpretations of reality.

Robert E. Stake [10], [11]:

Stake's epistemology has been labeled as relativist—constructivist/interpretivist [13], [14]. Constructivism suggests that knowledge is actively constructed by individuals based on their experiences, interactions, and interpretations of the world around them [15]. Finally, Stake describes himself as a qualitative researcher, with an emphasis on interpretation [10].

The philosophical diversity discussed in this section serves as a starting point for researchers interested in employing case study research methodology. We argue that the robustness of research lies in the researcher's introspection regarding their philosophical comprehension of knowledge and truth, as well as the intended objectives of the study, prior to determining the methodological approach to adopt [29]. This includes consideration of the epistemological perspectives of the authors who developed that methodology and how their epistemological beliefs align with the researcher's own.

Consequently, we believe this section should close with a brief description of the first author's (who wrote this section) epistemological beliefs and how they impact the way she approaches case study research. As a PhD candidate and novice scholar, epistemologically I position myself as subscribing to the constructivist/interpretivist paradigm. The interpretive perspective acknowledges that reality is socially constructed and recognizes the existence of multiple interpretations and understandings of a given phenomenon [30]. Due to this philosophical stance, I find myself epistemologically discordant with Yin and much more consonant with Merriam and Stake. However, because we acknowledge Yin's contributions to conceptualizing case study research, the following section includes some definitions and comments from Yin's work.

In summary, this section has clarified the definitions of single and multiple case study methodologies, supported by illustrative examples in engineering education, while also emphasizing the significance of epistemology in shaping research approaches. As we move forward, the subsequent section explores the essential procedures for conducting a multiple case study. Building upon this foundation and using examples from engineering education (Table 4 and Table 5), we aim to provide practical guidance for researchers to effectively navigate the complexities of this methodology and ensure methodological rigor in their studies.

KEY PROCEDURES OF CONDUCTING A MULTIPLE CASE STUDY

Five key procedures for conducting a multiple case study are described in the following: (1) Designing the multiple case study, (2) Case Study Sample Selection, (3) Data collection, (4) Data analysis, and (5) Assuring quality.

Designing the multiple case study

Initially, researchers need to assess the suitability of employing a case study methodology to investigate the research problem. As it was mentioned in the last section, multiple case study is suitable when the investigator can clearly define distinct cases with delineated boundaries, aims to offer a comprehensive understanding of these cases and compare multiple cases [6]. Merriam recommends that to design a multiple case study, it is important to start with a literature review, construct the theoretical framework, and identify the research problem [9].

In conducting a multiple case study, establishing a clear boundary delineating the focus, scope, and temporal framework for each case is crucial. A fundamental aspect in multiple case studies lies in the interrelation of these individual cases. Stake [11] introduces the concept of “Quintain,” which is defined as an object, phenomenon or condition to be studied. It is the umbrella that covers all the single cases. Each case within a multiple case study is relevant because it contributes to the holistic understanding of the Quintain by elucidating similarities and differences [11].

To better understand this section, let’s focus on the example presented in Table 4. Informed by a literature review, the authors emphasize the importance of getting a better understanding of factors that influence the academic and career decisions of female and minority engineering students. They argued that this understanding is critical to design and implement effective strategies to recruit, retain, and improve the career development of underrepresented students in engineering. Guided by the Social Capital Theory as their theoretical framework, the study aimed to investigate the role of social capital in shaping the experiences of Hispanic women within engineering majors (Quintain). To comprehend this overarching phenomenon, the authors meticulously outlined four distinct cases. Each case represented a distinct exploration into the experiences of Hispanic women students within engineering, contributing to a comprehensive understanding of role of social capital in their educational and professional journeys.

The design of a multiple case study is a meticulous process that begins with assessing the suitability of the methodology for the research problem at hand. It involves a thorough literature review, construction of a theoretical framework, and identification of the research problem. The example provided illustrates how a multiple case study can be effectively utilized to investigate complex phenomena, such as the factors influencing the academic and career decisions of underrepresented groups in engineering. Through careful delineation of four distinct cases, researchers can provide a comprehensive understanding of the role of social capital in shaping the experiences of Hispanic women within engineering majors.

Case Study Sample Selection

The second step in conducting a multiple case study involves the selection of cases. After identifying the quintain, the process proceeds with purposeful case selection, aimed at gaining a deeper understanding of the phenomenon of study. When deciding which cases to investigate, various strategies for purposeful sampling come into play. These strategies include Maximum Variation, Criterion, Snowball, Intensity, Critical Case, Typical Case, Negative/Disconfirming Case, and Theoretical/Conceptual sampling [15].

Literature suggests some criteria for selecting cases. Stake [11] recommends that there are three main criteria for selecting cases: the cases have to be relevant to the quintain, the cases should provide diversity across contexts, and the cases should provide good opportunities to learn about complexities and contexts. Similarly, Merriam [9] reminds that the cases need to be selected based on relevant criteria, which means the researcher must first determine what selection criteria are essential in choosing the people or sites to be studied [17]. The criteria you establish

directly reflects the purpose of the study and guide in the identification of information-rich cases [17].

Additionally, in case study research, it is important to consider two levels of sampling [9]. Firstly, the researcher identifies the case, which can be a person, a program, a university, among others. Secondly, within each case exists numerous sources of data, so the researcher needs to select how to better approach that decision to better understand or explore the phenomena under investigation. Lastly, one important consideration when selecting cases is accessibility, which means selecting cases based on willingness to participate, logistics, and resources [11].

To better understand this section, let's focus on the example presented in Table 3. The urge to improve education in STEM (science, technology, engineering, and mathematics) education, particularly in engineering, poses significant challenges for precollege education. Collaborations between engineering industries, universities, and schools show promise in supporting learning outcomes, but current research lacks a strong theoretical understanding in interorganizational collaboration. This study aimed to investigate the relationships between organizations, focusing on integrating engineering education into middle school curriculum. The research question for the study is: "In a public-private partnership aimed at integrating engineering into middle school science curriculum, how do stakeholders' perceptions of collaboration align with established frameworks of interorganizational collaboration?" [27, p. 546] To answer this question, the researchers used a purposeful sampling approach to select three cases—one for each school division and its corresponding industry partner, bounded by the first year and their geographical location. The criteria to select those cases were clearly stated:

- The schools participating in the research represent rural school districts nationwide. These communities encounter distinct obstacles concerning readiness for higher education and future career opportunities, including the fundamental idea of integrating engineering into their everyday experiences. Moreover, these counties serve as typical examples of challenges encountered in rural areas, such as poverty and limited educational achievement.
- The selected industry partners for this study are suitable as they typically embody a significant and influential technical workforce within the community.

Additionally, the authors highlighted that while the rural contexts share similarities, the diverse personal and professional backgrounds of participants make each case unique.

In conclusion, the process of selecting cases for a multiple case study is a critical step that directly influences the quality of the research findings. The example illustrates the meticulous approach required in case selection. The criteria for selection not only address overarching research goal but also recognize the unique characteristics within each case, potentially increasing the value of the analysis.

Data collection

The third step in conducting a multiple case study involves the data collection. Methodologically, case studies are characterized by a desire for greater detail, and depth description. In

consequence, these studies often employ a variety of data collection strategies. Yin [8] outlines several potential techniques for data collection in case study research, including documentation, archival records, interviews, direct observations, participant observation, and physical artifacts. Stake [10], [11] and Merriam [9] emphasize the significance of observations, interviews, and document reviews in enriching case study analyses.

The choice of data collection techniques should align with the theoretical framework, the purpose of the research and the unique characteristics of the study [9]. By carefully considering these factors, researchers can modify their data collection strategies to ensure a comprehensive and detailed understanding of the case under investigation. Stake [10] promotes the development of a detailed data gathering plan. This plan should include key elements such as clearly defining the case, formulating research questions, identifying potential collaborators, specifying data sources, allocating adequate time and resources, and delineating the intended approach for reporting the findings. This highlights the importance of careful planning and organization in the data collection phase, which will contribute to the overall rigor and reliability of the case study research.

To better understand this section, let's focus on the example presented in Table 3 and Table 4. In the first example, the authors chose semi structured, open-ended interviews as data collection technique. A total of 76 semi structured interviews of 30–60 minutes were conducted with before the first classroom lesson and after the last one. In the second example, the authors one-on-one interviews were recorded with each of the four participants. Additionally, answers from a survey were used to triangulate social capital data from the interviews for the four case study participants.

In conclusion, the data collection phase of a multiple case study is essential for obtaining detailed information. Various techniques, including documentation, interviews, and observations, might be used to gather rich data aligned with the study's purpose and theoretical framework. While it is possible to find many published case studies supported by only interviews, as the example in presented in Table 3, this strategy is not recommend it [31]. The ability to obtain sufficient data to provide an intensive and holistic description of the unit of analysis, should be a consideration when deciding whether case study is the appropriate methodology to use. Therefore, when researchers are limited to obtaining a single source of data, the recommendation is to choose another qualitative methodology [31].

Data analysis

The fourth step in conducting a multiple case study involves the data analysis. Synthesizing a coherent interpretation from the potentially substantial volume of data collected data be a significant challenge. Literature recommends approaching data analysis simultaneously with data collection [9], emphasizing the importance of an integrated and iterative process to ensure depth analysis.

In case study research, there is not universally correct or incorrect approach to data analysis. As outlined by Yin [8], potential techniques for data analysis, encompassing both quantitative and qualitative methods, include pattern matching, explanation building, time-series analysis,

program logic models, and cross-case synthesis. Stake [10] emphasizes the dual methodological approach of direct interpretation for individual instances and aggregation of instances to draw broader conclusions and generalize findings to a broader context or class of cases. Furthermore, Merriam [9] emphasize the flexibility of data analysis in case study, mentioning techniques such as ethnographic analysis, narrative analysis, phenomenological analysis, constant comparative method, content analysis, and analytic induction.

Particularly, for multiple case study two stages of analysis: within-case analysis and cross-case analysis [9]. The first one relates to a detail examination of single case studies, requiring comprehensive case reports that capture all significant information for subsequent cross-case analysis. Cross-case analysis involves a review of the single-case reports and the examination of notes compiled by researchers throughout the analysis process. The main goal of the second stage is to construct abstractions that transcend individual cases, fostering a broader understanding of patterns, similarities, and variations across the entire dataset [9].

Some general recommendations to approach data analysis within multiple case study are:

- a) Outlining themes that align directly with the research questions and theoretical framework, providing a structured foundation for the subsequent analytical phases [11].
- b) Identifying one unique individual to organize the completion of the multiple case study report, despite the potential involvement of multiple researchers in the data collection phase of single case studies [11].

Lastly, because of the nature of multiple case study research, the analysis process may encounter challenges due to the substantial volume of data involved. Establishing a systematic approach to organizing data from the inception of the collection process becomes paramount to navigating this challenge effectively [9].

To better understand this section, let's focus on the example presented in Table 3 and Table 4. In the first example, the authors structured their analysis around the theoretical framework, ensuring alignment with the study's conceptual foundations. Due to the multiple participants in the study, the authors run into a substantial volume of interview transcripts. To navigate this data, they employed qualitative analysis using holistic coding techniques. Their approach was meticulous, documenting analysis and interpretation procedures, including the development of memos and a statement addressing researcher bias. Specifically, their focus on cross-case analysis allowed them to derive conclusions that transcended individual cases.

In the second example, the authors initially conducted within-case analysis, thoroughly exploring individual cases. They provided detailed descriptions of each case, supported by pertinent interview quotes. Subsequently, they engaged in cross-case examination, organizing their findings into three themes that directly addressed the research question. This sequential approach ensured a comprehensive examination of each case while also facilitating the identification of overarching patterns and themes across cases.

In conclusion, conducting data analysis in multiple case studies is a involves two main stages: within-case analysis and cross-case analysis. In each of those stages, researchers can use various approaches to analyze data depending on the research questions and overall design of the study.

Assuring quality

The last step in conducting a multiple case study involves assuring quality. Generate knowledge that is both valid and reliable is a crucial element in research. Merriam [9] emphasizes three key concepts for quality assurance: internal validation, assessing alignment with real-world context; reliability, ensuring consistent replication of findings; and external validation, examining generalizability to diverse situations. Additionally, Stake [11] introduces triangulation to enhance research clarity and objectivity by minimizing biases and offering a comprehensive understanding of findings. Regardless of the chosen approach, ensuring quality is imperative in any study.

Literature has suggested several strategies or recommendations aimed to enhancing the validity and reliability of qualitative research, as the utilization of seeking feedback from colleagues, clarifying research biases, maintaining an audit trail, member checking, extended data-gathering period, multiple investigators, diverse data sources, or varied research methods to corroborate emerging findings [9].

For the context of engineering education, the framework proposed by Walther et al., [32] present a great and systematic approach for validation. The authors suggest that the research process consists of two primary stages: making the data and handling the data. They propose five categories of analysis, theoretical validation, procedural validation, communicative validation, pragmatic validation, and process reliability. In the example presented in Table 3, the authors utilized the qualitative research quality framework for engineering education by Walther et al., [32]. The definition of five categories of analysis [32] and detailed overview of the specific strategies implemented in the study are presented in Table 5.

Table 5 Descriptions of data quality constructs and specific study strategies

Criteria	Making the data	Handling the data
Theoretical validation assesses the alignment between the social reality being investigated and the theory produced.	Purposeful case selection and construction.	Combination of both deductive and inductive analysis techniques.
Procedural validation involves incorporating features into the research design to improve this alignment.	Triangulation and researcher bias statement.	Researcher bias statement (interpretive awareness)

Communicative validation accounts for the co-construction of knowledge in the social context under investigation and within the research community.	Informal member checking and considering contrasting accounts.	Peer debriefing, ensuring the connection between theory and literature, and using the language of the discourse community.
Pragmatic validation examines the compatibility of theories and concepts with empirical reality.	Diversity of participants.	Promoting transferability through detailed descriptions of context and assessing applicability of results through programmatic activities.
Process reliability ensures that the research process is as independent from random influences as possible and provides the necessary conditions for developing overall validation.	Transcript checking, interviewer training and data management.	Chronological research journal and levels of analysis explicated through case study design.

In conclusion, ensuring quality in multiple case studies is crucial for generating valid and reliable knowledge. While literature suggests various strategies to bolster the validity and reliability of qualitative research, the framework proposed by Walther et al. [32] provides a systematic validation approach with five key analysis categories to consider.

Conclusion

The primary objective of this methodological paper was to initiate a conversation on the application of multiple case studies in qualitative engineering education research. By exploring the perspectives of case study scholars, including Robert K. Yin, Sharan Merriam, and Robert E. Stake. The paper aimed to provide a comprehensive guide for researchers contemplating the use of multiple case studies as a methodology for their studies.

Multiple case studies offer a robust approach for understanding complex real-world phenomena. By analyzing data from various cases, researchers acquire intense understanding through cross-case analysis. Careful selection of cases, alignment with theoretical frameworks, and diverse data collection methods are essential in this process. Data analysis involves within-case and cross-case analyses to identify patterns and themes. Lastly, the framework proposed by Walther et al., [32] present a great and systematic approach for validation.

In conclusion, this methodological paper aimed to guide researchers, particularly those transitioning from quantitative backgrounds to qualitative methodologies, in understanding the complexities of case study research and, more specifically, the application of multi-case studies in the field of engineering education.

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