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Para-quantitative Methodology: Reclaiming experimentalism in educational research

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Abstract

This article focuses on the criticisms of current approaches in educational research methodology. It summarizes rationales for mixed methods and argues that the mixing quantitative paradigm and qualitative paradigm is problematic due to practical and philosophical arguments. It is also indicated that the current rise of mixed methods work has increased problems with quantitative and qualitative methods. In this article we offer a different symbolic system, with different logical form for describing educational phenomena based on the philosophical assumptions and new mathematical reasoning: para-quantitativism. Para-quantitative theory is an approach which has been developed in respect to close relationship between paradigm and method, using a postpositivist transcendental realism as a philosophical beginning of the research methodology, taking Operational Logic System or Fuzzy Logic System (OLS/FLS) as logic of scientific research in education.

Keywords: para-quantitative methodology, transcendental realism, experimentalism, educational research

Introduction

In this article it is argued that the actually long standing and considerable challenge between quantitative and qualitative methods and also the problem of the logical possibility of mixed method is more theoretical than practical or technical. Therefore, any solution to the challenge must address the philosophical assumptions underpinning of the methods.

Accordingly, we will discuss the major problems with current approaches in educational research methodology and provide some criticisms of mixed methods beyond the other

critics (Giddings & Grant, 2007; Sale, Lohfeld, & Brazil, 2002) to offer an alternative paradigm that addresses the problems. In this article, we will then explain how these problems can be solved by the application of para-mathematics. With para-mathematics, the complexity and contradictions inherent in educational phenomena can be preserved through methods that avoid the mechanistic mixing of qualitative and quantitative methods that is sometimes done in the name of mixed methods. We also discuss the philosophical theory underpinning para-quantitative methodology.

We believe that the current rise of mixed methods work has increased problems with quantitative and qualitative methods. In this article we offer a new approach called para-quantitativism, based on current developments in mathematics and its logical foundations. This approach applies new methodological reasoning in mathematics, called Operational Logic System (OLS)[1] or Fuzzy Logic System (FLS),[2] to educational research. Accordingly, mathematics will be replaced by para-mathematics. With this approach, research can address both quantitative and qualitative features of education.

Criticism of Educational Research

Research in education has been strongly criticized by educational experts during the last three decades.

Accordingly, Badley (2003) characterizes educational research as being at a crisis situation. Following Pring and others, he says that education research is beset by false dualism, false primacy, false certainty, and false expectation (Pring, 2000; see also Brew, 2001; Barnett, 2000; Hammersley, 2002). Excluding false expectation, all the faults mentioned earlier are closely related to methodological perspectives. A false dualism has been created between scientism (positivism/experimentalism) and constructivism; false primacy has been produced by favoring of objectivism (outcomes oriented approach) over subjectivism; false certainty has been raised by not facing up to the complexity of the world.

We believe that the long-standing challenge between quantitative and qualitative methods is more theoretical than practical or technical. Therefore, any solution to the challenge must address the philosophical assumptions underpinning of two paradigms. The contrasts between experimentalism and constructivism, objectivism and subjectivism, and complexity versus simplicity are the most important causes of the crises of educational research. These must be scrutinized to address the current criticisms.

Quantitative and Qualitative: Philosophical Debates

Positivism as a dominant paradigm in social sciences has been criticized since the middle of the twentieth century. However, epistemological challenges to positivism go back much farther. In the early 1890s, Dilthey argued that there is a fundamental epistemological and methodological difference between natural sciences and social sciences, which differ in viewing research as aimed explaining or understanding, respectively. Thereafter, the Frankfurt school of critical philosophers such as Horckheimer and Habermas criticized the conservative positivistic approach in social sciences and introduced the phenomenological approach as an alternative to positivism (Husen, 1988). Habermas identified this

orientation shift as moving from an Empirical–Analytic, to an Interpretive–Hermeneutic, and then to a Critical–Theoretic orientation (Pearse, 1992).

There are ontological, epistemological and axiological differences between quantitative and qualitative approaches. The quantitative paradigm is grounded in a belief in an external reality, that the inquirer is separate from inquired, and is based on a correspondence theory of truth (Pring, 2000). Quantitative purists believe that the world could be recognized and described as it is, that truth is defined by fact, and that the validity of knowledge depends on using specific techniques to find experimental verifiable evidence. According to qualitative approach, in contrast, *a priori* knowledge is privileged, so that scientific knowledge does not reflect the real world as it is. Reality, including social reality, is made rather than discovered. In other words, reality is concept-dependent, constructed by individuals and groups of individuals (Pring, 2000). In this paradigm, the validity of knowledge depends on consensus among researchers.

Thus the major debates between quantitative and qualitative paradigms are tied to worldviews and to epistemological, axiological, and methodological theories. Quantitative purists prefer mathematical modeling in educational research. Like natural scientists, they focus on context-independent research, on theory neutrality, on being value free. They see researchers as outsiders, working to discover nomothetic relations. Qualitative purists see reality as dependent on human minds, reject any attempt to apply positivistic techniques in educational research, and focus on contextual research. They see knowledge as theory laden, value laden, insider and idiographic (Lincoln & Guba, 1994).

If we accept that these two different approaches are based on such different perspectives on reality, truth, validity, and the aims of educational research, how would it be possible to use both? To mix methods? Smith and Heshusius argued that: 'The claim of compatibility and the call for cooperation between quantitative and qualitative inquiry cannot be sustained' (quoted in Husen, 1988, p. 7).

Nevertheless, many researchers believe mixing the two paradigms is reasonable. In the next section we take the major problems with quantitative and qualitative research and explain how mixed methods fail to solve them.

Rationales for Mixed Methods

Mixed methods research emerged as third research paradigm in educational research, positioned as a complement to qualitative and quantitative research.

> The goal of mixed methods research is not to replace either of these approaches but rather to draw from the strengths and minimize the weaknesses of both in single research studies and across studies. If you visualize a continuum with qualitative research anchored at one pole and quantitative research anchored at the other, mixed methods research covers the large set of points in the middle area. (Johnson & Onwuegbuzie, 2004, pp. 14–15)

Mixed research proponents argue that they respect all perspectives, point of views, and positions including quantitative and qualitative. Mixed method experts list several reasons to show how the combination of quantitative and qualitative research can be effective. These reasons are based on two types of considerations: practical and theoretical. At

the practical or technical level, mixing the arguments is related to the use of sampling, data collection, and data analysis techniques. At the theoretical or paradigmatic level, the reasons entail the pragmatic, the false duality and the warrant-through-triangulation arguments. However, we will explain that mixing the two paradigms is problematic due to practical and philosophical considerations.

Criticisms of Mixed Methods: Practical Arguments

Creswell's (2009) definition posits the 'mix' of the processes of data collection, analysis and presentation of findings. Therefore, what is combined in mixed method research are the methods, not the methodologies. However, papers published in journals in education, psychology and sociology that use mixed method indicate continual inconsistencies in the use of the terms 'methodology' and 'methods,' not only between papers, but within them. We see methodology is concerned with the theoretical assumptions underpinning a particular method and belong within a particular paradigm. Methods, in contrast, identify a practical orientation to research.

As Giddings (2006, pp. 198–199) articulated: 'The consistent use of these definitions would not only clarify what is being mixed, but would contribute to internal consistency so often lacking in mixed-method studies.' Giddings and Grant argue that seeing mixed methods as the best of both worlds, positivism and interpretivism, may arise from two critical confusions:

> [T]he first is a misunderstanding over the difference between the ideas of methodology and method and the second is that over the status of the terms qualitative and quantitative. (Giddings & Grant, 2007, p. 56)

Although some authors consider the labels, 'quantitative' and 'qualitative,' to be associated with research paradigms, we agree with Lincoln and Guba (1994), who argue that the two terms most usefully describe different types of methods. That is, mixed method studies are concretely operationalized at the technique level. While, two theories of inquiry can be used to approach the same target phenomenon, the positivist and the interpretivist theories may not be studying the same phenomenon. Pearce observed, 'a change of world view can change the world viewed' (quoted in Sandelowski, 2000, p. 247).

As Sandelowki (2000) explained, it is doubtful that a researcher can implement a project frame in two paradigms at the same time. Quantitative and qualitative researchers can make use of the same instrument; however, their paradigm may make their results different. The most important difference between researchers from these two paradigms is their attitude towards a particular phenomenon. Sandelowki, using the metaphor of trying to mix oil and water, argued that:

> Although techniques can be mixed, the resulting mix will reveal the researcher's viewing position (or, in cases of mixed-up research, the researcher's futile effort to mix the research equivalent of oil and water). (Sandelowski, 2000, p. 247)

Bryman (2006) also examined the rationales of mixed methods research based on a content analysis of 232 social science articles in which the two paradigms were said to be combined. He also examined the research findings from 20 interviews with UK

social researchers, who are practitioners of mixed research. He indicates that the ostensible uses of the two paradigms do not always correspond to mixed methods used in practice. According to Bryman, the implementation of mixed methods is being obstructed by the tendency observed by some researchers for quantitative and qualitative findings either not to be integrated or to be integrated to only a limited extent. Bryman identified several barriers to the integration of quantitative and qualitative research. He concluded that there may be a disjuncture between the two paradigms when concrete examples of research are examined. There is thus still considerable doubt concerning the means of combining findings in mixed method research (Bryman, 2006). Moreover, when researchers encounter a contradiction within a data set, they may tend to privilege quantitative data and draw their conclusions accordingly (Giddings & Grant, 2007). Mixed methods requires a synthesis, not a mixture.

Criticism of Mixed Method: Paradigmatic Arguments

As mentioned earlier, Scott (2007b) reformulated rationales of combined method in three categories: (1) the Pragmatic argument; (2) the False duality argument; (3) the warranty through triangulation argument. We take up these three arguments to explain how the mixed methods approach is also problematic at the paradigmatic level.

By the pragmatic argument, Scott refers to the fact that paradigms have epistemic dimensions, with unavoidable relationships between, on the one hand, paradigms and, on the other hand, data collection and data analysis methods. Bengtsson (2009) describes this relationship by using the familiar vase-face figure, which can been seen either as two profiles facing each other, or as a vase, depending on what is considered foreground and what background. Bengtsson applies this metaphor to educational research, explaining that philosophical assumptions are always presupposed as a background. If we change these assumptions (i.e. the background), a different reality will appear and so different methods should be used by the researcher (Bengtsson, 2009).

The pragmatic argument has two major problems. First, if we consider the practical consideration as an inevitable criterion to making decisions, then the common methods will be given undue weight, as compared to alternative methods. Second, this pragmatic argument is a form of epistemic relativism in which any decision will be made based on historical and social settings. Nevertheless, the epistemic relativistic position does not lead to making an appropriate decision, for researchers encounter a number of different and contradictory methodologies. A researcher is born in a methodological world already resourced by several conflicting approaches. The researcher must choose a particular approach. When researchers choose, they implicitly argue that the selected approach is more appropriate than other approaches.

> Making methodological choices per se means that the researcher is formulating a belief that the choice they make is a better choice than the one they did not make because it will lead to a more truthful representation of what they are trying to portray. (Scott, 2007b, p. 5)

Moreover, paradigms are worldviews that refer to particular ontological, epistemological, and axiological positions. When different paradigms have different and contradicting

positions, it is impossible to combine them. Each paradigm views things via its distinctive lens and so requires particular methods to answer a particular question.

> [T]wo or more paradigms of inquiry can be used to frame the same target phenomenon. Yet, arguably, the positivist and the critical theorist may not really be studying the same phenomenon, because to see a phenomenon in a certain way is to change that phenomenon. (Sandelowski, 2000, p. 247)

The false duality argument has been offered by Pring (2000) to describe paradigmatic models in educational research. In contrast to the pragmatic argument, the false duality argument views researchers' epistemological assumptions as a vital to choosing method. Pring characterizes two paradigms, naïve realism (A) and radical relativism (B): Paradigm (A) believes in an objective reality, believes in the separateness of researcher and researched, has a notion of truth as correspondence between the research account and what is the case independently of the researcher, and believes in generalization, which means that problem and solution can be generalized from one setting to another. In contrast, paradigm (B) believes that reality is a social construction of mind, blurs the separation between researcher and researched, and believes that truth is a matter of consensus among sophisticated constructors. He believes that many of these positions could not be justified and so the paradigmatic divide is unsustainable. Accordingly, quantitative and qualitative approaches could compensate their mutual and overlapping weaknesses.

As mentioned earlier, mixed methodologists offer some solutions including: alignment, compensation and translation. However, Scott provides several reasons that these strategies for reconciling the two paradigms are problematic. He contends that the paradigmatic divide could not be solved by alignment, because this strategy only operates at the technical level and so neglects the epistemological and ontological assumptions in educational research.[3]

Compensation reconciles the two paradigms at the ontological level. Accordingly, it could be argued that, based on the belief in multi-layered reality, researchers must choose either a quantitative and qualitative paradigm to describe the reality. Scott (2007a) makes three main points that should be considered at the indicator and explanation levels of educational research. First, properties of agent and structure have to be reconnected at the indicator level; second ontological intransitivity and epistemological transitivity have to be accounted for in the explanation; and third, extensionality and intentionality are not conflated all together. Taking this transcendental realist approach, he argues that compensation is a deficient approach because it could be met if reconciliation arises only at the ontological level and so, this approach:

> underplay[s] epistemological transitivity and ontological emergence; that a new dualism between structure and agency is created; and that inevitably intentionality and extensionality are conflated with the consequence that some meaning is logically bound to be lost. (Scott, 2007b, p. 9)

Finally, translation also logically results in lost meaning quantitative and qualitative data sets are reformulated so that they conform to each other. Scott concludes that the

a-epistemic approach underpinning mixed methods makes several false assumptions. He describes the false assumptions as follows:

> First, methods and strategies used by empirical researchers need not have any direct relationship to epistemic and ontological frames developed by philosophers. Second, decisions about methods and strategies can be made in relation to the research problem, without reference to the type of knowledge being produced and the view of reality that it espouses. (Scott, 2007b, p. 14)

Therefore, the philosophical consideration should be considered at the center of decision on method. The last argument for a theoretical rationale for mixed methods is the warranty by triangulation. As defined in several textbooks, triangulation refers to an assumption that if particular phenomena investigated in a number of different concurrent ways, then the researcher may claim that his or her account gives a better picture of the phenomena. However Scott gives three reasons why the triangulation argument is deficient to resolve the paradigmatic division.

> If another strategy or method is then used to confirm or disconfirm the truth of the *first*, it would have to have the same truth value, and would therefore be redundant. *Again*, if an assumption is made that the first set of strategies and methods was inadequate as a producer of true propositions, then likewise the use of another strategy or method which again may be flawed cannot result in the identification of any inadequacies that may exist in the first set of strategies and methods. *The third* claim is that different methods and strategies may have different philosophical premises and if they do then the comparison between them is invalid. (Scott, 2007b, p. 13)

We conclude that mixing quantitative and qualitative methods operates at the shop floor and concrete or technical level of research, but do not operate appropriately at the paradigmatic floor. We also emphasize that quantitative and qualitative approaches belong to two different scientific cultures. Any solution for the historical paradigmatic debates between quantitative and qualitative methods must refer to a new philosophical theory to support a new scientific culture.

In the following, we provide an alternative point of view as an overarching philosophical perspective that provides researcher with a realm in which they are able to choose an appropriate strategy and method, logically following from their paradigmatic stand.

Transcendental Realism and Para-quatitativism in Educational Research: An Alternative

Transcendental realism is a Kantian term referring to a form of transcendentalism that allows researchers to be aware of the mind's limitations. Knowledge can be adjusted, based on understanding the noumenon. Kant was distinguished between noumenon (the world as it is) and phenomenon (the world as it appears). Kant was a transcendental idealist, not a transcendental realist. That is, he believed that one could never understand things in themselves. Transcendental realism is, like positivism, a realistic and empiricist approach, holding that objects are independent of human consciousness, whether known or not. However, it is not a positivistic paradigm. The postpositivist transcendental

realist believes that all observation and measurement is fallible and accordingly all theory is revisable. Transcendental realists thus hold that empirical research is informative, but lacks certainty. While positivists believe that the goal of scientific research is uncover the truth and so we are able to know reality with certainty, the postpositivist transcendental realists adopt the goal of getting a right picture about reality, acknowledging that it is not possible to achieve the goal, perfectly, due to fallibility of observation and measurement (Trochim, 2006). All scientific research is theory laden. Researchers or scientists are 'biased' through their background of knowledge, cultural experience, and view of the world *per se*. This should not lead to despair, however. It is possible for every researcher to translate his or her experience to others. Researchers are, at least to some extent, able to understand each others' experience. Accordingly, the transcendental realist is critical of the incommensurability[4] of different points of view espoused by radical subjectivists. People may construct understandings from their own points of view, but the fallibility of observation and measurement implies that individual constructions are not perfect. Objectivity, however, is an important property in scientific research. Objectivity is a social phenomenon which could be achieved when multiple individuals criticize each others' opinions. To improve objectivity, researchers operate in a critical academic community whose members criticize each others' research. Trochim (2006) and Phillips and Burbules (2000) describe this by pointing to the evolutionary struggle in which theories like the species survive in the academic contentious community.

> The natural selection theory of knowledge and holds that ideas have survival value and that knowledge evolves through a process of variation, selection and retention. These theories have adaptive value and are probably as close as the human species can come to being objective and understanding reality. (Trochim, 2006, p. 20)

Transcendental realism is a branch of realism that is raised as a fundamental alternative to positivism and radical subjectivism. Bhaskar describes four principles of transcendental realism:

> There are objects in the world whether they are known or not; knowledge is fallible because any claim to knowledge may be open to refutation; there are transphenomenalist truths, in which one may only have knowledge of what appears, but these refer to underlying structures, which are not easily apprehended; most importantly, there are counter-phenomenalist truths in which those deep structures may actually contradict or be in conflict with their appearances. (Quoted in Scott, 2000, p. 14; see also Shabani Varaki & Earl, 2005, pp. 283–284)

These principles are relevant to Bhaskar's description of reality as stratified ontology including: the empirical, the actual and the real. The empirical is the surface layer, which refers to our experiences of phenomena in the world. The actual is the second level and refers to the events that happen in the time and space. The deepest layer is the real, which refers to the structure, mechanism, power and liability that may cause effects.

The relationship between the three layers of the reality is contingent and so events may occur in the world which no one observes. Mechanisms may neutralize each other and may not even be activated, but hold potential to influence phenomena (Bhaskar, 1989).

Therefore, transcendental realism retains the most of positivistic assumptions including: objectivity, bias free research, commensurability, and scientific research in social sciences. Nevertheless, transcendental realist has the advantage that these concepts operate in their own perspective and worldview. We thereby avoid the mistakes of assuming determinism, theory neutrality, verifiability and certainty. Instead, we approach the contradictable and unpredictable character of human life, recognizing that knowledge is theory laden, influenced by context, and falsifiable.

New Mathematical Methodology: Operational Logic System/Fuzzy Logic System (OLS/FLS)

Here we suggest a new approach to mathematical modeling in educational research. We consider the development of mathematical reasoning or methodology and try to transfer this to educational research. We argue that the new approach could be justified with reference to OLS or FLS.

Five fundamental terms describe key aspects of the new quantitative approach, so called 'para-quantitativism.' These terms help to explain how the approach could be considered as a superior alternative to quantitative, qualitative, and mixed methodology. The terms come from Polak and Zadeh's logic system, which constitutes the new mathematical methodology, so called para-mathematics.[5] Therefore, para-quantitativism is a methodological approach which supports para-mathematical modeling in educational research. It recasts mathematics in educational research in a new perspective to eliminate the restrictions of the traditional mathematical modeling.

Imprecision

Polak and Zadeh recognize that imprecision or grayness is the most important characteristic of phenomena in the real world (Fourali, 1997). Instead of the two extreme and disparate positions, they highlight several levels of grayness in a continuum between the two poles (0 and 1), resembling our daily life and the descriptions in natural language. Para-quantitativism takes this to indicate how researchers can solve problems in the world full of imprecise phenomena, events, situations and issues. Based on the para-quantitative approach, we believe that researchers will be able to improve their knowledge of the imprecise world. Educational discourse has too many imprecise words that are incompatible with conventional quantitative black or white methodology, including: achievement, opinion, satisfaction, motivation, competency, low, moderate, mature, adequate, and so on. Law (1996) provided a structural model for a fuzzy educational grading system and an associated algorithm, indicating that there are three main reasons for the use of FLS in an educational grading system.

First, the observed scores of students are vague data that vary from one occasion to the next. Second, scores on different questions of one examination are also vague and FLS is better for aggregating the scores. Third, the linguistic variable in the single letter grade system (A, B, … , F) is more compatible to OLS/FLS. So, by using OLS/FLS, teachers can come up with reasonable expectations. That is, if the grade to be assigned corresponds to the degree of membership of a given set, it would be more defensible.

Law (1996) also explains that, by predetermining the ideal of mastery, it makes a reasonable decision to identify students who truly master the contents in a course and are thus ready to pass. This approach applies to a group as well as to an individual. Teachers can average students' degrees of membership and check which grade it is associated as a reference grade to help them make decisions. For instance, when a teacher decides whether to revise an instructional procedure for a group of students, he or she can inspect the reference grade of the students. Accordingly, this approach will more likely be able to help teachers to use an accurate description of the students' academic performance as an imprecise phenomenon. Bassey (2001) also criticizes the scientific and probabilistic generalization in terms of imprecision. He indicates that there is a class of statements which are imprecisely probable. Educational researchers should therefore use fuzzy prediction and generalization. Bassey provides examples of papers published in the *British Journal of Educational Psychology* and examines the 1997 volume of this journal, looking under the heading of 'Conclusions' for the papers' scientific generalizations. He judged them inappropriate and emphasized that:

> Fuzzy predictions with best-estimates-of-trustworthiness may provide a powerful tool for researchers to communicate with potential users of research and also to develop a cumulative approach to the creation of educational theory. (Bassey, 2001, p. 20)

Human Intentionality, Purposive Choice, or Agency

Traditional quantitative analysis takes a deterministic perspective to human behavior, neglecting human intention and creativity in its description of educational activities—the so called 'deterministic fallacy' (Scott, 2000). All educational phenomena involve intentionality and purposive choice. Intentions and beliefs in human performance should be considered in terms of the intentional idioms in educational research. Traditional mathematical modeling in educational research unduly emphasizes on closed systems, neglecting the intentional dimension of education. New quantitative methodology is superior to traditional mathematical modeling with respect to human intentionality and agency, because it accommodates purposive choice based on OLS/ FLS and transcendental realistic assumptions.

Possibility Theory versus Probability Theory

Both Zadeh and Polak believe in possibility theory in opposition to probability theory, as used in conventional statistics.[6] They offer an alternative framework to consider psychological and purposive explanation of the world under the certain conditions (Polák, 1983; see also Zadeh, 1999). We take an example of students' achievement in the US Department of Education to show how possibility theory creates different results to solve an educational problem.

Based on 64 true and quasi-experimental research studies and single subject designs, researchers reported a result regarding instructional decision. In the Department's practice guide they offered individual recommendations, assigning each of them one of three possible ratings. They indicated that

> a strong rating refers to consistent and generalizable evidence that an intervention program improves outcomes, a moderate rating refers either to evidence from studies that allow strong causal conclusion but cannot be generalized with assurance to the population on which a recommendation is focused and a low rating refers to evidence either from studies such as case studies and descriptive studies that do not meet the standards for moderate or strong evidence or from expert opinion based on reasonable extrapolations from research and theory. (Hamilton *et al.*, 2009, pp. 1–2)

Researchers thereby tackled questions about students' academic achievement from a probability perspective, dividing the probability distribution into strong, moderate and low. Accordingly, they report something about the population and not about individual students. Thus they are never able to describe a particular student's status before he or she is selected from the population. Once a particular student is selected, the probability disappears. As Cox (1994) puts it, probability is uncertainty associated with time. Moreover, probability is not capable of capturing ambiguity about the phenomena. So, as Fourali articulated, probability does not recognize the uncertainty, the fuzzy world.

> Probability theory, as argued by fuzzy logic researchers, does not readily recognize the uncertainty between a white or black answer. (Fourali, 1997, p. 146)

Achievement, for example, can be divided into sub-states stretching from strong (as a clear existence of achievement) to low (as a non-existence of the achievement), with gradations between. OLS/FLS provide a new opportunity to deal with all characteristics, including individual cases, ambiguity, and overlap so as to allow the semantic partitions to overlap. In that way, the measure of a value conforms to a semantic ideal.

Natural language contains vague and imprecise concepts that are difficult to translate into more precise language without losing some of their semantic value. Conventional statistical analysis typically shares this problem. For example, the statement, 'UCSMP Algebra was found to have no discernible effects on math achievement,' does not explicitly state that the intervention has no effect for students in a particular culture (What Works Clearinghouse, 2009).

The central notion in OLS/FLS is indicated by membership value range (0, 1), with zero representing absolutely ineffective and one representing effective. The previous statement could, for example, be translated as: 'The intervention effective rating is a member of the set of effective interventions.' As we see, both OLS/FLS and probability operate over the same numeric range (0, 1). However, the difference is that the probabilistic approach yields a language statement that supposes that there is a 70% chance that the intervention is effective or not, while the OLS/FLS approach supposes that the intervention's degree of membership within the set of effective interventions is 0.70. Therefore, OLS/FLS is a significant improvement over traditional probability which identifies a group of people or interventions as either having or not a specific property, based on black or white logic.

Contradiction

OLS/FLS emphasizes contradiction and allows the semantic partitions to overlap, a feature important when making decisions. A university teacher may ask students to do

assignments requiring particular skills, then must decide whether students have achieved mastery. The teacher will award a 'pass' and, if not, a 'fail.' However, there are more than two alternatives along the continuum between the two polarized possibilities of mastery and non-mastery. The problem is increased when a student is situated half way between two polarized positions. This is a contradictional situation, while it is perfectly acceptable in terms of OLS/FLS, but unacceptable in Aristotelian logic. OLS/FLS considers the two poles as only two extremes of a number of other possible alternatives (Fourali, 1997). While a teacher who uses the binary system is missing important information about the students' competency, teachers who assess students in terms of OLS/FLS capture the information and so make a more precise decision. Accordingly we argue that there are no clear-cut situations in the real world and OLS/FLS achieves more precision than the binary system in educational research.

Situation

In terms of OLS/FLS, different notions may be interpreted in different situations. This logic refers to well-defined formulas (Semantic Language Clause) and the Way of Reasoning (Modus Ponens grouped into Production System Block). A production system block is a sequence of modus ponens rules such that in a given reasoning process only modus ponens rules from a given production system block may be used (Polák, 1983; see also Polák & Poláková, 1981, 1982). Notions such as success, achievement, and competency have different meanings in different situations. Different results in reasoning thus come from different Production System Blocks.

Quantitative and qualitative methods share properties with para-quantitative methods. Differences are related to the semantics and logic underlying a statement, which a researcher applies in an investigation. For example, we know the concept of uncertainty is central in both probability and possibility. Researchers recognize that evaluation of a program is made under risk and uncertainty. Values, opinions, and preferences of teachers, students, parents, and principals lead to uncertainty in educational situations. Decisions must be made under uncertainty in such a vague system.

Classical probability theory is less effective in fields where the dependencies between variables are not well defined, the systems are not mechanistic, and human reasoning, perceptions, emotion play an important role (Zadeh, 1995). At first glance, probability and possibility theory seem similar, but they differ in aspects such as the adoption in probability theory of the Law of the Excluded Middle; in possibility theory, complexity is recognized as a fundamental feature of knowledge and so the law of the included middle is proffered.[7]

Conclusion

Para-quantitative theory is an approach which has been developed in respect to close relationship between paradigm and method, using a postpositivist transcendental realism as a philosophical beginning of the research methodology, taking OLS/FLS as a logic of scientific research in education.

Consequently, the focus of this article is an objection to what is offered as a mixed method approach, and providing an alternative solution to the quantitative–qualitative divide in educational research. This article also summarizes rationales for mixed

methods and recognizes that the mixing of quantitative paradigm and qualitative paradigm is problematic due to practical and philosophical arguments. It is indicated that the current rise of mixed methods work has increased problems with quantitative and qualitative methods. We believe that the two paradigms are two different symbolic systems and they are using different logic systems to describe the properties of phenomena (Scott, 2007b). Simply mixing the two does not resolve the long standing debate between proponents of quantitative and qualitative.

In this article, in opposition to the pragmatic view and in respect to a paradigmatic view, we have suggested that philosophical assumptions are significant in educational research methodology. Accordingly, decisions about method should be made with reference to researchers' beliefs about the type of knowledge (epistemology) and reality (ontology). Transcendental realism has features that distinguish it from positivism, radical subjectivism, and pragmatism. It resembles positivism in being realistic and empiricist. That is, it holds that objects exist in the world whether they are known or not. However, in contrast with positivism, it emphasizes fallibility of measurement and observation.

Transcendental realism resembles radical subjectivism in acknowledging the role of the knowledge and cultural experience of researchers. It denies, however, the incommensurability of different perspectives and argues that objectivity is central to scientific research. Transcendental realism considers objectivity as a social phenomenon that can be improved by operating in a self-critical academic community. Transcendental realism sees the social world as stratified—the empirical, the actual and the real. It also includes the belief that there are trans-phenomenalist and counter-phenomenalist truths.

Researchers should consider the close relationship between the binary properties and implement their investigation at the intersection of transitivity of knowing and the intransitivity of being, intentionality and extensionality, structure and agent, and consider reality based on stratified ontology. Given this argument, transcendental realism embodies key implications for a solution to the challenge of bridging the quantitative and qualitative paradigms.

Also, rethinking the assumptions behind OLS/FLS provides information to explain how OLS/FLS is congruent with transcendental realism. OLS/FLS involves imprecision with highlighting several levels of grayness in direction of a continuum between the two poles (0 and 1). It holds that the world is full of imprecise phenomena, events, situations and issues. Educational life consists of many instances for human intentionality and purposive choice. There are no clear-cut situations in the real world. Different notions may be interpreted in different situations. These major assumptions; imprecision, human intentionality and choice, contradiction and allowance the semantic overlap and Production System Block as a situation of reasoning seem ideal for the postpositivist transcendental realistic research. The assumptions in OLS/FLS match those of transcendental realism. Therefore, imprecise knowledge on the stratified world with trans-phenomenalist and counter-phenomenalist truths, relative knowledge on the super-complex world, acknowledge of human agency and theory and value laden knowledge on the open system is a world in which researchers operate.

OLS/FLS also adheres to the mathematical precision postulated by transcendental realism in educational research. Here is objectivity and noumenon that should be recognized in education research. Accordingly OLS/FLS could be used by researchers to give

mathematical precision and to make decisions about imprecise educational phenomena. We offer a different symbolic system, with different logical form for describing educational phenomena based on the philosophical assumptions and new mathematical reasoning: para-quantitativism.

Notes

1. Operational Logic System (OLS) was discovered by Vaclav Polak and his wife, Nadezda Polakva, in the 1970s.
2. Fuzzy Logic System (FLS) was discovered by Lotfi A. Zadeh in the 1960s.
3. Alignment is asynchronous with the triangulate procedure. While, in triangulation a number of different concurrent ways are used for validating of the research account, alignment includes the construction of quantitative and qualitative instruments for producing a coherent data set that could be analyzed in one particular way (Scott, 2007b).
4. Incommensurability refers to an idea that emphasizes people are never able to understand each other due to their different background of knowledge, experience and culture.
5. This is a term that has been used by Polák (1992) in his book entitled *Mathematized Humanities via Humanized Mathematics.*
6. Possibility theory, as an extension of FLS, first introduced by Zadeh in 1978.
7. However, as Zadeh explained, although probability theory and possibility are distinct, and probability theory is not sufficient by itself in dealing with uncertainty and imprecision, probability and possibility theory are complementary rather than competitive. Probability theory has been and continues to be employed with success in those fields in which the systems are mechanistic, and human reasoning, perceptions, and emotions do not play a significant role. To enhance its effectiveness in dealing with organisict systems, which human reasoning, perceptions, and emotions do play a significant role, probability theory needs an infusion of fuzzy logic. Such an infusion serves to fuzzify some of the most basic concepts of probability theory including probability, event, random sample, causality, independence, similarity, and convergence. This is the sense in which the complementarity of probability theory and fuzzy logic should be understood. In a reverse direction, the concepts of measure, cardinality, and probability have played and are certain to play an increasingly important role in fuzzy logic. In such applications, what fuzzy logic offers is an effective methodology for exploiting the tolerance for imprecision, uncertainty, and partial truth to achieve tractability and low solution cost. The key concept in this methodology is that of a linguistic variable—that is, a variable whose values are words rather than numbers. The concept of a linguistic variable is the point of departure for the development of the calculus of fuzzy if-then rules (Zadeh, 1995, 1999).

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