

Occasional Paper No. 8

The Role of Formative Evaluation in the Development of an Interdisciplinary Academic Center

Susan B. Millar



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The NISE issues papers to facilitate the exchange of ideas among the research and development community in science, mathematics, engineering, and technology (SMET) education and leading reformers of SMET education as found in schools, universities, and professional organizations across the country. The NISE Occasional Papers provide comment and analysis on current issues in SMET education including SMET innovations and practices. The papers in the NISE Research Monograph series report findings of original research. The NISE Conference and Workshop Reports result from conferences, forums, and workshops sponsored by the NISE. In addition to these three publication series, the NISE publishes Briefs on a variety of SMET issues.

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of an Interdisciplinary Academic Center**

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About the Author

Susan B. Millar is director of the center for Learning through Evaluation, Adaptation and Dissemination (LEAD). Created in 1994, the center researches learning and educational reform processes across campus. As leader of NISE's Formative Evaluation Team, she helped the Institute improve its organizational structure, management, and communication through the use of evaluations that emerged from interviews with team leaders and others and from observations of NISE activities.

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Executive Summary

This Occasional Paper illustrates how formative evaluation helped the leaders of an interdisciplinary academic center—the National Institute for Science Education (NISE)—not only achieve a number of their original stated goals, but also develop from an amorphous group into an institute with many truly shared and well-defined goals, intentional organizational practices, and a distinctive culture. Evaluators played a critical role by providing information and heuristic models that helped the NISE reflect on itself and make numerous pragmatic improvements in organizational practices. More importantly, the process of working with the evaluators encouraged within the leadership a questioning and problem-solving organizational style that enabled them to become more reflective practitioners of the art of developing a productive interdisciplinary organization.

The paper describes the formative evaluation processes used and the range of outcomes that resulted from these processes. Examples of the outcomes—from the specific and pragmatic to the conceptual and broad—are that formative evaluation helped the leaders

- redefine their goal for including individuals from heterogeneous backgrounds;
- redistribute their budget to fund fewer people for a higher percentage of their time;
- more fully appreciate the difficulty and value of genuine interdisciplinary work;
- improve the quality of cross-team communication processes by instituting retreats and a new members' orientation packet; and
- continuously see themselves anew, as a result of being invited to view themselves through a series of heuristic lenses—including “goals, strategies and outcomes,” “tightly and loosely coupled systems,” “forming, storming, norming, performing,” and “a knowledge building entity.”

The paper suggests that other groups seeking benefits of this type should consider working with an evaluator. The saga that unfolds for other groups, working with other evaluators, will surely be different from the one told here. However, formative evaluation should, at a minimum, provide the following benefits to any emerging organization.

- The experience of being interviewed by evaluators should help participants articulate their reasons for getting involved, the goals they hoped to achieve through their participation, and the relationships between these goals and the methods they were using to achieve them.
- Formative feedback documents and other “feedback” interactions with the evaluators should

provide the organization's leaders with a synthesized view of the ideas and experiences of the various participants, and enable the leaders to perceive patterns and themes in the way the organization is taking shape;

highlight situations where the goals held by the leaders and the participants are or are not aligned, and where implementation strategies are or are not adequate for achieving the stated goals, thus enabling the leaders to make effective midcourse corrections;

invite the clients to view taken-for-granted organizational events and processes in the new light cast by carefully chosen or heuristic models, thereby fostering cognitive

conflict for the clients, and helping them notice practices and beliefs that inhibit achievement of their envisioned goals; and

describe and help the leaders understand the character of the emerging organization.

In short, formative evaluation should provide ideas, information, models, and language that an emerging interdisciplinary organization can use to reframe and revision what it is accomplishing and what kind of organization it is becoming. It should enhance the leaders' capacity to function as reflective practitioners by assisting them in tacking dialectically between their most local of local detail and their most global of global structures.

Introduction

Conflict is the gadfly of thought. It stirs us to observation and memory. It instigates invention. It shocks us out of sheeplike passivity, and sets us at noting and contriving. . . . conflict is a *sine qua non* of reflection and ingenuity.

—John Dewey

The purpose of this paper is to illustrate how formative evaluation¹ helped an interdisciplinary academic organization not only achieve a number of its original stated goals, but also develop from an amorphous group into an institute with many truly shared and well-defined goals, intentional organizational practices, and a distinctive culture. The paper demonstrates one way to encourage understanding among those who wish to improve the effectiveness of interdisciplinary groups. Such methods are of increasing importance because we are accelerating into a period when the complexity of problems in science, engineering, and social science increasingly demands interdisciplinary collaboration (Schrage, 1990), yet few experts are trained to create, and work in, effective interdisciplinary teams (Thompson-Klein, 1990).

Formative evaluation requires both technique and art. The technique entails knowledge of and skill with basic social science methods of research design, data collection, and analysis (Atkinson, 1990; Coffey & Atkinson, 1996; Denzin & Lincoln, 1994; Miles & Huberman, 1994; Patton, 1990). The art, of course, lies in the wise choice of methods, the implementation of these methods, and the capacity to manage, and learn from, the inevitable problems arising during the evaluation process (Schön, 1983).

In particular, the art of formative evaluation lies in the “continuous dialectical tacking between the most local of local detail and the most global of global structure in such a way as to bring them into simultaneous view” (Geertz, 1983, p. 69). It involves inviting the clients to peer at very particular and familiar organizational events and processes in the new light cast by carefully chosen “global structures,” “sensitizing concepts” (Blumer, 1969; Patton 1990), or heuristic models. That is, the evaluator asks the clients to regard themselves through the lens of a particular heuristic model. Typically, this “restructured viewing” fosters cognitive conflict and makes the familiar strange. This, in turn, leads the clients to notice—and thus begin to change—taken-for-granted everyday practices and beliefs that inhibit achievement of their envisioned goals. In other words, formative evaluation encourages the clients to develop a questioning and problem-solving organizational style, a habit of reflecting that quite naturally results in wise mid-course corrections.

The paper is presented primarily in the first person voice of the evaluator. I take this approach in order to illustrate, at some level, the “tacking” process that the evaluator and, if she is successful, the client experience.

¹ The term *formative evaluation* refers to the process of providing program insiders with information about, and insights into, the organizational processes of their program while it is being developed in order to guide improvement (Joint Committee on Standards, 1994). The findings of a formative evaluation are not provided to parties external to the program, and are not used for accountability purposes.

The paper is organized into three parts:

- A chronology of the organization,² told in the third person, that provides context needed for the remaining sections. The organization, now in its fifth year, is the National Institute for Science Education (NISE). It is located at the University of Wisconsin-Madison and funded by the National Science Foundation. Its leaders invested in formative evaluation from the beginning of the project, trusting that the resulting improvements in their organizational processes would enhance the quality of the Institute's intellectual contributions. This chronology does not assess how changes in organizational processes resulting from the formative evaluation affected the intellectual contributions produced, as the author is not qualified to judge the value of these products. In line with its purpose, the chronology only presents the NISE's evolution *as* an organization.
- A description of the evolution and activities of the organizational process study conducted by the NISE's Formative Evaluation team. Here I present typical feedback issues that the Formative Evaluation team presented to the NISE leaders, and describe some of the effects—at both practical and broadly conceptual levels—of the formative evaluation effort. An example of the latter is that the evaluation process helped the NISE leaders become aware that they had formed themselves into an organization whose values and norms are different in important ways from those of their departments.
- A discussion of how and why formative evaluation can foster the development of other interdisciplinary organizations.

Chronology of the NISE

In early 1994, the NSF's Education and Human Resources (EHR) Directorate announced an "institute" program that would fund "a selected group of scholars, representing educational levels from kindergarten through undergraduate years, and the full range of institutional types, to study in a sustained, thoughtful, comprehensive and in-depth manner science, mathematics, engineering, and technology (SMET) education." Scholars at the UW-Madison and the Washington, DC-based National Center for Improving Science Education submitted a Phase I proposal presenting an ambitious research and dissemination agenda. The proposal also stated that, to accomplish this agenda, science and mathematics faculty from both the K-12 and higher education sectors would collaborate productively with each other and with education researchers, an "outrageous experiment," according to John Bollinger, then dean of the UW College of Engineering. UW-Madison was one of six institutions selected to prepare a Phase II proposal. In that process, developers held a mini-institute to provide NSF reviewers with proof of the concept of their outrageous experiment. In May 1995, the EHR Directorate officially announced that its institute award would go to UW-Madison. The award came in the form of a cooperative agreement for \$10 million to be spent over five years, starting in July 1995. During summer 1995, the institute was officially named the National Institute for Science Education. The Institute's vision is that all students should acquire an ability to make informed decisions about matters related to science, mathematics, engineering, and technology (SMET) that they encounter in their daily lives. In this vision, all stakeholders in SMET education engage in active,

² The present tense is used throughout this paper except when the situation described does not prevail at the time of this writing. The chronology section is written in the third person because, in contrast to the rest of the paper, it is a formal outsider's account of the organization, whereas the rest is the evaluator's story about the NISE.

contextual learning to acquire both a strong foundation in SMET and the ability to enhance that foundation as lifelong learners.

To achieve this vision, the NISE's primary strategies include the following:

- synthesize the extant research on improving student learning in the SMET fields, kindergarten through graduate school;
- formulate the implications of these syntheses for the practice of SMET education, and communicate both the research findings and implications to relevant professional and mass audiences; and
- on the basis of its scholarly work, suggest directions for further research.

The proposal indicated that the NISE would be unusually effective in implementing its primary strategies because it would seek to benefit from the strengths of interdisciplinary collaboration. The proposal writers believed that an interdisciplinary approach, though potentially very productive, had been absent from most education reform efforts to date. In line with this approach, the director team is comprised of faculty from both education and SMET fields.³ In addition, three heterogeneous groups have advised the directors since year one.

- The Team Leaders Team, comprised of the co-directors, the project manager, and the leaders of the working teams, meets on a regular basis to share progress and provide advice on both micro- and macro-level Institute practices and activities.
- The Advisory Team of scientists, education researchers, education practitioners, and representatives of the industrial sector meets quarterly to offer advice on the quality and direction of the NISE work.
- The National Advisory Board of 18 scientists, education researchers, education practitioners, and representatives from business, industry, government, and foundations meets annually, provides advice, and enhances the NISE's visibility.

The members of the NISE (approximately 150 in number) are faculty, staff, and graduate students from the SMET and education disciplines at the University of Wisconsin-Madison (UW), staff of the National Center for Improving Science Education in Washington, DC, and visiting Fellows (an average of eight per year) who work with a particular NISE team for about a year. NISE research teams are charged with producing syntheses of key issues in SMET education, and other teams are charged primarily with providing infrastructure support to the research teams.

During early spring of each year, the Institute has held a national forum that features the work of one of the research teams, draws on national talent, and fosters significant interaction among some 300 participants from across the country. Each spring also found the NISE leaders developing a document that described its work to date and proposed work for the next year. The

NSF program officers who worked with the NISE visited each year, reviewed the plans, and granted the funds for the next year.

³ During year one (1995-96), there were two co-directors, Denice Denton, an electrical engineer, and Andrew Porter, an educational psychologist. With Denton's departure for another institution in 1996, Terrence Millar, a mathematician, became interim co-director. In year four (1998-99), Porter assumed the role of director, and Robert Mathieu, an astronomer, and Barrett Caldwell, an industrial engineer, became associate directors.

During the first two years, the teams devoted to research were the Professional Development, College Level One, Policy Analysis of Systemic Reform, and Strategies for Evaluating Systemic Reform teams. At the end of year two, the Policy Analysis of Systemic Reform and the Strategies for Evaluating Systemic Reform teams were merged into a single team, with dual team leaders. Two teams were dedicated to providing infrastructure: the Interacting with Professional Audiences, and Formative Evaluation teams. Two others both conducted research and provided infrastructure: the Communicating with Mass Audiences team, which supported the Institute through news stories, developed *The Why Files* Web site (which seeks to foster SMET learning through informal public channels), and, as of year two, began conducting research on this web site; and the Cognitive Studies of Interdisciplinary Communication, which conducted research while also providing insights about the NISE's organizational processes.

As the NISE moved into year three, it added the Graduate SMET Education team, funded by a special grant from the NSF. In preparation for an especially thorough NSF review of the NISE at the end of year three, the co-directors held a Team Leaders Team planning retreat (September 1997). In October, the NISE National Advisory Board expressed strong support for both the organizational processes and Institute products by suggesting that the NISE extend its planning horizon beyond the five-year limit of the cooperative agreement. Based on their review of the Institute in spring 1998, the NSF officers provided very positive feedback. The NISE team leaders completed year three with hopes that the NSF would continue its institute program by running a competition for a second five-year period, to which the NISE would apply.

Year four began with a number of changes in the teams. The NISE expanded as a result of a grant from a private funder that enabled the Systemic Reform team to conduct action research on activity underway in the Milwaukee Public School System. The Communicating with Mass Audiences team transferred production of *The Why Files* Web site to the UW-Madison Graduate School and focused all of its attention on the study of how people learn from *The Why Files* and other science-based sites. The Cognitive Studies of Interdisciplinary Communication team completed its work, and its team leader assumed responsibility for a new team, the Secondary Teacher Education Project. Two new associate directors were appointed, with one also leading a new team, the Information Resource Coordination team, and the other also working in close conjunction with the College Level One team leader. Last, the team leaders decided that the Formative Evaluation team's work evaluating the NISE's organizational processes was largely accomplished, and that this team should focus instead on evaluating the emerging products of particular teams.

A review of the products of the Institute at the end of year four suggests that the organization had achieved "lift off": 46 NISE documents had been published or accepted by reviewed journals. The NISE itself had produced five web sites, published 16 research monographs, seven occasional papers, six workshop reports, seven briefs, and three books (with four more under consideration by publishers) and had held five successful national forums and three other major meetings.

Year five brought with it a dramatic change. The NSF did not intend to re-compete its institute program for a second five-year period. While no promises had been made, NISE team leaders realized how much they had hoped that NSF would continue the program. This hope gone, they

were forced to view their future in a new light. During a retreat in August 1999, the team leaders considered whether to proceed, and, if yes, whether to go forward as an institute or as a set of separate teams. They rapidly decided they wanted to continue. While discussing how to go forward, they generated a list of pros and cons for proceeding as an institute (Table 1) and decided that they would go forward together. In October 1999, the NISE National Advisory Board expressed strong support for this decision to proceed and offered advice on sources of funding.

Table 1
Pros and Cons for the NISE Seeking to Proceed as an Institute

Pros

- A strong shared mission
- Visionary leadership
- A productive community of scholarship
- Name recognition, credibility, visibility
- Cross-disciplinary synergy
- Cross-fertilization and communication
- Greater depth and breadth of work
- More ambitious goals
- Efficiency of central management
- Continuity, momentum and security
- Fellows, NISE publication series, and Web sites
- Improved dissemination channels
- More attention to external customers

Cons

- More complex to propose
- Support for core funding may be difficult to obtain
- Interdisciplinary work is difficult
- Pressure to produce quickly
- Greater visibility generates greater scrutiny
- Anxiety over external relations
- Need to devote time to institute-wide events
- Be willing to replace some discipline-specific activity with interdisciplinary activity

The Evolution and Activities of the NISE's Formative Evaluation Team

The Formative Evaluation (FE) team began working with the NISE when it was funded in July 1995. The team consisted of researchers from the UW-Madison Learning through Evaluation, Adaptation and Dissemination (LEAD) Center.⁴ We worked closely with the NISE leaders on

⁴ Dianne C. Bowcock (Ph.D. in Educational Policy Studies, with extensive background in evaluation at the K-12 level) and Susan B. Millar (Ph.D. in cultural anthropology) participated during years one and two. Anne C. Burda

all our projects. We also worked closely as a team, benefiting substantially from cross-researcher triangulation during extended analysis meetings, in which we debated the meaning of our data and developed the themes and interpretations that we presented to the NISE leaders.

We conducted three different types of work: formative evaluation of the organizational processes of the NISE itself (undertaken formally during years one and two and informally during years three, four, and five); evaluation of the national Annual Forums held by the NISE (years one, two, and three)⁵; and evaluation of the products of one of the teams (year five). Here I only describe the organizational process study.

As I indicated in the introduction, a critical role of the evaluator is to develop and or choose heuristic models and use them as lenses to help the evaluated group perceive itself in a useful—and often uncomfortable—new way. The resulting experience of cognitive conflict leads the group to reflect on itself and make changes to bring itself in line with an emerging vision of itself. As we worked with the NISE, we became aware that, as it evolved, the sensitizing concepts or heuristic models that we used to help the organization examine itself would need to change if we were to help the Institute continue to evolve.

The need to change models is related to the insight that every model can be understood as a system of “constraints and affordances” (Greeno, 1998); every way of seeing is also a way of not seeing. What a model affords—its strengths—also entails certain constraints, and it is necessary to shift to different models when the opportunities and constraints the organization experiences change. In the account that follows, I describe the different heuristic models we used and illustrate how these built on each other and helped the NISE leaders become reflective practitioners of the art of developing a productive interdisciplinary organization (Schön, 1983; Senge, 1990).

Before turning to the different models we used with the NISE, I return to Geertz’s point about the art of “continuous dialectical tacking between the most local of local detail and the most global of global structure in such a way as to bring them into simultaneous view.” Evaluation researchers seek to sustain the state of dialectical tacking. From this general interpretive stance they figure out which global structures or heuristic models are likely to bring into view selected details, as well as more wide-ranging features of the organization, to which the evaluators believe the organization should attend to achieve its goals. The Formative Evaluation team tried to maintain this interpretive stance throughout its work with the NISE.

(doctoral student in Curriculum and Instruction) participated during year one; Sarah K. A. Pfattheicher (Ph.D. in History of Science) and Ramona L. Gunter (MS in anthropology), during year two.

⁵ The Formative Evaluation team’s evaluation of the forums helped the NISE develop a format for national meetings that has been judged highly successful by diverse stakeholders. Lessons learned from the forum evaluation reports are incorporated in a forthcoming NISE book on designing, planning, and evaluating professional meetings and conferences (Mundry, Britton, Raizen, & Loucks-Horsley, in press).

The Goals-Strategies-Outcomes Model

Upon accepting the challenge of providing useful lenses through which the NISE leaders could scrutinize their organization, we knew we would have to tack back and forth between local detail and global structure. We sought the detail through interviews with NISE participants. In addition, we observed NISE meetings, including all the meetings of the Team Leader Team, the Strategies for Evaluating Systemic Reform multidisciplinary advisory group, the Forums, the National Advisory Board meetings, and the invited conferences held by the various teams. We also read NISE emails sent by the co-directors and one of the teams.

We chose for our starting heuristic model one that has served exceptionally well in many LEAD Center projects, which we call the “goals-strategies-outcomes” (GSO) model, which links together three sensitizing concepts commonly used by evaluators. We at the LEAD Center find the GSO model valuable for use at the beginning of projects because many clients’ goals, strategies, and outcomes exist largely on paper—as they were stated in a proposal for funding. In such cases, not only are the group’s goals and strategies amorphous, but its future existence is entirely uncertain. Upon being funded, clients need opportunities to develop shared, lived meaning for their goals and strategies. We have found that if we use a GSO lens at the outset of a project, we can help the often diverse members of a new organization (1) articulate the relationships among their goals, strategies, and anticipated outcomes, (2) more rapidly and effectively perceive and address gaps between their goals and strategies than they otherwise would, (3) develop a shared working language, (4) develop the practice of critically assessing their organizational processes and principles, and (5) begin to experience a shared identity.

By contrast, we might start with a heuristic model based on organizational theory. In the case of the NISE, it would have been necessary to choose a model without knowing whether it would fit the emerging organization. If the fit between the selected model and the emerging NISE were poor, the value of the evaluation would be weak. Rather than helping, such an approach might have been irrelevant, or possibly harmful, to the NISE.

We asked all interviewees about their teams’ and the Institute’s goals, the strategies, activities, and organizational processes they were using, and the specific outcomes they anticipated achieving. We took an inductive approach to analyzing transcripts of these interviews and identifying patterns and issues across the diverse participants. We provided these themes and issues as feedback in verbal and written reports. In so doing, we helped the team leaders examine their organization from new angles, in a different light.

This evaluation work produced two types of outcomes for the NISE. The first type consists of the experience of being interviewed—in one way or another, all NISE participants stated that their interview experience was valuable. It forced them to reflect on their values, methods, and expectations and notice gaps in their reasoning. It helped participants articulate their reasons for getting involved in the organization, the goals they hoped to achieve through this participation, and the relationships between these goals and the methods they were using to achieve them.

The second type of outcome consisted of findings provided in Formative Feedback Internal Document (ID) Numbers 1 – 5 (see Documentation). Each presented results in both summary

and detailed terms, and each featured a set of recommendations from both the participants' and the evaluators' viewpoints. The Team Leaders Team and Advisory Team read and discussed each report and used the findings to guide changes in the NISE's organizational processes both at the team level and NISE-wide. Below I present sample themes from these reports and describe how the NISE leaders used them. (Because the findings of Internal Document No. 3, *Baseline Report on NISE "Intermediaries,"* are based on the views of members of professional organizations that hope to benefit from the NISE products, the themes in this report are fundamentally different from those presented in the other four internal document reports.)

Heterogeneity of NISE members. To evaluate accomplishment of the third goal stated in the NISE proposal ("Encourage a nationwide community of SMET and education researchers and practitioners to work collaboratively to continually strengthen SMET education"), we asked participants to assess the heterogeneity of the NISE membership. All acknowledged gaps between this goal and the reality. Representation of women was strong, and a range of education and other social science disciplines were represented. However, participation by SMET faculty was low, with experts in instructional technology or technology education all but absent. In addition, very few members of ethnic minority groups, education practitioners, and people not employed in academia were part of the Institute.

Of interest, however, were the explanations that many interviewees offered for the gap between this stated goal and the reality. Members recognized that working with people from heterogeneous disciplinary and experiential backgrounds may provide valuable intellectual challenges, but "takes massive amounts of time" and thus limits productivity (ID 4, pp. 23-28; ID 5, pp. 11-13). That is, they observed that the intellectual advantages of heterogeneity conflict with the advantage of homogeneity—the capacity to efficiently produce academic products. This "finding" illustrates a strength of the GSO approach: it enabled the interviewees to perceive their situation in a different light and enabled us to draw from their perceptions an unexpected and valuable theme.

The leaders' response to the Formative Evaluation team's findings on this issue was constrained by a bottom-line requirement placed on them by the funder: ongoing support of the Institute was contingent on the rapid delivery of products. Despite being constrained by the need to deliver products rapidly, the leaders responded in two ways. First, they made a limited effort to address the gap between their stated goal and the reality. For example, they increased heterogeneity by discipline and ethnic identity with the addition of the two co-directors in year four and with the addition of a biologist, a chemist, and an engineer as Fellows of the College Level One team in year five. Two of these individuals are African American. The NISE leaders also responded by redefining the goal such that individuals from heterogeneous backgrounds would be sought only when their participation did not jeopardize efficient production of deliverables intended to improve SMET education. As noted above, the leaders felt constrained to assign their highest priority to efficient delivery of products.

Allocation of members' time. The Formative Evaluation team discovered that a major concern expressed across the NISE teams was that many participants, including some team leaders, had too small a percentage of their time devoted to the NISE to allow them to become fully invested in the NISE and accomplish significant work (ID 4, p. 29). We recommended that the budget be

redistributed to fund fewer people for a higher percentage of their time. In response to this recommendation, the directors took steps within a year to ensure the time devoted to NISE by each team leader exceeded 25 percent. The directors noted subsequent improvements in team productivity.

Types of audiences served and outcomes achieved. During our interviews we pursued questions about matching outcomes with audience by asking participants to describe what the Institute should produce to achieve its goal—improved education for students from kindergarten through graduate school (ID 3; ID 4, pp. 11-12; ID 5, pp. 21-22). They responded by describing a dilemma. Some participants—primarily Fellows working on their own, and teams with members of homogeneous backgrounds—argued for scholarly publications and reports. These outcomes were valued because they might provide theoretical contributions that have significant impact in the longer term, and because they both meet the immediate professional needs of the NISE researchers and are easily assessed by the funder and others. Others—primarily team members committed to interdisciplinary outcomes and representatives of SMET professional organizations who were interviewed for one of the feedback reports (ID 3)—argued for products that meet the immediate needs of SMET instructors and other education practitioners.

Associated with their dilemma about the type of Institute products, members described obligations to serve competing audiences. On the one hand, all believed it was critical to meet the expectations of the NSF. On the other hand, many believed that, unless they also addressed the needs of professional organizations that directly serve teachers, faculty, and administrators, they would fail to achieve the NISE's most basic mission—improving SMET learning for all students.

The NISE leaders responded to the audience and product dilemmas that we presented by learning to value the full range of views on these issues and by experimenting with an emerging NISE-type synthesis process that could meet the needs of all its intended audiences. As William Clune, co-leader of the Systemic Reform team put it in fall 1999, as the NISE teams responded to what they eventually realized was a common set of constraints, they evolved a “common model for collaboration and research development.” He labeled this model the “interactive design experiment” (W. H. Clune, personal communication, September, 1999).

Communication and organizational identity. The NISE participants consistently expressed concerns about weak communication processes within and across NISE teams and with groups external to the Institute. Their concerns and suggestions for improvement appeared as a central theme in IDs 1 and 3. IDs 4 and 5 repeated these themes, while also reporting that improvements were evident. The Formative Evaluation team assessed these concerns in light of the need to improve communication experienced by most new organizations and made the typical recommendations for improvement—start a newsletter, distribute a participant list, further develop the Web site, improve communications with external groups, and so forth. The directors responded rapidly and enthusiastically to all of these suggestions and added some of their own ideas, such as establishing guidelines for submission and review of documents to appear in a formal publications series. The Formative Evaluation team observed improvements in the efficiency of organizational communication processes by the beginning of the third year.

At the same time, some NISE participants were especially worried about communication matters because they were hoping for interdisciplinary group interactions. These participants also noted that they lacked an understanding of the NISE as an entity and thus found it difficult to describe the organization to others and to identify with it. In response to these issues, the Formative Evaluation team made several recommendations, some of which were based on participant suggestions. Noting that some members wanted to know whether the role of the NISE directors was to provide a mechanism for funding and publishing the work of independent scholars or to run an organization characterized by shared values, goals and methods, we suggested that they clarify the directors' roles (ID 4, pp. 6-8, 12-17) and the role of the Advisory Team (ID 1, pp. 15-17). We relayed that, in connection with their question about how centralized this organization was, participants wondered how Fellows were selected and what role they should play (ID 1, pp. 25-26). To develop members' identity with the NISE overall, we suggested that the directors develop a process for orienting new members to the NISE and hold an annual Institute-wide symposium.

The directors responded to these recommendations with some ambivalence. On the one hand, they held two daylong retreats (one in year 3 and one in year 5). They reconstituted and redefined the role of the Advisory Team and produced a new member's orientation packet. On the other hand, the directors decided against implementing an annual pan-NISE symposium and chose to leave considerable ambiguity about the role of Fellows. These responses were consistent with their decisions about the heterogeneity-of-members issue: each response was based on a careful assessment of whether the implementation of the recommendation would enable the NISE to increase its efficiency and productivity.

The use of the GSO model enabled the NISE interviewees and the Formative Evaluation team to articulate a useful set of issues, as indicated in the sample themes presented here. However, as noted above, every heuristic model can be understood as a system of constraints and affordances, of weaknesses and strengths. A strength of the GSO model is that it helped the NISE assess its organizational effectiveness in terms of the goals and strategies articulated in its proposal for funding. Because these goals and strategies were devised while the identity of the Institute was still unformed, the participants needed opportunities to develop a shared, lived meaning for them. The GSO model helped by bringing into view for them—when they needed it, and in a way they could understand and use—the usually tacit goals and organizational models, as well as the taken-for-granted organizational practices with which they began. However, this very process helped the organization outgrow the usefulness of the GSO model. Once the NISE leaders had critically examined their starting goals and strategies and begun to search for ways to improve and evolve, the Formative Evaluation team became aware of a weakness in the GSO model: it is very local in its focus and not well-suited to the job of helping the leaders explore possible new practices and identities they might develop for the organization.

Models from Organizational Theory

Placing the details of interviews, observations, and email material on hold, the Formative Evaluation team began casting about for sensitizing concepts that could help us make new sense of the themes visible using the GSO lens and help the NISE leaders make a new and useful kind of sense of their organization. We turned to the literature on organizational theory for heuristic

models and chose to highlight two relatively well-known organizational process models. By interpreting our GSO-based information in light of these, we were able to provide the Institute leaders with new language and concepts with which to think about their emerging organization.

Tightly coupled center or loosely coupled “umbrella.” In our fourth internal document, we drew on the notion of loosely coupled systems (Weick, 1976), as developed in Birnbaum’s study (1988) of institutions of higher education. Birnbaum proposes that most academic institutions use a loosely coupled organizational model, in contrast to a tightly coupled bureaucratic model more commonly found in business organizations. A loosely coupled organization functions as an umbrella structure that supports the creative and largely independent efforts of individuals and small groups. A loosely coupled system tends to be unwieldy due to its use of consensus-based decision-making processes, but can support remarkable productivity because different members are relatively free to respond rapidly to, or create, new opportunities. A tightly coupled organization is less likely to foster this kind of creativity, but is more coherent and able to pursue a common goal because of its more centralized and directive leadership. With this organizational model in mind, we pointed out that NISE participants held a range of views on how the NISE operated: some experienced it as loosely coupled and others as more tightly coupled. In light of the confusion these views generated, we suggested that the directors more clearly establish a role for themselves that combined the best of both a loosely and a tightly coupled organization.

Tuckman’s stages of group development. In our fourth internal document, we also drew on a different organizational theory, Tuckman’s “forming, storming, norming, performing” theory of group development (Tuckman, 1965; ID 4, pp. 23-28). We noted correlations between the organizational processes of certain teams and the constraints limiting and the resources available to those teams, and then we related these patterns to those observed in Tuckman’s theory. In particular, we noted that teams with well-defined tasks and members with similar professional training moved rapidly into the performing stage, while those teams with amorphous tasks and members with diverse backgrounds (those who were more seriously attempting the “outrageous experiment”) spent a much longer time in the forming and storming stages. In noting these patterns, we did not judge the quality of the intellectual contribution made by either type of team, but did suggest that the more interdisciplinary teams needed a longer start-up time if they were to succeed. The result was to help the NISE leaders understand the differences among the teams and to enable them to more fully appreciate the circumstances facing those teams that were taking longer to produce “deliverables.”

By using Birnbaum’s and Tuckman’s organizational theories as additional sensitizing concepts, the Formative Evaluation team provided the NISE leaders new language and ideas with which to scrutinize themselves. The leaders used these ideas to “try on” different possible emerging identities and to guide their decisions about how to develop the identity that best suited their research questions and the felt needs of the audiences they sought to serve.

The Knowledge Building Entity Model

At the end of year two, the team leaders (including myself) decided that the Formative Evaluation team had learned most of what it could for the time being, and should, for the most part, cease formal work on its organizational process study. Because the team was still pursuing

its other types of evaluation work (e.g., Clune et al., 1997; Millar, 1998; Millar, 2000), and because the director asked me to continue functioning on an informal basis as an organizational process evaluator, I continued participating as a member of the Team Leaders Team. In addition, I became a member of the College Level One (CL-1) team, participating as the lead Fellow of its year five project. I was asked to take this role not because of my experience conducting formative evaluation of the NISE, but on the basis of knowledge of reform in college level SMET education acquired through work at the LEAD Center. Thus, during years three, four, and five, I adopted a “participant observer” stance (a standard data gathering method used in cultural anthropology). During this period, I believe I generally succeeded in sustaining the “continuous dialectical tacking” between the local and the global.

Toward the end of year three, the co-directors asked me to work with another team leader to summarize the findings to date of the Formative Evaluation team’s organizational processes study. This team leader is Sharon Derry, a cognitive psychologist who led the Cognitive Studies of Interdisciplinary Communication team and currently leads the Secondary Teacher Education Project. My findings-to-date summary was informed by work with Derry as well as by observations she and I made of the development during year three of the Team Leaders Team.

In preparing to work with Derry, I read the research papers she and her NISE teammates had produced. Her Cognitive Studies of Interdisciplinary Communication team had reviewed the literature on cognitive processes in interdisciplinary groups and developed a “distributed cognition theory of interdisciplinary collaboration” (O’Donnell, DuRussell & Derry, 1997; Derry, DuRussel & O’Donnell, 1997). Pursuing this line of work, Derry and colleagues proposed processes for assessing knowledge construction in on-line learning communities (Derry, Gance, Gance & Schlager, in press; Derry & DuRussel, 1999). In this more recent work, they defined a particular type of organization, a “knowledge building entity” (KBE), in terms of standards of evidence that are based on four “accepted views of social knowledge construction”: a situative/socioculture perspective, sociocognitive theory, argumentation, and group processing theory (Derry & DuRussel, 1999). According to Derry, Gance, Gance, and Schlager (in press), an organization is a knowledge building entity if the following standards have been/are being achieved (see Figure 1).

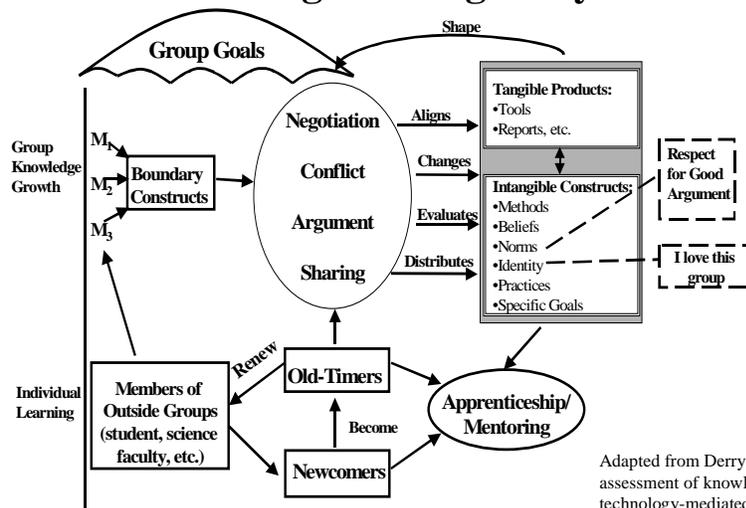
- *Participants construct knowledge by developing a shared understanding of their respective “boundary constructs.”* Each distinct viewpoint/way of knowing affords, or permits, certain perspectives and knowledge, yet inhibits others. Thus, when the members of an organization represent heterogeneous backgrounds, all participants contribute a distinct set of ideas, methods, and tools, as permitted by their discipline and experiences, and come with “blind spots” with respect to other ideas and tools. Some key ideas (e.g., “synthesis”) overlap the boundaries of many disciplines, yet are understood differently by participants from diverse backgrounds. These ideas are “boundary constructs.” If the organization is a KBE then these boundary constructs “evolve into mutually understood ‘new’ ideas, behavioral norms, and other intangible constructs that shape and are shaped by teamwork” (Derry & DuRussell, 1999, p. 2)
- *Processes of negotiation, argumentation, and information sharing—which are known to enable members to evolve new ideas from their boundary constructs—are nurtured.* Group negotiation processes show respect for good argument, as indicated by the use of evidence

and valid argument in decision-making. The group is aware of and maximizes the effectiveness of processes by which information is shared, handled, and transformed from private into group knowledge. Group negotiation processes also encourage exploration of cognitive conflict: the experience of cognitive conflict pushes participants into states of mental disequilibrium, which in turn motivates more active information sharing and drives conceptual change.

- *Processes of apprenticeship and mentoring enable members to internalize the group's language and other cultural tools.*
- *Individual team members' mental models of group tasks, community constructs, and the community itself become more aligned as a result of working together.*

Figure 1

Interdisciplinary Group as a Knowledge Building Entity



Adapted from Derry et al. (in press). Toward assessment of knowledge building practices in technology-mediated work group interactions. S. Lajoie (Ed.), *Computers as cognitive tools II*. Mahwah, NJ: Erlbaum.

Tacking between the “field information” collected by the Formative Evaluation team during years one and two, plus Derry’s and my observations of the NISE during year three (the “local detail”), and the theories proposed by Derry and her colleagues (the “global structure”), I realized two things. First, the NISE was changing in significant ways. During year three, the team leaders had begun adjusting their mental model of what kind of organization NISE was, had modified their goals, and had enriched their understanding of desired NISE outcomes. Over time, and with help from both the Formative Evaluation and Derry’s Cognitive Studies of Interdisciplinary Communication teams, the team leaders were becoming aware that the implicit organizational models they brought to the NISE when they began in 1995 fit neither their emerging experiences together, nor their goal of performing an “outrageous experiment” as a collaborative, interdisciplinary organization. The time was right to look for a new set of sensitizing concepts or lenses.

Second, Derry's team had produced a heuristic model that offered the NISE leaders a particularly robust new way to reflect on itself at this time. Recall that the GSO lens used during years one and two helped answer the question, "How well are the organizational processes used by the NISE enabling it to achieve the goals the NISE has set for itself?" The Tuckman and the Weick models from organizational theory allowed us to ask, "How does the NISE look when measured against patterns observed in other organizations?" The KBE model, in turn, provided theories about interdisciplinary organizations based on research in diverse social science fields (and especially the cognitive sciences) that the NISE could use to explore yet a different set of options for improving its productivity.

Accordingly, I endeavored to restructure the NISE leaders' view of the Institute once again. In May 1998 (year three), I presented the Team Leaders Team with a findings-to-date document that asked them to regard themselves as a knowledge building entity. The document was organized into two parts. The first drew on both the Formative Evaluation team's findings and Derry et al.'s (in press) standards for assessing knowledge building entities to produce a set of "idealized attributes of the NISE as an knowledge producing entity." The second part used this "NISE as ideal KBE" model as an interpretive lens through which I re-analyzed the field information the Formative Evaluation team had gathered, combined with Derry's and my year three observations.

To illustrate the additional value to the NISE of viewing itself in terms of this new heuristic model, I present the attributes of the "NISE as ideal KBE," based on the May 1998 document, and re-analyze the information presented above, along with new information obtained through my participation in the NISE during years three, four, and five, through this KBE lens. In so doing, I repeat some of the information presented earlier to demonstrate how its meaning changed when interpreted through different lenses. In the following discussion, the idealized characteristics appear in italics.

Ideal Intellectual Tasks

The intellectual tasks of the NISE as an ideal KBE are chosen so that

- *the various teams address problems that members are committed to, if not passionate about, and happen to be aligned with the funders' concerns; and*
- *the intellectual problems that the teams' tasks embody are sufficiently aligned that the knowledge building process within each team (including the Team Leaders Team) is likely to be catalyzed by the knowledge generated by the other teams.*

As viewed through the KBE lens, our field information affirmed that all along the participants had been strongly committed to the problems on which the Institute focused. Our field information also showed that, in the case of at least one team, the funders did not entirely agree with the problems on which the researchers focused. In this case, the pressure to meet the expectations of the funder conflicted with the value that academic researchers place on their intellectual independence. While planning for year four, the leaders succeeded in selecting

problems for all the teams that the researchers and the funders agreed addressed the most important work to be accomplished. That is, the researchers were able to answer “yes” to the question of whether they were passionate about things that the funders wanted to fund. This helped resolve the “audiences and types of products” dilemma that emerged in the GSO-based feedback.

In addition, the NISE worked effectively during year three to achieve greater alignment among the problems on which the various teams were working. To a much greater degree than in previous years, the team leaders’ year four planning efforts were characterized by an active consideration of how the various NISE teams might benefit from each other’s learning and activities. The Advisory Team—whose membership was diversified and strengthened during year three—also played a significant role, reviewing all the NISE teams and advising the co-directors as they planned for years four and five.

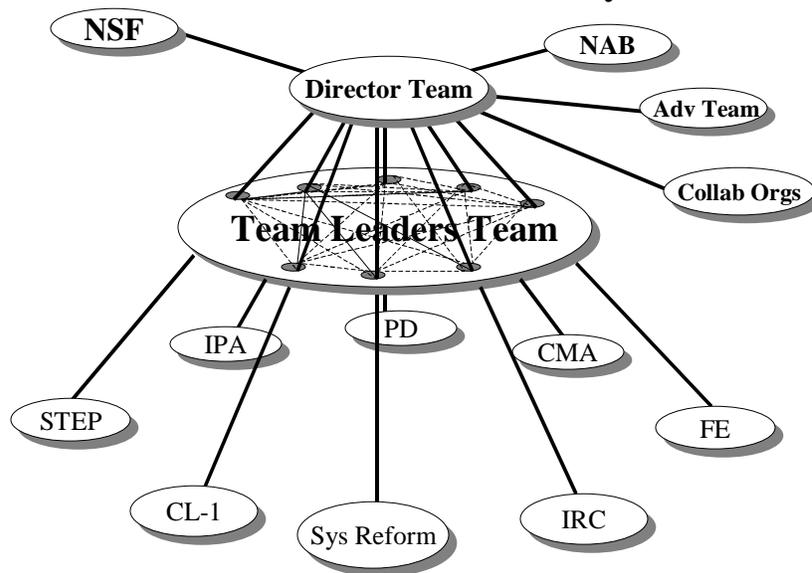
Ideal Organizational Processes

The organizational processes of the NISE as an ideal KBE are designed to ensure that the right people belong to the organization and that they get invested in joint intellectual problems, which in turn engage them in conflicts that matter to them and lead to the joint construction of new knowledge. These processes include those described below.

- *Recruitment processes. To ensure that the right people belong to the organization, the leaders establish and implement a process for recruiting members and Fellows who have: background characteristics aligned with the organization’s need for heterogeneity, with disciplinary diversity of greatest importance, and heterogeneity by other relevant features (such as academic status and authority, ethnicity, gender, practitioner/scholar, and sector representation) less critical; capacity to produce excellent ideas and products while working collaboratively; professional goals that are aligned with their team’s goals; willingness to participate in a community that develops norms supporting genuine negotiation of differences, as indicated by their ability to devote sufficient percent time (necessary in order to avoid cognitive overload), stay engaged for sufficient length of time (measured in years), and meet frequently in face-to-face and in other genuinely dialogical contexts.*
- *Apprenticeship and mentoring processes. To ensure that new members are fully integrated and effective, senior members of the organization mentor new and junior members by (among other things): making conscious efforts to increase the alignment between the professional goals and the initial boundary constructs of both mentors and apprentices; immersing the apprentices in teams working on challenging problems; providing opportunities to learn organizational history and norms; and providing opportunities for proactive feedback on performance and development.*
- *Team productivity and identity processes. Each team leader supports their team by articulating the team’s emerging goals, ensuring that needed information is available to all in a timely manner, holding frequent meetings over a sustained period of time, framing agendas that focus time and attention on the joint intellectual problems members are trying to solve, creating a work atmosphere that is challenging yet safe, and celebrating accomplishments of team members.*

- Institute-wide knowledge building processes. *To foster significant cross-team negotiations among individual members of the Institute, a large proportion of the membership participates in organization-wide events. Under the leadership of the directors, the Team Leaders Team catalyzes knowledge building across the teams. Each team leader draws on the knowledge developed within his/her own team and communicates it to the Team Leaders Team in ways that drive conceptual change for the team leaders and directors, and in turn communicates knowledge developed in Team Leader Team meetings to his/her team in ways that likewise catalyze knowledge-building process. (See Figure 2.)*

Figure 2
NISE TLT as KBE Catalyst



The challenge of interpreting all our field information about the NISE organizational processes through the KBE lens is complex. One approach is to consider authorship patterns of the products of the various teams as an indicator of whether the NISE had selected and developed its members in line with the KBE model and, if the theory behind the model is robust, whether these products embody the kinds of cognitive outcomes that the model predicts.

The outcomes of the NISE include an impressive set of papers, briefs, monographs, workshop reports, books, Web sites, national forums, and articles in newsletters of professional organizations. By standard academic measures, the quality of the intellectual contributions can be assessed by the fact that many of the documents have been published in respected disciplinary journals and by established academic publishers, and two of the Web sites and all of the forums have attracted national attention from SMET practitioners and education researchers. Using the KBE lens, we are led to consider the authorship patterns of these products. Most of the papers, monographs, and books were produced by single authors or groups with relatively homogeneous backgrounds, while a few of the documents, two of the Web sites and most of forums were produced by people with diverse disciplinary backgrounds. We surmise, therefore, that most of

the papers, monographs, and books cannot be attributed to strong interdisciplinary collaboration, whereas the other products can be.

That the majority of the products developed in the first two years were not developed by interdisciplinary groups is not surprising and possibly could not have been otherwise. The organization was under substantial pressure to produce “deliverables” from the very start, and the leaders understood that efficient production of scholarly work is a function of a scholar’s familiarity with the paradigms he or she uses and the homogeneity of the research group (if any) in which the scholars work. However much they believed that interdisciplinary processes that challenge and push participants beyond the intellectual boundaries that they bring to the organization would yield powerful results, they were constrained to limit the extent to which they devoted organizational resources to these kinds of interactions. This said, we can use the KBE lens to articulate a number of factors that helped the NISE function more like a KBE by year three, and that might have helped it function in this manner sooner, while still meeting the funder’s expectations for early products. Keying on the idealized characteristics of a KBE, I describe a number of these factors.

Recruit individuals on the basis of both their diverse backgrounds and their ability and readiness to engage in an “outrageous experiment.” Not all members, and particularly not all Fellows, demonstrated a willingness to engage in and be changed by the intellectual community (White, 1998). The pressure to develop products early, caused the leaders to hire Fellows and others to write papers, often with little or no participation on an interdisciplinary NISE team; convincing scholars to relocate to Madison, even temporarily, was difficult since the Institute had not yet emerged as a well-defined organization. Thus, through year three, the NISE found it necessary to recruit primarily from the professional networks of the current leaders and from the UW-Madison campus. A shift became evident during years four and five—the College Level One team, which hired most of the new Fellows, recruited nationally and assessed candidates on the basis of KBE criteria.

Recruit individuals whose professional goals are strongly aligned with the NISE overall and with their NISE team’s goals. For the most part, this alignment was very strong all along. However, some members who potentially had much to offer others within the NISE chose to participate very infrequently. In addition, members might have developed greater ownership in and identity with the NISE if they had been involved early and deeply in the process of planning the work in which they were engaged.

Foster team and Institute-wide knowledge building and identity processes. The year one and two interviews made clear that most of the NISE participants joined primarily because the Institute offered a funded opportunity to pursue a research area in which they already were invested. Most came with plans to pursue their academic specialties as a member of a particular team. They had little understanding of the NISE overall, and moreover they had little time or interest in further developing such understanding and were content in the thought that someone else was managing the “NISE big picture.” It should come as no surprise, therefore, that many Institute participants explained that their capacity to engage in the envisioned “outrageous experiment” was limited because they lacked a clear understanding of what the NISE was—at the Institute level and, in some cases, at the team level.

One factor that contributed to this attitude was that some leaders treated their teams like an academic department chair treats a department (Austin, 1990, 1994; Becher, 1987; Massey, Wilger, & Colbeck, 1994). For example, they held team meetings only rarely, when it was necessary to discuss bureaucratic issues. Even members whose teams met regularly to discuss issues of intellectual interest and who developed team identity often indicated that it was not clear how to get engaged with the larger NISE community.

Another factor that inhibited creation of organizational identity was that many participants were not hired at a sufficient percent time to allow them to meet face-to-face and in other genuinely dialogical contexts for sustained periods of time. This assertion is supported by changes in the Team Leader Team's interactions during year three: they had finally spent enough time together (that is, had become comfortable enough with each other) to be willing to disagree and honestly negotiate differences. My assertion also is supported by improvement in team productivity when the leaders of the Policy Analysis of Systemic Reform and the Strategies for Evaluating Systemic Reform teams began working together as leaders of a single team, and as they and other team leaders increased their percent time.

A third factor is that, while many junior and even senior members have benefited and are benefiting from apprenticeship and mentoring activities with NISE colleagues, these activities are neither well-defined nor consistently implemented. It appears that the New Members' Packet, the *NISE News*, and the NISE brown bag lecture series are steps in this direction, but new data would need to be collected to assess the effectiveness of these strategies and to ascertain whether other mentoring and apprenticeship activities are underway.

The year one and two interviews conveyed that the NISE participants and leaders had been trained in, and rewarded for years for using, the cultural and organizational norms common in research institutions (Austin, 1990, 1994; Becher, 1987; Massey, Wilger, & Colbeck, 1994). Each had developed a strong professional identity by producing cutting edge research findings in a very specific arena of expertise. Each was trained to function as an autonomous entrepreneur within a discipline-based organizational unit—"department." Departments provided resources and rewards for making original and deep additions to the knowledge base of the discipline, while remaining generally indifferent to scholarly efforts that take a broad and synthetic approach. Thus, while many members of the 1995 NISE expressed an interest in working on teams with scholars from other disciplines, they did not realize that such activity would lead to valuable outcomes only if the participants spent long hours (1) learning how to *recognize* key disciplinary concepts and habits of mind that they take for granted and others do not understand and then (2) figuring out how to *communicate* these concepts in ways that are concise enough to be understood in a relatively short time, yet rich enough to provide their interdisciplinary colleagues with new insights. The members of the 1995 NISE had no idea that, to realize the full benefit of their "outrageous experiment," they would have to allow the NISE to push them into states of cognitive conflict. They had not envisioned themselves as people about to embark on an experiment in identity transformation.

Another factor that contributed to limited organizational identity was that, at the outset, few team leaders were prepared, or even wanted, to develop a team culture characterized by acceptance,

trust, and mutual appreciation. Such cultures encourage members to take intellectual risks, challenge one another, expose their lack of knowledge, and admit error. Nor had most team leaders considered whether they should make efforts to frequently articulate their team's emerging goals, include members in decisions about the team's new directions, activities, and products, or celebrate the teams' accomplishments. However, by year three, most of the leaders had begun, more or less consciously, to use these KBE-type processes that foster team productivity and identity.

In the first two years, little cross-team intellectual life was apparent, with the exception of activity centering on the development of the forums and the production of the year two Annual Forum proceedings (e.g., Clune et al., 1997). Most NISE products were read and or discussed only by the director and the members of the team that produced them. A year one attempt to generate an on-line conversation on the NISE internal website was not successful. The brownbag lecture series introduced during year two did not (and still does not) consistently attract a core cross-team group of NISE members. Participation in the annual forums was mostly limited to the team leaders and the members of the team that sponsored it. As of year two, the directors produced more integrative material on the NISE's directions and goals, as evident in the new brochure, the overview sections of the Annual Reports, the *NISE News*, and presentations developed for the National Advisory Board, NSF, and the annual forums. While these documents were readily available, many participants were only aware of the *NISE News*, and most did not have opportunities to view the integrative presentations developed for outsiders.

However, a number of factors were in place that promoted cross-team negotiation. As the Formative Evaluation team noted in ID 1, the NISE's organizational structure was designed so that some of the teams would function to provide organizational "glue." These teams—Team Leader Team, Formative Evaluation (FE), Cognitive Studies of Interdisciplinary Communication (CSIC), and Interacting with Professional Audiences (IPA)—shared the goal of studying and or fostering linkages among the teams. The FE, CSIC, and IPA teams helped develop the cross-team and Institute-wide channels of communication during the first three years.

During years one and two, however, the TLT was not particularly effective at providing organizational glue. Because the team met only monthly for a two-hour business-focused session, it was difficult for the co-directors to foster a working environment where members learn how to interact as colleagues who can trust each other. Since the TLT agendas generally focused on "business," individual team leaders could not readily draw on the knowledge developed within their own team and communicate it to the Team Leader Team or, conversely, communicate knowledge developed in Team Leader Team meetings to their teams in ways that catalyzed knowledge building. Change in the culture of TLT was fostered, however, through an all-day TLT retreat in September 1997 (beginning of year 3), during which issues of common intellectual concern were discussed in a sustained manner. At this retreat, the TLT agreed that they would focus their monthly agendas on substantive issues and suggested that the CSIC and Formative Evaluation team leaders support this effort by more actively encouraging interaction. Informal responses to these meetings indicate that they were moderately successful. Preparation for the NISE's October 1997 National Advisory Board meeting generated intensive cross-team interaction. During the meeting itself, this higher level of interaction was sustained and was met with strong Advisory Board approval. Thus, by the beginning of year four, the Team Leader

Team had evolved to the point where it functioned, with continuing support from the IPA team, to maintain and develop cross-team communication.

The beginning of year five was a watershed with respect to the emerging organizational culture of the TLT. At the very end of year four, it had become clear that the NSF would not recompute its institute program. The director began year five with an all-day retreat (August 1999) that focused on the question of how, if at all, the NISE should proceed in light of this development. During the retreat, the team leaders considered the mature products of the various teams and realized—somewhat to everyone’s surprise—that they had evolved a common research paradigm entailing collaborative problem solving research and development. It was in a white paper written after this retreat that team leader William Clune used the term “interactive design experiment” for this emerging paradigm. He explained its emergence as follows:

A common research paradigm or model underlies every NISE project. The model did not result from conscious application of a common theory but, rather, has emerged from a common purpose (helping improve student achievement) and the way that diverse projects seeking to improve practice through better information are shaped by common constraints. Because we now understand our own and others’ research projects at a deeper level, we can see that research projects aiming to improve education through better information confront a common set of issues (or inevitably serve as partial contributions insofar as they do not). (W. H. Clune, personal communication, September, 1999).

During this retreat, the team leaders acknowledged that they had learned, and have much more to learn, from one another. They decided that they wanted to take up new challenges and projects together, agreeing that they could do this successfully only if they were able to sustain the cycle of discourse, reframing and revisioning, and activity that they had developed together. Thus, their answer to the question of whether they would go forward without NSF core funding was, in KBE terms, “Yes, and not as a confederation of specialists, but as an interdisciplinary knowledge building institute.” They had, in short, evolved a set of shared and well-defined goals, intentional organizational practices, and a common research paradigm.

Conclusion

We shall not cease from exploration
And the end of all our exploring
Will be to arrive where we started
And know the place for the first time.

—T.S. Eliot

In the summer of 1995, the NISE leaders and other participants did not understand what it might mean to embark on an “outrageous experiment” whereby a group of academic specialists would be transformed into a knowledge building entity. This notion of transformation is inherently comparative: it forces us to bring into focus the “baseline” norms and organizational constraints and opportunities that the NISE researchers took for granted at the outset. As I noted above, for each researcher, this baseline was an identity as an academic specialist in a department. On the

basis of my observation of and participation in the NISE during years three, four, and five, it was evident that, by the beginning of year five, they had evolved into a community that valued and supported one another's efforts to take a broad and synthetic approach to scholarship. The process of inviting them to peer at themselves through a series of heuristic lenses—from “goals, strategies, and outcomes,” to “tightly and loosely coupled systems” and “forming, storming, norming, performing,” to knowledge building entity—helped them continuously to see themselves anew. This process, in turn, helped them affirm and deepen an identity as a successful interdisciplinary institute and make choices—such as the decision to “go forward together”—that have enabled the NISE to continue to evolve.

The processes and outcomes described above demonstrate that the Formative Evaluation team's work helped the NISE develop the shared and well-defined goals, intentional practices, and distinctive culture it has at this time. Key among the practices that the leaders developed in response to formative evaluation is the habit of bringing into view and thinking about organizational processes and assumptions, of taking a questioning and problem-solving stance toward emerging organizational situations. Indeed, I believe that at this point the leaders have developed the capacity to act as their own formative evaluator. Contemplating the organization at this time, I can only wonder which heuristic models will be useful to it in the future, as it continues to evolve.

I suggest that interdisciplinary groups seeking to promote the kind of organizational development described here should consider working with an evaluator. The saga that unfolds for other groups, working with other evaluators, will surely be different than the one told here. However, formative evaluation should, at a minimum, provide the following benefits to any emerging organization.

- The experience of being interviewed by evaluators should help participants articulate their reasons for getting involved, the goals they hoped to achieve through their participation, and the relationships between these goals and the methods they were using to achieve them.
- Formative feedback documents and other “feedback” interactions with the evaluators should
 - ◆ provide the organization's leaders with a synthesized view of the ideas and experiences of the various participants and enable the leaders to perceive patterns and themes in the way the organization is taking shape;
 - ◆ highlight situations where the goals held by the leaders and the participants are or are not aligned, and where implementation strategies are or are not adequate for achieving the stated goals, thus enabling the leaders to make effective midcourse corrections;
 - ◆ invite the clients to view taken-for-granted organizational events and processes in the new light cast by carefully chosen or heuristic models, thereby fostering cognitive conflict for the clients and helping them notice practices and beliefs that inhibit achievement of their envisioned goals; and
 - ◆ describe and help the leaders understand the character of the emerging organization.

In short, formative evaluation should provide ideas, information, models, and language that an emerging interdisciplinary organization can use to reframe and revision what it is accomplishing and what kind of organization it is becoming. It should enhance the leaders' capacity to function as reflective practitioners by assisting them in tacking dialectically between their most local of local detail and their most global of global structures.

Documentation

NISE Formative Feedback Internal Documents

These reports are part of the NISE's Internal Document series, are confidential, and are not to be copied or distributed without permission of the NISE Leadership Team. They are listed here for reference purposes only.

ID 1. Baseline report on the Team Leaders Team and Management Team. (October 1995). Susan B. Millar, Dianne C. Bowcock, & Anne C. Burda.

ID 3. Baseline report on NISE "Intermediaries." (April 1996). Susan B. Millar, Dianne C. Bowcock, & Anne C. Burda.

ID 4. Report on non-Team Leader Team/Management Team participants. (April 1996). Susan B. Millar, Anne C. Burda, & Dianne C. Bowcock.

ID 5. Report on perspectives of the Co-Directors, Team Leaders Team & Management Team. (Sept. 1996). Dianne C. Bowcock & Sarah K. A. Pfatteicher, with Susan B. Millar.

ID 6. Report on perspectives of the NISE membership. (April 1997). Dianne C. Bowcock, Ramona L. Gunter, Susan B. Millar, & Sarah K. A. Pfatteicher.

References

- Atkinson, P. (1990). *The ethnographic imagination: Textual constructions of reality*. London: Routledge.
- Austin, A. E. (1990). Faculty cultures, faculty values. In W. G. Tierney (Ed.), *Assessing academic climates and cultures* (New Directions for Institutional Research No. 68, pp. 61-74). San Francisco: Jossey-Bass.
- Austin, A. E. (1994). Understanding and assessing faculty cultures and climates. In M. K. Kinnick (Ed.), *Providing useful information for deans and department chairs* (New Directions for Institutional Research No. 84, pp. 45-63). San Francisco: Jossey-Bass.
- Becher, T. (1987). The disciplinary shaping of the profession. In B. R. Clark (Ed.), *The academic profession* (pp. 271-303). Berkeley: University of California Press.
- Birnbaum, R. (1988). *How colleges work: The cybernetics of academic organization and leadership*. San Francisco: Jossey-Bass.
- Blumer, H. (1969). *Symbolic interactionism: Perspective and method*. Englewood Cliffs, NJ: Prentice Hall.
- Clune, W. H., Millar, S. B., Raizen, S. A., Webb, N. L., Bowcock, D. C., Britton, E. D., Gunter, R. L., & Mesquita, R. (1997). *Research on systemic reform: What have we learned? What do we need to know? Synthesis of the second Annual NISE Forum* (NISE Workshop Report No. 4, Vol. 1: Analysis, Vol. 2: Proceedings). Madison: University of Wisconsin-Madison, National Institute for Science Education.
- Coffey, A., & Atkinson, P. (1996). *Making sense of qualitative data: Complementary research strategies*. Thousand Oaks, CA: Sage.

- Denzin, N. K., & Lincoln, Y. S. (Eds.). (1994). *Handbook of qualitative research*. Thousand Oaks, CA: Sage.
- Derry, S. J., & DuRussel, L. A. (1999). Assessing knowledge construction processes in on-line learning communities. In S. Lajoie & M. Vivet (Eds.), *Artificial intelligence in education* (pp. 431-438). Amsterdam: IOS Press.
- Derry, S. J., DuRussel, L. A., & O'Donnell, A. M. (1997). *Individual and distributed cognitions in interdisciplinary teamwork: A developing case study and emerging theory* (NISE Research Monograph No. 7). Madison: University of Wisconsin-Madison, National Institute for Science Education.
- Derry, S. J., Gance, S. P., Gance, L. L., & Schlager, M. (in press). Toward assessment of knowledge building practices in technology-mediated work group interactions. In S. Lajoie (Ed.), *Computers as cognitive tools II*. Mahwah, NJ: Erlbaum
- Geertz, C. (1983). "From the native's point of view": On the nature of anthropological understanding. *Local knowledge: Further essays in interpretive anthropology*. New York: Basic Books.
- Greeno, J. G. (1998). The situativity of knowing, learning, and research. *American Psychologist*, 53(1), 5-26.
- Joint Committee on Standards for Educational Evaluation. (1994). *The program evaluation standards* (2nd ed.). Thousand Oaks, CA: Sage.
- Massey, W. F., Wilger, A. K., & Colbeck, C. (1994, July/August). Overcoming "hollowed" collegiality. *Change*, 26(4), 10-20.
- Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks, CA: Sage.
- Millar, S. B. (Ed.) (1998). *Indicators of success in postsecondary SMET education: Shapes of the future. Synthesis and Proceedings of the Third Annual NISE Forum* (NISE Workshop Report No. 6). Madison: University of Wisconsin-Madison, National Institute for Science Education.
- Millar, T. S., Mason, S. A., Gunter, R. L., & Millar, S. B. (2000). *Synthesis of the science, mathematics, engineering and technology graduate education* (NISE Workshop Report No. 7). Madison: University of Wisconsin-Madison, National Institute for Science Education.
- Mundry, S., Britton, T., Raizen, S., & Loucks-Horsley, S. (in press). *Professional meetings and conferences in education: Designing, planning and evaluating*. Thousand Oaks, CA: Corwin.
- O'Donnell, A. M., DuRussel, L. A., & Derry, S. J. (1997, April). *Cognitive processes in interdisciplinary groups: Problems and possibilities* (NISE Research Monograph No. 5). Madison: University of Wisconsin-Madison, National Institute for Science Education.
- Patton, M. Q. (1990). *Qualitative evaluation and research methods* (2nd ed.). Newbury Park, CA: Sage.
- Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.
- Senge, P. (1990). *The fifth discipline: The art and practice of the learning organization*. New York: Doubleday/Currency.
- Schrage, M. (1990). *Shared minds*. New York: Random House.
- Thompson-Klein, J. (1990). *Interdisciplinarity*. Detroit, MI : Wayne State University Press.

- Tuckman, B. W. (1965). Developmental sequences in small groups. *Psychological Bulletin*, 63, 384-399.
- Weick, K. E. (1976). Educational organizations as loosely coupled systems. *Administrative Science Quarterly*, 21(1), 1-19.
- White, P. A. (1998). *NISE Fellows program: Feedback from past Fellows* (Occasional Paper No. 7). Madison: University of Wisconsin–Madison, National Institute for Science Education.

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