

Proffitt Grant Proposal:

**Bridging Qualitative and Quantitative Methods
in Educational Research:**

Analysis of Patterns in Time and Configuration (APT&C)

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**Please note: This approach has since been renamed MAPSAT: Map & Analyze
Patterns and Structures Across Time. See <https://mapsat.iu.edu>**

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Abstract

The field of education is under attack. NCLB threatens to undermine our public K-12 school system. Schools of Education are seen by K-12 principals as out of touch and lacking curriculum rigor. The problem, in part, is due to limitations of research methodologies used during the past century. APT&C is proposed as a mixed-mode research methodology and software tool to help create knowledge of education that is directly linked to K-12 practice. APT&C bridges the gap between traditional linear models in quantitative research and qualitative research findings that lack generalizability. Empirical findings by APT&C on patterns of practice can be used in higher education to better prepare K-12 teachers and educational leaders for professional practice. Not only can this software be used by educational researchers, but also by practitioners. K-12 administrators can use it to help redesign school systems. K-12 teachers can use it as a learning tool for students to see the impact of organization choices and teaching strategies to optimize learning.

I propose to extend 32 years of my previous research with APT to further develop software tools, so that both temporal *processes* and organizational *structures* in education can be understood and used for making practical decisions. Like epidemiological research in medicine, APT&C and tools can be used to create research from which practical decisions flow. While epidemiological research does not prove that smoking causes lung cancer, the results for heavy smokers support a health decision to refrain from smoking. Likewise, APT&C can be used to frame research at every level of education.

Bridging Qualitative and Quantitative Methods in Educational Research: Analysis of Patterns in Time and Configuration (APT&C)

The Problem

The field of education is under attack. The *No Child Left Behind Act of 2001* is causing alarm in the K-12 community. NCLB requires schools to assess annually student achievement at numerous grade levels. Based on average test scores, schools will be identified as succeeding or failing. Schools that repeatedly fail to meet current state standards for student achievement will be held accountable. Parents will have the opportunity to send their children to different schools, if their present school is not succeeding. If, in the future, parents have *vouchers* (which are part of President Bush's hidden agenda), they could spend them at newly created private schools which might ultimately subvert our K-12 public education system and our ideals of democratic education.

Those of us in schools and colleges of education in universities may also find our institutions in jeopardy. Dean Gerardo Gonzalez has repeatedly warned us that the university teacher preparation programs are coming under increased scrutiny and doubt (cf. [response to George Will's Editorial](#), 2001).

The *New York Times* recently reported:

American colleges and universities do such a poor job of training the nation's future teachers and school administrators that 9 of every 10 principals consider the graduates unprepared for what awaits them in the classroom, a new survey has found. Nearly half the elementary- and secondary-school principals surveyed said the curriculums at schools of education, whether graduate or undergraduate, lacked academic rigor and were outdated, at times using materials decades older than the children whom teachers are now instructing. Beyond that, more than 80 percent of principals said the education schools were too detached from what went on at local elementary and high schools, a factor that made for a rift between educational theory and practice.” ([Winter, 2005](#))

This four-year study, [Educating School Leaders](#), was directed by Arthur Levine (2005).

Further evidence of the problem is the reaction of federal funding agencies. Recent policy changes have been influenced by the likes of arguments by Shavelson and Towne in *Scientific Research in Education* (2002). “Randomized trials” and “what works” have become rallying cries for those seeking accountability in educational research.

How did we get into this predicament? Part of the problem, I believe, is due to limitations of research methodologies that educational researchers have used. These limitations, in turn, have impeded the development of *generalizable* knowledge of education that can be directly linked to practice. The intensity of debates between quantitative and qualitative research methodologists during the latter part of the 20th century is symptomatic of the dilemma that well-intentioned and competent researchers face.

Background of the Problem

Research methods in education used for much of the 20th century were largely quantitative methods. Experimental and quasi-experimental designs were commonplace (e.g., Campbell & Stanley, 1966), and analytical techniques included ANOVA, regression analysis and their extensions (i.e., discriminate, factor, canonical and path analysis). The basic problem is that this general linear models approach seldom yielded findings that could be directly linked to educational practice. Within-group and within-person variance was often large, typically obfuscating differences between groups that could be attributed to so-called treatments, practices or programs (Medley, 1977; 1979; Frick & Semmel, 1978). Cronbach & Snow (1977) further extended ANOVA to deal with aptitude-treatment interactions (ATI), with hopes of reducing the within-group variance. But this, too, was seldom successful in yielding significant results.

Egon Guba, an education professor at Indiana University, and others began to explore alternative approaches in the 1970s and 80s that later became known as qualitative and case study

methodology (cf. Guba & Lincoln, 1985; Merriam, 1997; Stake, 1995; Yin, 2003). Qualitative methods have become widely used in educational research in the past two decades. One clear advantage of qualitative methods is “thick description,” as Guba called it. Rich details of individual cases can give readers helpful insight into and understanding of the educational phenomena investigated. The unavoidable dilemma that often accompanies this approach is lack of justification for generalizability of findings. When samples are purposive and small, generalizability in the sense of making inferences from sample to population is seriously compromised. Indeed, respected books on qualitative methods avoid the term ‘generalizability’ and instead employ the notion of ‘transfer’ – i.e., results of what was found in this particular investigation *may* transfer to other similar situations the reader encounters (cf. Merriam, 1997).

To the great dismay of many researchers who use qualitative methods, the pendulum has swung back to an emphasis on funding research that would be expected, on the surface at least, to create reliable and generalizable knowledge of education (cf., Shavelson & Town, 2002). There is no good reason to believe that history will not repeat itself here – the inescapable problem is within-group and within-person variance. Human behavior is purposive and difficult to predict using such deterministic methods (linear models approach).

A Middle Ground: Analysis of Patterns in Time (APT)

In the early 1970s, I experienced firsthand the limitations of the linear models approach for creating knowledge about education (cf. Semmel & Frick, 1985). At the same time, I was first introduced to general systems theory, particularly through the SIGGS theory model (Maccia & Maccia, 1966). Out of this experience grew an analytic-measurement procedure that I created, later called Analysis of Patterns in Time (APT). This was, and still is, a *paradigm shift in thinking* for quantitative methodologists steeped in the linear models tradition and the measurement theory it

depends on (cf. Kuhn, 1962). The fundamental difference is that the *linear models approach relates independent measures through a mathematical function and treats deviation as error variance*, but *APT measures a relation directly by counting occurrences of when a temporal pattern is true or false in observational data*. Linear models relate the measures; APT measures the relation. The difference is subtle, but significant, as I emphasized in a seminal article on APT published in AERJ in 1990. Clearly APT has value in classroom observational research and also for computer adaptive mastery testing (EXSPRT). Some of my doctoral students have since used APT in their research (e.g., An, 2003; Yin, 1998; Wang, 1996; Luk, 1994; Plew, 1989). Over the past decade, I have used APT concepts in usability evaluation for Web design.

APT is well explicated in Frick (1990; 1983). As an example of conclusions when using APT: In an observational study of mildly handicapped children in elementary school Rieth and Frick (1982) found that, regardless of classroom context, when direct instruction was occurring these students were engaged on average about 97 percent of the time. In the absence of direct instruction, their engagement was about 57 percent. In other words, such students were 13 times more likely to be off-task during non-direct instruction. This kind of APT finding is similar to epidemiological findings in medicine. For example, heavy cigarette smokers are 5-10 times more likely to have lung cancer later in their lives (Kumar, et al., 2005), and if they quit smoking the likelihood decreases. While causal conclusions cannot be made in the absence of controlled experiments, nonetheless one can make practical decisions based on such epidemiological evidence. We can do likewise with APT.

The best example of use of APT was done in a study of mode errors in human-computer interfaces by An (2003). Hers, and also the Yin (1998) study, show the value of the merging of qualitative methods and quantification via APT. An (2003) investigated conditions of mode errors

when people use modern software. Software has a ‘mode’ if the same user action does one thing in one context and different thing in another – e.g., pressing the ‘d’ key echoes the letter ‘d’ but it also deletes a file. She videotaped 18 people using three different typical software products: a word processor, graphics program and an address book. They were asked to do the same authentic tasks and to think aloud (e.g., insert a different header in MS Word). Stimulated recall interviews were conducted immediately afterwards to clarify why participants took certain actions during the usability evaluations. After conducting a content analysis of these qualitative data, three major conditions for mode errors became evident.

An used qualitative methods initially because she did not know what conditions of mode errors would emerge. Then once those became clear, she was able to develop a coding system in a manner that would then allow quantification of patterns through APT. She found, for example, that when users did the right action but got the wrong result, the source of user error was often software interface elements that lacked affordance (functionality that is not obvious). This frequently resulted in users being unable to find a software function that was hidden from view, or they thought they did the task correctly only to find out later they had not (false success). She concluded that when these conditions for modes occurred, software users were unsuccessful *67 percent of time* in tasks they were trying to do. This was one of many practical APT findings that have direct implication for how we design computer interfaces for humans to use successfully.

This kind of mixed method approach to research was also used by Jacob Kounin (1970) when studying classroom group management. A qualitative analysis of videotapes from 80 elementary classrooms led to identification of patterns of behavior. He discovered that teachers who were ‘with-it’ had classrooms with much higher student engagement rates. Teachers who were not ‘with-it’ made targeting and timing errors in dealing with classroom behavior problems, and there

was much more student off-task behavior in their classes. He then devised an observation system in order to code the videotapes and to subsequently quantify his findings that allowed generalization. Kounin's research helped to identify patterns of practice that teachers could use in their classrooms. Although I had not formalized APT at that time, Kounin was essentially doing APT.

An (2003), Yin (1998) and others could only do APT by manually coding data, counting pattern occurrences by hand, and by estimating likelihoods on pocket calculators, since modern APT software does not exist. Yet these studies have demonstrated the practical value of mixed methodologies where one first uses qualitative methods for gaining understanding of patterns and relationships, and then uses APT to code and quantify those relationships in a manner that is useful to practitioners for making decisions based on APT predictions.

Most important, if a researcher selects a sample which is large enough and representative of the population, then generalizability of findings about patterns is possible. APT thus addresses limitations of typical qualitative research which lacks generalizability. If a proper sampling strategy is used, inductive inferences from sample to population can be made from APT findings – without being bound by the constraints of linear models in quantitative research.

Extending APT to Analysis of Configurations: APT&C

Thompson (2004) noted that APT could be extended to characterize structure or configuration of educational systems. In our ongoing co-development of an educational systems theory we have identified a need for measurement procedures for empirical verification of theorems which contain structural properties such as centralization, wholeness, compactness, passive dependence, and hierarchical order. When I formally defined APT (Frick, 1983), it allowed us to characterize and count occurrences of temporal *processes* in education. Based on recent research, we believe that we can extend APT to measure and analyze configurations in education. Configurational

patterns characterize *structures* in education – i.e., how education is organized, or relations between parts and whole.

In the late fall, 2004, a group of IST doctoral students in my R690 class examined extant research in education for verifying 14 theorems in our partially developed educational systems theory. They did an extensive literature review and found *empirical* support for 12 of the 14 theorems (these were listed in the Proffitt proposal rejected last fall, but we did not have those data at the time the proposal was written. See <http://www.indiana.edu/~tedfrick/est/verification14theorems.pdf>). These students noted that we need better methods of measurement for validating these theorems when conducting new studies. They could not use APT in their study since the original data were not collected in an APT framework. They could not use APT&C, because it has not been developed, nor were original data collected in such a framework.

APT Software and Instruction Need to Be Developed

I initially developed and programmed APT software in BASIC for TRS-80 and Apple II microcomputers (Frick, 1980; 1981). While these highly complex programs still actually work, they can only be run on an IBM PC compatible computer in DOS mode (not in Windows or on a Mac), and the interface is primitive by today's standards (e.g., no mouse, no graphics – i.e., not GUI). I propose to bring the APT software up to today's interface standards and computing environments (i.e., Web, server-side PHP, Flash, ActionScript and XML technologies). The software modules will include the following:

Define: Create, save and modify one's own observation systems (i.e., classifications and categories for coding).

Code: Enter, store and modify observational data using the classifications and categories defined. Temporal aspects of data are automatically stored with each event entry (i.e., date/time stamps), so that temporal configuration of the data is preserved.

Convey: Display temporal data for observations as events “riding on parallel conveyer belts” which move in the direction of time through a scrolling window – to help with visual identification of temporal patterns.

List Files: Display names of files containing definitions of observation systems, and names of data files coded with those observation systems. One or more files can be selected by clicking on them. The files then become input to other programs such as Convey and Analyze.

Analyze: Specify a temporal pattern using “If...then...then....?” query syntax, with classification and category names defined earlier, and with optional Boolean operators (and, or, not) – e.g., see table of query results from An (in Appendix A). Alternatively, one could highlight and select an instance of the pattern from the “conveyor view” to form a query. This module will report FLDPT results (frequency, likelihood, duration and proportion time) for the temporal pattern for each observational data file (case) selected. It will compute means and standard deviations for these FLDPT results when multiple files (cases) are selected. As a further option it will export FLDPT results in spreadsheet format for further analysis in other programs (e.g., SPSS, EXCEL). This module will be the most challenging to re-develop – due to its highly complex, recursive, pattern-matching algorithms.

Help: An online help system will be included which explains APT and provides short tutorials which demonstrate how to use it.

I have [extensive background in computer software development](#) for complex statistical algorithms (e.g., CAT, EXSPRT, IRT, Bayesian reasoning, maximum likelihood, amortization –

e.g., Frick 2001; 2005) and have programmed in a number of different languages over the past three decades, including FORTRAN-V, BASIC, C, DAL, TenCORE, ToolBook, and PHP. As Web Director for the School of Education, I have extensive experience in user-centered design and usability testing to improve a product's usefulness. Our highly successful Website is visited by millions of people annually (Frick, Su & An, 2005). This combination of expertise in computer programming, interface design, and usability evaluation puts me in a unique position to revise and further develop the APT software described above – with some assistance from a GA with programming and design skills. I expect this inquiry-based design process to result in a software product that will be useful to educational researchers, easy to use, and that will allow them to conduct research with APT that will have clear and understandable implications for educational practice in K-12. In other words, you won't need to be a statistician to use and understand APT, nor to interpret the findings. As part of the development process, I plan to include School of Education faculty in usability evaluations of APT software and subsequently to conduct workshops for faculty and graduate students near the end of the first year.

Extending APT to APT&C and Development of Further Software

As mentioned above, APT will be extended to APT&C in order to characterize, measure and analyze *structural patterns* in educational phenomena. These are technically 'affect relations' as defined by Thompson. "Affect relations determine the structure of the system by the connectedness of the components. This is important since structure provides the basis for predicting *system* behavior." (Thompson, in press 2005, p. 6). We are concerned with systems that contain a large population – e.g., education systems, corporations – we are not trying to predict what someone will do tomorrow afternoon. During Year 2, I propose to develop APT&C software that will allow educational researchers to define affect relation sets, to enter empirical observations into affect

relation matrices that characterize configuration. APT&C will report results from measures of properties of affect relation sets (e.g., centralization, hierarchical order, compactness, vulnerability, etc.).

Thompson will work on the theoretical foundations during Year 1, applying his expertise in general systems theory, logic, set theory and topology. During the second year, I will do the computer programming with assistance of a GA and with the consulting from Thompson to confirm the computational accuracy and logical validity. I expect to use the same user-centered design and development process described above.

Benefits of this Research and Development

- APT&C bridges the gap between qualitative and quantitative research methodologies; overcomes problems of generalizability often encountered in qualitative research with small sample sizes or in case studies; and provides findings that practitioners can understand and apply in their classrooms.
- APT&C empirical findings on patterns of practice can be used in programs in higher education to better prepare K-12 teachers and educational leaders for professional practice.
- APT&C software can be licensed and bring money to IU and the School of Education. I expect this software to be in demand by scholars who conduct observational research in K-12 settings. It will be a powerful research tool for studying processes and structure in education, and will run on laptop computers. APT&C can also be used by school administrators and teachers. Administrators can use it to redesign efficient school systems. Teachers can use it as a learning tool for students to see the impact of organization and teaching strategies to optimize learning.
- APT&C software will constitute core technologies for simulating and modeling educational systems, as part of the larger *SimEd* research and development program (Frick, 2004).

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***Budget Notes and Justification**

The primary consultant is Kenneth Thompson. He is the head researcher of Raven58 Technologies, located in Columbus, Ohio. His expertise is in general systems theory, logic (sentential and predicate calculus), mathematics (set theory, di-graph theory, and topology) and education (systems and organization). His role during Year 1 will be to develop the important theoretical foundations for the &C part of APT&C. He will be applying concepts from set, di-graph and topological theories in mathematics and from axiomatic-general systems behavioral theory (AGSBT) in order to build the *quantitative* measures of configuration required by APT&C, which include: complexity, hierarchical order, compactness, centralization, active dependence, passive dependence, independence, interdependence, strongness, unilateralness, weakness, disconnectivity, wholeness, integration, segregation, homomorphism, isomorphism, automorphism, and vulnerability.

Thompson's role during Year 2 will be to refine these measures as we attempt to write computer software to carry them out and to help ensure the logical validity and accuracy of software computational algorithms.

A graduate assistant with expertise in computer programming in Flash ActionScript and human-computer interface design will be needed. While I will be the lead programmer, the GA will carry out significant software development and quality assurance testing. The GA will be needed for both Years 1 and 2.

Timeline

Phase 1: July 1 – Dec. 31, 2005:

- Develop the object-oriented class architecture for APT&C and XML specifications for observation system and data file structures, observation data coding and file structures, APT query structures, FLDPT results structures (from Analyze) for export to SPSS, EXCEL, etc.
- Write and debug software for programs: Define, Code, Convey, List.
- Begin software for program: Analyze.
- Verify consistency of set-theoretic property measure definitions to assure compatibility of empirical validations. Verify consistency and completeness of system axioms that have structural property measure parameters. Verify consistency of these axioms with all axioms that are extensions of these structural axioms; that is, axioms that have structural and non-structural parameters.

Phase 2: Jan. 1, 2006 – June 30, 2006:

- Develop topological measures for structural properties. This is new basic research and requires extensive development, as there is no current work in this area.

- Continue writing and testing software for program: Analyze.
- Write software for program: Help (including online tutorials).
- Perform quality assurance tests of software.
- Conduct usability evaluations of APT with School of Education faculty and graduate students.
- Conduct workshops on APT for SoE faculty and graduate students.

Phase 3: July 1, 2006 – December 31, 2006:

- Continue development of topological measures. Define various topological properties as required and verify consistency with other system properties, extending the properties as required. Begin validation of measures.
- Write and debug software for &C measures: complexity, hierarchical order, compactness, centralization, active dependence, passive dependence, independence, interdependence, strongness, unilateralness, weakness, disconnectivity, wholeness, integration, segregation, homomorphism, isomorphism, automorphism, and vulnerability.

Phase 4: Jan. 1, 2007 – June 30, 2007:

- Continue to validate topological measures and define decision procedures for application to empirical systems.
- Finish writing and quality assurance testing of software for &C measures.
- Conduct usability evaluations of APT with School of Education faculty and graduate students
- Conduct workshops on APT for SoE faculty and graduate students.

Other Proffitt Grants

Elizabeth Boling (PI), Kennon Smith, Malinda Eccarius, and Ted Frick. Visual Representations to Support Learning: Effectiveness of Graphical Elements Used to Extend the Meaning of Instructional Illustrations. (Award amount: \$39,864.00, funded from June 2003 - June 2005.) This grant is funded by the Proffitt Foundation. Elizabeth Boling is the principal investigator. My role is minor, mostly to assist with research methodology issues such as reliability of measurement and statistical analysis. The project is making good progress. Data on interpretation of meanings of graphical elements from different populations and cultures have been collected and analyzed. Several conference presentations have been made, a paper submitted for publication, and further populations are currently being compared.

Other Grant Support and Pending Proposals

At this time, I have no grant support for the research proposed here, and no pending proposals.

Appendix A

Example of APT Queries and Associated Conclusions

Reprinted with permission from An (2003, p. 130 and p. 5)

<i>Query</i>	<i>Frequency</i>	<i>Likelihood (p)</i>
For type A 'right action, wrong result' mode errors ($p = 34/52 = 0.65$)		
a) If source is <i>unaffordance</i> ,	15 out of 34	0.44
then consequence is <i>can't find hidden function</i> or <i>false success?</i>	10 out of 15	0.67
b) If source is <i>invisibility</i> ,	6 out of 34	0.18
then consequence is <i>stuck performance?</i>	5 out of 6	0.83
c) If source is <i>misled expectation</i> ,	7 out of 34	0.21
then consequence is <i>false success?</i>	6 out of 7	0.86
For type B 'it isn't there where I need it' mode errors ($p = 8/52 = 0.15$)		
d) If source is <i>mismatched expectation</i> ,	8 out of 8	1.00
then consequence is <i>can't find hidden function?</i>	8 out of 8	1.00
For type C 'it isn't there at all' mode errors ($p = 10/52 = 0.19$)		
e) If source is <i>unmet expectation</i> ,	10 out of 10	1.00
then consequence is <i>can't find unavailable function?</i>	10 out of 10	1.00
f) If source is <i>unaffordance</i> ,	3 out of 10	0.30
then source is <i>unmet expectation</i> ,	3 out of 3	1.00
then consequence is <i>can't find unavailable function?</i>	3 out of 3	1.00

....Analysis of Patterns in Time (APT) indicated that type A mode errors were most likely to be associated with 'unaffordance,' often resulting in 'can't find hidden function' or 'false success.' Type B mode errors were all associated with 'mismatched expectation' and always resulted in 'can't find hidden function.' Type C mode errors were most often associated with 'unmet expectation,' always resulting in 'can't find unavailable function.'