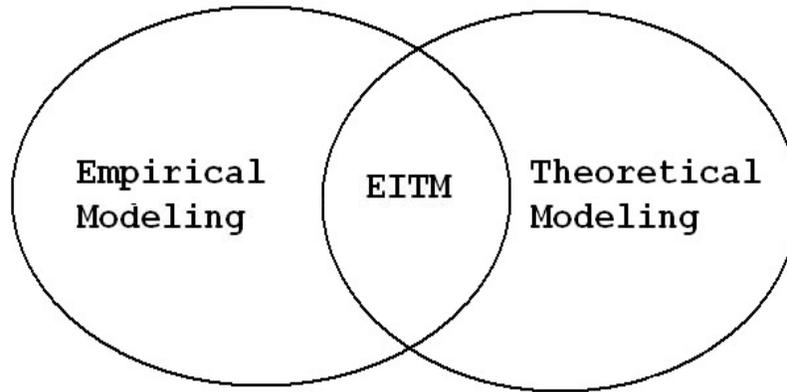


**A WORKSHOP ON THE INTEGRATION OF EMERGING
FORMAL AND EMPIRICAL METHODS AND TOOLS TO
ENHANCE SOCIAL SCIENTIFIC DEVELOPMENT**



A SUMMARY REPORT

FOR THE

**POLITICAL SCIENCE PROGRAM, DIRECTORATE FOR
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Executive Summary

On October 29, 2009, the Political Science Program of the National Science Foundation (NSF) convened a Workshop to evaluate the progress that the Empirical Implications of Theoretical Models (EITM) initiative – the program to unify formal and empirical analysis – had made since it was first introduced in 2002. More importantly, given that funding for all EITM initiatives end in the summer of 2010 it was deemed appropriate to determine whether to make EITM a continuing focus of the Political Science Program at NSF – and to consider whether to extend the initiative to other social science disciplines.

The interdisciplinary Workshop participants found the EITM initiative to be “one of the best things NSF has done” and that it has been “money well spent.” **They unanimously agreed that the EITM initiative should continue within political science but also expand to other social science disciplines.** In both written (via e-mail) or spoken commentaries, Workshop participants identified the following achievements of the EITM initiative and its goals for the upcoming years:

I. EITM Achievements between 2002-2009

- EITM Summer Institutes:
 - Approximately 400 graduates, both graduate students and junior faculty.
 - Important and growing international component.
 - Major positive impact on participants over the past eight years - graduates indicated that the training helped them achieve tenure-track faculty positions, enhanced their dissertation projects, and facilitated cross-university collaboration.
- Key scholars (including Elinor Ostrom) recognize the benefits of integration between formal and empirical methods (improves the research and the results of scholars who had earlier used either formal or empirical modes of analysis in isolation).
- In recent years, approximately 40-50 percent of NSF grants awarded to political scientists have an EITM component.

II. Goal 1: Continue to facilitate the accumulation of knowledge in the social sciences

- Keep providing the scientific community with methodological tools employing *both* formal and empirical methods. The employment of both can help uncover the mechanisms behind the analyzed social phenomena.
- Promote *methodological* integration across social sciences as well as non-social sciences.
- Promote *substantive* integration across social sciences.
- Encourage further development of formal models that correspond to salient observed features of human behavior.

III. Goal 2: Continue overcoming training and integration challenges in the social sciences

- Establish formal and empirical modeling competency in social science training.
- Facilitate EITM-inspired interdisciplinary collaboration and networks.
- Seek to unify scientific vocabulary.

IV. Goal 3: Focus on human capital development, curriculum reorientation, and infrastructure enhancement

- Extend EITM beyond the Summer Institutes – provide support for graduate training, post-doctoral opportunities, and mid-career re-tooling.
- Facilitate the reorientation of graduate curricula by offering support for capstone courses and new syllabi to social science departments.
- Support physical and virtual infrastructure to help build a self-sustaining EITM community.

V. Goal 4: Broader Impact

- Achieve broad recognition of the EITM's transformative thinking and the broad application to people's lives by the academic community (including "hard" sciences) *and* the general public.
- Achieve a better understanding of the political and social world, more accurate predictions, and reliable policy recommendations aimed at improving citizens' quality of life.
- Create new funding opportunities and public support for EITM and for NSF in general by also focusing on policy relevant issues that had been previously the province of the natural sciences and engineering.

CONTENTS

Executive Summary	2
Acknowledgments	5
Part One: Background and Executive Summary	
I. Background	6
Part Two: Motivation, Framework, and Implementation Challenges	
I. Motivation	10
II. Framework	11
III. Implementation Challenges	13
Part Three: Reorientation in Training and Social Science Integration	
I. Reorientation in Training	15
II. Social Science Integration	16
Part Four: Priorities	
I. Human Capital Development	17
II. Curriculum Reorientation	18
III. Infrastructure Enhancement	18
Part Five: Broader Impact	
I. Past and Current Intellectual Impact	20
II. Future Impact on Science, Policy, and Society	20
Appendix A: Workshop Agenda	22

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Part One: Background

I. Background

On October 29th, 2009, the National Science Foundation (NSF) hosted a Workshop on the integration of formal and empirical methods in the social sciences. The Workshop aimed at accomplishing three objectives.¹ The first objective was to evaluate the education initiatives that started in 2002 (with emphasis on the summer institutes) and to discuss their overall effectiveness. The second objective was to explore emerging trends in training and methodology and the impediments to implementing new training opportunities. The final task was to recommend projects and strategies that not only account for impediments to methodological innovation, but also seek to create the foundation for a multidisciplinary initiative that facilitates these scientifically justified improvements.

As with the 2001 Empirical Implications of Theoretical Models (EITM) Workshop, the 2009 participants were senior scholars with extensive research experience in various technical-analytical areas and proven track records in activities that have improved the technical-analytical expertise in various sciences. They have been editors, NSF program officers, served on editorial boards of leading journals, participated in various EITM projects, and directed EITM Summer Training Institutes. Participants were from a wide range of disciplines, including: political science, economics, sociology, statistics, mathematics, and public policy.

A prime motivating factor for the 2001 EITM Workshop was the intellectual divide between formal modeling and empirical (e.g., applied statistical) modeling. The EITM Report concluded that the scientific ramifications of this continuing divide were harmful to the accumulation of knowledge in political science.

As a consequence, a good deal of research in political science is competent in one technical area, but lacking in another, that is, a formal approach with substandard (or no) empirical tests or an empirical approach without formal clarity. Such impaired competency contributes to a failure to identify the proximate causes explicated in a theory and, in turn, increases the difficulty of achieving a meaningful increase in scientific knowledge (Page 1).

More importantly, the 2001 Workshop highlighted the key contribution of the EITM approach to both political science and the social sciences:

If one were to summarize in one word what bridging the divide between formal and empirical modeling means for the political and social sciences, that word would be *identification*. The ability of a researcher to **identify** or parse out specific causal linkages among the many factors is fundamental to the scientific enterprise. Specifying a model that links both formal and empirical approaches alerts researchers to outcomes *when specific*

¹ See Appendix A.

conditions are in place – and is also one of the best ways to determine an **identified** relationship (Pages 1-2).

The 2001 EITM Workshop culminated in recommendations to provide support for education, knowledge dissemination, and research specifically designed to bridge the gap between formal and empirical modeling. The recommendations were circulated – in the form of a “Dear Colleague Letter” – approximately 3 weeks after the Workshop concluded and covered a call for establishing EITM summer training institutes, workshops, and assembling research work teams.

The call was answered and the first competition was completed in March, 2002 with the first EITM activities underway in the summer of 2002. There have been subsequent competitions for the summer training institutes and a one-time only EITM graduate fellowship program that was competed in fiscal year 2003.

The key achievement of the EITM initiative over the past eight years has been the EITM Summer Institutes. So far, the Summer Institutes have taken place at:

- Harvard University (2002).
- The University of Michigan (2003 (<http://www.isr.umich.edu/cps/eitm/eitm.html>), 2006 (<http://www.isr.umich.edu/cps/eitm/eitm2006/previous2006.html>), 2009 (<http://www.fordschool.umich.edu/eitm/index.php>)).
- Duke University (2004 (<http://www.poli.duke.edu/eitm/eitm2004/>), 2008 (<http://www.poli.duke.edu/eitm/>)).
- UC-Berkeley (2005).
- UCLA (2007(<http://www.sscnet.ucla.edu/polisci/eitm/>)).
- Washington University, St. Louis (2003-2009(<http://wc.wustl.edu/eitm.html>)).

Generally, the EITM Summer Institutes cover two to four weeks of intensive training (the two- and three-week institutes often provide training six-days per week) with morning and afternoon instructional presentations, and evening laboratories or workshops where participants complete their daily assignments.

Additionally, the Summer Institutes are sequenced. For example, the program offered by Washington University, St. Louis (WashU), is geared towards second- and third-year graduate students and covers the foundations in theoretical modeling (e.g., game-theoretic modeling including equilibrium correspondence and comparative statistics) and empirical modeling (e.g., probability models and an introduction to Bayesian techniques). Each year, approximately 25 graduate students participate in the WashU EITM program. The majority of participants are political scientists, but several graduates were also sociologists.

If interested in further training, the graduates can apply for an alternative EITM program that has rotated between several universities (noted above). The most recent was at the University of Michigan. The rotating EITM Summer Institute is targeted towards more advanced graduate students, typically at the dissertation stage, and junior faculty. Classroom sessions focus less on fundamental skills instruction and more on research design, methodological integration, and project implementation. Participants supplement classroom

work with intensive faculty and peer mentoring sessions. Approximately 25 students and junior faculty participate each year.

Since the inception of the EITM initiative, approximately 400 students graduated from the Summer Institutes, both stipend and non-stipend. WashU reports that for 2003-2009 there were 163 stipend participants, and at least 75 non-stipend. The latter included about a dozen from European universities as well as a large number of Washington University PhD students, some of whom only participated in certain sessions but some of whom did the whole program.

Regarding the impact of the EITM Summer Institutes, the most recent email survey conducted by WashU shows a positive effect of the Institute on the participants' future progress. For example, 36 out of 43 respondents indicated that the Institute played an important role in framing their dissertation projects, and 11 engaged in further collaboration with other EITM participants. More objectively, 23 of the 43 EITM graduates who participated in the study went into tenure-track faculty positions. Similarly, a recent email survey of participants from the first six rotating Summer Institutes found that 83 currently hold tenure-track assistant professor positions, five hold tenured associate or full professor positions, six are currently completing post-doctoral fellowships, three have other research positions, and nine are still students (the remaining 33 did not respond to the survey).

With this history in mind, the 2009 Workshop participants were asked to consider the following questions:

- What has been the impact of the EITM initiative and, more specifically, the summer institutes?
- Should the summer institutes be continued in their current form?
- If not, should they be eliminated, or should they be replaced with some other institution?
- Are there students whose needs are not being addressed by the summer institutes? If so, how can we address these needs? For example, if students do not receive the requisite coursework at their graduate institutions to benefit from the summer institutes, is there a way to provide them with that foundational material?
- Is there a need for a similar focus in other disciplines? If so, could the summer institutes be expanded to incorporate other disciplines?

The reassessment will also include some issues that go to the heart of current practice (and training in basic research in the social sciences) – and that were the scientific inspiration for EITM. These include:

- **Modeling Practice:** How do we advance ways to better characterize human behavior using a mathematical approach?
- **Instruction:** How do we reduce impediments to training for extremely capable students with underdeveloped mathematical skills?
- **Integration:** What can be done to provide greater integration with the tools of non-social science disciplines?

- **Adaptation:** What processes can NSF advance that both preserve valid research design protocol, but are totally different from (and yet superior to) the current practice?

Workshop participants discussed each of these challenges, as detailed below.

In their spoken and written commentaries the Workshop participants indicated that EITM had a major positive scientific impact in the past decade. They noted the support and participation of many prominent scholars in various components of the EITM initiative, including such outstanding social scientists as 2009 Nobel Laureate Elinor Ostrom.

In their discussion of the existing EITM components, Workshop participants noted the effectiveness and a growing number of graduate students and junior faculty who are participating. This was particularly true about the EITM Summer Institutes which have trained hundreds of students over the past eight years, not only in the United States, but also in Europe.² EITM has been included in the curriculum at one of the oldest social science summer schools in methodology – the *Essex Summer School in Social Science Data Analysis*.³

Within the political science community EITM is used with greater frequency in contrast to a decade earlier. This increasing presence is evident in journal articles, dissertation proposals, books, and research grants. It was estimated that 40 percent of NSF grants awarded in political science program now include an EITM component.

Along with these indicators of progress, Workshop participants also discussed the current obstacles to implementing EITM. Short term barriers to adoption of EITM include basic misunderstanding as to what EITM means. Longer term barriers include rigid training traditions within and across social science disciplines. A major focus of the Workshop discussion was to determine ways to overcome the current barriers and to build on an already successful and transformative NSF initiative for the social sciences.

³ See <http://www.essex.ac.uk/methods/>. EITM courses are also taught at the University of Mannheim (2009 (<http://eitm.sowi.uni-mannheim.de/>)).

Part Two: Motivation, Framework, and Implementation Challenges

I. Motivation

At its most elementary level EITM is a framework to unify formal and empirical analysis. This type of *methodological unification* is not new in the social sciences. It can be traced back to the accomplishments of the Cowles Commission.⁴ Nevertheless, misperceptions exist about the purpose and application of EITM (e.g., “*that is what we are doing anyway*”). The Workshop participants agreed that these misperceptions need to be addressed and that the academic community must be alerted to the benefits of EITM and its broad applicability, significance, and transformative contribution.

At least four scientific issues motivated the creation of EITM at NSF. The first issue is that the ultimate focus of a model and test should be to support a cumulative scientific process geared toward finding causal mechanisms. However, employing only a formal component or only an applied statistical component limits the ability of a researcher to parse out specific causal linkages among the many factors affecting complex social processes. Specifying a model that links both formal and empirical approaches alerts researchers to outcomes *when specific conditions are in place* – and it is also one of the best ways to determine an identified causal relation.

A second issue is that the *status quo* in political and social sciences is the methodological isolation of fields and sub-fields. Among the consequences of this isolation is the schism between formal and empirical modeling and the concomitant weaknesses in how social science researchers specify and test their models. An aim of EITM-type research is to break down barriers to methodological unification.

The third issue follows the second: not only are the various fields in political and social sciences isolated methodologically, but also substantively. EITM-type collaborations in education, knowledge dissemination, and research organized around specific issues (e.g., climate change, energy, inequality) can promote interdisciplinary interactions and improve the quality and depth of knowledge in each field. The EITM framework is inspired by the original work of the Cowles Commission in the field of economics but it is meant to strengthen and advance research in all social science disciplines.

Fourth, despite a focus by numerous social science disciplines on interactions between agent behavior and public policies, the current research practices can fail to develop formal models of such behavior. If one were to strictly adhere to the Cowles Commission approach we would, for example, forego the chance of modeling new uncertainty created by shifts in behavioral traits (e.g., public tastes, attitudes, expectations, and learning). EITM places

⁴ Created in the 1930s, the Cowles Commission was designed “to foster the development and application of rigorous logical, mathematical, and statistical methods of analysis” for application in economics and related social sciences. (See <http://cowles.econ.yale.edu/about/index.htm>).

emphasis on finding ways to model human behavior and action and, thereby, aids in creating realistic representations that improve upon simple socio-economic categorization.

II. Framework

In its initial NSF conception, EITM was seen as a simple three-step framework. This framework, in turn, influences procedures for implementing EITM in research and reorients methodological training. The framework is summarized as follows:

1. Unify Theoretical Mechanisms and Applied Statistical Concepts: Given that human beings are the agents of action, theoretical mechanisms should reflect overarching social and behavioral processes. Examples include (*but are not limited to*): decision making; bargaining; expectations; learning; and social interaction. It is also important to find an appropriate statistical concept to match with the theoretical concept. Examples of applied statistical concepts include (*but are not limited to*): persistence; measurement error; nominal choice; and simultaneity.

2. Develop Behavioral (Formal) and Applied Statistical Analogues: To link concepts with tests, we need analogues. An analogue is a device in which a concept is represented by variable – and measurable – quantities. Examples of analogues for the behavioral (formal) concepts such as decision making, expectations, and learning include (*but are not limited to*): decision theory (e.g., utility maximization); conditional expectations procedures; and adaptive and Bayesian learning procedures. Examples of applied statistical analogues for the applied statistical concepts of persistence, measurement error, nominal choice, and simultaneity include (respectively): autoregressive estimation; error-in-variables regression; discrete choice modeling; and multi-stage estimation (e.g., two-stage least squares).

3. Unify and Evaluate the Analogues: The third step unifies the mutually reinforcing properties of the formal and empirical analogues. There are various ways to establish the linkage. For example, when researchers assume citizens (voters) or economic agents are rational actors who make decisions to maximize their own payoffs, a common analogue is utility (or profit) maximization. With this theoretical analogue in place, the other consideration is to determine the appropriate statistical concept and analogue to test the theoretical relationship. Consider a basic Downsian model of voting. Voters decide to vote for one of the parties to maximize their utilities (e.g., decision theory). This theoretical concept/analogue can be unified with the applied statistical concept, nominal choice, and its analogue, discrete choice modeling.

In translating the EITM framework into research practice, workshop participants noted that there are some typical procedures when using formal and empirical analysis.

Procedure 1: Derive comparative statics, get a sign on an effect (e.g., if gas prices rise, people will drive less). Run a regression with suitable controls to approximate *ceteris paribus*, and see whether the linear regression coefficient (NOT the correlation coefficient) is right.

Procedure 2: Test the exact functional form implied by the theory – for example, Bayesian models of voter behavior. These often imply nonlinear effects, so we would not use linear regression as in the first approach.

The advantage of the first procedure is that it does not require knowledge of the functional form, which may be hard to learn. The disadvantage is that it provides only a linear approximation in the vicinity of current values of other variables. The advantages of the second procedure are the opposite: One may get powerful global results that truly help both understanding and prediction if the researcher is right about the functional form but are nonsensical if she is wrong. By bridging the gap between formal and empirical analysis, EITM yields much more transparent research results and causal linkages that can be representative of actual human behavior.

The EITM framework, and the procedures above, influence training and research practice in the following way.

Training: Students could first learn empirical and formal analysis separately (e.g., first econometrics, then game theory *or* first game theory, then econometrics) with an EITM course to follow and bridge the gap between the two approaches. An alternative would be to let both econometrics and game theory have more EITM substance from the very start and EITM will still help people to see the connection between the two. *Of course, one could substitute another form of formal theory than game theory (e.g., agent based modeling) and another form of empirical analysis for econometrics (e.g., experiments).*

What is clear is that EITM can lead to a reorientation of training (see Part 3 for further details).

Research: In terms of research, EITM can take many forms. Workshop participants in their written and spoken commentaries suggested that it would be useful to assemble and publicly share a set of prototypes or templates of EITM papers, consolidating best practices within the scientific community and communicating them to researchers still new to the EITM approach. Any paper that fits the template may be considered an EITM paper. This is a way of building on the past, of achieving cumulation, of showing how social science already has a healthy EITM presence.

The identification of the EITM templates and the web posting of the EITM templates will a) provide an outlet for the work of researchers who are graduates of the Summer Institutes; b) inspire and guide grad students and researchers with Ph.D. in hand as they plan EITM research; c) provide outreach to social scientists outside political scientists. It is also a way of showing how much room there is for diversity and creativity. EITM can help focus and provide direction to these creative energies.

The EITM templates can include the following three types of papers.

1. A paper which focuses on one topic or topical domain and then shows how it can be illuminated and more deeply understood by using multiple approaches or multiple theories or multiple methods.
2. A paper which begins with one method and shows how this one method illuminates many topical domains; and
3. A paper which begins with one theory (one set of first principles) and derives many implications of the theory for wide-ranging topical domains.⁵

III. Implementation Challenges

Workshop participants in written and spoken commentaries cited implementation barriers. These challenges take several forms which are sourced:

- lack of cooperation between disciplines.
- lack of linkage between summer institutes and applied statistical methods entities.
- few incentives to motivate tenured faculty to try new methods.
- strong resistance from departments which have an empirical modeling tradition.
- reticence from students against complicated formal and behavioral models.
- insufficient training in formal modelling.
- lack of interest from students who don't have training in formal modelling.
- resistance from reviewers and journal editors caused by specialization on only formal or empirical work, not on both.

The sources of resistance are not surprising. EITM Workshop participants (in the past and current workshops) noted the resistance to unifying formal and empirical modeling was due to several factors.⁶ Among those factors were:

⁵ We could also lay out additional EITM templates, such as the following four:

- a paper which develops (an element of) the framework for studying a substantive area;
- a paper which develops a deductive theory using elements of the framework;
- a paper which unifies two or more theories of one set of phenomena; and
- a paper which unifies two or more theories of different sets of phenomena.

⁶ It was noted in the 2001 EITM Report:

The literature in political science consists of a proliferation of non-cumulative empirical studies usually without any formal component. Computing power has made it possible for more detailed, robust, and sophisticated data analysis than ever before, but this has become an end unto itself. The number of empirical modeling articles far exceeds that of articles that use formal models (Page 6).

1. The Intellectual Investment: the intellectual investment needed for formal modeling is different than the knowledge needed for empirical modeling. As such, scholars have to invest in different skill sets.
2. Training Differences: Empirical modelers devote their energies to data collection, measurement, and statistical matters, while formal modelers center on mathematical rigor.
3. Research Practice: For empirical modelers, model failures lead to emphasis on more statistical training or more sophisticated uses of statistics – usually to “patch over” – a model failure. Formal modelers, on the other hand, deal with model controversies by considering alternative mathematical formulations but this is usually done piecemeal. However, the one similarity between these two approaches is that both formal and empirical modelers tend to remain tied to their particular technique despite the warning signals evidenced in model breakdown.

These implementation challenges are deeply rooted in the academic community and will take years to overcome. However, the EITM progress accomplished since 2002 shows that a gradual change is possible and should continue and expand.

Part 3: Reorientation and Integration

While the previous section indicated the challenges EITM poses for reorientation of training, the 2009 EITM Workshop participants also discussed how the transformative nature and the significant scientific benefits offered by EITM may help overcome them. Additionally, while the EITM initiative originated in political science, the participants also debated the ways to integrate EITM's attributes with other social science disciplines.

The importance of using EITM to spur training reorientation and integration within and between disciplines cannot be overstated. Disciplines that provide incentives for this type of risk taking and re-tooling will reduce the threat of an:

“assembly-line model of research production that imperils innovative theories and methodologies and, in turn, scientific breakthroughs. One could make the argument that EITM or initiatives like it are unnecessary because the unfettered marketplace of ideas expedites best scientific practices and progress. But, it is precisely because there are significant rigidities (training and otherwise) in the current academic setting (imperfect competition) which makes EITM-type initiatives not only necessary—but imperative” (EITM Report, 2002, Page 8).

I. Reorientation in Training

Establishing formal and empirical modeling competency in training in the social sciences is a necessity. Without that foundation any substantial progress in social science research will be limited. Fortunately, one social science discipline, economics, has been successful in technical training and may serve as a guide for other disciplines to build foundational courses that would foster EITM *integration*.⁷

Formal and empirical training in economics has the following characteristics:

1. Economics graduate students are required to take one full year (usually) of mathematics for economists.
2. This mathematical (and quantitative) approach is reinforced in substantive courses which typically are taught as an analytic science in a theorem-proof mode.
3. Mathematical (quantitative) competency in most economics graduate programs is demonstrated not only in these foundational courses, but also in qualifying examinations in the summer after the first year of coursework.
4. Students must clear this hurdle before being allowed to proceed with their Ph.D.

It should be noted that a social science discipline such as political science faces the largest challenges in the area of formal modeling. For example, a WashU survey of EITM participants indicates that the majority of EITM participants consider themselves to be

⁷ While the economics training regimen is an important and successful model for technical training it was noted by Workshop participants that it does share the same “siloeing” problems that other social science disciplines.

better trained in empirical (60.9 percent) rather than formal modeling (17.4 percent), while only 21.7 percent consider themselves to be equally trained in both methods.

For the short term the EITM Summer Institutes can continue to provide the additional training and bridge the gap between formal and empirical analysis, but the hope is that over the long term, political science and other social science departments would recognize and embrace the benefits of this form of conducting research and training. Ideally, reorientation in training would involve two parts: 1) the addition of courses to make sure there are sufficient coverage of both formal and empirical tools *and* 2) a coherent sequencing of the courses so that skills can be built over time (see Part 4 for detailed suggestions).

The 2009 Workshop participants also discussed providing training options for faculty who could use their new tools for both research and teaching purposes, and acknowledged that support would be necessary, particularly for junior faculty. However, several discussants expressed concerns about “old habits” learned in graduate school that would inhibit the desire to make the changes in skill development and suggested that resources were better spent on graduate students.⁸

II. Social Science Integration

As evidenced by the interdisciplinary makeup of Workshop participants for the prior as well as the most recent workshops, there was support for making EITM a priority across the social sciences.

Because of its very nature, EITM-inspired linkages between formal and empirical analysis can lead to collaborations in education, knowledge dissemination, and research. Research groups might include political scientists together with anthropologists, economists, sociologists, experimental psychologists, and computer scientists. 2009 Nobel Laureate in Economics, Lin Ostrom – a supporter of EITM – has created a decades-long body of research that is known for its integration of various social science disciplines and their tools.

EITM-inspired collaboration can also help unify the vocabulary used for analyzing a problem in various disciplines. An additional benefit of collaboration is enhancing research designs in the involved disciplines, as evidenced by Ostrom’s work.

Under the umbrella of EITM, truly interdisciplinary research work teams and networks can encourage new research orientations for senior members of the profession and expose younger members (graduate students and post-docs) to new ways of thinking that have not yet entered the standard curriculum.

⁸ There was some discussion about undergraduate training, but priority was given to graduate student training. This does not preclude the possibility of supporting training and research initiatives that are directed to undergraduates.

Part Four: Priorities

Funding priorities, where NSF has played a role in the past, are intended to *enhance training and research reorientation, unify scientific knowledge, as well as integrate a common social scientific language*. EITM Workshop participants recommended several components that can be classified along three areas:

- I. Human Capital Development
- II. Curriculum Reorientation
- III. Infrastructure Enhancement

For the priorities listed, NSF can, for example, assist in the following ways.

- NSF can help develop EITM courses and facilitate their systematic inclusion in university curricula.
- To motivate scholars to adopt this initiative, NSF can include EITM components in requirements for NSF fund proposals.
- Current NSF budgets for infrastructure development can be used for EITM visualization technologies and human resource development for multi-disciplinary EITM workshops.
- The NSF can provide additional funding for the EITM Summer Institutes, for setting up the EITM Web site, and for monitoring EITM success.

I. Human Capital Development

To address the skills deficit, support can be provided for 1) graduate training, 2) post-doctoral opportunities, and 3) mid-career re-tooling. Such support can include courses in formal and empirical modeling, experimental methods (which link formal and empirical tools), and courses that link visualization tools that enhance model and test development.

Graduate student options in human capital development could include:

- Support for an additional year or two of graduate school to complete both formal and empirical modeling sequences.
- Support for summer training institutes. One new area would be to focus on having multi-disciplinary EITM Summer Institutes that have simultaneous modules for the separate disciplines, but also provided that all disciplines meet every week to discuss avenues to devise and learn a common scientific vocabulary. In one participant's experience, such a course has enabled the reorientation of the home institution's training.⁹

⁹ By way of example, all social sciences could be taught inequality measurement. Everyone should know how to measure inequality (Gini Index, Theil, etc.) and how to interpret these measures. There is no particular disciplinary content with these measures. In addition to the measurement, the additional step would be to develop – using all attributes of each represented discipline – a set of EITM-inspired research designs.

Faculty options in human capital development could include:

- Support for mid-career, ideally post-tenure EITM training.
- Support for faculty to visit another department on campus or another institution.
- Provide for a specific CAREER competition that requires training and teaching along EITM lines.

For both faculty and graduate students support could be provided for:

- The creation of an EITM society with periodic meetings.

II. Curriculum Reorientation

To advance new developments in technical training, Workshop participants suggested the following:

- Support at the department level with Dean approval for any of the following:
 - Capstone courses that integrate formal and empirical modeling prerequisites.
 - New syllabi in either formal or empirical modeling that also incorporate elements of EITM.
- Support for annual workshops where faculty and students from around the country gather to create and revise new syllabi.
- Support for *annual multidisciplinary workshops* where faculty and students from at least three disciplines within a university (or from around the country) gather to create and revise new syllabi.
- Inclusion of a data gathering component in EITM – because new technologies have an impact on theoretical implications, the curricula should reflect the fact that theory should guide data collection.

III. Infrastructure Enhancement

EITM-related research activities can be supported in ways that provide linkages to the infrastructure needs of the social sciences over the next decade.

Physical infrastructure support would include:

- Shared – multidisciplinary and multi-scholar facilities – that allow for formal and empirical studies, for cohort and peer-based interaction organized around a central research question, and also for experimental research and pilot studies made with very fast turnaround to the scholars involved and the scholarly community at large. It would bring together faculty of all levels including graduate students, post-doctoral students, junior and senior faculty.¹⁰

¹⁰ Data fusion and data visualization are particularly important for enhancing communication and eventual collaboration with, for example, computer scientists and engineers.

These types of facilities will be required to pick one problem or theme of study. They should also include representatives from different theoretical (deductive and inductive) frameworks to explain the problem. A contingent of young scholars will also be encouraged.

Virtual infrastructure involves the following:

- The creation and continued development of interdisciplinary web sites that will be based on an EITM membership. The web sites may also build upon existing infrastructure (e.g. H-NET). The EITM web sites would include:
 - List of members.
 - Templates of EITM papers.
 - Archive of published articles using EITM.
 - Chat room for problem solving and tutorials.
 - Computer program archive.
 - Communication of ongoing EITM events.
 - The new revised EITM syllabi.

Part Five: Broader Impact

I. Past and Current Intellectual Impact

The inaugural 2002 EITM Report concluded with the following thoughts:

Significant scientific progress can be made by a synthesis of formal and empirical modeling. The advancement of this synthesis requires the highest possible levels of communication between the two groups. Formal modelers must subject their theories to closely related tests while, at the same time, empirical modelers must formalize their models before they conduct various statistical tests. The point is not to sacrifice logically coherent and mathematical models. Rather, it is to apply that same rigor to include new developments in bounded rationality, learning, and evolutionary modeling. These breakthroughs in theory will be accomplished with the assistance of empirical models in experimental and non-experimental settings (Page 13).

In the eight years since the inaugural workshop, and with the benefit today of hindsight, the consensus view of current Workshop participants is that advancing an initiative to unify formal and empirical analysis – EITM – is “one of the best things NSF has done” and that it has been “money well spent.” Workshop participants were also unanimous in their view that the transformative impact was clearly in the direction of fostering a real intellectual change in political science. If we measure progress by the number of articles that use formal and empirical analysis in the major professional journals, the number of NSF grant proposal submissions by faculty and graduate students (doctoral dissertations) that use EITM, and the rise of syllabi, then the past eight years has shown measurable change.

Workshop participants suggested the following metrics for measuring future accomplishments of the EITM initiative:

- Increase in the number of articles implementing EITM approach in the leading political science journals to 25 percent by 2015.
- Increase in job offers requiring training in EITM to 50 percent by 2020.

To properly evaluate the EITM success, the following tools were suggested:

- Solicit feedback from EITM attendants and systematically monitor their personal success.
- Monitor articles with an EITM component in social science journals.

II. Future Impact on Science, Policy, and Society

A new goal in the 2009 Workshop was to find ways to make the initiative extend to other disciplines and also solidify a lasting change so that social scientists will consider it natural to

unify formal and empirical analysis in their research designs. Or to put it another way, true change will have been reached when the social scientists are viewed in this light by other “hard” sciences and the word EITM is no longer mentioned.

EITM-inspired efforts that lead to greater cooperation between the various sciences can enhance policy acumen and aid society. The old way of conducting policy research, where integration between the social sciences, natural sciences, and engineering is rare, can lead to inaccurate predictions and policy failure. Ignoring behavioral responses will have negative ramifications for public policies regarding energy (i.e., the smart grid), education, health, and many other policy areas where human response is involved.¹¹

Because it places an emphasis on modeling and testing analogues of human behavior, EITM enhances the chances for policy success. The reason is EITM takes a fundamental attribute of social science, *examining phenomena (i.e., human beings) that make forecasts about the future that affect current behavior*, to the study and implementation of policy. Among the most important broader impacts of EITM --- and one with the most lasting consequence --- will be simply raising awareness of the complexities and challenges to modeling and testing human response.

¹¹ This is particularly true in research questions that have been traditionally analyzed in the natural sciences and engineering. An example is current work on developing a smart grid for residential energy. Social science research would be of use in this endeavor since behavioral responses to new and potentially invasive technologies can minimize unintended consequences that would otherwise create barriers to effective implementation.

Appendix

Appendix A: EITM Workshop Agenda

Thursday, October 29, 8:30am.-3:30pm., Room 1235

- 8:30-8:45am.: Introductions and Preliminary Considerations
- 8:45-9:00am.: Opening Statements from Harold Clarke and Brian Humes
- 9:00-9:45am.: Report on Existing EITM Summer Institutes
(Presentations by Gerber and Calvert)
- 9:45-10:00am.: Discussion
- 10:00-10:10am.: Break
- 10:10-11:00am.: **Discussion Point 1: What exactly did EITM give us?**
-Science
-Education
(Achen as discussion leader)
- 11:00am.-12:00pm.: **Discussion Point 2: What are some other empirical and theoretical approaches to consider?**
-Articulating Theory and Testing
-Other Theoretical Approaches
-Role of Experimental Work
-Role of Qualitative Methods
-Role of data “visualization”
(Eckel, Simon, Whitten, and Wilson as discussion leaders)
- 12:00-12:45pm: Lunch

- 12:45-1:45pm: **Discussion Point 3: What to do with the educational component.**
- Expansion?
How to expand?
Topics?
Disciplines?
*Assistance to students from nonquantitative departments
Partnership with Existing Sources
- (All discuss)*
- 1:45-1:55pm: Break
- 1:55-2:55pm: **Discussion Point 4: Extending to other social sciences.**
- (Jasso and McCutcheon as discussion leaders)*
- 2:55-3:30pm: **Discussion Point 5: Where do we go from here?
Role for NSF, ESRC, etc.**
- Recommendations.
- (All discuss)*
- 3:30pm: **Adjourn**