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Mosaics, Triangles, and DNA: Metaphors for Integrated Analysis in Mixed Methods Research

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Abstract

Metaphors used to describe the process of integration of analyses in mixed methods research are analyzed to determine various ways in which researchers think and write about integration. By examining the metaphors used and through examples of the application of each metaphor, the authors clarify the integrative processes they point to. The authors conclude this analysis by identifying from these metaphors eight principles to guide the effective integration of analyses in mixed methods research.

Keywords

mixed methods, integration, metaphors, analysis

Integrating Analyses

Increasing recognition of the utility of applying more than one approach and multiple methods to research problems of many different kinds is leading to the widespread adoption of mixed methods as a valid methodological approach in social research. *Mixed methods research*, for the current context, is broadly defined to include research in which more than one paradigmatic or methodological approach, method of data collection, and/or type of analysis strategy is integrated during the course of undertaking the research, regardless of how those approaches or methods might individually be classified, and with a common purpose that goes beyond that which could be achieved with either method alone. Concomitantly, with increasing acceptance and use, the focus of theorizing about mixing methods has shifted from paradigmatic issues and design typologies to methods issues, including sampling, analysis, and validity. However, the challenge of how different methodologies and methods might interact across integrated designs remains not fully resolved (Flick, 2007). Integration has been variously described as ''not achieved and difficult to do'' (Bryman, 2008, p. 93) and as being undertheorized and understudied (Greene, 2007).

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There are multiple rationales for mixing or integrating methods. Integration of component parts of the study will be shaped quite differently, depending on the rationale or purpose for the study:

- The value most often expressed is that integration of methods assists in building stronger conclusions, as the strengths of one approach or method serve to compensate for the weaknesses of the other (e.g., Johnson & Onweugbuzie, 2004). The strengths approach implies the use of a complementary or extension design for mixing methods to more effectively support the outcomes, and indeed, this is the most common design recorded in published studies (Bryman, 2006).
- Mixing methods, alternatively, is seen as a way of initiating new understanding of the topic at hand. A dialectical approach, for example, with its goal of initiation, celebrates tensions created through the use of different approaches and methods, as a means of prompting further exploration and deeper understanding (Greene, 2007).
- Alternatively, again, mixing methods is seen as a way of providing a more complete understanding, for example, of causal processes. A critical realist approach demonstrates the need to consider both regularities that are assessed through empirical observation *and* mechanisms that are identified through a qualitative approach (Maxwell, 2004; Maxwell & Mittapalli, 2010). Such studies might use either a complementary or a generative design that serves to initiate new understanding.

To achieve one or the other of these purposes, integration in a study involving more than one approach, source or type of data, and/or strategy for data analysis necessarily involves the following:

- Having a common purpose or goal to unite these
- Interdependence of these different elements in reaching the goal
- Having a sum greater than the parts (Bazeley, 2010a)

Our approach recognizes ''the reality that there can be many different 'mixes' or combinations of methods'' (Yin, 2006, p. 41) and rejects a clear demarcation between qualitative and quantitative methods or approaches to research (Bergman, 2008), seeing these rather as being end points on factors within a multidimensional continuum.

In our reading, we have become very aware of the lack of integration in the analyses presented in a very large proportion of articles reporting studies that used mixed methods (see also O'Cathain, Murphy, & Nicholl, 2007). Lack of integration is problematic, for example, in studies where greater understanding or more valid results might have been obtained if all types of available data had been considered together (Bazeley, 2009). Typically, quantitative results, usually from surveys, are presented first in reports of studies, to be followed by a necessarily brief thematic analysis of interview material or answers to open-ended questions. Sometimes the threads from both strands are drawn together as a basis for a model or some other conclusion but not always. Thus, not only is integration of methods undertheorized and understudied but also the level of integration practiced in many mixed methods studies remains underdeveloped; although on a more positive note, we would suggest that this situation is changing for the better as more people accept and explore the use of mixed methods approaches to research.

Metaphors in the Discourse of Social Research

A metaphor carries over, or transfers, meaning from one conceptual domain to another (Lackoff & Johnson, 1980); thus, information is *consumed* and *digested* and theory is *constructed*, *built*, or *grown*. Metaphors create images that facilitate understanding, communication, and remembering through using something familiar—such as eating, building, or agriculture—to explain or describe something new or more difficult to comprehend (Bonner & Greenwood, 2005).

Metaphors often convey more than the literal meaning: Their implied meanings create new realities for recipients by affecting their perceptions and thus their actions (Krippendorff, 1993)—they are ''a device of representation through which new meaning can be learned'' (Coffey & Atkinson, 1996, p. 85). ''Metaphor in general creeps up on you, surprises you'' (Janesick, 2000, p. 380).

In the context of social research, researchers have studied the use of metaphor in various settings; for example, Seale (2001) looked at the use of military and sporting metaphors in media reports describing people's responses to a diagnosis of cancer; Brinton (1938) used the metaphors of fever and chills to describe the ebb and flow and peaking of fervor in major political revolutions. Researchers have also mixed metaphors as a way of provoking new questions and stimulating new insights, for example, in talking about night as a frontier, cities as organisms, deviance as a career, or capitalism as punctuated equilibrium between economic tectonic plates (Brewer & Hunter, 2006). Mathison (1988) referred to the practitioner of mixed methods as needing to be like a detective, a car mechanic, and a doctor insofar as they needed to deal with uncertainty and exercise intuition and purposive action.

Metaphors have been applied to methods also. Janesick (2000) framed her key principles of qualitative research design around the familiar (for her) domain of choreography. Richardson (1994) used the crystal to explain qualitative research and writing because what one sees depends on how it is held up to light, that is, how it is viewed; the different facets and angles lead to a more complex understanding.

Mixed methods researchers readily adopt metaphors to describe the integrative process they are using, and metaphors for integrating methods abound, but they are used often without particular thought as to exactly what is being conveyed (Bryman, 2008). The term *triangulation*, for example, has been used to refer to any kind of combination of methods and more specifically, to both corroborative, or convergent, and complementary designs.

The problem, for the current context, is that mixed methods researchers assume a shared understanding of commonly used metaphors. This shared understanding may not exist, however, because the field is still so young and complex—yet precise use of metaphor is revealing, and so there is value in clarifying and analyzing the metaphors used to illuminate some principles, including roles, purposes, and strategies, for integrating data. In doing so, we hope to advance thinking about what is going on when analyses are integrated in mixed methods studies.

Methods for This Review

Rather than attempting to undertake a systematic review of the use of metaphors for integration in reports of mixed methods studies, we have drawn on our wide experience of both methodological and research writing across a diverse range of fields to identify a selection of metaphors that have been applied. When we started analyzing the metaphors we had found in the literature, we found we often disagreed with the way in which they had been used. Moran-Ellis et al. (2006) also found that the interchangeable use of terms and metaphors in this area obscured the different processes involved.

Metaphors were examined, therefore, in both their original (i.e., descriptive) and applied (metaphorical) contexts to determine their essential elements and processes. They were then sorted and classified to arrive at a framework that helped clarify the principles involved and their applications. Our difficulty in doing this was that these metaphors were not mutually exclusive, and indeed, we found in many studies that multiple strategies were used and could be used as examples for multiple metaphors—as noted by Jang, McDougall, Pollon, Herbert, and Russell (2008) in their discussion of research designs:

> Mixed methods design alternatives are useful for clarifying the inquiry purpose and linking it to methodologies, [but] in practice such design options are neither exclusive nor singular

> because actual mixed methods studies are often much more complex than any single-design alternative can adequately represent. (p. 225)

Consequently, any attempt at classification is open to discussion and revision, as, indeed, has occurred throughout the past few decades with typologies of mixed methods research designs. It is what this analysis of metaphors and the dimensions identified from them reveals about principles and strategies for integration in mixed methods studies that is more important, however. These will be summed up in the concluding discussion of this article.

Metaphors for Integrating Analyses

Each metaphor we explore points to particular processes involved in integrating analyses of mixed data. We found that processes vary on a range of dimensions with relevance to thinking about and planning for integration. They differ with respect to the following:

- The purpose for integration, whether that be to strengthen through complementarity or initiate new ideas or understanding of processes and consequences
- Their design, whether that is a priori or emergent
- The approach to analysis, whether descriptive or analytic/theory building
- The degree of interdependence of the different data elements, as seen in the following:
  - The integrity of each component part of the study—whether each was complete in itself or only when together
  - The degree of integration, seen in the extent to which each contributing method retained recognizable individual identity, and the capacity to disaggregate them once integrated
  - The complexity of the integration, evident in the amount of change and exchange in and between data gathered by different methods during the process of integration

For presentation purposes, the metaphors we present are grouped and arranged along a primary dimension of interdependence. Change within each of the elements being integrated becomes more evident as we move through, and there is an increasing level of exchange between elements in contributing to the integrated outcome, with a corresponding loss of recognizable identity in the particular elements being integrated. Thus, we describe the following strategies:

Complementary strategies:

- Combining for completion
- Combining for enhancement
- Combining to detail a more significant whole

Generative strategies:

- Iterative exchange for initiation and development
- Transformation for initiation through exploration

We conclude with principles for integration in mixed methods studies.

Combining for Completion: Bricolage, Mosaics, and Jigsaws

This first group of metaphors, including bricolage, mosaics, and jigsaws, are the weakest in terms of integration. Pieces of separate components are placed side by side, not necessarily in any particular sequence, without changing the structure of any piece. The information makes sense when

the different component parts, which may be of equal or unequal status, are combined in a complementary way to create a comprehensive understanding or to achieve a single, unified outcome.

A *bricolage* is something that is made or put together from whatever materials happen to be available, including pieces that may be discards from other projects. The pieces may or may not have meaning on their own; the final product does not necessarily need (or receive) a lot of design. The outcome could be a bit ''patchy,'' drawing attention to some bits and not others. Denzin and Lincoln (2000) referred to the (qualitative) researcher as a *bricoleur* or quilt maker who borrows from many different disciplines, perspectives, theories, or methods, working between and within competing and overlapping paradigms and perspectives, with the resulting quilt, collage, or montage being a ''set of fluid, interconnected images and representations'' (p. 6).

In contrast to the bricolage, design is critical in *mosaics and jigsaws* as each piece contributes to the total—the integration has to be purposeful. In these metaphors, integration is only complete when all the pieces are placed to make the final product.

Just as artists vary in their ability to create a holistic image from the elements they place together, so also researchers might vary in the degree to which they are able to integrate their component data items. But the greater the degree of integration, the more likely it is that the combined product will create an impression that is quite different from, and richer than, the separate components.

To explore residents' preparedness to evacuate in the event of eruption of the Katla volcano in Iceland and the consequent glacial outburst flooding into the surrounding hazard zones, geographer Deanne Bird (2010) used maps of the area that showed rivers, roads, and settlements; observed an evacuation trial; interviewed emergency workers; and survey-interviewed residents. In the event of an eruption, residents in three of the farming communities were to be evacuated due to the risk of flooding, while houses in the low-lying coastal section of a fourth area were to be evacuated due to tsunami risk. Evacuation for the farming communities is a more complex process involving disconnecting electric fencing and releasing livestock, and one of these communities will have only 15 minutes for warning in contrast to 30 minutes for everyone else.

When the maps, box plots indicating levels of preparedness, and resident comments were viewed in conjunction with each other, a clear picture of some of the factors influencing residents' preparedness for such an event emerged. The group of residents who were given less warning time than others felt least confident about their preparedness for evacuation, whereas the residents of the coastal town, who were just 5 minutes away from their evacuation center, generally felt more prepared. Residents in one community were better prepared because they had worked together on developing an alternative plan to the official one, as the latter required that they leave their higher homes to cross a low-lying area in the direct path of the flood in order to get to their evacuation center. Recently arrived residents were unprepared, whereas the persons who had actively sought information on previous eruptions, risk mitigation procedures, and current events felt completely prepared. Thus, the picture of a community that is partially but not completely prepared, with an understanding of the contribution of both geographical and social factors, is built from placing the various components together and seeing them in relation to each other.

Combining for Enhancement: Sprinkling and Mixing/Stirring

These metaphors of sprinkling and mixing are somewhat similar to the previous, but their combination is directed toward enhancing rather than completing an image. Typically, one component will be primary, with the secondary component extending results from the primary one. The

primary method may be complete but inadequate without the supplementary method, but the latter is unlikely to be in a form that could support a complete analysis. Whether they fit a definition of mixed methods depends primarily on when all components are first considered together and whether the combination of components serves to enhance the quality of the overall results.

Sprinkling was used to describe the common situation in which participant quotes or vignettes are ''thrown in'' to satisfy an agenda or give meaning to a statistic. Alternatively, a few numbers might be thrown in to enhance a descriptive report and to impress policy makers. David Karp (as cited in Hesse-Biber, 2010) referred to sprinkling as being ''like going to the ice cream store and throwing a few M&Ms onto the top of the ice cream to make it look pretty, and it might taste a little bit better'' (p. 23). He did not regard this as a valid mixed methods approach. If this is all that sprinkling consists of, then we would agree with Karp. Sprinkling is at best a minimalist form of mixed methods integration, as disassociated numbers or single quotes on their own are not evidence for anything. To have value, even as an illustration, the sprinkles must add meaning to the alternative-method argument and must always be undergirded by data from across the sample more generally.

When things are *mixed* (or *stirred*) together, such as when making a salad mix or stir-fry, the degree of mixing is greater than for sprinkling as it involves turning them around together rather than simply dropping one onto the other. Ingredients added to complement the main ingredient may or may not remain fully distinguishable within the mix. The quality of the resulting flavor depends on the skill applied to the selection and stirring of the components.

In a project charged with the task of developing a definition of early career in research, suitable for implementation by the Australian Research Council across the full range of disciplines within its mandate (from pure and applied sciences to the humanities and professions), information was sought from multiple sources that included surveys, reviews of documentary evidence, observations, e-mails, and interviews. Although the statistical analysis of survey data provided the foundational material for the report and its conclusions, the evidence of these data was greatly enhanced by material derived from the additional sources. By ''stirring together'' data from all these sources (organizing it by issue rather than by source), five progressive and critical milestones on the path to becoming a successful academic researcher were identified for the Australian setting. These were the following:

- Gaining a high-level research qualification
- Acquiring an academic appointment
- Balancing the demands of teaching with the need/desire to research
- Maintaining a research profile when promotion brings increased nonresearch responsibilities
- Achieving a profile as an established researcher

Based on a review of these critical points passed by research-oriented academics on their journey from research training to becoming established in a research career, it was then possible to identify features that were foundational for a promising research career. Environmental or other circumstances that inhibited the development of research potential, the presence of which warranted giving consideration to those affected by them, were also identified. Each of the factors identified as potentially relevant was then verified against the full body of quantitative and qualitative evidence, leading to the development of a well-supported and widely applicable definition for an early-career researcher (Bazeley, 2003; Bazeley et al., 1996).

Combining to Detail a More Significant Whole: Triangulation and Archipelago

Triangulation and the image of an archipelago are metaphors that demonstrate how data elements can complement each other and interact to reveal an end point that is clearly in perspective but

that cannot be obtained from either individual methods or a simple combination of methods. In completion and mixing, you have all the pieces at hand, whereas here the integration is directed to identifying or understanding an entity that is not contained within the separate parts.

Triangulation is one of the oldest metaphors in the mixed methods lexicon. It remains the most used and perhaps the most abused metaphor of all. Use of the term in the methodological literature can be traced to Campbell and Fiske's landmark article in 1959, which argued for the value of a multitrait–multimethod (correlation) matrix to assess both the validity and the discriminatory power of measures of multiple traits associated with personality. This reflected matrix embraced a series of heterotrait–heteromethod and heterotrait–monomethod *triangles* separated by validity diagonals and a reliability diagonal (Figure 1). Although their discussion focused on the meaning of the figures in the diagonals in relation to those in the triangles for various aspects of validity, they did not specifically use the term *triangulation* in that article. The term was first used a few years later, when Webb, Campbell, Schwartz, and Sechrest (1966) argued that ''once a proposition has been confirmed by two or more independent measurement processes, the uncertainty of its interpretation is greatly reduced. The most persuasive evidence comes through a *triangulation of measurement processes*'' (p. 3, italics added). They provided no explanation for their use of that particular term, but they used it in the context of a discussion about operational definitions and multiple measurements for social concepts in which they referred to Campbell and Fiske's article, among others (note Donald Campbell's common authorship). The term *triangulation* was popularized in the context of qualitative research, as most readers will know, by Denzin (1970, 1978). Of Denzin's (1978) four types of triangulation, by far the most commonly referred to is methodological triangulation. Historically, then, triangulation was seen as a tool for validation (strongly supported, for example, in the more recent mixed methods context by Greene, 2007; Greene, Caracelli, & Graham, 1989). When viewed in this way, triangulation does not belong to this list of metaphors as it says nothing about integration of methods but rather emphasizes that the methods involved must remain independent to allow ''uncontaminated'' results to be compared.[1] Difficulties with the idea of mixing methods as a form of validation were later noted by Denzin (1989) himself, along with others who argued that different theories and methods arise from different traditions that, when combined, can give a fuller, more complete, or enhanced picture but not necessarily a more valid one (Flick, 1992). This use of the term continues, however.

This outcome of many studies intending triangulation, that is, complementarity rather than validation, and the common use of triangulation to refer to studies where methods are complementary rather than confirmatory, means that the use of triangulation as a technique for mapping by surveyors is potentially more helpful as a metaphor for this use of the term. In surveying (and the mathematical fields of trigonometry and geometry on which surveying is based), triangulation allows the surveyor to fix the location of an observable point by using the baseline between the two known points and the angles made at each end of the baseline when viewing the distant point to construct the sides of a triangle. Each of the two sidelines so created will meet, and so they can now be measured and the location of the distant point fixed (Figure 2).

This understanding of the metaphor suggests an approach involving a combined use of two different types of knowledge (the lines and angles of the triangle) to point to information beyond what is already known in order to construct new knowledge. One could also argue that this metaphor could be extended to studies that have a developmental focus as well, as each completed calculation provides baseline information (using a previously defined sideline) for further exploration and mapping.

From this example of triangulation, we draw four points about triangulation as a metaphor for mixing methods:

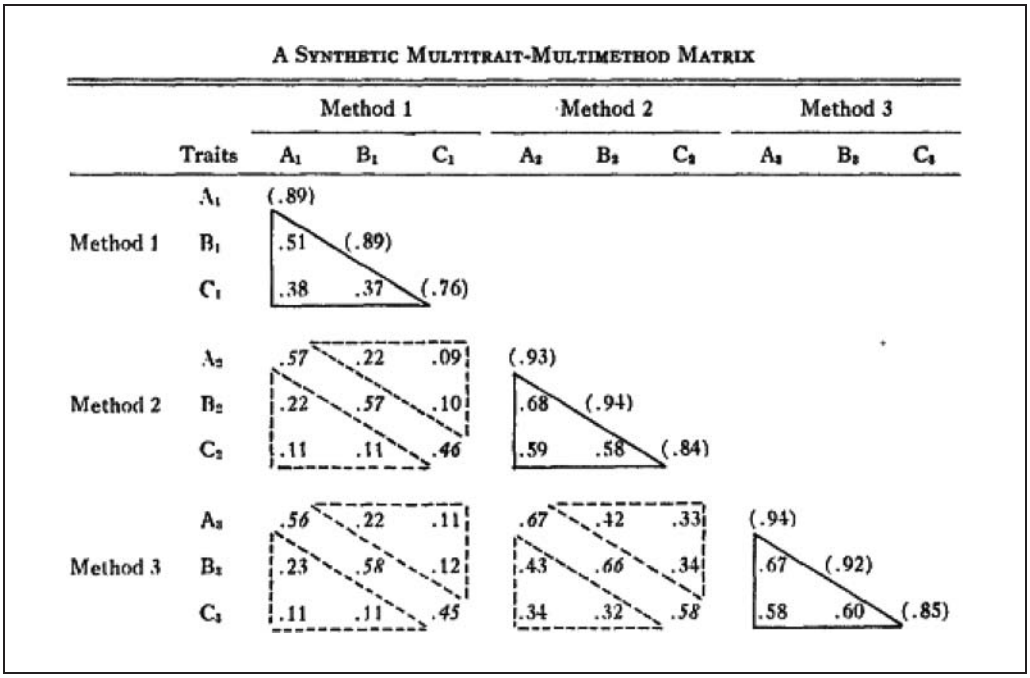

Figure 1. The triangular shape of the multitrait–multimethod matrix, designed to test the validity of parallel measures of various personality traits

Note: The validity diagonals are the three sets of italicized vales. The reliability diagonals are the three sets of values in parentheses. Each heterotrait-monomethod triangle is enclosed by a solid line. Each heterotrait-heteromethod triangle is enclosed by a broken line.

Source: Campbell and Fiske (1959, p. 82, Table 1).

1. Focus on an identified goal point is needed—it is just details that are to be determined.
2. Multiple sources of information that are of at least two types are necessary to determine the location of that point.
3. Each source of information contributes equally to the calculation of its location.
4. Because neither method nor any source is adequate in itself to provide the necessary information, information derived from the various sources needs to be integrated during the analysis and preparation of the results in order to achieve the goal, that is, all sources must be used together.

Although many studies claim to be using this kind of triangulation approach, it is difficult to find any that go beyond combining for completion or enhancement, to meet the degree of integration suggested by the fourth of these criteria, in particular. For example, the health and health service usage of homeless youth in Germany was investigated by Uwe Flick (2010) using three methods: observation, interviews with youth, and planned interviews with experts. Data from observations and interviews with youth were combined in the presentation, but those from interviews with experts were presented separately (in that article, at least). Flick describes his study as one using triangulation, initially seeking validation, but he found instead the different methods worked in a complementary way to generate a picture of the conditions under which medical care for homeless youth became difficult to be claimed or supported when the issue of housing was ignored. In his conclusion, however, Flick described each of these methods

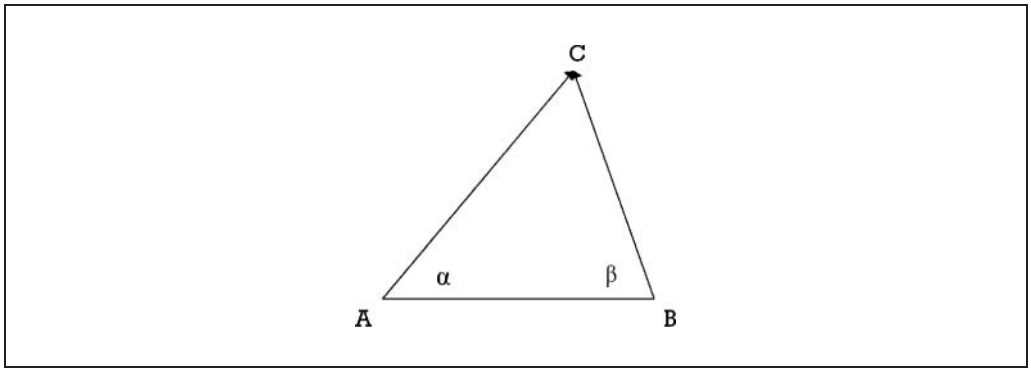

Figure 2. Triangulation involving complementary sources of information
Note: The exact location of the point C and the lengths of the lines AC and BC are determined from the combined location of the points A and B and the sizes of the angles BAC (α) and ABC (β).

used in the study as having an *additive* (rather than conjoint) benefit in building a more complete picture of health issues for homeless youth.

An *archipelago* is a set of islands connected underwater to form a group, such that the separate yet connected islands that show above the surface are just the tips that evidence the presence of a much larger underwater structure. Some evidence is in plain view, but much remains more or less hidden and can be difficult to reveal. Some islands are outliers; some others may not in fact be part of the archipelago but exist in their own right. Each island in the archipelago appears on the surface as a separate entity; not all are of the same size. Islands emerging as a result of undersea volcanic activity might develop later than others and shift position slightly over time.

The archipelago metaphor was proposed by Lawrenz and Huffman (2002) to describe those studies where integration of information from multiple separate sources of data points to a greater level of knowledge or understanding than that which could be obtained by a simple combination of those sources. The sources that evidence the presence of the whole might be somewhat randomly placed in relation to the whole, and the outline of the whole difficult to exactly determine. Each contributing element retains its distinctive character and varies in level of contribution.

In evaluating a teacher development program for science teachers, Lawrenz and Huffman (2002) used multiple approaches and multiple sources of information within and across those approaches. Their quasiexperimental approach, which accounted for approximately half of the ''islands,'' tested changes in student achievement in comparison with a within-school control group using a variety of assessment techniques. These islands provided a cluster of information about the knowledge and application of that knowledge by the students and teachers in the program. The second approach, accounting for another third of the islands, used observations and interviews to explore the social interactions of the teachers and students and generate a narrative description of each site. Phenomenological case studies of six of the teachers provided the remainder of the data. The pluralism of their approach ''provided the potential for dialogue between the approaches and ultimately enhanced perspectives'' (Lawrenz & Huffman, 2002, p. 336) as data from one island suggested things to look for on others.

The different sources of information could be balanced against each other as a means of ensuring greater validity in conclusions being drawn from them. Final integration of the data, to present an overall assessment of the value of the program, occurred through both within-cluster and across-cluster links. Thus, while the various measures of achievement presented a coherent set of information about the value of the program, so too did the cross-linkage between, for example, student reports of the frequency of laboratory skills activities and the more objective assessment

of their laboratory skills. Lawrenz and Huffman's (2002) approach allowed them to preserve the uniqueness of each school and classroom while also being able to see linkages across all to draw conclusions about the program as a whole. They argue that ''this metaphor goes beyond more linear ideas of triangulation and bracketing by viewing the interrelationships in multiple dimensions. It provides a framework for integrating [distinct] mixed methods stances and designs'' (p. 337).

Because the term triangulation derives from two different sources, each with a different purpose, it becomes important for anyone using the term to specify clearly which of those models they are following when they outline the purpose of and methods for their study. Additionally, given the historical trends in the ways in which the term triangulation is being used, and the difficulties in meeting all the criteria suggested by either triangulation or archipelagos, we are left to wonder whether they should not simply be included as further metaphors for completion rather than as a separate group? The difference, however, between these and earlier ones for completion or enhancement is that these require the *interactive* use of more than one type of data or analysis strategy to discover something beyond that which could be gained through additive use of the data. This interaction occurs as analysis of one component of the data contributes essentially to the researcher's making sense of another component. Flick's study probably met this criterion, but it was not clearly indicated by or described as such in his 2010 presentation.

Complementary Strategies for Integration: Overview

In our earlier days, we produced a number of consultancy reports that would have fitted one or the other of these metaphors for completion, enhancement, or triangulation. Over our career spans, we have read reports of many studies similarly describing or evidencing one or another of these complementary strategies. Did they constitute mixed methods? How did they demonstrate integration of methods? Our argument for including these strategies is that they are at least one step along the way, simply because during the analysis process and, critically, in the writing process, the various strands of data have been brought together in some way to build or add strength to the argument(s) being made. The different components generally remained distinguishable, and preliminary analyses were undoubtedly done separately, but they have not been written up separately, and in many cases the individual substudies would not have stood alone as a basis for the final conclusions. For each, we had to think about how they came together. Writing the methods together acted as a prompt along the analytic path to develop the analysis more interactively, particularly where discrepancies emerged.

Some of the approaches described above provide a more effective solution than others. Different aspects of examples might fit more than one metaphor, but for any of these metaphors, the information presented is enriched or the arguments are strengthened by the combination of different kinds of data in the analysis process—meeting the first of the aforementioned purposes for mixing methods.

Generative Strategies: Exploration Through Transformation Involving Blending, Morphing, or Fusion of Data Elements

These metaphors involve a process of change in the structure of the data that initiates possibilities for further exploration of the data. It makes sense to do so primarily when data need to be added to or compared with information that has an alternative structure (and thus it is commonly used in metasyntheses), or to facilitate additional, alternative forms of analysis.

Blending data or methods of working with that data can be the key to moving beyond an impasse in analysis. The integration of data through blending creates the opportunity to go beyond what was possible when the original elements involved are treated separately or simply stirred or mixed together, for example, when a new variable is created through combining qualitative information with an existing scaled or categorical variable.

In a study in which different approaches were blended and new variables created, Jang et al. (2008) engaged in a study of the innovative leadership processes that had contributed to school improvement and student achievement across 20 schools in challenging physical and social environments. They used a 75-item School Life Survey, as well as individual interviews with principals and teachers, and focus groups with students and parents. Statistical analysis of the survey data yielded nine factors with acceptable internal consistency. Sixteen themes related to school improvement (later reduced to 11) were identified through analysis of the qualitative data. A critical inconsistency emerged, however. The quantitative variables from teachers did not show any significant variation between schools, but the qualitative data (which reflected a wider range of perspectives than did the quantitative data) showed meaningful variations between schools. The investigators, therefore, wondered how school staff might have viewed and rated these thematically defined issues.

In a further step to resolve this, the investigators identified 63 of the 75 survey items as addressing the content of 8 of the 11 themes from the qualitative analysis and used these to create 8 consolidated thematic variables to use in a survey of a second sample of teachers. Although they were of lower internal consistency than the previous set of factors, these new blended thematic variables were found to identify greater variations in school practices and were considered to better reflect accounts of school success. One new variable, in particular, caught their attention: Community outreach to the school was rated as very low by the teachers. Returning to the qualitative data, the authors found that this was because the children were largely from immigrant families who valued education but did not see how they could contribute to the life of their children's school. Finally, data from the two schools that performed at comparatively very high or very low levels for each of the eight blended variables were further investigated with respect to those variables, and comparative case studies were prepared.

Morphing describes the smooth transformation of an object (usually a digital image) from one form into another, typically through a series of stages. A single source of data may change form several times as part of an iterative sequential design (Teddlie & Tashakkori, 2009), although, more commonly, the transformation is completed in one step. The *transformation* of data may result in quantitative (numeric) data becoming qualitative (text based), or in qualitative coding being quantized.

Transformation of numeric data to textual description occurs commonly as data are reported in the course of a study. Cluster analysis has been used as the basis for more complex transformations of this type. In her review of educational articles, Niglas (2004) applied cluster analysis to tabulated characteristics of mixed methods studies to derive eight groups, which she then described qualitatively. Nickel, Berger, Schmidt, and Plies (1995) similarly used cluster analysis of survey data to define and profile clusters of young people in terms of their sexual attitudes and practices, as a basis for further sampling.

Categorization (transformation) of open-ended qualitative responses is especially common in survey analysis, as it allows a combination of those responses with the bulk of the quantitative data for further analyses—without losing the availability of the original text. Alternatively, dichotomized coding from qualitative data can be used in a study involving a moderate-sized sample and limited variables to generate a truth table for qualitative comparative analysis (Rihoux & Ragin, 2009). Or, given an appropriate sample, quantized qualitative coding might contribute scaled or dichotomized (dummy) variables to standard bivariate or multivariate (e.g.,

regression) analyses; be considered in relation to other variable data using correspondence analysis; or the pattern of interrelationships of quantized codes may be treated as a similarity matrix and analyzed using multidimensional scaling (Bazeley, 2010a). One advantage of multivariate exploratory analyses when compared with bivariate or regression-based analyses is that they do not presume normality of distribution for the included variables. To properly understand and interpret results that use morphed or transformed data, it is necessary to continue to have access to and make use of the data in its original form—thus requiring interdependence rather than simple dependency. Appropriate software is needed to assist with transformations for larger samples, as well as for subsequent analyses.

Hume, Salmon, and Ball (2005) investigated the association between children's perception of their environments and their levels of physical activity. Ten-year-old children ($N = 147$) drew maps of their home and neighborhood. These were coded for type of content and the number of instances of each type was counted. Associations with physical activity, measured with accelerometers, were assessed using *t* tests and linear regression analyses. Results were counterintuitive; for example, boys who drew more opportunities for sedentary activity in their homes were actually more likely than others to engage in vigorous activity outdoors, $F(1, 60) = 4.06, p = .05$, and spent less time being sedentary.

When *fusion* occurs, components are combined (joined) to create a single, new whole that cannot, practicably, be taken apart. It can occur on several levels:

- In partial fusion, the identity of each component within that whole continues to be partly or fully distinguishable. One might imagine strands of plastic being fused together through the application of heat, with elements of the original colors still evident in the combined result, or fused joints now working as a single entity, but one which still evidences the structure of the original bones.
- In cell fusion, a new single cell is created from two preexisting cells, either from the same organism or as a hybrid cell from cells of two different species. For example, when HIV infects the body it binds with specific receptors and, thus, fuses with the membranes of immune system cells.
- Nuclear fusion generates (dangerous) energy! It is a union that can set off an almost uncontrollable chain reaction. The process involves forcing multiple atomic nuclei to form a single heavier nucleus. If the elements being fused are light enough, energy is released; if the elements are heavier than lead, production of the fused nucleus absorbs rather than emits energy.

In a study of conceptual understandings of research performance, Bazeley asked respondents to describe researchers exhibiting each of eight different positive-performance attributes. They were also asked to quantitatively rate the relative importance of each of those attributes for undertaking high-quality research and for assessing research. She then used the dichotomized data derived (transformed) from the qualitatively coded descriptors and weighted each code for each attribute for each of the 295 respondents by their individual importance rating for that attribute. She then summed the resulting scores for each descriptor across all cases, repeating the process with weights for both doing and assessing research. She also explored factor analyses and other exploratory multivariate techniques using both weighted and raw (unweighted) data.

Just as cell fusion can potentially create a hybrid that is either sterile or disastrous, and nuclear fusion can fail if the nuclei to be fused are too heavy, so also this attempt at fusion was frustratingly sterile and not helpful in contributing to delineating a concept of research performance, which was the primary purpose of the study. It involved a heavy amount of computation (even when mechanical tasks were automated as much as possible), and the results were no more enlightening than those provided by raw counts of dichotomized (unweighted) data.

Moving forward with concept development, on this occasion, involved setting aside the statistical analyses and working interpretively with the text responses (Bazeley, 2010b). Fusion of this kind could well be valuable for other purposes and in other studies, but there are no guarantees!

Generative Strategies: Conversation and DNA as Iterative Exchange

One component of a study may inform or prompt another component, perhaps to prompt something further again in the search for a solution. In the process of initiating and developing fresh approaches and/or more complex outcomes, iterative exchange between methods can be brief, as in some of the complementary methods reviewed earlier, or extended. Similarly, the complexity of the iterations can vary in terms of the amount of change that occurs with each exchange. Sometimes these strategies will incorporate, along the way, the kind of exploratory or transformative strategies described above.

A *conversation* moves back and forth between two or more speakers. Sometimes while speaking, one is dominant, although in a genuine conversation there is equality. As well as working iteratively, a conversation might involve using numbers, strong statements, or some other stimulus to prompt a response from the other party. Each conversant maintains his or her identity, although their ideas and form of communication are likely to be modified in response to the other speaker. Conversational integration can be viewed, most often, as an exchange of ideas, and in this sense, it speaks of the use of mixed methods for iterative development of a project in which different segments (or components) progressively prompt the next part of the study or, perhaps, recursively contribute to interpreting and understanding what has been found already. Complementary studies may become iterative when a contradiction occurs in findings from different methods, necessitating further investigation informed by the earlier contradictory findings.

Kane and Trochim (2007) report a strategy of working back and forth between text and numbers as a means of assessing and/or evaluating need. Once a core need or issue has been determined, qualitative statements about it are generated from discussion among or interviews with those most affected by it. These statements are then sorted into groups and rated for importance and feasibility by a wider group of participants. Assessments are aggregated and used, via cluster analysis and multidimensional scaling, to generate various maps and other visual displays that are returned to a participant group to interpret and discuss in terms of their significance for planning or evaluation.

Kemp (2001) proposed *DNA* as a metaphor for *doing integrated analysis*, to capture an iterative process of reconciliation and progression that is particularly useful when data analyses in a mixed methods study provide divergent results or in a study designed to initiate new thinking. More recently, Medlinger and Cwikel (2008) have explored the spiraling character of the same metaphor in an iterative series of studies that were used for development, complementary, and initiation purposes. The double helix of DNA comprises a sense and an antisense strand that twist around each other, unwind, reorganize, or mutate through a process of protein transfer between the strands, and rewind to reform, in an iterative process of reconstruction. This process allows for both undoing and rebuilding as the different strands come together to create a cohesive organism.

When presented with divergent results, the first step in achieving an integrated and reconciled analysis is to determine the sense strand of the analysis. This might be what best accords with previous literature or with empirical observations. The dissonant (antisense) findings, such as people's interpretations of experiences, are then considered in counterpoint. Equally well, reported experience could ''make sense,'' and the literature or numbers could be dissonant. The divergence of findings can then be used as a promoter (or initiator) for questioning, transferring, combining, rearranging, and resequencing the data, and rebuilding the analysis as ideas and

information are transferred between the strands of the analysis. These processes can continue in a series of iterations. At each iteration, the sense and antisense strands may be derived from words or numbers or, increasingly, a blend of these. Thus, reconciliation is sought by undertaking analysis that facilitates a continuing dialogue or exchange between the multiple data to understand the phenomenon of interest, such that each strand transforms the other in the process to make something different and distinct, rebuilding the analysis in much the same way that genetic material reconstructs itself. DNA in mixed methods, therefore, typically involves the use, also, of blended or transformed variables.

The rigor of this type of integration derives from an inability to force any part into the organic helix; each component in the DNA sequence has a key and it has to fit in place. As in the construction of DNA, only certain sequences are possible, and only particular proteins (data) can bind together, yet variation and improvisation are important, and, as in nature, infinite variety can result. Ultimately, at the conclusion of the process, everything must ''fit'' and ''work'' so that the rigor and the validity of the integrated analysis can then be judged by the functionality of the resultant organism.

In her study of the community service needs of people with spinal injuries in New South Wales, Kemp (2001) found a mismatch between need and care delivery. Her initial problem was that there were many different ways of defining and assessing need. This was compounded by the finding that, although her quantitative data revealed a desperate shortage of community services, the qualitative data spoke of people feeling ambivalent about whether they would access services that they had most complained about not having. She started from the ''sense'' strand, that there was a quantitatively demonstrable shortage of services for people with spinal injuries. She then took the ''antisense,'' counterintuitive qualitative data, that people were ambivalent about not having services. This had been coded using qualitative data analysis software, and so she was able to import the codes reflecting feelings about services into the project's statistical database. These data were blended to create a quantitative variable that reflected both the current use of services and the desire for services. Subsequent rebuilding of the quantitative analyses revealed that the qualitative ambivalence to services was the response of the people with spinal injuries to the apparently arbitrary distribution of community services rather than its being based on their need for the service, defined either quantitatively or qualitatively.

Data from policy documents, however, clearly indicated that services were legislatively mandated to be allocated according to need. Once again, there was dissonance. The rebuilding of the qualitative analysis then proceeded by adding the permutated quantitative data to the qualitative database for inclusion in the qualitative analysis. Quantitative service satisfaction scales augmented by the previously created use and desire variable were combined with respondents' qualitative responses about the beneficial and detrimental effects of services. When reanalyzed qualitatively, the quantitative arbitrariness of the service provision was, in fact, not so arbitrary. Services were allocated on the proviso that persons with spinal injuries adopt life plans that met the expectations of service providers, demonstrated by being ''just right,'' that is, being not too independent, nor too dependent, and evidenced in demonstrating suitable levels of gratitude and humility.

As can be seen from these descriptions and examples, iterative models for mixing methods can be valuable for exploration, for development, for initiation of fresh ideas, or for resolution of emerging issues in the analysis.

Generative Strategies: Overview

Generative strategies are generally more complex in their execution than complementary strategies and provide processes for use where the researcher deliberately seeks initiation or where

complementary or validation processes have not allowed the development of a clear understanding of the phenomenon of interest. In such situations, iterative, blended, or transformative methods can lead to a more integrated view and initiate deeper understanding.

Generative strategies are reported much less often than complementary approaches, but we suspect that they may be used more often than is declared. Generative strategies are likely to be underreported in literature where there is reluctance to publish dissonant or negative results and where there is a focus on presenting the final, integrated result as a fait accompli with limited attention to detailing the generative processes hidden behind the statement that findings ''emerged.'' As the conceptual and technical issues in transforming, merging, and blending data resolve and generative strategies become better described, their use may shift from the novel or experimental to being the more common approach for developing an understanding of complex issues.

Conclusion: Principles for Integration

These metaphors are not simply about bringing results of separately researched study components together in a conclusion. When integrating data or analyses, different elements or processes are brought together in some way to achieve a common purpose. We would argue that, for a project to be classified as mixed methods rather than multimethod, as a minimum there must be interdependence of component approaches *during the analytic writing process* (i.e., as results *are being formulated* for presentation) and, usually, well before that stage. Just having different sources of data does not necessarily imply mixing of methods, and simply preparing final conclusions on the basis of more than one approach, also, does not mean that the methods have been integrated. In most currently conducted research, more is often needed rather than less, but as with the fusion of elements heavier than lead, or even just the overbeating of muffin ingredients, more can also be too much. Thus, principles for integration include the following:

- There are many ways to integrate data.
- Integration might begin at any stage within a study.
- Integration needs to occur before conclusions are drawn—and essentially during analysis or during the analytic writing (formulation) of results. Usually and where possible, earlier is better.
- The level of integration must be appropriate to the goals and purposes of the study.
- The ways in which each varied component depends on or is enriched by other(s) will be clearly evident from the report of the study.
- The product of the integration will be something that would not have been available without that integration.
- The write-up of an integrated study will be organized around the substantive issues dealt with in the research, not according to the methods used to carry out the investigation. These substantive issues might then become the subject of different articles rather than having different methods provide the basis for division of articles.
- An integrated study should (ideally) not be written up as separated components as this is antithetical to the concept of interdependence. Where publication demands create limitations, a strategy needs to be adopted to ensure that the whole is kept in view.

The metaphors we have reviewed have opened up a broad array of approaches to integration; yet these, like islands in the archipelago, are but a sample of the creative alternatives that are increasingly being revealed in studies reported, for example, in this journal. Each metaphor has pointed to principles for integration and also to strategies for integration of analyses. Particularly, given the capacity now offered by a range of software (from simple use of Word or Excel

to specialized programs), we believe that every opportunity to fully exploit the integrative potential of mixed data sources and analysis methods should be taken where it will build stronger, more valid, and more useful conclusions.

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Note

1. We would propose that a better analogy (rather than metaphor) for validation would be the drawing of an accurately measured line. To ensure that a line is correctly placed, say, when doing carpentry, the distance from the baseline is measured in at least three places as a check. In describing validation, this analogy points to the need for three separate sources of information, as two are insufficient to ensure accuracy. Seeking three concurring sources overcomes the problem that lies in using just two: Both may be wrong in the same way, or if one is wrong, the conclusion drawn may be skewed. If there is a discrepancy, then a fourth measurement (i.e., data source) or a careful check of the discrepant source, or both, will usually be necessary to determine which of the three was misplaced.

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