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Visual Tools for Eliciting Connections and Cohesiveness in Mixed Methods Research

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In this commentary, we offer a set of visual tools that can assist education researchers, especially those in the field of mathematics, in developing cohesiveness from a mixed methods perspective, commencing at a study's research questions and literature review, through its data collection and analysis, and finally to its results. This expounds upon the ideas and methodological insights relating to research connections and structure presented by other scholars (e.g., Creswell, 2009; Heid & Blume, 2011; Mertens, 2010; Thanheiser, Ellis, & Herbel-Eisenmann, 2012). As faculty who work with graduate students in education, we have found that these visual tools help students elicit and maintain salient connections throughout the research process.

Introduction

The strength of a research study is determined by a multitude of factors, including its contribution to existing research literature, applicable research questions, relevant theoretical framework, reliable and valid measurement instrument, comprehensive data analysis, and appropriate conclusions (Creswell, 2009; Heid & Blume, 2011; Mertens, 2010; Thanheiser, Ellis, & Herbel-Eisenmann, 2012). In a strong mixed methods research study, these factors need to be weaved together, and the researcher must explicitly attend to the cohesiveness of a work.

As professors and researchers who mentor both master's and doctoral students in education, we have found commonalities through the years in students' struggles as they embark upon their first major research study, especially with mixed methods. We have come to agree with Thanheiser et al. (2012) that cohesion is difficult to achieve, especially for early career researchers, and not only does it need to be built in to the methodology, the author should be "explicitly telling the reader what one is doing, how one will do it, and why" (p. 154).

We present here a series of nine visual tools for helping researchers conceptualize the connections and create crosswalks among the research questions, theoretical framework, research literature, data collection, and data analysis. The tools were first developed and adapted by the first author to organize and visualize connections during the dissertation process (Murawska, 2013), oftentimes in collaboration with the second author, who served on the dissertation committee. Since that time, we have both shared these tools with our own graduate students in our respective institutions, and have observed our students' progress toward attaining more cohesive research designs. This has been instrumental in helping our students articulate their methodology as they move through the stages of their research. As such, we are sharing with the broader research community.

Mixed-Methods Model Study
Overview

The development of preservice elementary school teachers' conceptual understanding of place value was examined after participating in a research-based constructivist instructional unit on place value in a mathematics methods course (Murawska, 2013). Quantitative and qualitative data were collected concurrently throughout the study (Mertens, 2010). Over the course of ten-weeks, quantitative data (pre- and post-tests) were collected from 43 preservice teachers. Qualitative data (interviews, journals, and homework) were collected from six preservice teachers determined by their performance on the place value pre-test.

Findings showed preservice teachers demonstrated a statistically significant change in place value understanding. In the qualitative analyses, six common emergent mathematical qualities were identified: flexibility and reversibility, connections between mathematics topics, efficiency, development of self-created notation, improved mental mathematics proficiency, and precise vocabulary. Three common emergent qualities of disposition were also identified: comfort, trust, and confidence in doing mathematics, self-reflection and metacognition aided understanding, and an awareness of the need for both procedural and conceptual knowledge. All of these provided insight into the preservice teachers' thinking strategies.

Visual Tools

1. Research Questions and Data Collection Strategies Chart
2. Data Collection Timeline
3. Data Collection Logistics Chart
4. Theoretical Framework Figure
5. Analysis of Published Measurement Instruments Chart
6. Measurement Instrument and Research Literature Chart
7. Measurement Items and Theoretical Framework Chart
8. Threats to Reliability, Validity, and Objectivity Chart
9. Combining Quantitative and Qualitative Results Chart

For most every tool, a blank template is provided as well as a completed visual tool using relevant pieces of a model study as a context. Although the context of the model study comes from the field of mathematics, the efficacy of these visual tools can be generalized across any discipline. For the sake of brevity, only a portion of some completed tools are included.

Throughout this commentary, Tables/Figures labeled *a* will show the visual tool as a blank template, followed by Tables/Figures labeled *b* with the tool completed using the model study. For each tool, we state our observations of what new researchers struggle with, the purpose of each tool, and the ways in which the tool can be used.

Visual Tool 1: Research Questions and Data Collection Strategies Chart

In the initial stages of research design, we have found graduate students and early career researchers struggle with seeing the big picture of the proposed research project, thinking deeply about what questions are to be answered, and how best to answer these questions. The first tool we present, adapted from Wilkins (2011), encourages researchers to be purposeful in aligning research questions with appropriate data collection strategies (see Tables 1a and 1b). Although the original purpose of this tool was for planning in the early stages of a research study, many of our students decide to include the table in their final paper to provide clarity to their readers.

Table 1a
Template: Alignment of Research Questions with Data Collection Strategies

Research Questions and Hypotheses	Data Collection Strategies						
	A	B	C	D	E	F	G

Table 1b
Model Study: Alignment of Research Questions with Data Collection Strategies

Research Questions and Hypotheses	Pre-Test	Interview 1	Homework	Journal Entries	Post-Test 1	Interview 2	Post-Test 2
1. What level of prior knowledge of place value concepts do preservice elementary school teachers bring to the mathematics methods course?	X	X					
2. How does the place value understanding of preservice elementary school teachers change after they participate in a related constructivist-based place value instructional unit?	X	X	X	X	X	X	X
H_1: The differences among the means of the preservice teachers' level of place value understanding on the pre-test and on the post-tests is not zero.	X				X		X
3. What are the preservice elementary school teachers' perceptions of the constructivist framework components implemented during a unit of instruction on place value?				X	X	X	
4. What is the relationship between the preservice elementary school teachers' perceptions of the constructivist framework components implemented during instruction and their post-performance on the place value assessment instrument?					X		X
H_1: There is a positive correlation between the preservice teachers' perceptions of the constructivist framework components and their performance on the final place value assessment instrument.					X		X

Visual Tool 2: Data Collection Timeline

In a mixed methods study, a researcher will have numerous data collection strategies. New researchers may struggle with creating a master plan for data collection—when quantitative and qualitative data are collected, and how these collection strategies may inform each other. The purpose of the second tool (Figures 1a and 1b) is to help researchers develop a structure and an approximate timeline for data collection. This tool is introduced in the early stages of research design, and is also useful to provide clarity to the reader in the final paper.

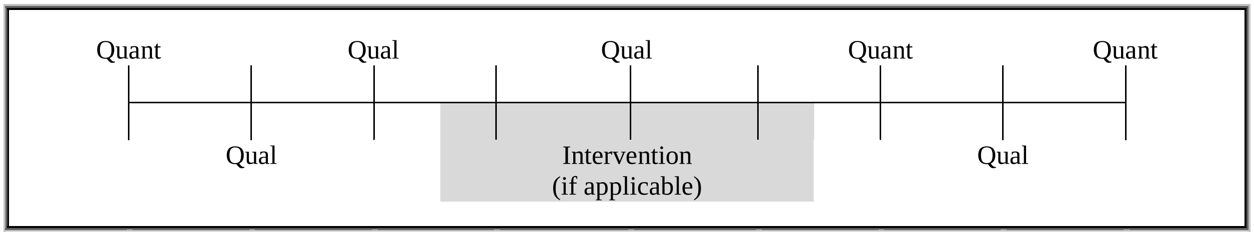

Figure 1a. Template: Structure of data collection in timeline form.

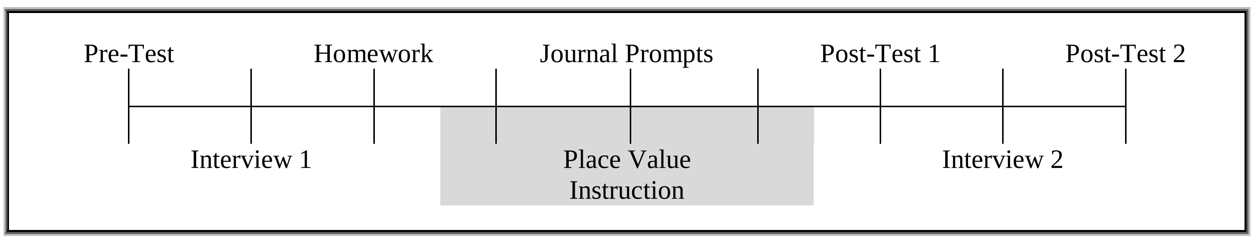

Figure 1b. Model Study: Structure of data collection in timeline form.

Visual Tool 3: Data Collection Logistics Chart

Inherent in designing a mixed methods research study is the need to carefully consider the logistics of each of the data collection strategies, and determine the feasibility of such strategies (Creswell, 2009). New researchers may have ambitious ideas of data collection, but often struggle with determining their feasibility. Hence, the purpose of the following visual tool (Tables 2a and 2b), adapted from the Centers for Disease Control program evaluation guide (CDC, 2011), is to serve as the template for the researcher's thoughtful consideration and detailed planning for data collection. This tool should be introduced before Institutional Review Board (IRB) approval is sought by the researcher.

Table 2a
Template: Data Collection Logistics

Data Collection Strategy	**Qualitative or Quantitative**	**From whom these data will be collected**	**By whom these data will be collected**	**By when these data will be collected**	**Security or confidentiality steps**

Table 2b
Model Study: Data Collection Logistics

Data Collection Strategy	Qualitative or Quantitative	From whom these data will be collected	By whom these data will be collected	By when these data will be collected	Security or confidentiality steps
Pre-Test	Quantitative	43 preservice teachers	Researcher	Week 3 of Term	IRB approval, Consent Form
Interview 1	Qualitative	6 preservice teachers	Researcher	Week 4 of Term	IRB approval, Consent Form
Homework	Qualitative	43 preservice teachers	Researcher	Week 4 of Term	IRB approval, Consent Form
Journal Entries	Qualitative	43 preservice teachers	Researcher	Weeks 5-6 of Term	IRB approval, Consent Form
Post-Test 1	Quantitative	43 preservice teachers	Researcher	Week 8 of Term	IRB approval, Consent Form
Interview 2	Qualitative	6 preservice teachers	Researcher	Week 9 of Term	IRB approval, Consent Form
Post-Test 2	Quantitative	43 preservice teachers	Researcher	After Week 10 of Term	IRB approval, Consent Form

Visual Tool 4: Theoretical Framework Figure

In our quest for cohesiveness, a visual representation of the chosen theoretical framework can serve as the foundation for many stages of the research process. According to Heid and Blume (2011), "The framework, like the literature review, should guide not only the data collection but also the analysis and discussion of results" (p. 108). Furthermore, the depiction of the theoretical framework should not just be a simple diagram with boxes and arrows (Heid & Blume, 2011). Instead, this framework must be built upon the key constructs from the research literature to guide the instrumentation as well as provide the lens for interpreting our results. This task is not an easy undertaking for newer researchers who often struggle with finding an appropriate theoretical framework.

Figure 2 is the representation for the theoretical framework underpinning the model study. A template is not provided for this visual tool, since each framework is unique. This representation was grounded in the research literature of constructivist learning theory (Cobb & Yackel, 1995; Fosnot, 1989; Fosnot & Perry, 2005; Kamii, 1986; Kamii & Housman, 2000; Noddings, 1990; Piaget, 1969; von Glasersfeld, 1989; Vygotsky, 1962) and the theoretical conceptions of number (Cobb & Wheatley, 1988; Fuson, 1990; Kamii, 1986; Steffe, 1994). This visual tool was developed over the course of many years, as it reflected the first author's evolving understanding of constructivism in the mathematics classroom. Recommendations for creating this visual tool are: incorporate the research literature, tie in the key constructs that should be operationalized to undergird the development and implementation of the intervention (if an intervention is applicable), and ultimately these notions should inform the construction of the measurement instruments and the related data analysis.

In sum, the purpose of this tool is to visually capture the essence of theories informing the research study. We share this tool with our students while they are working on their literature reviews, and we recommend they continually reassess their choice of theoretical framework as they gain a deeper understanding of the seminal research literature in their respective fields.

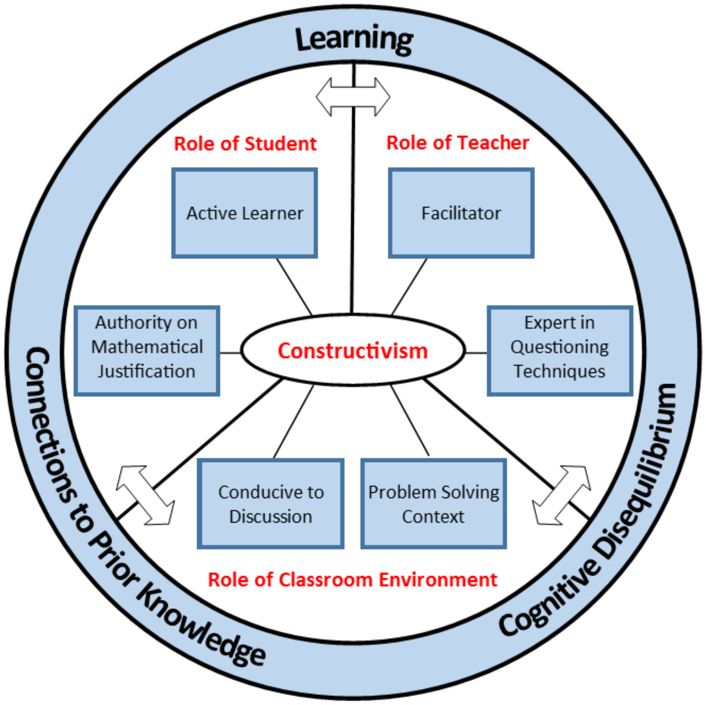

Figure 2. Visual representation of theoretical framework: Components of constructivism in the mathematics classroom.

Visual Tool 5: Analysis of Published Measurement Instruments Chart

Alignment between the theoretical framework, research literature, and the chosen measurement instrument must be intentional and ongoing, even in the early stages of planning the research study (Mertens, 2010). Sometimes, a researcher may find or modify an existing instrument suitable for the study; other times, no single instrument in the research literature exists that fulfills the researcher's needs, necessitating the development of a new instrument to collect quantitative data, a task that we have observed to be a struggle for new researchers. In either case, a careful analysis of published instruments is essential to determine the viability of each assessment item for the present research study.

The purpose of this tool (Tables 3a and 3b) is to assist researchers in applying key constructs from the research literature to make informed decisions on each assessment item. We introduce the tool during the literature review stage to our students who have decided to modify an existing instrument or develop their own instrument and may benefit from having a template to facilitate instrument design and alignment with research literature. Again, students often choose to include the completed chart in the final paper or as an appendix to provide clarity to the reader.

In Tables 3a and 3b, *Reliability* refers to how the scores from the instrument should be nearly the same or stable on repeated administrations of the instrument, and *dependability* is the parallel term used for qualitative data. *Validity* refers to the ability to draw meaningful and justifiable inferences from the scores derived from a sample or a population, and *credibility* is the parallel term used to describe a similar notion for qualitative data.

Table 3a

Template: Analysis of Published Measurement Instruments in Literature Review

Author	Pre-test Pilot Item(s)	Instrument Description	Rationale for Choice	Reliability/ Dependability	Score Validity/ Credibility

Table 3b

Model Study: Analysis of Published Mathematical Instruments with Whole Number Place Value Assessment Items in Non-Base 10

Author	Pre-test Pilot Item(s)	Instrument Description	Rationale for Choice	Reliability/ Dependability	Score Validity/ Credibility
McClain (2003)	11, 12, 15, 16, 17	Video recordings and transcripts, preservice teachers' work, instructor's journal, and field notes to document participants' experiences in the classroom.	Questions provided researchers a way to assess participants' thinking strategies in a problem- solving place value context.	The "constant comparison method" (McClain, 2003, p. 284) was used to create, test, and revise conjectures. This process was made transparent to the reader, increasing the study's dependability.	Study's nature enabled McClain to have what Mertens (2010) calls "prolonged and persistent engagement" (p. 256) between researcher as teacher and the community of learners, bringing considerable strength to the study's credibility.
Safi (2009)	14	Video recordings and transcripts of class sessions, interviews, and focus groups; fieldnotes, and pre- and post-tests using CKT-M database (Hill, Rowen, & Ball, 2005).	Candy Factory problems ask participants to quantify different arrangements where pictorial representations were given.	The team of researchers worked together to increase dependability of results.	Triangulation was used by a team of researchers that provided sufficiently detailed narrative of the case studies, increasing credibility of the study.
Yackel and Bowers (1997)	13	Video recordings, field notes, and copies of student work from class sessions and interviews	Question challenged students to decompose numbers in many ways. (items were in base ten but were easily adaptable to non-base ten).	A team of researchers worked together to formulate and describe children's thinking strategies, thus increasing dependability.	Descriptions of children's thinking were consistently linked to related research literature, increasing credibility,

Table 3c
Model Study: Analysis of Published Mathematical Instruments with Whole Number Place Value Assessment Items in Base 10

Author	Pre-test Pilot Item(s)	Instrument Description	Rationale for Choice	Reliability/ Dependability	Score Validity/ Credibility
Thanheiser (2009)	2	"Deliberately nonstandardized interviews" (p. 255)	Questions relate to quantification and decomposition.	Process of identifying emerging theories in the data analysis was clear to the reader, thus results are dependable. Original source of the interview questions was Phillip et al.'s (2007) instrument which had greater than .90 interrater agreement.	Member checks verified interpretations and established credibility. The results of this study are considered credible because Philipp et al.'s (2007) instrument was piloted extensively and the research was conducted by a team of well-known researchers, adding to this study's credibility.
Thanheiser (2009)	2	"Deliberately nonstandardized interviews" (p. 255)	Questions relate to quantification and decomposition.	Process of identifying emerging theories in the data analysis was clear to the reader, thus results are dependable. Original source of the interview questions was Phillip et al.'s (2007) instrument which had greater than .90 interrater agreement.	Member checks verified interpretations and established credibility. Study's results are considered credible because Philipp et al.'s (2007) instrument was piloted extensively and research was conducted by a team of well-known researchers.
White (1986)	3	50-item written mathematical assessment	Question asked respondent to decompose a base ten number in multiple ways.	Item analysis through student feedback was performed to ensure internal consistency and reliability. Kuder-Richardson reliability was 0.89.	White (1986) consulted expert mathematics educators to establish content validity. Test was piloted and subsequently revised.

Visual Tool 6: Measurement Instrument and Research Literature Chart

Whether developing a new instrument, which involves time-consuming rounds of analysis and revision, or whether selecting or modifying an existing instrument, newer researchers often struggle to keep connected to the broader framework—how the components of the instrument align to the research literature.

Therefore, the purpose of this visual tool (Tables 4a and 4b) is to enable the researcher to readily see the structure of the chosen measurement instrument in relation to the research literature. We recommend introducing this tool at the same point as the previous tool so that the researcher's analysis of published measurement instruments occurs simultaneously with evaluation of potential measurement items.

Table 4b shows the assessment instrument items from the model study categorized by the three place value subconstructs (quantification, composing and decomposing, and multi-digit addition and subtraction) and provides references to the sources from which the items were adapted. The unifying themes of place value (position of a digit determines its value, grouping and trading rules, and unitization) were weaved throughout the place value assessment instrument.

Table 4a

Template: Measurement Instrument and Research Literature Chart

Connection to Research Literature	Type of Measurement Item	Type of Measurement Item

Table 4b

Model Study: Structure of the Place Value Pre-Test as Related to Research Literature

Place Value Subconstruct	Non-Base Ten	Base Ten
(a) Quantification	Given 1 box, 2 rolls, and 5 pieces, how many total pieces of candy are there? (McClain, 2003) **9** Given a picture of 1 box, 11 rolls, and 3 pieces, how many total pieces of candy do you have? (McClain, 2003) **10**	How many tens are in the number 360? (Not from research literature - in textbook by Sowder, Sowder, & Nickerson, 2010) **1** How many hundreds are in a thousand? (Thanheiser, 2009) **2**
(b) Composing and decomposing	You have an order for 167 pieces of candy. How can you pack this candy most efficiently? Now pack this same amount of candy in another way. (Yackel & Bowers, 1997) **11** Given 198 pieces of candy, show two different ways to represent this same quantity. (Safi, 2009) **12**	Of these four numbers, three are the same. Which one is different? a. 63 hundreds and 49 ones; b. 6 thousands, 3 hundreds, 4 tens, and 9 ones; c. 63 tens and 49 ones; or d. 634 tens and 9 ones. (White, 1986) **3** The number 5,342 can be written as 5 thousands, 3 hundreds, 4 tens, and 2 ones. Write this same number in a different way. (Not from research literature - parallels problem above.) **4**
(c) Multi-digit addition and subtraction	A customer ordered 1 box, 5 rolls, and 4 pieces of candy. Then she needed an additional 2 boxes, 4 rolls, and 7 pieces. How will you pack her entire order? (McClain, 2003) **13** There are 3 boxes, 4 rolls, and 2 pieces of candy left in the storeroom. If you send out 1 box, 7 rolls, and 5 pieces, how many candies are left in the storeroom? (McClain, 2003) **14** There are 4 boxes and 3 pieces of candy left in the storeroom. If you need to send out 5 rolls and 7 pieces, how many candies are left in the storeroom? (McClain, 2003) **15** Find the sum: $243_{\text{five}} + 124_{\text{five}}$ (Not from research literature - in textbook by Sowder, Sowder, & Nickerson, 2010) **16**	Meaning of "1" when regrouping: 389 + 475 = 864. (Thanheiser, 2010) **5** Value of "1: when regrouping: 259 + 38 = 297, and 429 – 34 = 395 (Thanheiser, 2010) **6** Analyze equal additions method for subtraction: 91 – 24. (Reys, Lindquist, Lambdin, & Smith, 2009). **7** Analyze children's creative subtraction method: 62 – 47. (Not from research literature but parallels the problem above.) **8**

Note. Boldface numerals indicate the item number in the place value pre-test.

Visual Tool 7: Measurement Items and Theoretical Framework Chart

Not only does the researcher need to attend to connections between the measurement instrument and the literature, but the researcher also needs to ensure that the measurement items are aligned with the vision set forth in the theoretical framework, a task with which newer researchers sometimes struggle. This alignment, in turn, will help the researcher analyze the data accordingly. Hence, each piece of the research process continues to connect to the literature review and theoretical framework, while also building towards the results and conclusion sections (Thanheiser et al., 2012). The purpose of the visual tool shown in Tables 5a and 5b is to organize the intentional alignment between measurement items and the theoretical framework. Like the previous two tools, we recommend introducing this template during the literuare review stage for those students seeking to develop their own measurement instruments.

Table 5a
Template: Measurement Items and Theoretical Framework Chart

Item on Measurement Instrument	**Alignment to Theoretical Framework**	

Table 5b
Model Study: Alignment between Constructivist Perception Items on Post-Test 1 and the Constructivist Framework

Perception Item on Post-Test 1	**Alignment to Constructivist Framework**	
Answering homework questions with a partner before coming to class.	Role of student	active learner authority on mathematical justification
Discussing homework questions with the whole class guided by questions from the teacher.	Role of teacher	facilitator expert on questioning techniques
Demonstration of regrouping using electronic manipulatives.	Role of teacher	facilitator expert on questioning techniques
Discussing base eight decomposition problems with a partner or group.	Role of student	active learner
	Role of classroom environment	conducive to discussion problem solving context
Discussing base eight decomposition problems with the whole class guided by questions from the teacher.	Role of teacher	facilitator expert on questioning techniques
Discussing base eight addition and subtraction problems with a partner or group.	Role of student	active learner
	Role of classroom environment	conducive to discussion problem solving context
Discussing base eight addition and subtraction problems with the whole class guided by questions from the teacher.	Role of teacher	facilitator expert on questioning techniques
Using base eight manipulatives to help visualize trading and grouping rules.	Role of student	active learner authority on mathematical justification
Self-rated confidence in solving base eight addition and subtraction problems accurately.	Role of student	authority on mathematical justification

Visual Tool 8: Threats to Reliability, Validity, and Objectivity Chart

It is imperative for the researcher to be well aware of the study's limitations and to clearly communicate to the reader how threats to reliability, validity, and objectivity have been mediated. In a mixed methods study it can be especially difficult to articulate all of these threats; the complexity of analyzing both quantitative and qualitative data requires the researcher to simultaneously attend to multiple elements. In fact, this visual tool was developed by the first author as a result of a candidacy exam question that asked for a description of current mathematical instruments, including measures of reliability and validity. After six weeks of struggling to understand how these measures for both quantitative and qualitative data analyses are all related, a chart was constructed to illustrate the potential threats and the connections between them. Questions were resolved, and the resulting tool has proven to be particularly helpful to our graduate students.

The purpose of this tool (Figures 3a and 3b) is to ensure that the researcher can demonstrate how all relevant issues relating to both quantitative and qualitative data analyses were addressed. We provide this tool to our students when we begin to discuss their methodology chapter, and many students decide to also include the completed tool in their final papers.

Quantitative		Qualitative	
Internal Validity		**Credibility**	
Threat	How Mediated	Threat	How Mediated
Content Validity			
Threat	How Mediated		
External Validity/Generalizability		**Transferability**	
Threat	How Mediated	Threat	How Mediated
Reliability		**Dependability**	
Threat	How Mediated	Threat	How Mediated
Objectivity		**Confirmability**	
Threat	How Mediated	Threat	How Mediated

Figure 3a. Template: Summary of the Threats to Reliability, Validity, and Objectivity

Quantitative	
Internal Validity	
Threat	How Mediated
History: pre-existing factors may affect the outcome (Campbell & Stanley, 1963)	Included questions on past history (number of previous math classes taken, and highest level of math taken)
History: factors throughout the duration of the time-series testing may affect the outcome. (Campbell & Stanley, 1963)	Included questions which asked participants to rate the factors which influenced their change in conceptual understanding.
Instrumentation: if pre- and post-tests are different, differences in the level of difficulty may occur. (Creswell, 2009)	Mathematics education experts verified correlation of pre- and post-test items.
Content Validity	
Threat	How Mediated
Place value mathematical content may not be representative of both subject matter and cognitive processes.	Mathematics education experts reviewed the mathematical content. (Cohen & Swerdlik, 2010)
External Validity/Generalizability	
Threat	How Mediated
Possible effect of researcher as teacher. (Patten, 2002)	Described the instructional practices in detail.
When the treatment has more than one component, it is difficult to isolate the component that had the greatest effect.	Included questions which asked participants to identify which instructional components promoted the greatest changes in understanding.
Timing of post-test is too close to the experimental treatment.	Included an additional post-test at a later date.
Sample is a convenience sample.	This is a weakness. (Mertens, 2010)
Reliability	
Threat	How Mediated
Check for internal consistency. (Cohen & Swerdlik, 2010)	First sought interrater agreement through external auditors. Then calculated Cohen's κ. (Cohen & Swerdlik, 2010; Walker, 2010)
Potential introduction of bias to research results due to participants' access to pre-test results.	All assessments required participants to explain their thinking strategies in words in addition to showing mathematical computations.
Objectivity	
Threat	How Mediated
There may be researcher bias. (Creswell, 2009)	Established criteria for scoring responses then used a team of external auditors to code a sample of the data.

Qualitative	
Credibility	
Threat	How Mediated
There are discrepancies between the participants' interpretations of events and those of the researchers.	Used triangulation of multiple sources: pre-test, post-tests, interviews, homework assignment, journal prompts. (Mertens, 2010)
Transferability	
Threat	How Mediated
The results may not transfer to different educational settings. (Creswell, 2009)	Provided rich descriptions of preservice teachers' thinking strategies so the reader can best judge transferability to own setting. (Mertens, 2010)
Dependability	
Threat	How Mediated
Conclusions made by the researcher are not clearly supported by the data.	Made the process of identification of emerging themes very clear and provided evidence on how the interpretations were made.
Confirmability	
Threat	How Mediated
There may be researcher bias. (Creswell, 2009)	Researcher's experiences bracketed (Bogdan & Biklen, 2007)

Figure 3b. Model Study: Summary of the Threats to Reliability, Validity, and Objectivity

Visual Tool 9: Combining Quantitative and Qualitative Results

In the results sections of a mixed methods study, the researcher will not only communicate quantitative and qualitative outcomes separately, but he or she will also provide evidence on how the results from both types of data analysis inform each other depending on the chosen mixed method design—exploratory, explanatory, quant/qual, qual/quant, etc. Because newer researchers sometimes struggle with integrating the quantitative and qualitative and data analysis in a meaningful way, we provide a visual tool (see Table 6), which combines both types of data in one chart.

The purpose of this tool is to help illustrate explicit connections between the data, and we provide this to our students when discussing the content of the findings and conclusion chapter, though students sometimes choose to include the completed chart in their final paper as well. Again, we do not offer a template for this particular tool due to the unique nature of individual studies' results. General recommendations for creating this visual tool are as follows: consider the multiple perspectives used to analyze the same occurrences, list the most important quantitative data points for each person or event, then choose the most important nuggets of qualitative data to provide a rich description of that quantitative data point. In the case of the model study, we used the phrase *Growth Profile* to describe each student's improvements in conceptual understanding of place value; however, other researchers would choose appropriate descriptors to capture their most notable pieces of qualitative data.

Table 6

Growth Profile Combining Quantitative and Qualitative Results

<table>
<tr><th rowspan="2">Pre-test Level</th><th rowspan="2">Student</th><th colspan="3">Composite Scores</th><th rowspan="2">Growth Profile Based on Qualitative Data</th></tr>
<tr><th>Pre-test</th><th>Post-test 1</th><th>Post-test 2</th></tr>
<tr><td rowspan="4">Low-Performing</td><td rowspan="2">Sarah</td><td>1.364</td><td>2.500</td><td>2.818</td><td rowspan="2">• Notable improvement in conceptual place value understanding, especially with base ten unitization
• Discomfort with symbolic regrouping in base eight remained</td></tr>
<tr><td colspan="3">Perception of most helpful constructivist components: whole-class discussion of base eight symbolic regrouping facilitated by the teacher</td></tr>
<tr><td rowspan="2">Alyssa</td><td>1.682</td><td>2.864</td><td>2.955</td><td rowspan="2">• Conceptual understanding of unitization in the base ten standard algorithm for subtraction
• Development of an eloquent notation for base eight mental regrouping</td></tr>
<tr><td colspan="3">Perception of most helpful constructivist components: whole-class instruction, small group instruction, virtual base ten manipulatives, and mental math practice with one-digit base eight addends</td></tr>
<tr><td rowspan="4">Middle-Performing</td><td rowspan="2">Tori</td><td>2.000</td><td>2.682</td><td>2.955</td><td rowspan="2">• Substantial improvement in base ten conceptual understanding
• Development of an organized notation for base eight mental regrouping</td></tr>
<tr><td colspan="3">Perception of most helpful constructivist components: whole-class discussion of base eight symbolic regrouping</td></tr>
<tr><td rowspan="2">Liz</td><td>2.045</td><td>2.409</td><td>2.955</td><td rowspan="2">• Notable improvement in conceptual understanding of base ten unitization
• Recognition of the multiplicative structure of regrouping and complexity of written algorithms</td></tr>
<tr><td colspan="3">Perception of most helpful constructivist components: virtual base ten manipulatives, base eight manipulatives, mental math practice with one-digit base eight addends, counting in base eight</td></tr>
<tr><td rowspan="4">High-Performing</td><td rowspan="2">Michael</td><td>2.500</td><td>3.000</td><td>2.955</td><td rowspan="2">• Development of an organized and eloquent notation for base eight regrouping
• Mastery of mathematical content allowed for thinking in terms of the learner's perspective</td></tr>
<tr><td colspan="3">Perception of most helpful constructivist components: multiple representations such as base eight manipulatives and the number line, whole-class discussion facilitated by the teacher</td></tr>
<tr><td rowspan="2">Kate</td><td>2.909</td><td>2.955</td><td>2.955</td><td rowspan="2">• Awareness of her prior lack of conceptual knowledge underlying base ten algorithms
• Improvement in the articulation of unitization in the base ten standard algorithm for subtraction</td></tr>
<tr><td colspan="3">Perception of most helpful constructivist components: actively helping classmates in small-group discussion, mental math practice with one-digit base eight addends</td></tr>
</table>

Note. The student names presented are pseudonyms.

Conclusion

We recognize that designing a cohesive mixed methods research study is often difficult, especially for graduate students and early career researchers. To help elicit salient connections between the literature review, theoretical framework, data collection, analysis, and results, we have found that the visual tools contained herein to be fruitful in creating crosswalks at every stage in the research process. The visual tools not only assist the researcher in planning, but also provide clarity to the reader in the finished product.

Overall, we have found that our master's and doctoral graduate students have enjoyed having these visual tools as templates and models as they design, plan, and implement their research. As we are all aware, designing a new research project can be an overwhelming task, and these tools can help newer researchers conceptualize these connections in a manner that is not too daunting. Not only have the students expressed gratitude for the tools, but we have enjoyed seeing the resulting improvements in cohesiveness.

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