

Learning to replicate in mathematics education

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Introduction

Replication occupies a central place in scientific inquiry because it helps determine whether research findings extend beyond the specific conditions under which they were originally obtained. Across many scientific disciplines, replication has traditionally been regarded as one of the principal mechanisms through which scientific knowledge becomes cumulative (National Academies of Sciences, Engineering, and Medicine, 2019). Findings that can be reproduced under different circumstances provide greater confidence in the research from which they derive, whereas findings that cannot be replicated can stimulate the refinement of theoretical explanations or methodological procedures.

More than fifty years ago, Eastman (1975) questioned why replication studies were so scarce in mathematics education despite their scientific value. Since then, various scholars have continued advocating for greater attention to replication as an indispensable component of cumulative research programs. During the 1980s, French researchers explored issues related to reproducibility by examining the conditions under which instructional designs could produce similar learning effects when implemented in different contexts (e.g., Artigue, 1986). Later, Schoenfeld (2000) identified replicability as one of the characteristics that contribute to assessing the trustworthiness of educational research. More recently, the topic

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has gained renewed visibility through dedicated discussions in international conferences and special issues of leading educational research journals (e.g., *Educational Studies in Mathematics*, 2024; Inglis et al., 2018).

Despite this growing interest, replication studies remain scarce within mathematics education. Several factors help explain this situation. For instance, academic reward systems frequently prioritize originality and novelty, making replication research appear less attractive to researchers seeking publication opportunities or research funding. Published reports often omit methodological details that would enable other researchers to replicate previous work with sufficient fidelity. Furthermore, unlike experimental disciplines where exact replications may be feasible, educational research necessarily involves complex interactions among teachers, students, mathematical tasks, and institutional contexts.

Recent years have witnessed efforts to promote replication research in mathematics education. For instance, the issue on replication studies published by the *Journal for Research in Mathematics Education* (2018, volume 49, issue 1) contributed by presenting theoretical discussions, methodological guidance, and examples illustrating different forms of replication. Likewise, the establishment of the journal *Implementation and Replication Studies in Mathematics Education* (IRME) in 2021 reflects the increasing recognition that replication deserves dedicated publication venues capable of supporting cumulative research traditions within the field.

Although these developments create favorable conditions for replication research, another challenge remains largely unaddressed: many researchers have never received formal training in how replication studies are designed or reported. Graduate programs frequently discuss research design, qualitative and quantitative methodologies, and theoretical frameworks, but replication itself is rarely treated as an explicit topic of methodological instruction. Consequently, many early-career researchers are uncertain about how and why to undertake such studies. The workshop reported in this paper was conceived as a response to this need. Its purpose was not merely to introduce the concept of replication studies, but to provide participants with opportunities to analyze authentic examples, discuss methodological decisions, and begin designing their own replication studies.

Rationale and workshop design

The workshop was designed around the assumption that learning how to conduct replication studies requires more than knowing conceptual definitions. Researchers must develop the capacity to recognize

methodological decisions embedded within published studies, evaluate how those decisions affect the nature of a replication, and justify modifications introduced when adapting previous research to new contexts. This assumption led to the adoption of an instructional sequence organized around four stages:

- Introducing the concept of replication studies in mathematics education;
- Analyzing published replication studies in mathematics education;
- Designing replication studies through collaborative activities; and
- Disseminating the concept of replication studies by discussing publication opportunities and current developments within the field.

Rather than treating these stages as independent components, the workshop integrated them into a teaching trajectory in which each activity prepared participants for the next. The theoretical presentation established a common language that facilitated subsequent group discussions. The analysis of published articles enabled participants to identify how replication decisions are manifested in actual research reports. Finally, the design activity required participants to apply these ideas by constructing an outline for their own potential replication studies.

The workshop also recognized the diversity of participants' research backgrounds. Some participants were doctoral students beginning their research careers, whereas others were more experienced researchers. Consequently, activities were designed to encourage dialogue among participants with different levels of experience. Small-group discussions enabled researchers to compare perspectives regarding what constitutes an appropriate replication, which aspects of an original study deserve preservation, and which contextual adaptations can legitimately be introduced without altering the fundamental research questions.

Another design consideration concerned the relationship between theory and practice. Throughout the workshop, theoretical concepts were connected to concrete examples drawn from published mathematics education research. That is, participants were asked to examine published articles not only for the research findings they report, but also for the methodological reasoning that justified decisions related to the design of replication studies.

Workshop implementation

The workshop began with a presentation introducing the historical development of replication studies within mathematics education research. The presentation highlighted milestones that illustrate how interest in replication has evolved over time. Participants were first introduced to Eastman's (1975) early observation concerning the scarcity of replication

studies in mathematics education. This historical perspective was complemented by examples from the French tradition of didactical engineering, where issues of reproducibility had already been explored through investigations examining whether instructional designs could generate comparable learning outcomes when implemented across different educational contexts (e.g., Artigue, 1986).

The presentation then examined several definitions of replication, emphasizing that replication should not be understood as simple duplication of previous work. Drawing on Firmin's (2008) definition and subsequent discussions within mathematics education, replication was presented as the systematic re-examination of previously published research to evaluate the stability, robustness, or transferability of earlier findings. Different forms of replication were introduced, including close (or direct) replications and conceptual replications, as well as distinctions between internal and external replications that are increasingly used in the literature.

The introductory session also addressed the scientific value of replication studies. Rather than portraying replication as a secondary or derivative form of research, the presentation emphasized its contribution to cumulative knowledge building. Participants discussed arguments advanced by scholars such as Schoenfeld (2018) and Thanheiser (2018), who have argued that replication increases confidence in research findings, reduces confirmation bias, and helps examine the generality of educational theories across diverse populations and instructional settings.

To conclude the introductory presentation, participants examined recently published examples of replication studies in mathematics education (e.g., Hohensee & Borji, 2024). Some studies reproduced previous investigations with relatively minor contextual adaptations, whereas others intentionally modified participants, instructional settings, or theoretical perspectives to investigate the robustness of earlier findings. Examining these examples prepared participants for the collaborative activities that followed by demonstrating how methodological decisions are explicitly justified in published replication reports.

Activity 1: Analyzing published replication studies

Following the conceptual introduction, participants worked in small groups to analyze published replication studies. Each group received a different set of published articles representing various forms of replication. Participants were asked to discuss three central questions. First, they identified the type of replication represented in each article, distinguishing among close, conceptual, internal, and external replications whenever appropriate. Second, they analyzed which elements of the original study had been intentionally preserved and which had been modified. They examined

whether modifications concerned participants, instructional interventions, educational contexts, research instruments, or analytical procedures. Finally, participants discussed the purpose of each replication, considering whether the authors sought to verify previous findings, extend a theoretical explanation, investigate the robustness of an intervention, or examine the applicability of previous results in a different educational context. The activity concluded with a plenary discussion during which groups shared their analyses and compared their interpretations.

Activity 2: Designing a replication study

Whereas the first collaborative activity focused on interpreting published research, the second invited participants to assume the role of researchers designing their own replication studies. Working again in small groups, participants were asked to outline a potential replication project that could realistically be conducted within their own research contexts.

Each group first selected an original study that they considered sufficiently relevant to warrant replication. Groups then identified the principal objective of their proposed replication. A central component of the activity involved distinguishing between elements that should remain unchanged and those that could be modified. Groups were also asked to provide explicit justifications for every proposed modification. Finally, participants identified potential challenges that might arise during the implementation of their proposed studies. These included difficulties associated with reproducing instructional interventions, obtaining access to comparable participant populations, adapting research instruments, ensuring sufficient methodological transparency in the original publication, and interpreting discrepancies between original and replicated findings.

Plenary discussion

The workshop concluded with a plenary discussion intended to integrate insights emerging from both collaborative activities. Among the issues considered were the criteria that distinguish conceptual from close replications, the balance between methodological fidelity and contextual adaptation, and the role of replication in strengthening cumulative knowledge within mathematics education. An outcome of the discussion was the recognition that replication should not be viewed as a secondary form of research that merely confirms previous results. Instead, participants increasingly characterized replication as an opportunity to investigate the robustness, scope, and theoretical implications of existing findings.

Publication opportunities

The final component of the workshop introduced participants to *Implementation and Replication Studies in Mathematics Education (IRME)*, a

journal devoted to publishing implementation and replication research. This presentation emphasized that the emergence of specialized publication venues reflects the increasing recognition of replication as an important research methodology within mathematics education. Participants were introduced to the scope of the journal and to the different forms of contributions it welcomes, including conceptual replications, implementation studies, and methodological discussions concerning replication research. Emphasis was placed on the importance of clearly identifying the original study being replicated, explicitly documenting methodological similarities and differences, and discussing findings in relation to previous research.

Conclusion

Replication studies are increasingly recognized as essential for developing cumulative knowledge in mathematics education, yet opportunities to learn how to conduct such studies remain relatively scarce. The workshop described in this paper sought to respond to this need by integrating conceptual discussion, critical analysis of published research, collaborative design activities, and consideration of publication opportunities into a coherent professional development experience. It is hoped that initiatives such as this one will contribute not only to increasing the number of replication studies in mathematics education but also to strengthening the cumulative character of research in the field.

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