RESEARCH INTERESTS

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My research focuses on the teaching and learning of mathematics and knowledge for teaching mathematics using multiple analytic techniques such as Structural Equation Modeling, Hierarchical Linear Modeling, Meta-analysis, Item Response Theory, Multiple Imputation of Missing Data, Hierarchical Linear Modeling of Meta-Analysis Data, and Hierarchical Generalized Linear Models (e.g., Bernoulli, Binomial, and Logistic). I began my research of teaching and learning in mathematics by conducting a systematic review and meta-analysis of studies examining pedagogical strategies for improving achievement in algebra (Rakes, Valentine, McGatha, & Ronau, 2010). The results of that study highlighted the importance of conceptual understanding in promoting student achievement in algebra.

Concurrent to that study, I began an examination of the nature of mathematical misconceptions and the impact of probability instruction on those misconceptions through my dissertation project (Rakes, 2010). This study differentiated observable errors from misconceptions, defining a misconception as a fundamental misunderstanding of a concept or the relationship between a concept and procedure that may lead to observable errors. Qualitative analyses of student explanations for why particular responses were chosen formed the foundation for identifying the rationale used by students to arrive at particular responses on the assessment instrument. These rationales in turn demonstrated that some incorrect responses were linked to underlying misconceptions while others were associated with procedural errors within conceptually correct reasoning.

Moreover, the current literature categorized mathematics misconceptions by content areas (e.g., algebra, geometry) and that probability and rational number misconceptions might serve as predictors of algebra and geometry misconceptions. Structural equation modeling was used to compare these potential relationships hypothesized by the literature between misconceptions in algebra, geometry, probability, and rational number. The results did not support these hypothesized structures, but instead, suggested the potential of an underlying structure that could better explain the data.

Furthermore, the current literature also indicated that understanding probability concepts may reduce misconceptions in algebra, geometry, and rational number. A probability unit was therefore developed as an intervention, and its effect on misconceptions was tested using a cluster randomized design with random assignment at the classroom level. Participant teachers taught both treatment and control classes to minimize their effect on the outcome of interest. Because the treatment condition was assigned at the classroom level, multilevel modeling was used to evaluate the outcome effect. The results indicated no significant differences between the treatment and control group. Taking all of these analyses together, the conclusion was made that defining misconceptions by content area is insufficient for explaining how misconceptions affect the teaching and learning of mathematics. Instead, five structures seemed to be operational to the learning of mathematics across all four content areas, and when misunderstood, misconceptions arose, leading to incorrect responses. Currently, I am conducting a follow up to this study to corroborate such a conclusion.

In addition to examining the teaching and learning of mathematics, I am also interested in the underlying knowledge and experiences teachers need to support effective practice. I began this line of research by helping develop a framework for teacher knowledge (Comprehensive Framework of Teacher Knowledge, CFTK) that accounts for multi-dimensional interactions not addressed by previously existing teacher knowledge frameworks (Rakes, Wagener, & Ronau, 2010; Ronau, Wagener, & Rakes, 2009). My team and I consider the investigation of the validity of the framework to be an ongoing process, requiring a series of studies to examine the usefulness of the framework to model particular phenomena. We began investigating the validity of CFTK by conducting a systematic review of literature across a number of content areas to identify how aspects of teacher knowledge are defined in the literature and to determine if any conceptualizations of teacher knowledge could not be accounted for by the CFTK framework (Ronau & Rakes, 2011). We did not find evidence in the literature of any knowledge aspects or interactions left out of the CFTK framework, so we concluded that the framework is representative of teacher knowledge found in existing literature. Currently, we are planning the next stage of this research, which will consist of examining the validity of the framework against observable classroom practices.

We also examined the usefulness of the CFTK framework as a complementary lens to the Technology Pedagogy and Content Knowledge (TPACK) framework (Mishra & Koehler, 2006; Niess, 2005) and a Research Design framework (compiled from a number of sources such as Shadish, Cook, & Campbell, 2002; Teddlie & Tashakkori, 2009) for examining research in the use of technology to support teaching and learning. After examining over 900 manuscripts, we found that pedagogical knowledge was addressed in 65% of the studies and that knowledge of individual context was addressed in only 16% of the studies (Ronau et al., 2010). The original purpose of the study (to conduct a meta-analysis) was de-railed as we examined the quality of evidence presented and found major gaps in the content and validity of findings that appeared to be the result of inconsistencies in design and reporting of results, such as the application and alignment with clearly articulated theoretical frameworks, quality of validity evidence to justify the development of new theoretical frameworks, and quality of validity and reliability evidence provided to justify claims from primary and secondary analyses. We therefore set out to compile a guide to provide structural models and example studies for researchers and practitioners as they develop, implement, and interpret future research. The result was a peer-reviewed edited book (Ronau, Rakes, & Niess, 2011) that included chapters reviewing strategies that have been used to conduct research on teacher knowledge for educational technology, examining the current landscape of educational technology and teacher knowledge research, considering the role of research in guiding practice, and discussing research design issues that have inhibited the field from constructing high quality evidence to guide future research and practice. The CFTK, TPACK, and Research Design frameworks served as structures to guide the development of each study presented in the book.

As we considered our own research with the three frameworks, we found that they were useful but that several additional lenses were needed to capture the breadth and depth of the existing literature base. We therefore began a new investigation (Rakes et al., 2011), narrowing our focus to the use of technology in mathematics education and incorporating four additional lenses: data sources, technology type, outcomes, and the National Council of Teachers of Mathematics

Principles for School Mathematics (NCTM, 2000). This ongoing study will provide insight into the overall landscape of mathematics education technology literature as well as a synthesis of findings, the scope and quality of dissertation research in mathematics education technology, the scope and quality of teacher knowledge research in mathematics education technology, and the role of technology as a moderator of student achievement outcomes.

These two lines of research focus on significant issues in mathematics education, both of which directly impact the quality of mathematics instruction and student learning. Within both areas, the use of sophisticated analysis and design techniques help answer complex questions about effective strategies for teaching mathematics and issues relating to the preparation of mathematics teachers.

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