

A Preliminary Scoping Literature Review on Mixed Methods in RUME

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Through a scoping literature review of 40 RUME studies from 2019 to 2024, we examined how researchers use and describe mixed methods. We categorized these studies by country, subject area, and self-reported implementation process (e.g., sequential, parallel), methodological priority (qualitative or quantitative), and study design (exploratory, explanatory, triangulation). While mixed methods are used in RUME, we found that only half of the studies explicitly define their methodological framework, often missing opportunities to maximize the potential of integrating multiple data sources. Our findings highlight the importance of adopting more nuanced and deliberate mixed methods approaches to fully exploit the strengths of both qualitative and quantitative research in advancing the field.

Keywords: mixed methods, RUME

Much of the research in RUME uses qualitative methods. Artigue (2021) critiqued the field's "excessive predominance of small-scale qualitative studies, involving a very limited number of students or teacher" (p. 14). Our recent survey of the field's creation and use of quantitative measures suggests that RUME scholars do a substantial amount of quantitatively oriented work as well (Melhuish et al., 2024). What may be the case is that qualitative and quantitative researchers are operating in separate spheres. This is sensible when thinking about what kinds of research questions are answerable (broadly) by these paradigms. Questions of comparison or prediction cannot be paired with cognitive constructivist teaching experiments, for example. However, sometimes the weaknesses and biases in one approach (e.g., surveying college instructors about their practices) can be mitigated by the strengths of another approach (e.g., observing classrooms). So, the separation does lead to calls for increasing complementary approaches to investigating phenomena of interest to RUME (e.g., Weber, 2013).

Artigue's critique zeroes in on the *size* of the research sample, which is only one aspect of generating trustworthy information about a research topic – one that matters less for qualitative work than for quantitative. What does matter, quite a bit, is using the sample to get the right kinds of information to address a research question or to obtain convergent information about an issue. Quantitative methods are useful for measuring and aggregating patterns across individuals; qualitative methods aid in interpreting patterns of meaning to individuals. Mixed-methods approaches can draw on both paradigms to "provide a more complete understanding of a research problem than either approach alone" (Creswell, 2014, p. 4). They can answer questions like, "Which group performed better, and why?" or "To what extent does the frequency of negative teacher feedback reflect students' perceptions of their own competency?"

Yet, we do not frequently see these complex, multi-perspective questions posed in the RUME research literature. We became interested in detecting the extent to which RUME researchers had responded to calls to integrate quantitative methods in their work. In this preliminary report, we share a scoping literature review aimed at identifying and classifying the types of mixed methods approaches RUME researchers report they use. We share both how researchers describe their own work and the degree to which they are explicit and specific about the methods they use.

Background

An historical definition of mixed-methods research is an inquiry that includes “at least one quantitative method (designed to collect numbers) and one qualitative method (designed to collect words)” (Greene et al., 1989, p. 256). Contemporary descriptions recognize that qualitative methods are not merely about words-as-data and that there can be many configurations for how the qualitative and quantitative information are treated, relative to their level of integration and relative to their centrality to the research question. For example, qualitative inquiries in RUME include questions about the meanings teachers hold for equitable participation in a mathematics classroom, gestures that calculus students use to express changing rates, or the mental operations that produce novel quantities. Some methodologists have attempted to classify mixed-methods research approaches based on whether qualitative or quantitative data sources are given more prominence, whether data are sourced concurrently or not, and whether the analysis treats data from different sources in parallel, in sequence (and if so, in what order), in an integrated manner, an embedded manner, or seeks to convert one form to another (Buchholtz, 2019; Creswell, 2014). Each of these descriptive criteria for the methods used in a study is important because they correspond to analytic decisions which govern which research questions can be answered.

Types of Mixed Methods Approaches

Here, we focus on major descriptive features (Creswell et al., 2011); for the implementation process (concurrent, parallel, conversion), purpose of the study (exploratory, explanatory, development, triangulation, conversion, initiation, etc...), and priority of the methods (qualitative or quantitative). Priority is often indicated by how the researchers frame the study. A study meant to test relationships among variables that were created from written responses likely gives priority to quantitative methods. A study that uses a survey to identify individuals who hold certain beliefs about the nature of mathematics, and then conducts oral histories to understand how those beliefs may have formed gives priority to qualitative methods. In each case, one data source is subservient to the other. A related concept in mixed methods is the purpose of the study and how it uses the different data sources. When data sources are used in sequence, the study is usually described as exploratory sequential or explanatory sequential. Exploratory sequential may use qualitative findings to develop an intervention, and then test the intervention’s efficacy. This can be a useful approach when variables to include in the intervention are not known *a priori*. Explanatory sequential first collects and analyzes quantitative data, then digs into particular cases qualitatively to explain why quantitative patterns might exist. One can easily imagine that an ANCOVA comparing an IBL approach to teaching proof to a “business as usual” classroom would seem rather dry without examining paradigmatic cases of student reasoning that lead to one classroom outperforming the other. Data sources might also be analyzed in parallel, where the purpose is to establish multiple threads of evidence in favor of a claim. For example, measurement validity studies often seek multiple sources of information like open and closed form responses and clinical interviews about the items to ensure that items are behaving well. In other writings, this is *convergence* or *triangulation* (Flick, 2014). Evaluation studies might choose to use qualitative methods to analyze processes in parallel with quantitative methods to measure outcomes. In such a case both pieces may be given equal priority and address separate but related research questions about how an intervention is working in a setting. A particular approach to mixed methods research that is common in education and the social sciences is *conversion* of one data type to another data type. When the conversion is from qualitative to quantitative, the process is referred to as *quantizing*, where nominal or ordinal values are assigned to data that was initially conceived as non-numerical (Sandelowski et al., 2009). For

example, a classroom lesson could be analyzed using content analysis or constant comparison according to a conceptual framework, then assigned a count-based or time-based frequency and analyzed quantitatively.

Uses of Mixed-Methods in Mathematics Education Research

Mixed methods are not uncommon in mathematics education research or education research more broadly. Several researchers have examined the prevalence in particular journals including JRME (36% of articles from 1995-2005, Hart et al., 2009; 34% from 2006-2010, Ross & Onquegbuzie, 2012), ESM (17% from 1995-2005, Hart et al., 2009) and JMTE (22% 1995-2005, Hart et al., 2009). These researchers also argued, “Mathematics education researchers appear to utilize lower levels of quantitative analysis complexity, when used alongside qualitative procedures” (Ross & Onquegbuzie, 2014, p. 71) with majority of the mixed methods articles using only descriptive statistics. A cursory look at RUME proceedings from 2023 reflects a smaller number of mixed methods studies. Of the 151 papers, 9 stated they used mixed methods of some sort. However, we caution this small number but may reflect that proceedings may contain portions of studies.

Methods

Although typologies of mixed methods are useful for organizing and contrasting various approaches, especially for researchers new to thinking about mixing methods, they have limited utility for guiding mixed methods research due to the emergent needs for adjusting the procedures as the data sources are collected and analyzed (Poth, 2023). Nonetheless, we use a few dimensions of common typologies to help organize the RUME literature that purports to use mixed methods. For our scoping study, we limited our literature search to a five-year span (2019-2024) and to the twenty mathematics education research journals identified by (Williams & Leatham, 2017). To focus more on RUME, we also included the *International Journal of Research in Undergraduate Mathematics Education*. Our main search term was “mixed methods” anywhere in the text. We used Publish or Perish citation software to pull all 459 matching articles. We then preserved any article that explicitly purported to use mixed methods, included quantitative *and* qualitative data sources, and used a RUME sample. By RUME sample we mean undergraduate mathematics students or instructors. A total of 40 articles met these criteria. For each article, we then used a simplified blend of typologies from Teddlie and Tashakkori (2006) and Creswell & Clark (2011) to classify articles according to the following simplified criteria: (1) whether they cited a mixed methods article or methodological text to justify their approach, (2) which implementation process (sequential, parallel, conversion), (3) gave primacy to qualitative or quantitative methods (4) the research design (explanatory, exploratory, triangulation, complementary, experimental design). We note, we did not infer these designs nor evaluate if their goals were met, but rather report what was shared by the research team.

Preliminary Results

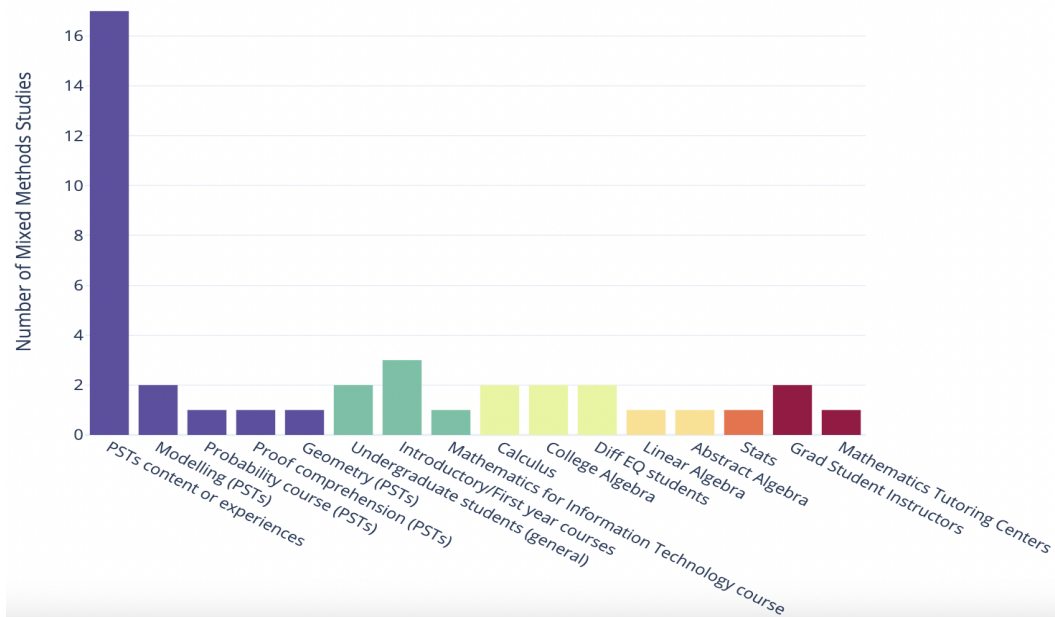


Figure 1. Distribution of $N = 40$ mixed-methods studies in RUME, across content areas and populations

We identified forty articles that met the criteria of being self-described as mixed methods and studying a population of undergraduate mathematics students or instructors. Slightly over half of the studies were conducted in the United States (21) with the remaining 19 spanning 12 countries (Iran, Finland, Australia, New Zealand, Vietnam, Germany, Turkey, Spain, Canada, Israel, South Korea, and Norway). The studies' focal content (which often entails a population/sample) can be found in Figure 1. Note that pre-service teacher content and experiences dominate the mixed methods studies. We conjecture that the mixed methods may be more reflective of teacher education researcher methods than the RUME community. If we removed studies with this focus, we would eliminate over half of the manuscripts.

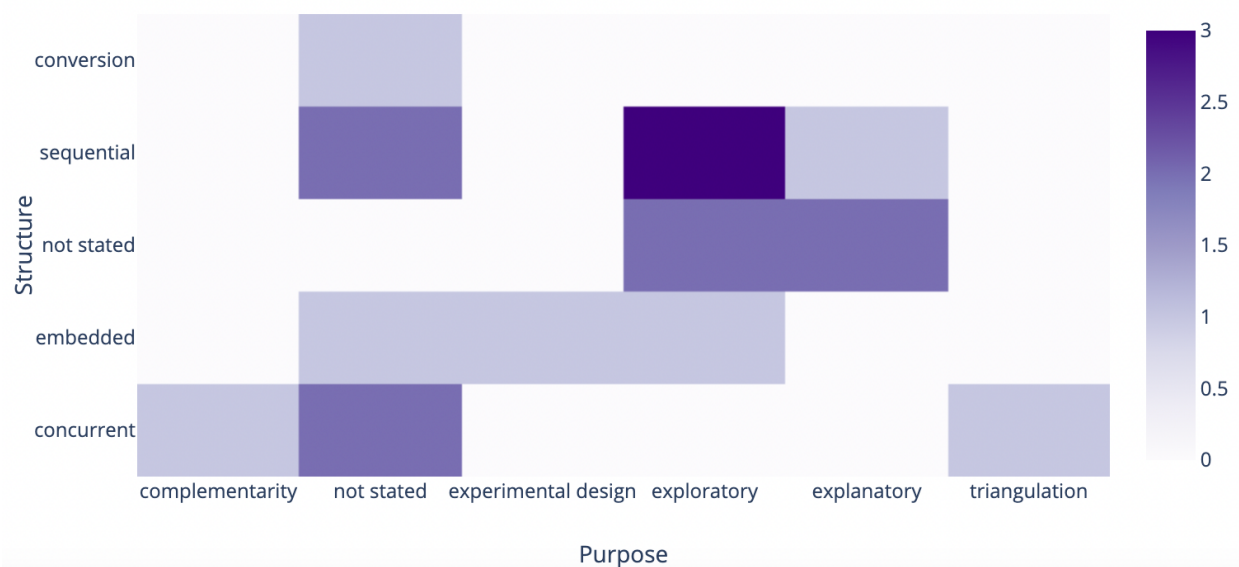


Figure 2. Heatmap of Purpose and Structure for the 20 Studies Explicating That Information

The most cited author was Creswell with 14 citations, followed by Yin with three, and Teddlie and Tashakkori with two. Of the forty articles, only half (20) explicated their mixed methods typology in any way beyond stating it was a mixed methods study. Several studies pointed to the mixed methods being embedded into other methodologies including one instance of instrument validation (Donovan et al., 2024), one “conceptual replication of a quasi-experimental study” (Yudt et al., 2024), and three case studies (Ellis et al., 2021; Galligan et al., 2019; Johns et al., 2023). Two studies indicated their larger approach was “longitudinal” (Woolcott et al., 2021) or “pseudo-longitudinal” (Safrudiannur, et al., 2022).

An overview of the 17 mixed methods studies that addressed their typology can be found in the Figure 2. Not that the most frequent type was exploratory sequential and only occurred three times. Note, an additional three studies mentioned the dominance of qualitative or quantitative data: two equal status and one qualitative dominated. Finally, we note one study (Yee et al., 2024) described their methods as an “integrated generalization design” (Srnrka & Koeszegi, 2007), labeled as conversion in the above figure.. This design is two stages and involves qualitatively coding dating, then quantifying these results in order to conduct statistical data analysis. Sometimes this structure is referred to as “quantizing” (Morgan & Hoffman, 2021) where qualitative data is converted to numbers, typically through counting. While it is a common approach in our field, it requires careful attention to sampling and generalization to make inferences from such an approach (Czoher & Melhuish, 2024).

Discussion

This preliminary analysis illustrated that RUME researchers are using mixed-methods, but often with little attention to unpacking key elements of the methodologies. Mixed-methods can be positioned as a way to avoid the limitations of using qualitative or quantitative approaches alone; however, they also introduce tensions and require careful attention to methodological details and theoretical assumptions. Quantitative approaches grew out of positivist and post-positivist paradigms, whereas qualitative approaches typically (though not exclusively) arise from constructionist or interpretivist paradigms. One key distinction is that qualitative approaches, especially naturalistic or interpretive ones, do not share the expectation of objectivity or the supremacy of the researcher’s perspective over the research subject’s perspective. As Denzin and Lincoln (2005) sharply observed: “The mixed-methods movement takes qualitative methods out of their natural home, which is within the critical, interpretive framework” (p. 9).

Guetterman et al. (2017) looked for Mixed Methods-Grounded Theory studies (“across disciplines”) and found that (1) lacking methods detail (2) lack of actual theoretical development (3) most were convergent mixed methods design, as opposed to sequential/exploratory designs. This finding comports with our own perception, as readers of mixed methods studies in mathematics education, that often “mixed methods” implies a coding procedure followed by reporting descriptive statistics for the frequencies of coded segments in the categories. This does not “reach the full potential” (Guetterman et al., 2017, p. 180) of mixing grounded theory, to say the least, let alone reaching the full potential of mixed methods more broadly.

Given the prevalence of grounded theory-based approaches to data analysis in RUME, it seems that exploratory sequential studies (creating a theory and testing it empirically) would be a natural fit (Smith et al., 2023). Future work can examine the extent to which these kinds of studies are following best practices (Guetterman et al., 2017; Smith et al., 2023) or just following their gut instincts towards the least publishable unit (as discussed in Stewart, 1998).

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