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Examining purposeful researchable questions in mathematics education

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Abstract

Often general, and frequently involving scholarly concepts, research questions are the cornerstone of studies. Thus, from their precise wording to their context, research questions play a vital role in uncovering information, determining answers given by participants, and drawing conclusions. However, poorly structured research questions and misalignments to purpose within theoretical and empirical studies can lead to miscommunication and unanswered queries. To this point, this paper discusses the importance of asking purposeful researchable questions in mathematics education and examines what purposeful questioning in mathematics education using quantitative and qualitative research designs entails. An extensive review of literature, is presented with the purpose of identifying strategies for asking purposeful questions, exploring various criteria for judging researchable questions in mathematics education, and discussing the importance of aligning research questions to methodology and frameworks. The key findings reveal that ambiguities of language and the powerful force of context in interpreting the meaning of questions and answers could influence the impact of studies. Implications exist for mathematics and science education scholars who, face various challenges in asking questions that will produce what they want to know. The paper concludes with a brief discussion as to the significance and possibilities of purposeful researchable questions in mathematics education.

Keywords: Mathematics Education, Purposeful Researchable Questions, Research Methods and Designs, Theoretical and Conceptual Frameworks

Introduction

Scholarly research in mathematics education encompasses various combinations of new and existing knowledge aimed at promoting much-needed change about the teaching and learning of mathematics (Kearney & Garfield, 2019). By practice, efforts to garner support to push those

combinations of academic knowledge typically start with the use of purposeful researchable questions (Patton, 2015). Research questions guide all stages of inquiry and analysis (Merriam, 2016; Patton, 2015). Purposeful researchable questions afford researchers with opportunities to generate, discuss, and examine the phenomenon in mathematics education that could lead to improved learning and teaching of mathematical content (Hoover, Mosvold, Ball, & Lai, 2016). Focused studies in mathematics education permit researchers, in meaningful ways, to add multiple perspectives about educational practices.

Researchable questions with specific focus pervade research in mathematics education in ways that influence the reporting of a study's purpose, significance, review of literature, methodology, findings, discussion, implications, and recommendations (Gherardi, 2012). With its exactness in language, ordering of words, and context, all requiring precision, research questions are crucial elements to uncovering information, determining answers, and drawing conclusions (Bradburn, Sudman, & Wansink, 2004; Mattick, Johnston, & de la Croix, 2018). Seemingly small changes in the wording of a researcher's research questions can cause substantial differences in responses (Bradburn, Sudman, & Wansink, 2004). As such, the development of researchable questions in mathematics education begins with the identification of areas that require more knowledge or change in mathematical understanding (Heid, 2010; Lesh & Lovitts, 2000; Popkewitz, 2006). Moreover, although that development process varies, and findings, implications, and recommendations of issues impacting mathematics education can sometimes be blurred much of the development of researchable questions require mathematics research scholars to consider strategies in asking uncompromising research questions (Ritter, Anderson, Koedinger, & Corbett, 2007; Schoenfeld, 2008).

In this article, the authors position purposeful researchable questions as structured examinations or explorations involving focused inquiry into a specific phenomenon of interest. The use of purposeful researchable questions in mathematics education guide the selection of a study's participants and sources of data in anticipation of intentionally informing the understanding of the research problem and central phenomenon within the study (Lesh & Lovitts, 2000; Ritter, Anderson, Koedinger, & Corbett, 2007; Schoenfeld, 2008). Thus, in conjunction with identifying the types of research studies employed in mathematics education, the authors discuss strategies for asking purposeful researchable questions and discussing criteria for judging focused inquiry. Additionally, a priority of this article is to highlight the importance of consistency, alignment, promises, and possibilities of purposeful researchable questioning in mathematics education.

Methods

This paper presents an extensive review of scholarly studies about understanding purpose in researchable mathematics education questions, purposeful researchable mathematics education questions by design, purposeful questioning using quantitative research design in mathematics education, purposeful questioning using qualitative research designs in mathematics education, strategies for asking purposeful questions in mathematics education, criteria for asking

purposeful questions in mathematics education, aligning purposeful research questions to framework and methodology, promises and possibilities with asking purposeful questions in mathematics education. The paper analyzed, synthesized, and critically evaluated previous studies on purposeful research questions in mathematics on both the theoretical and empirical fronts. Articles published between 1990 and 2020 were reviewed, with the authors sharing search terms and databases employed to yield 80 articles and books that met their criteria. Steps taken to summarize and analyze the literature were not shared because this is not a requirement or an expectation for writing a literature review article (Stake, 2010).

Results and Discussion

Purposeful Researchable Mathematics Education Questions by Design

Although a basic internet search for what it means for a study to ask purposeful researchable questions would generate a plethora of varying responses, many would argue that these retorts remain bound by a common theme. Which is, purposeful researchable questions seek to answer specific inquiries into concerns or issues (Merriam, 2016; Patton, 2015; Stake, 2010; Yilmaz, 2013). Specifically, purposeful researchable questions in mathematics education identify areas for improvement in mathematics in transformative ways (Bullock, 2012; Martin, 2003). Also, given that a study's research questions influence the extent, impact, and significance of its research findings (Merriam, 2016; Patton, 2015; Stake, 2010; Yilmaz, 2013), the essence of the study's research question has a presence in every aspect of the study's process and results.

Interestingly, purposeful research questions within mathematics education often begin as wonderings worth pursuing (Hubbard & Power, 1993) and are a reaction to the current educational context or historical happenings in need of changes (Capobianco & Feldman, 2010). The meaningful wonderings often transform into researchable questions (Hubbard & Power, 1993) and eventually, a focused study. Through such transformations or interests, educational policies impacting the practices within mathematics education emerge (Bullock, 2012). Making this process of meaningful deliberation of ideas, and the movement from a place of wondering to a place of knowing critical and purposeful. For example, it has long been understood that preschool children who score poorly on mathematics achievement tests are at higher risks for poor long-term mathematics outcomes (Duncan et al., 2007; Geary, Hoard, Nugent, Bailey, & Krueger, 2013). Identifying and remediating the contributing factors of these outcomes has the potential to substantially reduce this risk (Geary & van Marle, 2016). To this end, researchers Geary and van Marle (2016) conducted a quantitative study to exam whether young children's core symbolic and non-symbolic quantitative knowledge is a prediction of later mathematics achievement.

In proceeding with their meaningful wonderings, Geary and van Marle (2016) administered tasks that assessed a collection of non-symbolic and symbolic quantitative competencies and executive functions, verbal and nonverbal intelligence, pre-literacy skills and parental education level of 197 preschool children at the beginning of their preschool years and

again at the end of their preschool years. Geary and van Marle's (2016) meaningful inquiry and purposeful researchable questioning, along with analyzed results of pre -and -post-assessments assist with understanding theoretical models of the foundations of children's early quantitative development. Findings from their study being both critical and purposeful have practical implications for the design of early interventions for children at risk for poor long-term mathematics achievement.

Understandably, information consumes the attention of its recipients (Huang, Yeomans, Brooks, Minson, & Gino, 2017; Kollosche, 2018) and in an information-rich world, mathematics education scholars must be deliberate in their intentions to efficiently call attention to what is happening in academics (Cohen, Manion, & Morison, 2011). For many mathematics education researchers, purposeful or focused researchable questions help frame important things or persons from whom much of the field of mathematics education can learn from (Kollosche, 2018). Therefore, right from the start, researchers determine the type of research design methods to employ. The two types of research methods generally employed are quantitative and qualitative (Lach, 2014). Though some studies employ both techniques, typically, through quantitative or qualitative research designs (Lach, 2014; Neuman, 2006; Neuman & Robson, 2004) mathematics scholars employ different strategies and logics that require a process of decisive questioning (Heid, 2010; Lesh & Lovitts, 2000; Popketwiz, 2006). Together, the two research designs offer considerable insight into the needs and interests of mathematics schooling.

Purposeful Questioning using Quantitative Research Designs in Mathematics Education

There are many reasons for mathematics education scholars to choose a quantitative research study design method of inquiry (Gall, Borg, & Gall, 1996; Mertens, 1998; Punch, 2013). For example, a mathematics education researcher may choose quantitative research if there is a frequency in investigating student mathematics performances using a particular mathematics program design to improve student achievement and data from earlier studies are available. In other words, a researcher could be conducting a study that is confirmatory rather than explanatory and need quantifiable data. Researchers also employ quantitative designs in the event a lack of research exists on a particular topic, there are unanswered research questions, or if the research topic under consideration could make a meaningful impact in mathematics education (Lesh & Lovitts, 2000; Ritter, Anderson, Koedinger, & Corbett, 2007; Schoenfeld, 2008). Researchers employing quantitative designs are primarily interested in objectivity and the need to generalize findings (Robson, 2002; Yilmaz, 2013). This type of research is most preferred when a measurement is required (Bernard, 2012) as a quantitative research study enumerates (Punch, 2013).

Quantitative research is driven by a desire to explain events through existing or emerging data (Yilmaz, 2013). Such research places importance on generalizing, with confidence, from large randomly selected samples to the population it represents (Creswell, 2002; Yilmaz, 2013). Quantitative studies are mostly descriptive or experimental (Robson, 2002). Quantitative

methods emphasize objective measurements and the statistical, mathematical, or numerical analysis of data generalizing it across groups of people or to explain a phenomenon and to give emphasis to human values and experiences (Babbie, 2010; Muijs, 2010; Patton, 2015). This type of research uses a rigorous and controlled design to examine phenomena using precise measurement (Bernard, 2012; Mertens, 1998; Punch, 2013). For example, a quantitative study in mathematics education may investigate students' achievement or performance on an assessment before and after engagement with a specific mathematics resource to see if the resource was useful. Student participants in the study might be asked to use mathematics software as a resource to increase understanding for up to 1 hour a day over four weeks. Afterward, the participants could use the software as prescribed, and then the researcher would measure the participants' performance or achievement by administering the same assessment analyzing the data for significant changes.

In quantitative examinations of mathematics education, studies with purposeful research questions help advance the teaching and learning of mathematics through scholarship centered on quantifiable data (Lesh & Lovitts, 2000; Ritter, Anderson, Koedinger, & Corbett, 2007; Schoenfeld, 2008). In general, focused quantitative methods in mathematics education, often, involve experimental, quasi-experimental, and non-experimental research designs. Quantitative experimental design isolates the identified phenomena with a control group and has at least one experimental group (Creswell, 2014; Yilmaz, 2013). Unlike experimental research, quasi-experimental designs include an intervention in the design, but do not always include a control group (Campbell & Stanley, 2015; Harris et al., 2006). This type of design does not have randomization like the experimental design (Campbell & Stanley, 2015). Instead, there may be an intervention put into place with outcome measures based on pre- and post-intervention implementation and comparison used to identify if the intervention made a difference (Creswell, 2014; Harris et al., 2006; Yilmaz, 2013). Whereas, in a nonexperimental design, there is no manipulation of variables, but an interest exists to observe the phenomena and identify if a relationship exists (Muijs, 2010).

Selection of the appropriate quantitative design dictates the study's focused or purposeful research questions (Cohen, Manion, & Morison, 2011). For instance, in nonexperimental designs, mathematics education scholars utilize purposeful researchable questions to identify established relationships (Baumert et al., 2010; Hill, Rowan, & Ball, 2005; Kersting et al., 2010). Nonexperimental research questions can be broad, exploratory, about a single variable, a causal relationship, or about noncausal statistical relationships (Muijs, 2010). As an example, the question ‘Is there a correlation between verbal intelligence and mathematical intelligence?' is a purposeful and researchable question about a noncausal statistical relationship between variables. Its correlational implications would allow mathematics education scholars studying this phenomenon to identify variables or factors and look for a relationship between them. Overall, nonexperimental inquiries could prove meaningful to mathematics education scholars who examine the correlation between literacy and mathematics (Baumert et al., 2010; Hill, Rowan, & Ball, 2005; Kersting et al., 2010).

Question posing in quantitative studies emphasizes numerical data and measurable variables. Moreover, although purposeful researchable questions do not necessarily produce researchable inquiries, it should be made clear that poorly conceived or constructed questions can create problems that affect all subsequent stages of a study (Agee, 2009). Questions in quantitative designs seek to uncover numerical value and generally satisfy three categories (see Table 1). From these categories, researchers collect data under controlled conditions in ways that prevent the possibility that variables other than the ones under study can account for the relationships identified (Park & Park, 2016).

Table 1. Types of quantitative research questions

Types of Quantitative Research Questions	
Descriptive	Designed to uncover a response to a particular question or variable. An example of this type of question would include asking: *How often do elementary math teachers ask thought-provoking questions during a specific lesson?*
Comparative	Designed to identify apparent differences between a group or groups based on one or more variables. An example of this type of question would include asking: *What is the difference between in-service and pre-service teachers' attitudes about mathematics instruction?*
Relationship-Based	Designed to describe a trend or association between two or more variables within one or more demographic groups. An example of this type of question would include asking: *What is the relationship between gender and mathematics performance in elementary mathematics?*

Source: Tolmie, A., McAteer, E., & Muijs, D. (2011). Quantitative Methods in Educational and Social Research Using SPSS. Maidenhead: McGraw-Hill Education. Retrieved from https://search.ebscohost.com/

In their descriptive research design, Young, Young, and Ford (2017) used elements of a quasi-experimental study to conduct a comparative analysis of fourth-grade Black gifted girls' achievement in mathematics and science during the 2009-2010 NAEP administration. The purposeful research questions that the researchers sought to answer were:

1. How does access to gifted education differentiate the mathematics achievement of fourth-grade Black girls?
2. How does access to gifted education differentiate the science achievement of fourth-grade Black girls?

Young, Young, and Ford (2017) examined the effects of early gifted education on Black girls' achievement in science, technology, engineering, and mathematics (STEM). Young et al., utilized the mean difference effect sizes to examine the magnitude of differences between groups of Black girls. By convention, White girls were included as a comparison group. Girls receiving gifted instruction and girls not receiving gifted instruction were the populations of interest (N = 13,868). With such meaningful researchable questions, the mathematics results of

Young et al.'s, study, through its findings, suggests that Black girls participating in gifted education statistically significantly outperform Black girls in the comparison group.

Purposeful Questioning Using Qualitative Research Designs in Mathematics Education

Conversely, the integration of qualitative research in mathematics education research is a research design that is gaining increased attention and preference for many researchers (Hart, Smith, Swars & Smith, 2009; Sharma, 2013; Silver, 2004). Once viewed as philosophically incongruent with experimental research, qualitative research adds a new dimension to mathematics education research not evident quantitative measures alone. Qualitative research examines phenomena using an in-depth, holistic approach and a fluid research design that produces rich, telling narratives (Lichtman, 2013; Merriam, 2016; Stake 2010). An example of a qualitative study is exploring the student participants' preference for the type of mathematics resource, and the feelings or mood they experience after engaging with the mathematics resources. Additionally, it has opened its agenda to new paradigms and frameworks to better understand math and its impact on the education field from a social, political, and cultural perspective (Gutstein, 2003). Although the shifts are significant, researchers seek to extend the boundaries even further by not only examining questions of what, but how in the field of mathematics education (Pais, Stentoft & Valero, 2010).

Qualitative research is a process of naturalistic inquiry that seeks to understand a person's beliefs, experiences, behavior, attitudes, and interactions (Patton, 2005). The qualitative paradigm posits that multiple realities situate on various constructs of knowledge in which phenomena are studied in its natural setting (Charmaz & Belgrave, 2007). In essence, it requires talking with people and observing what they do and how they interact and interpret their situations. Observations combined with the participant's lived experience (Cashman & McCraw, 1993) determine the plan and ultimately, the types of open-ended questions that must be asked to enhance the researchers understanding of the phenomenon. Furthermore, the data it seeks to generate is non-numerical and allows for which is a departure from traditional modes of research which has often centered on quantitative methods (Arghode, 2012).

Unlike quantitative methods, qualitative methods do not begin with a hypothesis or a predetermined outcome. However, as Richards (2005) notes, a qualitative study cannot begin without a plan since qualitative research does not aim to generalize findings. The research questions that a researcher ultimately chooses guides their inquiry, and ultimately the plan for the design process (Flick, 2006). This plan in qualitative research is ‘emergent’ and often lends itself to an ongoing process of developing and modifying research questions during the research process. As the researcher gains information from participants, it is normal for the focus of the inquiry to shift so that purposeful research questions can be established (Agee, 2009).

The development of research questions entails an ongoing process of reflexivity and inquiry during each stage of the research process regardless of the qualitative design chosen by the researcher (Charmaz & Belgrave, 2007). As such, reflecting on and reformulating research questions are essential navigational tools that can help a researcher to map possible directions

but also inquire about the unpredictable. Defining the types of research questions is a critical step in qualitative research as it narrows down the aims and objectives to specific areas the research will address (Patton, 2005). Creswell (2014) recommend using questions that begin with what or why to convey an open and emergent qualitative design. Creswell's recommendation is evident in mathematics education, where qualitative research encompasses different types and purpose of research questions (see Table 2). These qualitative approaches, as described in Table 2, afford qualitative researchers with opportunities to understand and explore descriptive accounts, differences, and similarities of mathematics experiences.

Table 2. Types of qualitative research questions

Types of Qualitative Research Questions	
Exploratory	Seeks to understand something— without influencing the results with preconceived notions. An example of this type of question would include asking: *How does student discourse impact student achievement in the mathematics classroom*?
Explanatory	Seeks to gain a more in-depth understanding of a topic and the forces and networks that cause and shape the phenomenon of interest. An example of this type of question would include asking: *How does teaching emerging technologies in mathematics impact a student's interest in math?*
Descriptive	Seeks to understand and allow a clear description of a specific phenomenon or experience from the perspective of the individual or group. An example of this type of question would include asking: *What are the experiences of teachers who teach math to ESOL students in kindergarten?*
Emancipatory	Seeks to understand how socio-political factors impact individuals or groups to aid social critique and action. An example of this question would include asking: *How can educators address multiculturalism in Common Core math standards*?

Adapted from: Marshall and Rossman (2006)

Purposeful qualitative questions begin with an inquiry-based process based on multiple qualitative methods that seek to uncover the perspectives of individuals and groups. As such, questions should advance the researcher toward discovering what is happening in a specific setting with specific individuals or groups (Janesick, 2000). For example, in ethnographic studies, mathematics education scholars utilize purposeful researchable questions to understand how individuals or groups give meaning to the world (Hammersley & Atkinson, 2007; Fetterman, 2010). Specifically, Harper (2017) utilized a qualitative ethnographic design to examine 8th-grade students' sense-making about access to healthy food in their local community during two mathematics projects. The researcher sought to answer two purposeful research questions:

1. What storylines about investigating and understanding social justice issues through mathematics do students collectively construct?
2. How do those storylines vary across two different projects focused on the same social justice issue but enacted at different times in the school year to incorporate different mathematical content?

In the first project, students had to calculate the distance from their home to the nearest supermarket. In the second project, students used the USDA Food Access Research Atlas and triangle centers to locate broader areas of food deserts in their community (i.e., centroid, circumcenter, incenter, and orthocenter). Students also determined possible locations for grocery stores to help alleviate food deserts. Upon examination of the students through various focus groups, interviews, and observations over a year, findings highlighted storylines situated on food deserts in the students' local communities. As a result, mathematics was given limited agency upon examining student experiences in their local communities as students become enthralled with the social justice aspect of combating food deserts in their communities.

Additional qualitative designs such as case studies provide mathematics researchers with opportunities to study complex phenomena within their natural setting or context. Maasepp and Bobis (2014) utilize this method to explore factors contributing to the effectiveness of a mathematics content-based intervention designed to nurture positive mathematical beliefs. The researchers explored this phenomenon by asking the following questions:

1. What impact does a mathematics intervention have on prospective primary teachers' mathematical beliefs?
2. What are the key factors contributing to shifts in prospective primary teachers' mathematical beliefs?

The researchers' case centered on five preservice teachers (PSTs) ranging in age from 18 to 21 years, and who were enrolled in a four-year Bachelor of Education (B.Ed.) program at an Australian metropolitan university. Data was collected via semi-structured interviews; concept mapping; observations of participants during workshops; and assignments completed by participants as part of the course. Findings revealed that initial PST perceptions related to mathematics built on negative schooling experiences about mathematics. However, after the intervention program, PST beliefs about mathematics shifted and resulted in positive beliefs and confidence about teaching and learning mathematics.

Strategies for Asking Purposeful Questions in Mathematics Education

While question-asking is a ubiquitous and pervasive human experience Huang et al., (2017), researchers can benefit from employing specific strategies and criteria for asking purposeful researchable questions in mathematics education. Although research not closely related to classroom practices can influence classroom instruction, research strategies that have a more direct impact on daily classroom practice are needed. When evaluating strategies from this perspective, research questions that address teacher's instructional challenges and ones that

answer questions that help the mathematics education field understand why and how the answer provides a solution will likely be purposeful (Cai et al., 2019).

Regardless of the research method utilized, mathematics education studies embed purposeful research questions to provide rich information as to the interest or issues pertinent to the teaching and learning of mathematics that could be eliminated or improved (Lesh & Lovitts, 2000; Ritter, Anderson, Koedinger, & Corbett, 2007; Schoenfeld, 2008). Poorly structured research questions and misalignments to purpose within theoretical and empirical studies can lead to miscommunication and unanswered queries (Merriam, 2016; Patton, 2015; Stake, 2010). More specifically, the ambiguities of language and the powerful force of context in interpreting the meaning of questions and answers could influence the impact of studies (Bradburn, Sudman, & Wansink, 2004). These phenomena are of no surprise to mathematics and science education scholars who, ever so often, face various challenges in asking questions that will produce what they want to know. When asking purposeful researchable questions in mathematics education it is generally best practice to employ the following strategies: (a) use a coherent theoretical framework, (b) clearly state the research questions and hypotheses, (c) employ a sound research design and methods, (d) support the results and implications of the study with data, and (e) appropriately contribute to the field of mathematics education (Cai et al., 2017) (See Table 3).

Table 3. Strategies for asking purposeful researchable questions

Strategies for Asking Purposeful Researchable Questions	
Coherent Framework	Guided by a theoretical framework that influences the study's design, instrumentation, data collection, data analysis, and interpretation of its findings. Literature Review connects to and supports the theoretical framework. Clearly, demonstrate how the theoretical framework influenced decisions about the study's design.
Clear Research Questions	Explicitly stated research questions and hypotheses Questions guided by the theoretical framework
Sound Research Design	Give reliability and validity of research instruments Appropriate statistical procedures Uses member checking Address trustworthiness
Appropriate Contribution	Links Directly to classroom instructional practices Addresses teachers shared instructional problems Provides answers to help the field and mathematics practitioners

Adapted from: Cai, J., Morris, A., Hohensee, C., Hwang, S., Robison, V., Cirillo, M., . . . Hiebert, J. (2019). Choosing and Justifying Robust Methods for Educational Research. *Journal for Research in Mathematics Education, 50*(4), 342-348. Retrieved from https://www.jstor.org/stable/10.5951/jresematheduc.50.4.0342

Criteria for Asking Purposeful Questions in Mathematics Education

In terms of criteria, without appropriate questions or questions that leave no ambiguity of intent and provide opportunities for the variability of outcomes, research studies risk providing meaningless information. Fortunately, several criteria exist for judging researchable questions in mathematics education. Hulley et al., (2001) suggest the use of five characteristics when developing purposeful research questions: a feasible, interesting, novel, ethical, and relevant (FINER) (see Table 4). The FINER criteria outline essential criteria for developing purposeful research questions, and ultimately a good research project. A good research question should specify the population of interest, be of interest to the research community and potentially to the public and have relevance and further current knowledge in the field (Mattick, Johnston, & de la Croix, 2018).

Table 4. Finer criteria for asking purposeful researchable questions

FINER Criteria	
Feasible	Adequate number of subjects Adequate technical expertise Affordable in time and money Manageable in scope
Interesting	Intrigues and piques personal and professional interest among the researcher and community at large
Novel	Confirms, refutes, or extends previous findings Provides new findings
Ethical	Complies with research ethics and codes of conduct
Relevant	Generates new findings Contributes to the field Stimulates further research

Adapted from: Farrugia, BScN, Bradley A. Petrisor, MSc, MD, [...], and Mohit Bhandari, MD, MSc.

The feasibility of a research question is dependent on the researcher's ability to access the participants and data collection resources. It is essential to know the issues of studying a question early on before conducting a full study. As such, Hulley et al. (2001) recommend conducting a preliminary study in order to estimate the necessary participants and resources needed to carry out a meaningful study and to frame the research questions better. For instance, to prospectively study the effectiveness of a new math curriculum for students, consideration should be given to the amount of time it will take to recruit the required number of participants and data sources that will be required.

The development of an interesting research question is a necessary step to conducting successful research and establishing purpose (Hulley, 2007). Within mathematics education research, the researcher should pursue a research question with a purpose and passion for truth

and better understanding. Additionally, focused research should be novel and generate purposeful questions that produce results that can add new information to a given field (Mattick, Johnston, & de la Croix, 2018). For example, Larkin, Kevin, Jorgensen & Robyn (2016) examine elementary students' thoughts, feelings, and emotions as they engage with school mathematics using iPads as a mechanism for collecting information from students about attitudes towards mathematics. The researchers used the following questions to guide their study:

1. How do students report attitudes and emotions towards mathematics; and are there any patterns in this self-reporting that coincide with two junctures in primary schooling?
2. In what ways can the video functionality of an iPad be appropriate for collecting data regarding student attitudes and emotions towards mathematics?

The study further provides a comprehensive and rigorous literature search and review, which revealed 'gaps' in the knowledge that has yet to be reported in the literature. Moreover, the research questions utilized in the study provide a methodologically, robust tool for collecting information on student attitudes and emotions that is both novel and interesting.

A study's design and objectives should meet ethical guidelines as defined by the Institutional Review Board (IRB). An approved IRB must be acquired before conducting any study that utilizes research participants and any at-risk groups. In Worthington and van Oers (2016), the researchers employ purposeful research questions that seek to examine the experiences of preschool-aged children and the impact that pretends play has on mathematical foundations. Within the study, research questions ethically guided data collection as the researchers sought and received approval for the research by the British Educational Research Association's (BERA). Parents of the children were allowed the option to allow their child to participate and could withdraw at any point during the study. Additionally, the researchers explained the research to children in child-friendly language so that the children could agree.

When considering relevance, the researcher should determine whether the research questions are relevant. An excellent way to determine whether research questions are relevant is to assess how the possible theories and findings might advance knowledge, policy, or guide future research in the field (Hulley, 2007). Specifically, Xu and Dadgar (2018) study the causal impacts of low-level remedial math courses using data from the Virginia Community College System (VCCS) that included 23 community colleges. In order to examine this topic, the following question was posed: Would students with the lowest skills in math have better or worse outcomes if they were required to take only two remedial classes, rather than three? Xu and Dadgar's (2018) question guided the quasi-experimental research design and results. In particular, the researchers' findings help to inform the national effort in reforming remedial education for students in higher education. Specifically, in terms of whether removing some required remedial math courses would either benefit or harm the long-term academic success of students who are least prepared for college-level mathematics.

Aligning Purposeful Research Questions to Framework and Methodology

Designing and implementing an appropriate theoretical framework is vital to establishing important research questions. A well thought out theoretical framework strengthens the research study and improves the reporting of research findings (Cai et al., 2019) that describe and connect the theoretical framework to all the parts of a research study in a coherent way. The authors specifically discuss that a theoretical framework should help make a case for the study and frame the literature review, justify the design and methods, and guide the interpretation, reporting, and discussion of the results. Using a well-developed theoretical framework will justify the study and assist the researcher in conceptualizing the study. This justification and conceptualization will help the research continue to develop and ask new questions to improve the study as well as provide new areas of potential research.

Respective to the methodology section of a paper, like how researchers must justify the significance of research questions and the appropriateness of a theoretical framework, the same must be done for the choice of research methods (Cai et al., 2019). Additionally, the choice of particular research methods should be guided by the research questions and theoretical framework. These questions and framework should develop the constraints involved in selecting the most significant and useful research methods (Cai et al., 2019) argue that research should begin with informed hypotheses about what the expected outcomes of the study are. Researchers are then able to choose appropriate methods and data collection to address the hypotheses and yield the desired data. These researchers also suggest that following this process will be an effective means of addressing common problems faced with research methods.

When conducting high-quality research and asking significant research questions, in education, it is necessary to choose effective and appropriate methods that can be justified. Many common methodological errors can be avoided by explicitly connecting chosen methods to the research questions and theoretical framework. Even more, using methods that are well justified and closely connected to the other areas of the study help to support trustworthy findings for creating a high-quality research study.

Promises and Possibilities with Asking Purposeful Questions in Mathematics Education

A subject historically rooted in discoveries, and proofs researchable queries about mathematics education afford scholars, researchers, and practitioners with opportunities to engage in purposeful questioning centered on the doing and talking about mathematics. These aspects of mathematics present many promises and possibilities. Thus, purposeful questioning in mathematics education seeks to elucidate meaning as well as contribute to our understanding of how mathematics works. Whether research centered on assisting with understanding of theoretical models about foundations of early mathematics learning (Geary & van Marle, 2016), or on longitudinal investigations into the extent to which access and opportunity impact students' mathematics achievement (Young, Young, & Ford, 2017; Harper, 2017). Moreover, although the process of scholarly research could be challenging or knowing the right questions

to ask participants that would generate productive responses is not always clear, previous discussions in this article illustrate the value of purposeful researchable questions in mathematics education.

The significance of focused inquiries about the teaching and learning of mathematics is especially crucial for future studies into the complexities and dynamics of mathematics education. Such research would benefit from more investigations examining issues of equity and access in mathematics classrooms. Particularly research involving the analysis of mathematics experiences occurring at the many intersections of the problematization of established assumptions and paradigms deeply rooted in mathematics education. Such research would include focused investigations concentrated on analyzing the relationship between socioeconomics, power, culture, and mathematics education are needed. Within such research, lies to the potential to uncover long-held assumptions about equity and access that could stimulate more productive and needed deliberation about gender, culture, and educational inequities in mathematics education.

Unequivocally, the creative qualities of mathematics permit and expect, that researchers empirically, or otherwise, question the- what, where, why, and for whom mathematics education is for – making the promises and possibilities with purposeful questioning in mathematics education rooted in the understanding of mathematics education as a socio-political process. Thus, requiring researchers to consider how issues of power are manifested both inside and outside of the mathematics classroom. If, on the other hand, scholarly inquiries within mathematics education deprives the mathematics community of helpful and thoughtful discussions about mathematical knowledge and power, including the promotion of equitable mathematical practices, they risk providing meaningless information.

Conclusion

Conclusively, this article provided background knowledge and examined recent literature about the value of purposeful questioning in mathematics education. Focused questions illuminate the significance of building new, improved, and transformative knowledge, which is vital to mathematics education and has implications for research in mathematics education. Primarily, this research can become a reference for young scholars in mathematics education research. Often, these researchers lack clarity on how to engage in critical inquiry about mathematics education, and this article can be a good starting point. The examples given and information provided in the tables do well to summarize each of the points considered for the formulation of good research questions. Additionally, purposeful and resolute goal-oriented research in mathematics education remains necessary. So, if the goal of research in mathematics education is to enhance mathematical understanding and experiences for all, there must be calls for more considerable attention to and transparency around opportunity, access, diversity, equity, and inclusion. To this point, the authors posit that future research with carefully researched ideas and purposeful researchable questions should present new and important insights, data, and evidence-based interpretations to promote productive dialogue for equitable and just practices

in mathematics education. Furthermore, the authors call for those with a vested interest in the teaching and learning of mathematics to demand nothing less.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been covered completed by the authors.

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