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A Fully Integrated Systematic Review of Mixed Methods Design-Based Research

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Abstract
Design-based research (DBR) is an educational research methodology that is commonly used in the fields of education, instructional technology, and learning sciences. When conducting DBR, researchers collaborate with practitioners (e.g., educators) and other stakeholders (e.g., parents, community members), often including the learners themselves, for the purpose of developing and evaluating innovative solutions to real-world problems within specific contexts, with a primary focus on improving practice and generating practical knowledge. DBR is particularly suited to mixed methods research. However, it is not clear the extent to which mixed methods research approaches are used in DBR studies, as opposed to monomethod research approaches that involve the sole use of qualitative research approaches or the sole use of quantitative research approaches. Therefore, in this study, what we refer to as a fully integrated systematic review of Scopus-indexed works from January 1, 1960 to May 31, 2022 was conducted to determine the prevalence of mixed methods DBR (MM-DBR) studies. This review yielded only 68 published works wherein the author explicitly declared their study as representing some form of a MM-DBR study, with the majority of these MM-DBR studies being published within the last decade. Most notably, for all but 4 of these 68 studies, the level of integration occurred at the low end of the integration continuum, being characterized by mixed methods research designs wherein integration only occurred at the interpretation stage of the DBR process. More than two thirds of the authors (29.2%) neither explicitly specified nor described adequately their mixed methods research design. More than one half (i.e., 56.9%) of the MM-DBR studies were not grounded within the mixed methods research literature to any degree at all. Most notably, for all but four studies (i.e., 5.88%), the level of integration occurred at the low end of the integration continuum wherein integration only occurred at the interpretation stage of the MM-DBR process, representing only partial integration of the quantitative and qualitative research components/phases/cycles. As such, we call for more DBR researchers not only to consider using mixed methods research approaches but also to consider using full(er) integration approaches, as we move further into the fifth Industrial Revolution and beyond.

Keywords: *Design-based research, mixed methods design-based research, educational research methodology, 1 + 1 = 3 integration, 1 + 1 = 1 integration, partial integration, full(er) integration, fully integrated systematic review*

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A Fully Integrated Systematic Review of Mixed Methods Design-Based Research

Design-based research (DBR) is an educational research methodology that is commonly used in the fields of education, instructional technology, and learning sciences. When conducting DBR, researchers collaborate with practitioners (e.g., educators) and other stakeholders (e.g., parents, community members), often including the learners themselves, for the purpose of developing and evaluating innovative solutions to real-world problems within specific contexts, with a primary focus on improving practice and generating practical knowledge (Anderson & Shattuck, 2012). DBR is characterized by its iterative, collaborative, and problem-solving nature. More specifically, the aim of DBR is to bridge the gap between theory and practice, as well as between research and practice, by systematically designing, implementing, refining, and evaluating educational interventions or innovations within an authentic educational context.

Although DBR was originally developed for the fields of engineering and architecture, during the 1990s, it was adopted within the field of education (Tinoca et al., 2022). Brown (1992) and Collins (1992) independently played a seminal role in introducing the concept of DBR—in particular, they each outlined the essential principles and processes of DBR and highlighted its potential to address complex educational problems by intertwining design and research activities. These authors articulated the need for a more systematic and design-oriented approach to educational research, contending that traditional research methods in education often lacked practicality and relevance to educators and learners. They advocated for a shift towards a design science of education, which would focus on designing educational interventions and technologies to improve learning outcomes. Further, they emphasized the utility of embedding research within the design process, arguing that researchers and practitioners should collaborate to create innovative educational solutions, and the design process itself should be a means of inquiry and discovery.

Key Characteristics of Design-Based Research

Although DBR has been used to create an array of innovative educational solutions, these studies have several elements in common (see, for e.g., Wolcott et al., 2019). These elements are described as follows:

- *Authentic*: A major characteristic of DBR is that it is conducted in real-life settings, in contrast to laboratories or simulated settings.
- *Operational*: The aim of DBR is to create or to develop interventions as well as to understand them in order to scale them up so that they can be implemented in other settings.
- *Iterative Process*: DBR is a systematic process that has distinct cycles of design, implementation, refinement, and evaluation. Optimally, DBR researchers continuously refine their interventions and refining theories based on findings that emerge during each cycle. Instead of waiting until the end of the DBR process before an intervention is evaluated, researchers evaluate their designs early and often, using findings from the previous stage(s)/cycle(s) to inform subsequent development(s)/refinement(s) of their designs.
- *Contextualized*: Recognizing the importance of designing interventions that are tailored to the specific context in which they will be implemented, DBR researchers take into

account the specific context in which the research is conducted. This context may include factors such as the characteristics of learners, the learning environment, and the institutional constraints. Researchers work closely with practitioners and other stakeholders to ensure that the interventions are well-suited to the context and to address authentic problems.

- *Practical Solutions*: The primary goal of DBR is to produce practical solutions that can be used to address real-world educational challenges and to improve educational practice. This emphasis on applicability distinguishes it from purely theoretical research. These solutions may take the form of new teaching methods, curriculum designs, educational technologies, instructional strategies, or the like. Interventions created via DBR studies reflect the learner's needs to address the underlying problem while simultaneously addressing constraints in the system, such as limitations pertaining to the resources and technology.
- *Theory Development*: Although DBR is practical and context-specific, it is also theory-driven. DBR contributes to the development of theoretical frameworks by integrating theory with practice. In the context of education, relevant learning theories are used to develop interventions. Further, results from DBR studies/phases are utilized to derive, to confirm, or to refine theories as they are applied in the underlying setting in order to obtain a deeper understanding of the underlying mechanisms at work.
- *Design Principles*: DBR often results in the identification of design principles that can guide future educational interventions. These principles provide guidance for designing effective educational experiences.
- *Collaborative*: DBR promotes collaboration between researchers and practitioners, such as teachers or instructional designers, as well as partners/stakeholders (e.g., students, educators, administrators, parents), especially those with expertise in fields/disciplines/areas related to the learning context, in order to ensure the optimal design of interventions. Indeed, collaboration between researchers and practitioners is a fundamental aspect of DBR. This collaboration ensures that the research is grounded in the practical concerns and needs of the educational setting, that the interventions are feasible and relevant, and that the solutions generated are relevant to the field.
- *Data-Driven*: DBR relies on the collection, analysis, and interpretation of various types of data to inform decision-making. These data help researchers not only to refine their interventions but also to assess the impact of the intervention as well as to understand how and why certain outcomes have been achieved—thereby contributing to the development of broader theoretical knowledge.
- *Longitudinal Perspective*: DBR researchers often adopt a longitudinal approach. This approach involves examining the effects of interventions over time, which, in turn, helps researchers understand how changes unfold and how interventions can be sustained.

Mixed Methods Design-Based Research

Anderson and Shattuck (2012, pp. 16-18) posited that quality DBR studies contain the following eight characteristics, respectively: being situated in a real educational context, focusing on the design and testing of a significant intervention, using mixed methods, involving multiple iterations, involving a collaborative partnership between researchers and practitioners, involving evolution of practical design principles, being differentiated from other research

designs that include action research and formative evaluation designs, and having practical impact on practice. Of these eight characteristics, the characteristic that is most relevant to the mixed methods research community involves the use of mixed methods research approaches in DBR studies. According to Anderson and Shattuck (2012),

> DBR interventions are assessed on a wide variety of indices using multiple methodologies. DBR is largely agnostic when it comes to epistemological challenges to the choice of methodologies used and typically involves mixed methods using a variety of research tools and techniques. Most DBR researchers would concur with Maxcy (2003), who argued, "It is perfectly logical for researchers to select and use differing methods, selecting them as they see the need, applying their findings to a reality that is both plural and unknown" (p. 59). Moreover, the choice of methods and the focus on authentic and meaningful issues resonate with the pragmatic philosophy and outlook associated with American pragmatism, associated with, notably, Charles Sanders Peirce, John Dewey, and William James and later Abraham Kaplan and Richard Rorty. (p. 17)

Similarly, Wolcott et al. (2019) stated that "DBR incorporates a pragmatic approach to research design that incorporates both qualitative and quantitative data collection strategies (i.e. mixed methods) to gain a more holistic perspective of learning in real-life contexts" (p. 310).
The concept of mixed methods design-based research (MM-DBR) has intuitive appeal. First and foremost, integrating both qualitative and quantitative approaches allows DBR researchers to obtain a comprehensive understanding of the complex educational phenomena being studied, especially bearing in mind that DBR often involves studying multifaceted educational interventions in real-world contexts. More specifically, using mixed methods research approaches allows researchers to collect a wider range of *quantitative data* (e.g., surveys, test scores) and *qualitative data*—comprising the following four forms of data identified by Leech and Onwuegbuzie (2008): *talk* (e.g., individual interviews, paired-depth interviews, focus group discussions), *observations* (emic-based [e.g., onsite observations] vs. etic-based [e.g., Geographic Information Systems]; interactive [i.e., live observations] vs. non-interactive [i.e., past observations]; first hand [e.g., collected directly by the researcher] vs. second hand [e.g., by someone else]), *drawings/photographs/videos* (still [e.g., drawings, paintings] vs. moving [e.g., videos]; 2-dimensional [e.g., drawings, paintings] vs. multidimensional [e.g., movies]; non-virtual [e.g., drawings] vs. virtual [e.g., I-Phone, I-Pad, YouTube, Panoramio, Flickr, iMovie, Instagram, TikTok]), and *documents* (i.e., analogue [e.g., articles, books] vs. digital [e.g., blogs, tweets, Facebook, emails, chat room]). This greater comprehensive approach, compared to monomethod approaches (i.e., use of a qualitative DBR only or a quantitative DBR only) enables a more thorough understanding of the intervention's impact and the context in which it operates.

Greene et al. (1989) identified five purposes for combining, or mixing, qualitative and quantitative data. These purposes are triangulation, complementarity, development, initiation, and expansion. In the context of DBR, triangulation involves comparing qualitative findings stemming from one or more cycles of a DBR with the quantitative results stemming from one or more cycles of the same DBR for the purpose of examining the level of corroboration between the methodological strands to increase validity and/or to reduce researchers' biases. Complementarity involves enhancing or elaborating findings for the purpose of balancing the strengths and weaknesses of both approaches. Development involves using the data or findings from one analytical strand within or across cycles to inform the other strand in the same or

subsequent cycle(s). Initiation involves discovering paradoxes and contradictions that emerge when findings from the two analytical strands within or across cycles are compared that might lead to refinement of the theory, design, educational interventions/innovations, or some of element of the DBR study. Finally, expansion involves expanding the breadth and range of a DBR study by using multiple analytical strands for different cycles.

As stated previously, DBR is theory-driven, and the use of mixed methods research approaches also can enhance theory development. In particular, qualitative data can help to identify the underlying mechanisms and processes at work. Contrastingly, quantitative data can be used to test hypotheses derived from theoretical frameworks. Further, MM-DBR can be tailored to address the specific research question(s) and context. For instance, DBR researchers can decide how much emphasis to place on qualitative versus quantitative data collection and data analysis, based on the research goals, objectives, and questions.

Whereas the qualitative data extracted from a MM-DBR study provides *descriptive precision* (e.g., voices of practitioners and/or other stakeholders), quantitative data (e.g., scores representing cognitive, affective, psychomotor, and/or behavioral construct[s]) yield *empirical precision*. For example, qualitative data can shed light on the lived experiences of the DBR participants, whereas quantitative data can demonstrate the intervention's effectiveness. Moreover, qualitative data can provide depth and context, whereas quantitative data can establish patterns and relationships, and, together, both strands of data can help provide a more complete picture of the practical implications of an intervention, enhancing the depth and breadth of insights into educational interventions and their impact. In other words, in combination, the qualitative and quantitative data could serve as pathways to zoom in to microscopic detail or to zoom out to indefinite scope (Willems & Raush, 1969), thereby enhancing the ensuing meta-inferences (i.e., involving inferences stemming from both the qualitative and quantitative findings being combined into a coherent whole; Tashakkori & Teddlie, 1998). In a similar vein, qualitative data have the potential to add interpretive richness to the quantitative phase/component/cycle of a MM-DBR study, making thick description (Geertz, 1973; Ryle, 1949, 1971) more likely, thereby allowing DBR researchers better to understand and to absorb both the DBR context and the intervention's effectiveness.

The use of both qualitative and quantitative approaches in DBR studies can facilitate the translation of knowledge from basic research into the development of new interventions, programs, and treatments (i.e., T1 research); the translation of research findings into everyday practice (i.e., T2 research); and the translation of research findings to the immediate community and beyond (i.e., T3 research) (Abernethy & Wheeler, 2011; Ivankova et al., 2018; Woolf, 2008). According to Ivankova et al. (2018), moving from T1 to T3—three important elements of the DBR process—necessitates the following two vital elements: information flow (i.e., "availability and accessibility of data to guide change and transformation"; p. 358) and behavioral change. Integrating qualitative and quantitative data in a DBR study can promote both information flow and behavioral change by facilitating new communication patterns. Therefore, researchers should carefully consider the best combination of qualitative and quantitative research approaches based on the specific goals and context of their DBR study.

In summary, mixed methods research approaches can be highly beneficial in design-based research by providing a more comprehensive, holistic, and nuanced understanding of educational interventions, the underlying mechanisms at play, and the contextual factors

influencing outcomes; supporting theory development; and enhancing the practical applicability of research findings. In so doing, mixed methods research approaches can enhance the rigor and depth of DBR. The integration of qualitative and quantitative data strengthens the overall validity and usefulness of DBR findings. As such, Maxwell's (2016) claim that DBR has "received little if any recognition from the mixed methods community" (p. 19) is surprising, and warrants further investigation. This was the purpose of the present study. Specifically, in this investigation, we conducted what we refer to as a *fully integrated systematic review* in order to determine the prevalence of mixed methods research approaches in DBR studies.

Method and Results of Fully Integrated Systematic Review
Mixed Methods Research Approach

The systematic review involved what we refer to as a fully integrated systematic review because it represents full integration of the qualitative and quantitative elements during the systematic review process. The initial phase of this fully integrated systematic review involved a systematic review of Scopus-indexed works from January 1, 1960 (i.e., the earliest year for which records have been kept) to May 31, 2022 to determine the prevalence rate of mixed methods-declared DBR studies. Once the corpus of mixed methods-declared studies had been identified, a mixed methods case study (Sharp et al., 2012; Walton et al., 2020) was used to examine these MM-DBR studies. This mixed methods case study involved the collection of both quantitative data (e.g., publication year, number of citations for each work, impact factor of each journal) and qualitative data (e.g., title; abstract; each article's literature review section, method section, qualitative findings, discussion section) to examine the characteristics of these MM-DBR studies. In this mixed methods case study, the quantitative and qualitative phases occurred concurrently; that is, the quantitative data and qualitative data were collected simultaneously. The mixed methods case study took the form of an intrinsic case design. As described by Stake (2005), in an intrinsic case design, the goal of the researcher(s) is to obtain a better understanding of each particular (e.g., illustrative, deviant) element within the case. An intrinsic case design is not conducted primarily because the case is representative of many other cases but rather because in all its ordinariness and individuality, the actual case itself is of primary interest.

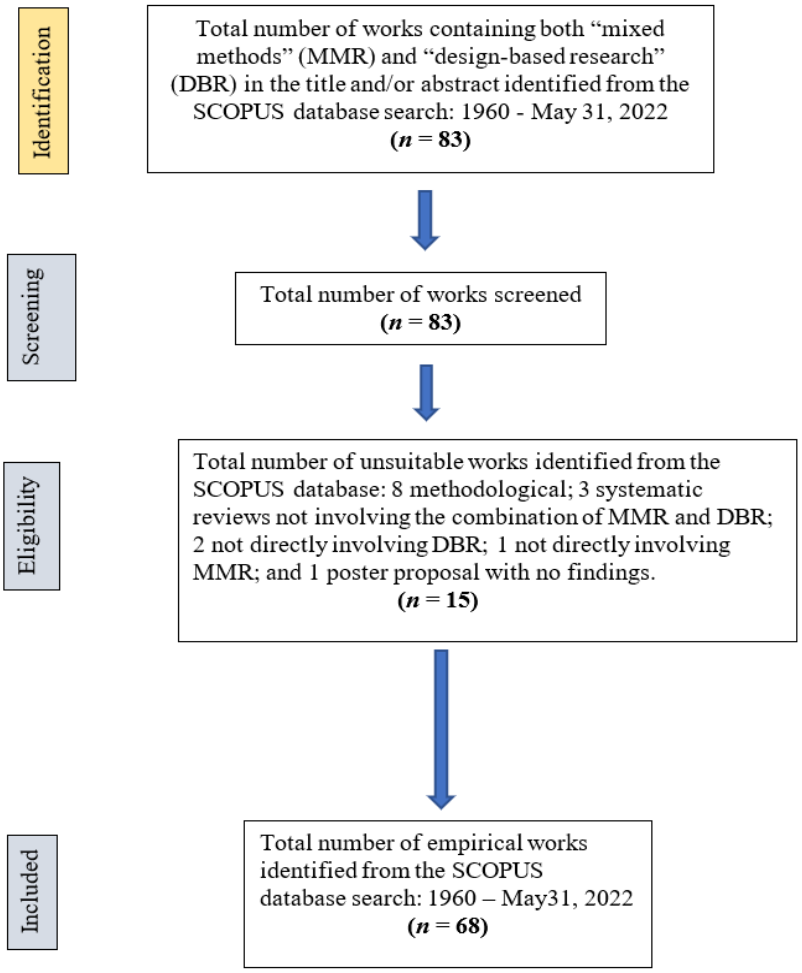
Data Collection

PRISMA (i.e., Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Moher et al. 2009) were used in the execution of the search process. As declared on the PRISMA Statement website (PRISMA, 2021), PRISMA provides detailed steps via a checklist (PRISMA, 2009) for the purpose of helping reviewers present a standardized reporting of systematic reviews and meta-analyses. Although it was originally developed to assess the benefits and risks of health care interventions, it can be applied to other fields and disciplines. PRISMA was used to identify the full set of relevant journal articles, books, and book chapters that was declared by the author(s) as representing an empirical research study that involved the use of both DBR and mixed methods research that was included in the Scopus database (i.e., indexed by Scopus) between 1960—the earliest year for which records have been kept) and May 31, 2022—the date on which the search was conducted. Specifically, an initial keyword search was conducted using the following string: (TITLE-ABS-KEY ("design-based research") AND TITLE-ABS-KEY ("mixed method*")). The goal in using these

keywords was to identify works wherein the author(s) declared their works as involving the intersection of DBR and mixed methods research.

As can be seen from the PRISMA flowchart (Figure 1), the initial search yielded 83 Scopus-indexed documents worldwide that represent some form of mixed methods research approach applied to a DBR process. After reading these 83 works, as documented in the PRISMA flowchart, we identified 15 works that did not qualify as a MM-DBR study for the following reasons: they represented either a methodological work, a systematic review that did not involve any form of mixed methods research approach applied to a DBR process, a mixed methods research study that not directly involve a DBR process, a DBR study that utilized a monomethod approach (i.e., quantitative research approach only or a qualitative research approach only), or a research proposal with no findings. This yielded a total of 68 works wherein the author explicitly declared their study as representing some form of a MM-DBR study. That 15 out of these initial 83 works did not qualify as a mixed methods design-based research study indicates that the *false positive rate* for identifying Scopus-indexed empirical research reports that involved the combination of mixed methods research and design-based research is 18.07% (i.e., 15 / 83).

Figure 1
PRISMA Flow Chart Detailing Steps in the Identification and Screening of Scopus-Indexed Empirically Based Sources that Involve the Use of Both Mixed Methods Research and Design-Based Research: 1960 - May 31, 2022



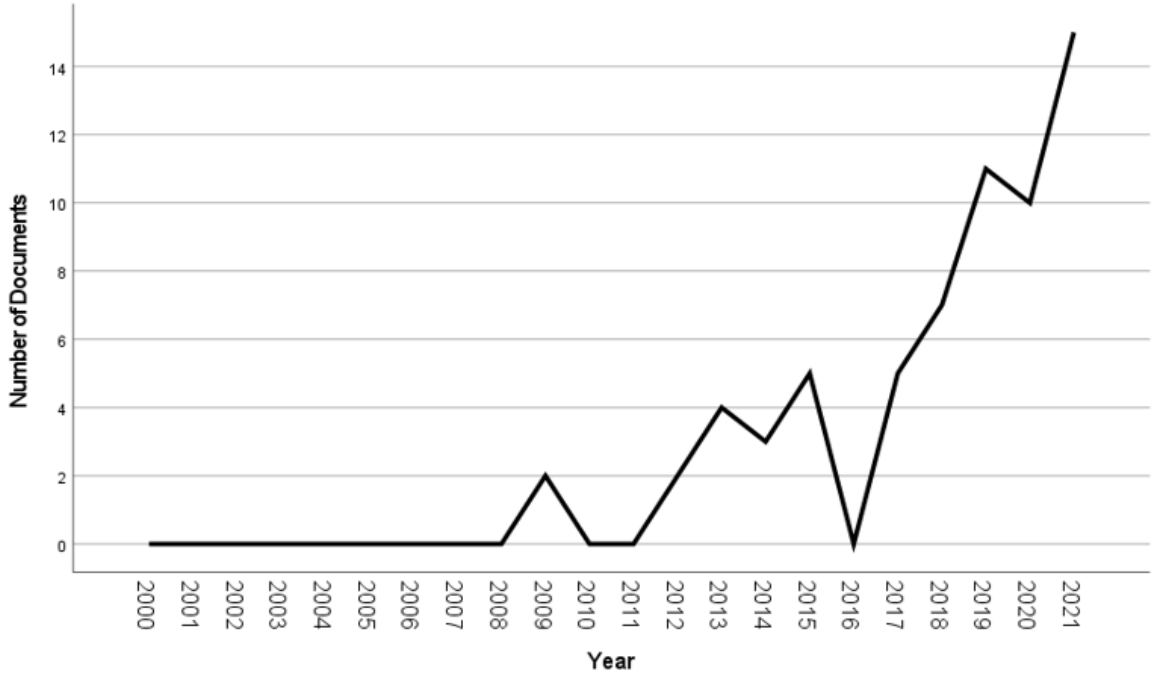
A follow-up Scopus-based rapid review—representing "a streamlined approach to synthesizing evidence in a timely manner" (Khangura et al., 2012, p. 1)—yielded an initial total of 2,141 works that specified "design-based research" in the title and/or abstract. Assuming a false positive rate of 18.07% that was derived earlier for MM-DBR studies provides an estimate of 387 (i.e., 18.07% x 2,141) DBR studies that represent false positives, which result in an approximate total of 1,754 DBR studies. In turn, this total suggests that the final total of 68 Scopus-indexed. DBR studies that have been declared by the authors as involving the use of some form of mixed methods research approaches between 1960 and May 31, 2022 represent only approximately 3.88% (i.e., 68 / 1,754) of the total design-based research studies that are included in the Scopus database (this percentage is even smaller if the potential false positive rate is ignored).

Growth Trajectory

Figure 2 displays the growth trajectory of the Scopus-indexed MM-DBR literature by documents for every complete year (i.e., 1960–2021). It can be seen from this figure that the first Scopus-indexed works that represent some form of mixed methods research approach applied to a DBR process were published in 2009. Two works were published in this year. Therefore, at the time of writing, the Scopus-indexed, MM-DBR literature has slightly more than a 12-year history. However, the bulk of this literature has been published within the last decade, with 96.28% of the Scopus-indexed works published since 2000, 86.16% of the works published since 2010, and 57.59% works appearing in the literature since 2015.

Figure 2

Growth Trajectory of the Literature by Documents Per Complete Year: 1960–2021 (n = 68)



Even though, as noted previously, Brown (1992) has been credited with first developing design-based research, the earliest Scopus-indexed work was published in 1989 (i.e., Mudrak et al., 1989). However, this work did not represent an empirical research study. Instead, the earliest empirically based DBR study indexed in the Scopus database was published in 1993 (i.e., Hickey et al., 1993). Further, with respect to mixed methods research, although K. M. T. Collins et al. (2007) documented that the first article in which the phrase *mixed methods* was used appeared in 1972 (Parkhurst et al., 1972), the earliest work appearing in the Scopus database is Gaber (1993). However, this work does not represent an empirical study. Instead, the study by Leithwood et al. (1999) represents the first Scopus-indexed mixed methods inquiry. These findings indicate that despite the fact that the first Scopus-indexed DBR study was published in 1993 and the first Scopus-indexed mixed methods research study was published in 1999, it took 10 more years before the first Scopus-indexed MM-DBR study was published in 2009. This delay likely reflects the lack of attention to DBR by the mixed methods research community, as mentioned earlier (cf. Maxwell, 2016).

General Characteristics of Scopus-indexed Mixed Methods Design-Based Research Studies

Each of the 68 Scopus-indexed mixed methods design-based research works was coded via the following variables:

- whether the topic of each work could be classified as representing the field of education, social sciences, or STEMM (i.e., science, technology, engineering, mathematics, and medicine)
- whether the data collected for each work represented process data and/or outcome data
- whether the underlying domains of each work represented a cognitive, affective, psychomotor, and/or behavioral construct(s)
- level of collaboration in each work
- number of pages of each work
- impact factor of each work
- number of times each work had been cited
- gender of the lead author of each work
- characteristics of the titles of the works
- whether each author(s) explicitly specified the type of mixed methods research design
- the extent to which each study was grounded within the mixed methods research literature
- whether each study involved the use of a quantitative-dominant, qualitative-dominant, or (approximately) equal-status mixed methods research design
- the clustering nature of authors of mixed methods design-based research studies
- the level of integration inherent in each mixed methods research design (0 = no integration of the quantitative and qualitative data; 1 = no integration of the quantitative and qualitative data until the interpretation stage; 2 = small to moderate integration of the quantitative and qualitative data; 3 = full[er] integration of the quantitative and qualitative data)

Subject Area of Each Work

With regard to subject area, education was the most represented field, with 91.2% of the MM-DBR studies representing the field of education. This supports the assertion by Anderson and Shattuck (2012) that design-based research is a "research methodology for education research" (p. 16) and that it is

> designed by and for educators that seeks to increase the impact, transfer, and translation of education research into improved practice. In addition, it stresses the need for theory building and the development of design principles that guide, inform, and improve both practice and research in educational contexts. (p. 16)

Interestingly, STEMM was represented by nearly two thirds (i.e., 61.8%) of the studies.

Type of Data Collected by Authors for Each Work

In terms of type of data collected, process data were by far the most common data collected, involving 85.3% of the data. In contrast, approximately one third (35.3%) of the studies involved the collection of outcome data. Please note that these two percentages sum to more than 100% because 20.6% of the studies involved the collection of both process data and

outcome data. With regard to the underlying domain, the cognitive domain was represented by the most studies (i.e., 63.2%), followed somewhat closely by affective (i.e., 52.9%), and then behavioral (i.e., 23.5%), and psychomotor (i.e., 1.5%), respectively. A series of Fisher's Exact tests revealed that MM-DBR studies that involved the cognitive domain (87.5%) were statistically significantly (p = .002) more likely to involve the collection of outcome data than were studies that did not involve the cognitive domain (50.0%). Contrastingly, MM-DBR studies that involved the affective domain (58.6%) were statistically significantly (p = .026) more likely to involve the collection of process data than were studies that did not involve the affective domain (20.0%).

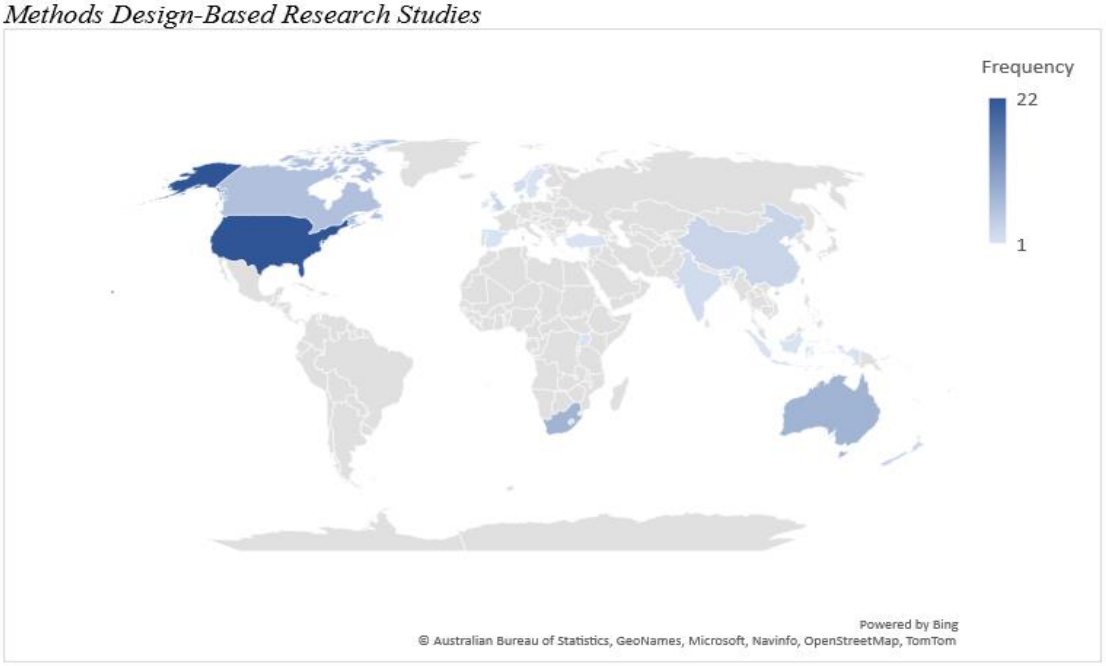
Level of Collaboration in Each Work

With respect to the level of collaboration, the number of authors ranged from one to nine. Representing the most popular combination, approximately one third (i.e., 34.3%) of the studies involved two co-authors, followed, respectively, by three co-authors (i.e., 23.9%), one author (i.e., 19.4%), four co-authors (i.e., 9.0%) and five co-authors (i.e., 9.0%), six co-authors (i.e., 3.0%), and nine co-authors (i.e., 1.5%). Interestingly, the overall level of collaboration (M = 2.72, SD = 1.53) was almost identical (i.e., statistically non-significant difference) to the overall level of collaboration (M = 2.71, SD = 1.72) reported by Onwuegbuzie, Wilcox, et al. (2018) across all articles published in the *Journal of Mixed Methods Research* (*JMMR*)—one of three journals devoted to mixed methods research in existence (the other two being the *International Journal of Multiple Research Approaches* and *Journal of Mixed Methods Studies*)—from 2007 (its inception) to 2014. To place the level of collaboration in MM-DBR studies in a further context, it is statistically significantly higher than that documented by Onwuegbuzie, Witchcock, et al. (2018) for two quantitative journals (i.e., *Journal of Educational and Behavioral Statistics* [(M = 2.14, SD = 1.00; d = 0.42] and *Journal of Applied Quantitative Methods* [M = 2.12, SD = 1.07; d = 0.35]) and two qualitative journals (i.e., *International Journal of Qualitative Methods* [M = 2.23, SD = 1.53; d = 0.29] and *The Qualitative Report* [M = 2.05, SD = 1.42; d = 0.35]). Interestingly, although the number of authors was not statistically significant related to the field of study (i.e., education, STEMM), the type of data collected (i.e., process data, outcome data), or domain (i.e., cognitive, affective, behavioral), a statistically significant and moderately negative relationship emerged between the number of authors and year of publication, r = -.27, p = .026. Specifically, the most recent MM-DBR studies were characterized by fewer authors than their older counterparts.

The 182 authors involved in these 68 MM-DBR studies represented 23 countries. The number of authors from each of these countries ranged from 1 to 22 (M = 3.22, SD = 4.61). The United States was the country most represented (n = 22), followed by Australia and South Africa (each n = 8), Canada (n = 6), and New Zealand and China (each n = 3). All remaining countries were represented in 1 or 2 studies. Figure 3 displays a Geographic Information Systems (GIS) map of countries represented by all authors of MM-DBR studies. Although this map provides evidence of a diverse pool of authors of MM-DBR studies, it should be noted that English-speaking Western countries (i.e., United States, United Kingdom, Ireland, Canada, Australia, New Zealand) represented two thirds (i.e., 66.2%) of these works. Interestingly, works containing at least one Western author were published statistically significantly (t = 2.77, p = .007) earlier than were works published that contained no Western authors, yielding a moderate Cohen's (1988) d effect size of 0.59 (95% confidence interval [CI] = 0.07, 1.11). Further, works containing at least one Western author (M = 3.00, SD = 1.68) contained statistically

significantly (t = 2.26, p = .028) more authors than did works published that contained no Western authors (M = 2.23, SD = 1.07), similarly yielding a moderate d effect size of .52 (95% CI = 0.01, 1.03). In addition, works containing at least one Western author (M = 29.42, SD = 60.53) yielded statistically significantly (t = 2.08, p = .043) more citations than did works published that contained no Western authors (M = 8.77, SD = 17.34), also yielding a moderate Cohen's (1988) d effect size of .41 (95% CI = 0.01, 0.93); however, this latter finding likely reflects the fact that works published that contained no Western authors tended to be newer and, thus, had not had the same amount of time to build up their citations.

Figure 3
Geographic Information Systems Map of Countries Represented by all Authors of Mixed Methods Design-Based Research Studies



Number of Pages of Each Work

The number of pages of the MM-DBR works ranged from 2 to 40 (M = 16.14, SD = 7.87). Interestingly, a statistically significant and moderately positive relationship emerged between the number of pages and the year of publication, r = .27, p = .029. In other words, to a moderate degree, the newest works tended to be associated with the longest works.

Impact Factor of Each Work

With respect to the contribution of each work to the literature, the impact factor ranged from 0.69 to 8.54 (M = 3.22, SD = 1.91). Sombatsompop and Markpin (2005) reported impact factors for 12 different fields. These fields comprised the Neurosciences (n = 197 journals; the 2002 Impact Factor for Journals Ranked in the top 25% [IF-A]= 3.275); Pharmacology and Pharmacy (n = 188; IF-A = 2.565); Medicine—General, and Internal (n = 107; IF-A = 1.673); Physics—Multidisciplinary (n = 68; IF-A = 1.565); Chemistry—Multidisciplinary (n = 119; IF-A = 1.421); Plant Sciences (n = 135; IF-A = 1.556); Biology (n = 62; IF-A = 1.934); Environmental Sciences (n = 132; IF-A = 1.496); Polymer Science (n = 74; IF-A = 1.182); Education—Scientific Disciplines (n = 16; IF-A = 0.797); Engineering—Mechanical (n = 102;

IF-A = 0.701); and Mathematics (n = 170; IF-A = 0.601). The IF-A for these 12 fields ranged from 0.601 to 3.275 (M = 1.56, SD = 0.77). Because the mean impact factor for the 68 MM-DBR studies (M = 3.22) was more than double (i.e., 1.56) the average 2002 impact factor across 12 different fields reported by Sombatsompop and Markpin (2005), it is clear that, on average, MM-DBR studies are being published in journals characterized by very high impact factors. Interestingly, MM-DBR studies with domains that represented a cognitive construct(s) were statistically significantly and moderately associated with being published in journals with the highest impact factors among the set of journals, r = .33, p = .02.

Number of Times Each Work had been Cited

The number of times the MM-DBR works had been cited ranged from 0 to 317 (M = 3.22, SD = 1.91). Of the 68 articles, 17 had not received any citations. However, it should be noted that these uncited articles were statistically significantly more likely to have been published the most recently (p = .035), representing a moderate effect size (d = 0.54). Not surprisingly, works with the most citations tended to be the oldest (r = .30, p = .035). Interestingly, works with the most citations also tended to be the longest (r = .45, p = .001) and to involve the most authors (r = .32, p = .007).

Gender of the Lead Author of Each Work

As described by Wilcox et al. (2019), "One of the most studied gender differences in academia is what Cole and Zuckerman (1984) called the *productivity puzzle*, representing the finding that men generally publish more works than women" (p. xxvii). As part of this productivity puzzle, some researchers have documented that, across numerous fields, women are underrepresented as lead authors. For example, Jagsi et al. (2006), who examined 35 years (i.e., 1970–2004) of the medical literature, reported that only 10.3% of articles were published with a woman as lead author among six prominent journals. As another example, Rigg et al. (2012) documented that, within the geography field, men dominated lead authorship within collaborative research studies across 15 journals over a 15-year period. Therefore, an encouraging finding is that women (59.4%) have been statistically significantly (p = .03) more likely than have men (40.6%) to be lead authors of MM-DBR works. This finding echoes very closely that of Wilcox et al. (2019), who reported that, for articles published in the *JMMR* from 2007 to 2014 revealed, women (57.7%) were statistically significantly (p = .0388) more likely than were men (42.3%) to be lead authors.

Predictors of Mixed Methods Design-Based Research Studies with Women Lead Authors.

A series of *All Possible Subsets* (APS) canonical discriminant analysis procedures was conducted to determine which of the variables that emerged from the fully integrated systematic review were predictors of the gender of the lead author. Each of these fully integrated systematic review variables served as a predictor variable in separate analyses, with the gender of the lead author serving as the dependent variable in the analyses. All possible models involving some or all of the fully integrated systematic review variables were examined (Onwuegbuzie & Daniel, 2003). In fact, in APS canonical discriminant analyses, separate discriminant functions are computed for all predictors variables singly, all possible pairs of predictors variables, all possible trios of predictors variables, and so forth, until the best subset of predictors variables is identified according to some prespecified criteria. In this case, the

criteria used were Wilks's lambda, the probability level (i.e., *p* value), the canonical correlation coefficient, and both the standardized canonical discriminant function coefficients and the structure coefficients (which served as primary effect size measures).

The selected discriminant analysis model revealed a statistically significant canonical function ($\chi^2[3] = 9.72$, $p < .021$; Wilks's Lambda = 0.85). The corresponding canonical correlation was 0.39, which suggested a large effect size (Cohen, 1988). In addition, the group centroid (the average score on the discriminant function for both types of lead authors) for this function was -0.50 for men lead authors and 0.34 for women lead authors. These statistics indicated that the discriminant function maximally separated these two types of lead authors.

An examination of the standardized canonical discriminant function coefficients (Table 1) revealed that, using a cutoff loading of 0.3 (Lambert & Durand, 1975), number of pages of the work, year of publication, and number of citations were practically significant. Further, the structure coefficients (i.e., structure matrix) between the independent variable set and the standardized canonical discriminant function (Table 1) indicated that, also using a cutoff loading of .3 (Lambert & Durand, 1975), number of pages significantly discriminated the types of lead authors. The negative coefficient for this variable (i.e., number of pages) suggests that the number of pages of works involving women lead authors ($M = 14.82$, $SD = 7.72$) was statistically significantly ($t = 1.65$, $p < .05$) lower than that involving men lead authors ($M = 18.12$, $SD = 8.10$).

A comparison of the standardized and structure coefficients implicated year of publication and number of citations as suppressor variables because although they both had a significant standardized coefficients (i.e., ≥ .30), as presented earlier, as can be seen in Table 1, their corresponding structure coefficients were small (i.e., < .30) (Onwuegbuzie & Daniel, 2003). Suppressor variables are variables that assist in the prediction of dependent variables (i.e., they increase the effect size) due to their correlation with other independent variables (Onwuegbuzie & Daniel, 2003). Specifically, in this case, year of publication and number of citations improved the predictive power of number of pages by suppressing variance that was irrelevant to this prediction, as a result of the relationship of number of citations ($r = .45$) and year of publication ($r = .19$) with the number of pages.

Table 1
Standardized and Structure Coefficients for Number of Pages of the Work, Year of Publication, and Number of Citations: Women Lead Authors versus Men Lead Authors

Variable	Standardized Coefficient	Structure Coefficient
Number of Pages of the Work	-1.18*	-.50*
Year of Publication	0.90*	.28
Number of Citations	1.03*	.15

Note: *Coefficients with effect sizes larger than .3 (Lambert & Durand, 1975).

Characteristics of the Titles of the Works

WordStat 8.0.28 (Provalis Research, 2020) also was used to conduct topic modeling using factor analysis to extract the main themes from the titles of the 68 MM-DBR works. The use of topic modeling represents a mixed methods analysis (i.e., mixed analysis) approach because it involves using quantitative analysis techniques to analyze text (i.e., qualitative) data (Van Haneghan, 2021). In the current study, topic modeling was undertaken by computing a word x word correlation matrix and then conducting a factor analysis in order to extract an appropriate number of factors. All words with a factor loading higher than a specific criterion then were retrieved as part of each extracted topic. Unlike the case for hierarchical cluster analysis, wherein each word appears only in one cluster, in topic modeling, the factor analysis might result in a word being associated with more than one factor, which, is "a characteristic that more realistically represents the polysemous nature of some words as well as the multiplicity of context of word usages" (Provalis Research, 2014, p. 45). In order to maximize the stability of the factoring solution, all low frequency items were excluded (Provalis Research, 2014).

Table 3 presents the high-probability terms from the k = 3 topic model for each of three topics in the 1960 to May 31, 2022 MM-DBR corpus of titles. For each topic, as recommended by topic modelists (e.g., O'Callaghan et al., 2015; Provalis Research, 2014; Wang et al., 2017), this table lists the 10 high-probability terms that best distinguish the topics from one another. Overall, across the 62-year time period, the following three topics emerged from the corpus: Digital and Environmental, Parent and Autism, and Computer Performance. Also, in Table 3 is the topic coherence, which is the semantic interpretability of the terms used to describe a particular topic, and the relative proportion pertaining to documents underlying these three topics. We present the topics (i.e., themes) extracted from Table 3, wherein the themes are presented in boldface text and the subthemes derived from these topics are presented in italics.

Table 3
Topics Extracted from the Titles of the Mixed Methods Design-Based Research documents, 1960–May 31 2022 (n = 68)

No.	Topic Labels	High Probability Terms	Coherence	Relative Proportion (%)
1	Digital and Environmental	Digital, environmental, games, India, exploring, influence, new, attitudes, based, effectiveness	.70	39.71
2	Parent and Autism	Parent, autism, community, training, mental, barriers, youth, system, health, perceived	.60	32.35
3	Computer Performance	Computer, performance, achievements, grade, effects, opinions, students, identity, gender, development	.54	66.18

It can be seen from Table 3 that **Computer Performance** (Topic 3) had the highest relative proportion of works, with high-probability terms including *achievements, grade, development, effects, opinions, students, identity*, and *gender*. This topic indicates that the computer performance is the major focus of MM-DBR researchers. Bearing in mind the conclusion of Anderson and Shattuck (2012) that DBR "seems to be especially attractive for use in K–12 contexts and with technological interventions" (p. 24), this topic has logical appeal. The Computer Performance topic is followed by **Digital and Environmental** (Topic 1), with high-probability terms such as *games, exploring, influence, new, attitudes*, and *effectiveness*. This topic similarly has a lot of intuitive appeal. Closely following the Digital and Environmental topic is the **Parent and Autism** topic (i.e., Topic 2). This topic includes high-probability terms, such as *mental, barriers, health, youth, community, system*, and *training*.

Mixed Methods-Based Characteristics of Scopus-indexed Mixed Methods Design-Based Research Studies

Whether the Author(s) Explicitly Specified the Type of Mixed Methods Research Design

A very disturbing finding is that less than one third of the authors (29.2%) explicitly specified the type of mixed methods research design. That is, they stated that their DBR studies involved use of a mixed methods research approach. However, they did not provide the name of their mixed methods research design, nor did they (adequately) describe their design. As a result, their research studies were not sufficiently transparent in terms of their overall MM-DBR approaches.

Predictors of Whether the Author(s) Explicitly Specified the Type of Mixed Methods Research Design. An APS canonical discriminant analysis revealed a statistically significant canonical function ($\chi^2[3] = 11.61$, $p = .009$; Wilks's Lambda = 0.82). The corresponding canonical correlation was .42, which suggested a large effect size (Cohen, 1988). In addition, the group centroid for this function was -0.29 for authors who did not explicitly specify the type of mixed methods research design and 0.72 for the author(s) who did explicitly specify the type of mixed methods research design. These statistics indicated that the discriminant function maximally separated these two types of authors.

An examination of the standardized canonical discriminant function coefficients (Table 2) revealed that, using a cut-off loading of 0.3 (Lambert & Durand, 1975), whether or not the study was grounded within the mixed methods research literature and whether or not a qualitative-dominant mixed methods research design was used were practically significant. Whether or not the study was grounded within the mixed methods research literature was, by far, the most significant predictor of whether or not the author(s) explicitly specified the type of mixed methods research design, followed by whether or not a qualitative-dominant mixed methods research design was used. Further, the structure coefficients (Table 2) indicated that all three predictor variables—publication year of the work, whether or not the study was grounded within the mixed methods research literature, and whether or not a qualitative-dominant mixed methods research design was used—significantly discriminated whether or not the author(s) explicitly specified the type of mixed methods research design.

A comparison of the standardized and structure coefficients implicated year of publication as being collinear because although it had a significant structured coefficient (i.e., ≥ .30), as can be seen in Table 2, its corresponding standardized coefficient was small (i.e., < .30)

(Onwuegbuzie & Daniel, 2003). The signs of the two variables with both significant standardized coefficients and structure coefficients indicate that author(s) who explicitly specified the type of mixed methods research design tended to write works that were grounded within the mixed methods research literature—which has intuitive appeal—as well as those studies that were less likely to represent a qualitative-dominant mixed methods research design.

Table 2

Standardized and Structure Coefficients for Year of Publication, Whether or Not the Study was Grounded Within the Mixed Methods Research Literature, and Whether or Not a Qualitative-Dominant Mixed Methods Research Design was Used: Author(s) who Explicitly Specified the Type of Mixed Methods Research Design versus Author(s) who did not

Variable	Standardized Coefficient	Structure Coefficient
Year of publication	0.26	.40*
Whether or not the study was grounded within the mixed methods research literature	0.82*	.87*
Whether or not a qualitative-dominant mixed methods research design was used	-0.43*	-.44*

Note: *Coefficients with effect sizes larger than .3 (Lambert & Durand, 1975).

Extent to Which the Study was Grounded Within the Mixed Methods Research Literature

An even more disturbing finding was that more than one half (i.e., 56.9%) of the MM-DBR studies did not ground their research approach within the mixed methods research literature to any degree at all. In particular, the authors of these studies did not cite a single mixed methodological work. A further 29.2% of the studies involved grounding of their work to a minimum degree, typically representing the mixed methods research literature with only one citation and describing their mixed methods research approach using as little as one sentence. Another 6.2% of the studies represented the mixed methods research literature moderately. Only 7.7% of the studies represented the mixed methods research literature in a significant manner. Interestingly, a statistically significant and moderate relationship emerged between the degree to which the authors grounded their research approach within the mixed methods research literature and the year of publication, $r = .25$, $p = .04$. In other words, authors of the most recent studies were more likely to ground their research approach within the mixed methods research literature than were their counterparts, which has intuitive appeal.

Of the authors of mixed methodological works who were cited, John Creswell (30.8% of the total number of studies) was the most common, followed by Vicki Plano Clark (17.2%); Charles Teddlie (12.3%); and Abbas Tashakkori, R. Burke Johnson, and Tony Onwuegbuzie (each at 10.8%). The remaining mixed methodological authors were cited in two studies (Nancy Leech, Tim Guetterman, Leslie Curry, Donna Mertens, Elizabeth Kemper, Samuel Stringfield, Fen Yu, William Hanson) or one study (Kathleen Collins, Michael Fetters, Janice

Morse, Robert Yin, Judith Schoonenboom, Thomas Christ, Jang, Symonds, Suna Ryu, Alejandra Martínez, Yannis Dimitriadis, Eduardo Gómez-Sánchez, Bartolomé Rubia-Avi, Iván Jorrín-Abellán, Jose A. Marcos, Michelle Guttmann, William E. Hanson).

Emphasis of Mixed Methods Research Design

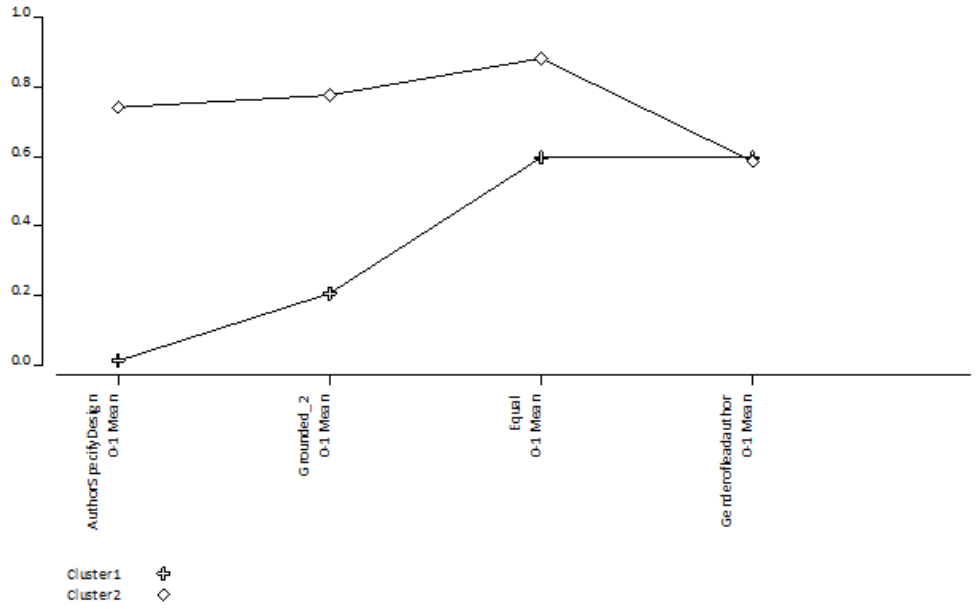
Although more than two thirds of the sets of authors did not explicitly specify the type of mixed methods research design used, it was still possible to determine (i.e., code) the emphasis placed between the quantitative and qualitative phases/components of their studies. An analysis of these codes revealed that the vast majority (71.4%) of mixed methods research designs involved (approximately) equal quantitative and qualitative phases/components. Nearly one fifth of the studies (17.5%) were qualitative-dominant. The remaining 11.1% of the files were quantitative-dominant.

Clustering Nature of Authors of Mixed Methods Design-Based Research Studies

A latent class analysis was conducted to determine the smallest number of clusters (i.e., latent classes) that explains the relationships among select fully integrated systematic review variables under the assumption that the 68 MM-DBR studies could be classified into a small number of distinct clusters, known as latent classes, such that each study belonged to only one cluster. The latent class analysis revealed a two-cluster solution (L^2 = 4.04, df = 6, p = .67, Bootstrap p = .82). This solution involved the following four fully integrated systematic review variables: whether or not the author(s) explicitly specified the type of mixed methods research design, whether or not the study was grounded within the mixed methods research literature, whether or not an equal-status mixed methods research design was used, and gender of the lead author. In this model, gender of the lead author served as a covariate. Figure 4 displays these two distinct groups of studies. It can be seen from Figure 4 that Cluster 1 (comprising 61.23% of the studies) was relatively high with respect to whether or not the author(s) explicitly specified the type of mixed methods research design, whether or not the study was grounded within the mixed methods research literature, and whether or not an equal-status mixed methods research design was used. In contrast, Cluster 2 (comprising 38.77% of the studies) was low on whether or not the author(s) explicitly specified the type of mixed methods research design, relatively low on whether or not the study was grounded within the mixed methods research literature, and moderate on whether or not an equal-status mixed methods research design was used. More specifically, this two-cluster solution illustrates that among this group of authors of MM-DBR studies, the authors who utilized equal-status mixed methods research designs were more likely to implement the best practices of specifying the type of mixed methods research design and grounding their studies within the mixed methods research literature.

Figure 4

Profiles of the Mixed Methods Design-Based Studies with respect to Select Systematic Review Variables



Level of Integration Inherent in the Mixed Methods Research Design

Indubitably, the most significant finding pertained to the level of integration inherent in the mixed methods research designs. In fact, for all but four studies, the level of integration occurred at the low end of the integration continuum, being characterized by mixed methods research designs wherein integration only occurred at the interpretation stage of the DBR process in an attempt to generate meta-inferences. Broadly speaking, meta-inferences involve combining or integrating inferences stemming from both the qualitative and quantitative findings into a coherent whole (Tashakkori & Teddlie, 1998). This form of integration represents what Fetters and Freshwater (2015) referred to as the "1 + 1 = 3 integration formula" (p. 116). In this editorial, these authors introduced what they called "The 1 + 1 = 3 integration formula" (p. 116), as follows:

> Moving forward, we are posing to the mixed methods community to focus even greater attention to the "integration challenge." We describe the integration challenge qualitatively as the imperative to produce a whole through integration that is greater than the sum of the individual qualitative and quantitative parts….Now, with more experience under the field's belt, we hope to get all mixed methods researchers to consider the mixed methods challenge. Quantitatively, we express this as 1 + 1 = 3. That is, qualitative + quantitative = more than the individual components. We believe this framework should push all mixed methodologists to think about how integration has and can push research methods to higher levels that would not have been achieved by simply adding together the results of separate qualitative and quantitative studies conducted without full attention to integration….The 1 + 1 = 3 integration formula also gives permission to question the assumptions of qualitative and quantitative

> disciplinary borders and blinders, to test the waters, and to create and discover new ways of thinking and producing mixed methods results… (Fetters & Freshwater, 2015, pp. 115-116).

Although the 1 + 1 = 3 integration formula has logical appeal, it provides only partial integration. Indeed, as noted by Onwuegbuzie (2017) and Onwuegbuzie and Hitchcock (2019a, 2019b, 2022), the 1 + 1 = 3 integration formula reifies the dichotomy between quantitative research and qualitative research. As noted by Onwuegbuzie and Hitchcock (2019a),

> a potential problem emanating from this 1 + 1 = 3 integration approach is that it hypostatizes and reifies a quantitative–qualitative dichotomy[2]—which implies a strict one-to-one correspondence between data and analyses, with qualitative analyses used *only* to analyze qualitative data and quantitative analyses used *only* to analyze quantitative data (i.e., "non-cross-over mixed analyses"; Onwuegbuzie & Combs, 2010, p. 423). As such, with the 1 + 1 = 3 integration approach, the integration (mostly) occurs at the data interpretation stage, thereby potentially stunting innovation around integration. (p. 10)

In other words, this 1 + 1 = 3 integration formula "reinforces an old one [binary], namely, QL/QN [qualitative/quantitative] research…[whereon]…qualitative (QL) and quantitative (QN) research [are] conceived as two categorically different entities" (Sandelowski, 2014, p. 3). However, this dichotomy-promoting stance contradicts the fact that "no ostensibly QN [quantitative] study escapes qualitizing, and few ostensibly QL [qualitative] studies escape quantitizing" (Sandelowski, 2014, p. 3), whereby *qualitizing* involves converting quantitative data into a qualitative form that can (a) stem not only from quantitative data but also from qualitative data, (c) involve qualitative analyses and/or quantitative analyses, (d) involve a single analysis or multiple analyses, (d) yield a fully integrated analysis, and (e) yield numerous representations (Onwuegbuzie & Leech, 2019, 2021); and quantitizing involves converting qualitative data into numerical codes that can be analyzed statistically (Miles & Huberman, 1994; Onwuegbuzie & Teddlie, 2003; Sandelowski et al., 2009; Tashakkori & Teddlie, 1998). Therefore, adopting a 1 + 1 = 3 integration stance during the design-based research process leads to what Onwuegbuzie and Hitchcock (2019a) refer to as only *partial* integration of the quantitative and qualitative research components/phases.

Discussion

Evidently, DBR is particularly suited to mixed methods research approaches (Anderson & Shattuck, 2012; Wolcott et al., 2019). Yet, Maxwell (2016) claimed that DBR has "received little if any recognition from the mixed methods community" (p. 19). Therefore, the purpose of the present study was to evaluate Maxwell's (2016) claim by conducting a fully integrated systematic review to determine the prevalence of mixed methods research approaches in DBR studies.

This fully integrated systematic review yielded only 68 published DBR works within a 62-year period wherein the authors explicitly declared their studies as utilizing some form of a mixed methods research approach—what we refer to as a MM-DBR. This frequency represents approximately one published work per year over this period, on average. This is not only surprising but concerning, bearing in mind the efficacy and effectiveness of mixed methods research for conducting DBR studies. This low number of published works supports Maxwell's

(2016) contention that DBR has been largely ignored by mixed methods researchers. That the majority of these MM-DBR studies has been published within the last decade, with 86.16% of the works being published since 2010 and 57.59% works appearing in the literature since 2015, indicates that the use of MM-DBR studies is a very recent phenomenon.

The findings that process data were by far the most common data collected (i.e., 85.3%) and that approximately one third (35.3%) of the studies involved the collection of outcome data are compelling. These findings indicate that MM-DBR researchers investigate not only the impact of the educational interventions but also the underlying mechanisms at play as well as the contextual factors influencing outcomes. And, further examination indicates that the qualitative research approaches play an important role in generating these process data. Also, the result that both the cognitive domain (i.e., 63.2%) and the affective domain (i.e., 52.9%) were well represented by the MM-DBR studies has intuitive appeal because it suggests similarly that both these domains were considered by the researchers as providing data regarding the impact of the educational interventions.

Interestingly, the overall level of collaboration in the MM-DBR works (M = 2.72, SD = 1.53) is almost identical to the overall level of collaboration for articles published in *JMMR* (M = 2.71, SD = 1.72). This is significantly higher than for two prominent qualitative journals and two prominent quantitative journals, using the prevalence rates reported by Onwuegbuzie, Wilcox, et al. (2018). This finding also has intuitive appeal because compared to monomethod studies, the relatively complex nature of DBR studies—typically involving cycles of design, implementation, refinement, and evaluation—likely would make it challenging for a single researcher to conduct a MM-DBR study. However, the finding that the most recent MM-DBR studies were characterized by fewer authors than were their older counterparts is somewhat surprising, bearing in mind that one might expect the level of complexity of educational interventions would have increased over time, especially reflecting the movement from the third industrial revolution (i.e., a period characterized by computers, digitalization, and the Internet; circa 1969 – 2000), to the fourth industrial revolution (i.e., a period characterized by Artificial Intelligence (AI), robotics, Internet of Things [IoT], blockchain, and crypto; circa 2000 to present), and to the fifth industrial revolution (i.e., a period characterized by innovation purpose and inclusivity; deep, multi-level cooperation between people and machines; consciousness; circa April 27, 2022 to present) (cf. Onwuegbuzie, in press). Therefore, this negative relationship between the number of authors and year of publication should be the subject of future investigations.

That the 182 authors involved in these 68 MM-DBR studies represented 23 countries is an encouraging finding because it suggests a level of diversity. However, the finding that English-speaking Western countries represented two thirds (i.e., 66.2%) of these works suggests that the level of diversity can and should be increased further. Another encouraging finding is that the MM-DBR studies are being published in journals characterized by very high impact factors. In turn, this finding suggests that MM-DBR studies are being published in high-profile journals, likely reflecting the relative importance and quality of these works.

A particularly positive finding stems from the fact that women (59.4%) have been statistically significantly (p = .03) more likely than have men (40.6%) to be lead authors of MM-DBR works. This outcome represents a departure from many other numerous fields of study, wherein women are underrepresented as lead authors (e.g., Jagsi et al., 2006; Rigg et al., 2012).

Interestingly, across the corpus of MM-DBR studies, the following three topics emerged: Parent and Autism, Digital and Environmental, and Computer Performance. Of these topics, the latter two likely reflect the periods of the fourth and fifth Industrial Revolutions.

Less than one third of the authors (29.2%) explicitly specified and described adequately their mixed methods research design. This finding is problematic because it suggests that two thirds of these studies were not sufficiently transparent in terms of their overall MM-DBR approaches. Even more disturbing was the finding that more than one half (i.e., 56.9%) of the MM-DBR studies were not grounded within the mixed methods research literature to any degree at all, with an additional approximately two thirds (i.e., 29.2%) of the studies involving grounding of their work to a minimum degree—usually involving only one citation and describing their mixed methods research approach using as little as one sentence. In fact, only 7.7% of the studies represented the mixed methods research literature in a significant manner, with these studies most likely to be among the most recent studies. This latter finding might be considered somewhat encouraging because it might suggest that the trend of not grounding MM-DBR studies within the mixed methods literature is starting to change, albeit slowly. Not surprisingly, authors who explicitly specified the type of mixed methods research design tended to be those who grounded their studies within the mixed methods research literature. However, the finding that MM-DBR studies wherein authors explicitly specified the type of mixed methods research design were less likely to represent a qualitative-dominant mixed methods research design is interesting, which is worthy of future examination.

The most notable finding was that, for all but four studies (i.e., 5.88%), the level of integration occurred at the low end of the integration continuum. For these studies, integration only occurred at the interpretation stage of the MM-DBR process for the purpose of yielding meta-inferences. Therefore, these studies represented only *partial* integration of the quantitative and qualitative research components/phases/cycles. Partial integration approaches are extremely useful for addressing certain types of research questions (Fetters & Freshwater, 2015; Onwuegbuzie, 2023), especially when *parallel sampling designs* are involved—which refers to the situation wherein samples for the qualitative and quantitative components/phases/cycles of the research are different but are drawn from the same population of interest (Onwuegbuzie & Collins, 2007). However, they are not optimal for some of the other types of sampling designs, including *nested sampling designs* (i.e., when the participants selected for one component/phase/cycle of the study represent a subset of those sample members selected for the other component[s]/phase[s]/cycle[s] of the research), and *multilevel sampling designs* (i.e., involving the use of two or more sets of samples that are extracted from different levels of the population of interest [e.g., students vs. teachers]). And, partial integration is especially non-optimal when identical sampling designs are used, which involve exactly the same participants being involved in both the qualitative and quantitative components/phases/cycles of the study. Identical sampling designs involve all participants contributing all the quantitative and qualitative data. For nested sampling designs, multilevel sampling designs, and especially identical sampling designs, a full integration approach—namely, what is being referred to as the 1 + 1 = 1 integration approach—is optimal.

The 1 + 1 = 1 integration approach, introduced by Onwuegbuzie (2017) and further developed by Onwuegbuzie, Hitchcock, et al. (2018) and Onwuegbuzie and Hitchcock (2019a) as a complement to, but not a replacement of, the partial (i.e., 1 + 1 = 3 integration approach), represents *full(er)* integration of qualitative and quantitative elements (e.g., components,

phases, cycles) at *all* stages of the mixed methods research process. The current fully integrated systematic review represents an example of a 1 + 1 = 1 integration approach because each of the 68 MM-DBR studies yielded both quantitative data (e.g., publication year, number of citations for each work, impact factor of each journal) and qualitative data (e.g., title; abstract; each article's literature review section, method section, qualitative findings, discussion section) that were subjected to a fully integrated analysis, This analysis involved both quantitizing (e.g., via use of topic modeling in order to extract emergent themes from the corpus of titles) and qualitizing (e.g., via use of latent class analysis in order to determine the smallest number of clusters that explains the relationships among select fully integrated systematic review variables).

In particular, the 1 + 1 = 1 integration approach involves a replacement of the quantitative–qualitative dichotomy by continua that facilitate this full(er) integration (Natesan et al., 2019; Newman et al., 2015)—thereby preventing a MM-DBR study from being conducted in a piecemeal manner that is characterized by one or more distinct quantitative components/phases/cycles and one or more distinct qualitative components/phases/cycles. In turn, the 1 + 1 = 1 integration approach optimizes synergy both within and across cycles of a DBR study. Therefore, we call for more DBR researchers not only to consider using mixed methods research approaches—and explaining these approaches more fully—but also to consider using full(er) integration approaches, as we move further into the fifth Industrial Revolution and beyond.

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