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ABSTRACT

Educational practitioners tend to resist or avoid doing educational research primarily for two reasons: their prior experience with statistics, computers, and research design has produced insecurity and anxiety; and, they have acquired a basic misunderstanding of the nature and purpose of research. Good research should be both technically sound and practically oriented. Practitioners can develop researchable questions from their own needs and from elements in their own environment: a special population with which they deal, a procedure they are considering trying, or a problem that they want to solve. There is a common misunderstanding that real research must utilize a true experimental design; however, a qualitative research design may be more appropriate for educational settings. Examples of these designs include: comparing two or more groups with regard to some outcomes; evaluation research or impact assessment; correlational research; descriptive studies; and case studies. Words, not numbers, may be a more appropriate focus when collecting data. The data can be summarized using the matrix or table shell method. In addition, using multimethod research designs which combine quantitative and qualitative approaches to collect and analyze data can increase the internal validity or believability of findings and conclusions. When it is necessary or appropriate to utilize quantitative procedures, the research project will proceed more smoothly if the educational practitioner follows certain guidelines in working with statistics and computer specialists. (IAH)

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MAKING "HI-TECH" MY TECH

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Helpful Hints for Educational Practitioners
on Planning & Conducting Educational Research
with the Help of Technical Specialists

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Introduction

Research. The very term often strikes fear into the hearts of graduate students. Images come to mind of piles of printouts and unintelligible statistical jargon. Above all, research is seen only as a means to some very limited ends. These include completing a course requirement, master's thesis, doctoral dissertation, or a publication written solely for promotion and tenure purposes. Terror and tedium are often synonymous with the idea of research, while enjoyment is not.

These images are unfortunate ... and, above all, unnecessary. All of us, whether graduate students, classroom teachers, or administrators, have what it takes to do "meaningful" research and at the same time bypass a great deal of the pain.

Much of this fear and avoidance is associated with "the numbers part" of research. Let's face it: computer programming, statistics, and research design are not particularly high on everyone's "favorite course" list. Initially negative experiences in these classes are partly to blame for a spillover effect which translates into avoidance of research activities outside of school requirements.

It shouldn't have to be that way. Fact is, plenty of outside help is available ... AND accessible ... in the technical areas of statistics and computer use. Of course, you have to know how to look for it, as well as how to use it most effectively once you do find it. That is the primary purpose of this paper.

But strange as it may sound to you, all of those impressive-looking tables, graphs and numbers are NOT the heart and soul of research. In the honest judgment of this statistician, YOU are actually the driving force behind good, solid, researchable problems. That is because of the richness of daily experience which you, as educational practitioners, encounter every single day. In all honesty, numbers for the sake of numbers aren't too meaningful. However, take those very numbers and apply them to an interesting classroom problem -- which is how I get my greatest satisfaction in working with you -- and they take on a life of their own. Simply put: YOUR great ideas, needs to know and outright curiosities are where "good research" originates. It's hard to imagine a teacher or administrator who doesn't, from time to time, wonder "why," "how" or "what if" as he/she goes about the daily business of educating students. Take one of those questions, discuss it with a technician like me who can help you go about the steps of answering it ... and you've got yourself a research project. Furthermore, it is one that will be more than a grade for a course: the answer to your question will obviously mean something "real" to you.

This paper is an invitation to you to accept that challenge. It begins with an honest look at the reasons people typically avoid research: the fears, myths and other causes of resistance. These barriers will be followed by a very basic outline of what "real" research is intended to do. This will include a look at the "elusive ideal" of the true experimental design -- the one you probably learned as "best" in your required research methods course -- and how, surprisingly, this method may fall far short of the mark for what you as an educational researcher need to find out. Sometimes the best way to study what you need to study is to gather your data in words: qualitative research designs and data collection and analysis procedures. In fact, the "wave of the future" is to combine both numbers and words, or multimethod designs. Next, some tips will be presented on how you can approach the research process with far greater confidence and make the best use of the technical help that you may need.

Traditional Barriers to Doing Research

As mentioned above, people tend to shy away from research, particularly if it is not a requirement for a course, a degree, or a condition of promotion. The reasons for such avoidance stem primarily from two sources. The first of these is an unfortunate spillover effect from prior coursework experiences in statistics, computers and research design. The second has to do with a basic misunderstanding of the nature and purpose of research. Some typical barriers are identified below.

1. "It's too hard (corollary: "You have to be a genius")." This overall indictment of research activities is primarily a combination of both general barriers discussed above. Images of Einstein come to mind and generate an unfair comparison to oneself and one's assumed lack of qualification to conduct research. Quite the contrary -- anyone with a need to know anything has the potential makings of a "good, researchable" question. That is why, in my estimation, educational practitioners such as teachers and administrators are actually in the BEST position to identify a solid, practical, and above all useful research question -- generally emanating from their own day-to-day experience.
2. "It takes too long." Horror studies told by lifetime doctoral A.B.D.'s are to blame for this one, as are recollections of Margaret Mead-type decades-long immersions in the field being studied. In fact, some of the best and most useful studies are very, very limited in terms of time and cost considerations.
3. "I'm no statistician." (or "computer expert," "researcher," etc.) Granted, "the numbers part" has traditionally also been the HARDEST part. However, there is no law that says one researcher must do it ALL, is there?! Collaborations between technical specialists (like me) and content-area practitioners (like YOU!) generally

lead to the best "meeting of the minds" in terms of shared expertise. For another thing, it may surprise some of you to discover that numbers are not the only, or EVEN the BEST way, to collect and analyze your research data! More on that point later.

4. "It's only for college professors (or master's theses, or doctoral dissertations)." As indicated earlier in Point # 1, it's the rare teacher or administrator who hasn't faced a practical problem or need to know something in the course of doing his/her daily job. Is it a student with a particular learning disability? A challenge to find a way to motivate one's teaching staff during tough times when monetary rewards are unlikely? A desire to try a totally different approach to teaching mathematics in the junior high grades? A frustration with one's inability to stem the tide of high school dropouts? All of the above -- and MORE -- have tremendous potential for turning into research studies which are technically correct, doable ... and above all, USEFUL in answering a need to know.

The Essence of Research

It may come as a surprise to you that "good" research can (and SHOULD) be both technically sound AND practically oriented. With terror in our hearts, we typically recall the unwieldy, 30-step statistical formulas and accompanying multisyllabic jargon ... and thus think of research only in the first regard. Yet the true, underlying purpose behind even the most sophisticated quantitative treatment is to answer an actual question ... and no more. To put it another way, without some "real-life substance" behind it, number-crunching for its own sake is absolutely worthless.

Thus, in actuality, the whole process should begin with an idea, curiosity, or need to know -- it's that simple. A "good statistician" can, and should, take it from there. Computers and statistics are very much the supporting players in this scenario ... no matter how elaborately costumed they may be! No doubt about it: the real star of the show is the research question.

As mentioned previously, you as educational practitioners have a wonderfully rich and close-up view of the very raw material of such research questions. It would be hard for me to imagine a day in which you go about the course of your work and don't "wonder" about something.

All practitioners essentially face these "3 P's": they deal with people, apply procedures, and identify and solve problems. Researchable questions could be developed from any, or all, of the following elements:

- A special population to deal with (e.g., students with a particular learning difficulty or, in the case of gifted students, a challenge; first-year teachers; staff members; parents)
- A procedure to try (would a new teaching method work better? how about a new policy? or could we modify an existing policy or teaching method to get better results?)
- A problem to be solved (why isn't X working?)

" The True Experiment:" An Elegant (but Often Irrelevant) Ideal for Research Designs

Perhaps the most common misunderstanding regarding educational research is "if it's not a "true experimental design," then it "isn't REAL research" and thus isn't worth doing. Granted, experimental designs give the researcher a greater measure of control over conditions and thus confidence in the results. He/she can in essence safely assume, "I got what I got for the reasons I thought, and NOT some other 'hidden' cause that crept in and contaminated my results." By randomly selecting the subjects of one's study, and then randomly assigning them to some 'treatment' whose effects are being tested (e.g., who gets the hands-on science instruction vs. the traditional lecture), the researcher hopes to ensure a "good enough mix" of all of those other invisible causes among the groups. Thus, he/she helps to get a more focused look at the actual effect of the 'one key difference' that is of primary interest in the study (the two types of lessons). By doing so, the "internal validity" or confidence in the results is enhanced (Borg and Gall, 1989).

However, the busy educational practitioner can probably relate to the rather elusive ideal of "the best laid plans" and how often such by-the-numbers preplanned-down-to-the-last-detail goals seldom run as anticipated. Plain truth: students in a classroom are hardly comparable to rats in a laboratory setting! They come into the school setting for several hours a day with "built-in" differences in aptitudes, beliefs, emotions, perceptions, demographic characteristics and the like; many of which simply cannot be "controlled away" by the researcher. Nor would he/she want to do so, if the general idea of research is to understand "real life" as lived and experienced by the participants. (This is where qualitative research procedures -- that is, using words instead of numbers to get at "grounded theory" -- are particularly valuable. More will be said on this point later.) In short, true experimental designs may be impractical to set up, AND undesirable in terms of their artificiality, for educational researchers. Yet, unfortunately, the mythical ideal of the experimental design is still espoused as the 'only right' way to 'do research' in many of the basic introductory research classes taken by educators in master's degree programs and the like.

The important point to note here is: "true experimental designs" are but ONE (and in most cases, not the only or even the best) way to design research studies. In (more realistically encountered) educational settings which lack such absolute control and ability to randomize, a number of equally acceptable design alternatives are available. The following is intended to be a very rudimentary and partial listing. (Marshall and Rossman (1989) have developed a convenient and easy-to-follow chart matching research needs or questions to a variety of alternative research designs using qualitative data collection procedures (p. 78). The reader is encouraged to glance through this chart for some eye-opening choices with regard to selecting the 'best' design to address one's informational needs. Maruyama and Deno (1992) have written a very practically based book on the "practical realities" of doing educational research with "real" subjects and in "real" settings. This book nicely augments the "textbook-type" treatments of educational research with a refreshingly honest peek at life in the field and what the researcher may expect to encounter in conducting educational research.)

Research designs that might fit the informational needs of educational practitioners include the following scenarios:

- Comparing two or more groups with regard to some outcome (e.g., do sixth-grade boys and girls differ significantly with respect to average science aptitude scores? do high school freshmen, sophomores, juniors and seniors differ significantly with regard to attitude towards the quality of extracurricular activities offered by their school?). This comparative-type of research scenario starts with a 'curiosity' about why some outcome seems to vary and tries to 'explain' or 'account' for it by pointing to some grouping condition as the primary reason. (For instance, the outcome of interest might be the science aptitude scores. By "pile-sorting" into two groups -- boys and girls -- the researcher might discover that the variation, or difference, in the average science aptitude score is in effect "explained" by gender. He or she may find that such grouping by gender results in "within-group" scores being "more alike" and "between-group" scores being "more different" (e.g., boys' scores vary or differ less among themselves than do the average scores between boys and girls). What you will be doing, when you "test the significance" of such a group difference, is seeing if that average difference that you've observed is "big enough" to safely assume that these groups would indeed differ on average -- or if it could have been due to chance (e.g., more a reflection of your particular sample than a true difference) (Jaeger, 1990). For our science example, suppose that we have observed a 3.5-point average score difference between the sixth-grade boys and girls in our study. In a scientific research study, we will essentially be asking if such a 3.5 difference is "big enough" to assume with confidence that sixth-grade boys and girls will indeed differ in general. On the other hand, we may find that the test statistic indicates that 3.5 points of difference could have occurred solely due to the vagaries of OUR PARTICULAR individual sample -- and over the long range (typical sixth-grade boys and girls that would be considered the "population" from whom we drew our "sample" subjects for study) would not, on average, differ).

It is important to note that you can do such a between-group comparison WITHOUT having had an "experimental-type" treatment (e.g., a special tutorial or lesson given to one group) under your direct control. This would make your design an "after-the-fact," or ex post facto (also called causal comparative) research design (Borg and Gall, 1989). Of course, you have to be much more careful in this case to make sure that you've identified, and ruled out, as many other possible "causes" of your difference. For instance, in the science example, we want to be reasonably sure that "gender," or the grouping variable that we have selected, is indeed the "cause" of the average between-group science score difference. Without the benefits of the tight control and randomization (e.g., "getting a good mix" on all other possible causes across boys and girls), it is entirely possible that some other variable (e.g., differences in aptitude or intelligence) actually "caused" the difference that we are accidentally attributing to gender. The researcher can in essence do some solid brainstorming and detective work, to identify as many such outside causal factors as possible, and check for whether boys and girls were actually different on them. If he/she can show that these factors were about equally distributed between the groupings of boys and girls, then the researcher can more confidently rule out these outside explanatory influences and safely stick with gender as the "cause." Another procedure which may be available with the help of a statistician is to "mathematically slice out" any such inherent outside differences between the groups so that the researcher arrives at a "more purified" measure of the group difference (e.g., gender) which was originally of interest to him or her. This quantitative procedure of "correcting, after the fact" for such factors which the researcher did not have the "luxury" of randomly mixing between/among the groups beforehand, is known as covariance analysis (Jaeger, 1990).

- Seeing if a particular educational policy, program or procedure "worked" in obtaining the desired outcomes. For instance, did a special evening series of jobhunting-tips workshops increase the number of job interviews and job offers of high-school dropouts in a given community? This is known as evaluation research or impact assessment. As pointed out by Dereshiwsky and Packard (1992), evaluation research seems to be the most universal and applicable branch of scientific inquiry. Most, if not all, of educational endeavors involve some sort of "intervention" (a new method of teaching; a counseling program; a tutorial series) targeted at a predefined set of results which the "intervention" is designed to accomplish (increased academic achievement; improved self-esteem; other academic social, emotional and behavioral outcomes). Lots of readable references exist dealing with how to plan and implement evaluation research studies (Patton, 1990; Berk and Rossi, 1990; Rossi and Freeman, 1989).

- Seeing "what goes with what." Identifying the direction and amount of change in some outcome (e.g., increased self-confidence) as a result of a change in direction and amount of some other outcome (e.g., improved academic achievement) would constitute a correlational research design. In a way, this type of research question is the polar opposite of the preceding one: rather than focusing on WHY THERE ARE DIFFERENCES, the practitioner wants to know WHAT'S RELATED OR ASSOCIATED. Knowing how, and how much, one outcome changes with a change in some other outcome could be very useful in a predictive sense, especially if one precedes the other. Again, the researcher needs to exercise particular care before assuming that, just because two things 'move together,' that one necessary "caused" the other. For instance, there could have been a third, "hidden" cause of BOTH the increased self-confidence AND the improved academic achievement, such as a special one-on-one tutoring experience with peer counselors that happened to run concurrently during the study time. Once again, however, the astute educational researcher will "play detective" and either rule out or mathematically remove as many such effects as possible. This will be done to "zero in" more efficiently on the two (or more) factors that he/she has preidentified and wishes to understand in a correlational or relationship sense.

- "Just mucking around." Yes -- this one is actually OK to do! In fact, it may be critically needed. Packard (1992) has warned of the danger of going ahead and blindly applying textbook models of some educational process or procedure -- which may look slick on paper but may also have little to do with life as it is lived in actual classrooms by students, teachers and administrators.

The ideal way to "emerge" such models is through "grounded theory" approaches: identifying, in a descriptive study design sense, the key issues, problems, and factors faced by these important players on the stage of an actual school setting. This in turn may need to involve extensive use of qualitative procedures, or having the words augment (or even replace) the numbers. Only after sifting through these "real-world" data can the researcher validly begin to piece together a "model" or process of what he/she thinks can account for, or explain, what is actually happening in the school setting.

Naturally, such a model can then be "road-tested" in other, similar situations or settings to see how well it holds up, or if it needs to be modified in order to be more generally applicable. Yin (1989) has referred to this step-by-step validation and refinement as "cross-case analysis" (p. 57). He and other qualitative researchers such as Miles and Huberman (1984) have advocated selecting "extreme" cases, or polar opposites -- e.g., schools identified as having "exceptional" and "suboptimal" climate by whatever means of classification -- and seeing if the model "holds up" for the condition that it is expected to (e.g., are the factors in the model "present" for the "good climate" schools and "absent" (or at low levels) for the "poor climate" schools?). Yin has termed this process "literal" vs. "theoretical replication," respectively (p. 53).

In summary, the educational researcher may simply not "know enough yet" about the underlying process, procedure or model to be ready to jump to the next step of testing similarities and differences. In other words, according to Packard (1992), he/she first needs to know "what it is." This would necessitate the sort of descriptive research study described above, as an essential prelude to refinement and (eventually, upon gradual development of a well-validated and reasonably generalizable model) the more traditional experimental research designs, in order to test for causes, effects, differences, and the like.

In the preceding alternatives to true experimental designs, a number of references have been made by this dyed-in-the-wool statistician to the use of qualitative research procedures. This may seem surprising, given the "feared/revered" phenomenon associating with statistics. On the contrary: collecting and analyzing data in words, as opposed to (or in addition to) numbers often makes for a tighter, more believable study. Thus, before proceeding to a discussion of numbers and statistical help per se, a brief overview of the nature and role of qualitative and multimethod research procedures is in order.

The Power of Words: Rich and Revealing

As mentioned in Barrier # 3, pgs. 2-3, numbers may not necessarily even be the best tool for you to use to address your research question. Ironically, for all of my love of things quantitative, since coming to Northern Arizona University I've spent the greater part of my time on qualitative data collection and analysis techniques. The research world is gradually coming to the (long-overdue) realization that words are superior to numbers in a great deal of context-rich research situations such as those that practitioners face. Interviews, log books, written diaries, both official and unofficial documents -- these sources, and more, may be just what you need to answer your research question -- instead of the computer programs and statistical tables.

Yin (1989) has nicely elaborated on the different (not "better" or "worse") settings in which one might wish to use words vs. numbers. He refers to this distinction as "analytic" vs. "statistical generalization," respectively.

> The external validity problem has been a major barrier in doing case studies. Critics typically state that single cases offer a poor basis for generalizing. However, such critics are implicitly contrasting the situation to survey research, where a "sample" (if selected correctly) readily generalizes to a larger universe. *This analogy to samples and universes is incorrect when dealing with case studies.* This is because survey research relies on *statistical* generalization, whereas case studies (as with experiments) rely on *analytic* generalization (p. 43, emphases in original text).

Yin goes on to describe analytic generalization as wishing to obtain an in-depth understanding of a locally based process, procedure or phenomenon. This would involve looking at multiple facets or characteristics of the entity being studied, such as for instance a single classroom, student population or teaching procedure. Such analytic generalization contrasts with the more conventional statistical generalization, the latter involving a desired projection of a more greatly limited quantity far beyond the scope of one's study setting. An example of this would be "I predict, with 95% confidence, that the average (Standardized Test name) score for fourth-graders generally will be between 87.5 and 91.3 points." If it is indeed your desire to make such broad generalizations of limited quantities, across thousands or even millions of subjects, than you definitely would need to employ inferential statistical procedures to test your assertions. However, if you are looking to understand a wider variety of factors with regard to YOUR school system or locally unique populations of students and teachers, you may need to "go qualitative." For one thing, some if not all of these factors may not be readily "numberizable." For another, the richness of the words as spoken or written by these subjects may give you a more informative and revealing look at what is really happening.

Qualitative research has truly come into its own element as a long-overdue, and until recently misunderstood, branch of scientific scholarly inquiry. A number of sources (Patton (1990); Marshall and Rossman (1989); Krueger (1989); and Denzin (1978), to name but a handful) have documented how to apply such procedures to educational research settings. As stated by Dereshiwsky and Packard (1992):

> Learning to collect and analyze qualitative data requires relatively little training, as compared with inferential statistical procedures (and, often, related computer programming skill). Yet for all its surface simplicity, a quotation can be tremendously revealing in terms of its wording, content, examples, detail and the like. As ethnographers have known for quite some time, there is nothing quite like letting subjects "tell a story in their own words." In doing so, the evaluation researcher gains a valuable peek into the "world" of the key stakeholder and the full impact of the program as he/she lived and experienced it from a unique and personal perspective. (p. 4)

Easy-to-use procedures also exist for summarizing these words into conveniently readable and understood form. The most popular of these is a chart or graphic known as the "matrix" or "table shell" method, developed and creatively illustrated by Miles and Huberman (1984). Summarized key themes appear in the "boxes" of this graphic, enabling the reader to spot key themes, trends and between-group comparisons at a glance. Packard and Dereshiwsky have extensively applied the matrix method in a number of evaluation studies. These include a baseline needs assessment of the organizational climate of a private high school located in a Navajo reservation community (1991, November). A second recent application involved pilot-testing of educational materials for use with Navajo families identified as being "at risk" for developing diabetes (1991, August). The reader is referred to these publications for illustrations of the matrix method of compiling qualitative data. (A partial listing of recent qualitative evaluation research publications by Packard and Dereshiwsky appears as Section B of the references to this paper.)

The second method of compiling qualitative data is known as the "summary narrative" method (Denzin, 1989; McCracken, 1988). It consists of writing a greatly condensed summary of key themes, trends and other information gleaned from reading, reviewing and coding the totality of qualitative data. Such summary narrative is then "interwoven" with a sprinkling of illustrative quotations.

Both of the preceding methods of compiling and reporting qualitative data were designed to address what until recently had been the biggest complaint about it: namely. that words were not as readily condensable as numbers. For all of the fearsome formulas and such. at least statistics (once eventually mastered and reasonably understood by their users!) enjoyed the reputation of being "concisely reportable." For instance. chi square and analysis of variance (ANOVA) tables are reasonably standard and focused in format. While words were readily acknowledged to be more revealing, easy to understand and undoubtedly more inherently interesting than numbers. they were thought to elude such condensation and concise compilation. That is, it was feared that the only way to report them would be to reproduce page after page of verbatim quotations -- resulting in an overwhelmingly lengthy report that no one would bother to read from cover to cover. With the development of the matrix and summary narrative procedures, however, one could indeed have the "best of both worlds." The researcher would enjoy the revelatory nature of the words as "packaged" in a more manageable format, be it a shorter report or a creative graphic.

This invariably leads to the idea: why not, indeed, employ the "best of both worlds" in one's research design? Can words and numbers be made to mix compatibly? Thanks to a very exciting new direction of research design, the answer is a resounding "yes."

Having It All: Multimethod Research Designs

Multimethod research procedures are indeed the wave of the future in scholarly inquiry. due to their ability to integrate the precision of numbers with the rich, revelatory nature of the words. Brewer and Hunter (1989) have stated, "Its fundamental strategy is to *attack a research problem with an arsenal of methods that have nonoverlapping weaknesses in addition to complementary strengths* (p. 17, emphasis in original text)." The use of more than one procedure to collect and analyze data furthermore tightens the internal validity or believability of the study's findings and conclusions. Brewer and Hunter have explained this phenomenon of *triangulation* as follows:

> Broadly speaking. measurement is the operation of assigning either qualitative or quantitative values (that is, either names or numbers) to social phenomena. Triangulated measurement tries to pinpoint the value of a phenomenon more accurately by sighting in on it from different methodological viewpoints. To be useful. a measuring instrument must both give consistent results and measure the phenomenon that it purports to measure. When two reliable instruments yield conflicting results. then the validity of each is cast into doubt. When the findings of different methods agree. we are more confident (p. 17).

Packard and Dereshiwsky (1992) have applied multimethodological research procedures to cross-validate data fr m four alternative sources to obtain an in-depth understanding of the psychological environment of organizational settings and related human emotional responses. These three sources are: an intensive historical ("document analysis") literature review; two alternative forms of instrumentation (the Organizational Performance Scale (Packard, 1986) and the Perception Assessment Scale (Packard, Kundin and Bierlein, 1986); and a series of focus group interviews conducted with graduate students enrolled in various research classes taught by the two authors. A matrix was developed which contains a comparative listing of the positive and negative factors of communication and associated feelings and emotional responses of educational personnel (pgs. 5-6). These are grouped by: 1) Type and Level of Communication: 2) Receptor Feelings; and 3) Receptor Emotions.

These findings, in turn, have been cross-validated through a factor analysis of the responses to the organizational climate items of the Perception Assessment Scale (Packard and Dereshiwsky, 1992). Four factors which accounted for 59.1% of response variance were identified and extracted. These were: 1) Program Reform and Accountability; 2) Communication and Emotional Health; 3) Evaluation and Placement; and 4) Psychological Self-Actualization. Individual survey items "clustering" with each factor (e.g., having "robust loadings") were identified in this paper.

There you have it: the statistician turned qualitative researcher who enjoys having the best of both worlds by using the two procedures effectively in research designs. Having established the appropriateness of qualitative research methods, attention will now be turned back to "the numbers part" and how to make it work for YOU in on-site educational research designs.

Making "Hi-Tech" MY Tech:
What You Should Expect from a Good Technical Specialist

I admit it: I'm crazy about numbers. That's why I chose to major in applied statistics. In addition, I also love computers, having struggled to overcome an initial phobia which frankly developed in the days before the point-&-click Macintosh. (Who wouldn't learn to freeze up at the thought of boxes of punched cards, hieroglyphic-y programming code, and above all, reams of computer printouts with nothing but line after line of error messages that provided not a clue as to the one missing comma that actually triggered all 250 of them?!)

Now, please look back at the word that precedes "statistics" in the second sentence of the paragraph that you just finished reading. I want you to know that I take that word "applied" very, very seriously. For one thing, I've always thought of myself as a teacher first and statistician second. Crunching away at a computer for twelve-hour days for a mega-insurance company in Hartford is certainly something that I'd be qualified to do; but frankly, it would hold absolutely no appeal for me. My joy comes from making statistics "mean something real" to people. (I live for that visual light-bulb, that moment where I've worked with someone on a quantitative procedure and I can see that they've grasped what the statistic "really means, in English.")

To me, the real essence of statistics isn't in contorting the foot-long formulas; a computer can be programmed to do that for you. Rather, it is in matching the right tool to the right need: understanding conceptually what a given statistic is supposed to do; being able to pick the right procedure(s) for an actual research question; and helping the originator of that question gain a solid understanding of what the statistic is doing -- enough so that he/she can see its purpose in the overall scheme of things. Thus, it may surprise you to know that probably 95% of my time with so-called "consulting clients" is spent, not in plugging away at computer keyboards or manipulating formulas, but rather in careful listening and talking about IDEAS.

Furthermore, as mentioned in Barrier # 3, above, numbers may not necessarily even be the best tool for you to use to address your research question. Ironically, for all of my love of things quantitative, since coming to Northern Arizona University I've spent the greater part of my time on qualitative data collection and analysis techniques. The research world is gradually coming to the (long-overdue) realization that words are superior to numbers in a great deal of context-rich research situations such as those that practitioners face. Interviews, log books, written diaries, both official and unofficial documents -- these sources, and more, may be just what you need to answer your research question -- instead of the computer programs and statistical tables.

I'd like to think that I've acquired enough tools of the trade, both quantitative and qualitative, to be able to match the most appropriate procedure(s) to your research needs. The most rewarding part of my academic job assignment has been working with educators from a variety of diverse fields (e.g., educational leadership, curriculum and instruction; educational psychology; gifted and talented education) on the technical aspects of their research projects. Based upon my own experience, I'd like to offer you some tips for working effectively with technical specialists. These suggestions are designed to make your initial venture into the world of research not only (relatively) painless, but actually rewarding, for you.

1. Back to basics: start small. Please don't think that you have to have an elaborately worked-out, jargon-heavy researchable question the first time you meet with a statistician, computer person or other technical expert. In fact, the sooner you can begin to bounce rough ideas off, the better. You need to know if they're doable, testable, and the like -- which may mean some give-and-take as you and the technician successively add, change, shape and refine your original idea. It's perfectly OK to start by saying, "I'm curious about X, but I don't have any idea how to turn this into a researchable topic." That's a very valuable starting point for further dialogue between you and your collaborator, because it says something about your general area(s) of interest.

2. Be patient with the "field-outsider" when explaining your area of interest. It's a sad fact that the unknown (and therefore scary) is sometimes also given undue glory and importance. I've seen this phenomenon at work with respect to statistics ... and statisticians.

Well ... I'd like to let you in on a little secret. When I meet you for the first time to find out about what you're interested in studying, I'm sitting there and wondering a bit anxiously, "I hope he/she will explain slowly enough and be patient with me, and not go TOO fast, so that I can follow what he/she is trying to do." In other words, your field jargon is as scary and intimidating to me as mine is to you!

What this means is that I'll be needing to "do homework" -- probably asking you lots of follow-up questions, and maybe even requesting additional readings and/or clarification meetings -- all designed to give me a good, thorough soaking in your field of study. This phase is akin to a second or third diagnostic medical opinion -- time-consuming and perhaps tedious, yet essential to getting at the heart of reality. A "good" technician will not rush to his/her computer before ensuring that he/she has acquired a solid understanding of exactly what the researcher is trying to accomplish. Please be patient with us while we learn to "speak your language."

Given the critical importance of the research question or problem, I should be able to restate it to you in my own words at the end of this phase. My practice is not to proceed with any analysis until I can say, "It seems to me that this is what you are trying to find out. Have I restated it correctly?" If not, it is essential to keep the discussion going until there is a meeting of the minds of both the researcher and the technician as to the purpose of the research study.

3. Know the research roadmap. At this particular point I will tell my research collaborator(s), "It sounds to me like (Statistic X or Qualitative Procedure Y) would be best to answer your research question. But first, let me talk with you a little bit about what this procedure does and how it works." Granted, for practical purposes all parties may have

agreed in advance that the technical specialist alone will be responsible for all of the computer programming and number-crunching aspects of the work. (This makes good sense in terms of division of labor: after all, it's "what I do best!") However, this does NOT preclude the same honest two-way communication process that was applied to identifying a researchable problem. In essence, the roles are now reversed: the technical expert will be expected to do the same kind of patient explaining about the HOW as the practitioner did about the WHAT.

As the source of the research problem or question, you are yourself a researcher worthy of respect and professional consideration. Do NOT, under any circumstances, allow for any of the following events to occur:

a) The technical expert simply "runs to his/her machine" without first telling you what he/she will be doing, and expects you to accept the end product(s) without comment or question;

b) The technical expert does tell you what procedure(s) he/she recommends, but "speaks in jargon" to you about them. You either dare not ask a question for fear of "looking dumb," or if you do, you are treated in a patronizing and/or dismissive manner ("What do you mean -- you didn't understand that?!").

Insist on your right to be an "informed consumer" and to have full and complete prior knowledge of the recommended ways to go about doing the research. There is one additional benefit to this step besides your basic right to know. For me, as the outside technical expert, it is one final "cross-check," if you will, that I did indeed understand the research question and what needs to be done to answer it.

4. <u>Allow ample time for the data collection and analysis phases</u>. In my individual work with doctoral candidates on the analytic portions of their dissertations, I never cease to be amazed -- and saddened -- at how consistently they underestimate the amount of time it will take to collect and analyze their data. For one thing, while computers have admittedly accelerated the time that it takes to create databases and perform calculations, it is NOT a matter of "pushing one button," as some people still seem to assume. In fact, some of the more sophisticated quantitative procedures (such as multiple regression and categorical data analysis models) actually consist of a series of computer runs and associated statistical tests. One needs to look at the outputs from step one to decide what variables to include or exclude and repeat the process for step two, and so forth.

Also, anyone who's ever had even the most basic computer programming course knows what a tedious and time-consuming process debugging a computer program can be. "The best-laid plans" on coding sheets seldom, if ever, translate into a perfectly executed computer run on the first try. Moreover, the causes of crashes can be as diverse as a single comma or slash gone astray, to a typo in the database, to an internal system or hardware glitch that had nothing to do with your well-written program but caused it to dive-bomb anyway.

Qualitative data collection may initially look quite appealing as an alternative to such fearsome number-crunching. However, talk with anyone who has spent just 1 1/2 hours conducting a single focus group interview session and ask to see their notes and source tapes. The sheer volume of qualitative data is often an overwhelming surprise to those researchers who may have thought that it was "the easy way out" but who must now spend hours and hours condensing these data into some sort of meaningful pattern. Furthermore, unlike the precision associated with inferential statistics, there simply is no "one right way" in condensing and summarizing qualitative data. The process is quite unlike arriving at a final t- or F-value which you can have a computer crunch out for you and which you (or the machine) then look up against a value in a table to decide if it is "statistically significant." It is not unheard of, and in fact quite common, to decide that one's initial coding or matrix breakdown scheme for summarizing qualitative data isn't working ... and to have to start all over with a different model or procedure.

What this all boils down to is: be as patient with your technical expert during this stage as you were during the problem-definition stage (step #3). Do not put undue deadlines or related pressures on your technical specialist to "crank out the results" without first consulting him or her as to what the projected time lines are likely to be. Or, better yet, ask your expert to describe to you the sequence of steps in data collection and analysis, as well as a ballpark of how long (best- and worst-case scenarios) each step is likely to take. I make sure that I have a thorough discussion with my client-collaborator(s) in which I spell out all of the key steps, from database formatting design through write-up of results. I also "gently warn" them of any potential stumbling blocks, such as not getting a 70% survey response on the first mail-out, which could cause slowdowns, so that we can jointly plan what to do if these contingencies should occur. That way, we all have a clear and agreed-upon idea ahead of time of what needs to be done and approximately how long each step can be expected to take.

5. <u>Make it your own</u>. Once the end product of analysis is completed, a "good" technical specialist will not simply "dump" it on you and expect you to instantly understand it. I actively work with my client-collaborators to explain the resulting statistical and/or qualitative (tabular or narrative) outputs. In the case of quantitative methods, I never just hand over a computer printout. Rather, I usually "distill" from it first, making shorter tables, graphs and charts in pencil or using a basic computer software graphics package. Next, I sit down with my collaborator and go through these "more-bare-bones" results.

taking care to explain each statistic or procedure thoroughly and, above all, linking it back to the research question so that the client can see what it was supposed to accomplish.

As my introduction to research class knows very well, a "good" researcher must never forget to "answer the question!" The goal of the technical specialist at this point is to help the client-collaborator do exactly that. No one will ever expect you to "re-derive" your formula. They will, however, expect you to be able to tell someone what the statistic helped you to find out, and how that information can be used to answer your research question. Just as in step #3, insist on your right to know at this point. Do not accept jargon, abstract formulas, and the like, as substitutes for a solid grounding as to what the research findings are.

6. Oh, and one more thing: statisticians are people, too! I know -- this one surely goes against the stereotype of your worst memories of the toughest statistics class you ever took. Horror stories about "inhuman" statistics and computer professors can be heard with alarming frequency within the walls of any graduate institution. (P.S. We all share in that nightmare: I've had some terrible experiences along those lines myself.) As a result, it is tempting to think of statisticians as being in the same league with the machinery and formulas which we use to do our jobs -- with not a single social skill in evidence.

While I'm not denying that such stereotypes may have a grain of truth to them, I also believe that it is dangerous to generalize from extreme cases. As I look back on my own experiences, I've also been most fortunate to work closely with researchers who are VERY MUCH "human" -- who have taught me as much, if not more, about human development (and joyful living) than the mechanics of the research process. I also believe that it is their very "humanity" that makes them such especially proficient technical experts and outstanding researchers, for they gain ready access to a wide variety of people, places and situations as a result. As I indicated at the outset, I think of myself as a teacher first and a statistician or researcher second. I have also conscientiously tried to apply what my humanistic mentors have taught me in my own interactions with my students, clients and collaborators. In short, I like to think that technical proficiency and humanity not only go hand in hand but work in synergy.

There is tremendous potential for positive communication and interaction in ALL of us -- regardless of who we are or what we do. Here are some thoughts on how to elicit them in the case of collaborating with a technical specialist:

a) Ask questions if you're confused. Don't be afraid or ashamed to admit that you don't understand something. (We ALL have to start somewhere.)

b) By the same token, don't attribute "mind-reading" capabilities to your technical expert. (We're not THAT talented!) If something confuses you, if you want to make a change of direction. if you are frustrated, challenged, or just plain don't know where to go or what to do next ... speak up. Ambiguity is not only OK. but is to be expected, as part of the research process. Communication does not consist of being a walking thesaurus; rather, it is a process which can be VERY non-linear. (A side note: linearity really exists only in analytic geometry and multiple regression classes -- and even these two have established procedures in case of departures from the deceptively simple and elegant straight line. Remember that.)

c) Let the technical expert also know when something is "very right." As implementers and teachers of traditionally difficult material, we statisticians and computer types are all too accustomed to "the negative:" confusion, frustration. anxiety, and the like. Well, having reminded you to KEEP telling us when these emotions are in fact present, I now feel compelled to focus on the other (perhaps rarer) extreme. It wouldn't hurt to let us know if we've done especially well at something, too! That information, by the way, doesn't have to come in the form of effusive, gooey words of praise, either. It could be a direct, honest statement like. "I never really understood that statistic before. but from the way you just explained it to me, I now have a feel for what it's supposed to do and how it works." (I've heard that, and it's just made my day.)

d) Let us be a valued part of the process too. This point goes along with its immediate predecessor. While a computer can be turned on or off at will, I as a researcher and a person get mentally and actively involved with my topic. As a result, I inherently like to feel that I'm a valued member of the team. So ... don't let my involvement end with my delivery of the analytic results. Share your entire written draft with me and ask me for my reactions to the document as a whole. Tell me what you're going to do with the research results. If you're applying for a grant, keep me posted as to whether you got it. Invite me to come and listen, if possible, if you're presenting the results at some sort of official meeting. Or, better yet, offer me a chance at a co-authorship with you. including perhaps a joint presentation at a local. regional or national professional conference. Statisticians, practitioners. and content-area experts approach the research task from very different. but equally valued, perspectives. There is no "better" or "worse" -- ALL are equally vital to its success.

Good Help Need Not Be THAT Hard to Find: How to Locate Your Technical Expert

As with other professionals (e.g., physicians and lawyers), the same search maxims apply: shop around carefully and ask trusted sources for referrals. An "out-of-the-phone-book" approach may sound efficient but might well end in disaster. A "good fit" interpersonally is probably as important -- if not more -- than absolute credentials and technical expertise per se.

For the educational practitioner, the first step might be to ask around within the district to see if statistical consultants have recently been hired to assist with wide-scale research projects. He/she might also check with recent Ed.D. graduates who live and work nearby: colleges and universities with graduate programs often feature "help-for-hire" postings by computer and statistical specialists. Another prime source of names to call is the academic computing department of nearby universities. Employees may "moonlight" as consultants; or, if they are too busy themselves with university duties, they may in turn know of friends, recent graduates or other such contacts.

As cautioned above and in the preceding section, make sure that YOU are comfortable with the technical expert BEFORE committing to a contract or other long-term business arrangement. Communication style, as well as statistical/computer substance, should be critical in your decision of working partner(s). Expertise must not masquerade as arrogance: a sincere respect for your respective position is absolutely essential, in my opinion.

Concluding Comments

We've all no doubt heard the old maxim, "Anything worth doing is worth doing well." However, this saying does not automatically imply that we alone must do it all -- and do it perfectly on our very first try. I am fond of telling my research students that "99% of what I've learned on the computer, I've learned from having to undo catastrophic errors."

I also share with my classes that "Good research is messy." The creative challenge lies in trying to anticipate twists and turns in the road, as well as to have backup plans, procedures and resources ready to help at those particular points.

As educational practitioners, you indeed have the world at your disposal: that is, a world which is sometimes equally messy and occasionally leaves you with more problems than solutions. If you'll allow me yet another maxim at this point, you also know that since "tomorrow is another day," you'll be back in the classroom facing that same concern.

problem or challenge. This is precisely the point at which the research process stands ready to help you meet the challenges of addressing your needs to know. This readiness includes access to, and collaboration with, so-called "technical experts" in certain parts of the process, like me. The opportunities to change your world and mine, by each of us being who we are and applying the best of what we know as part of this process of discovery, are virtually unlimited.

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