NSF/NCES
UNDERGRADUATE MATHEMATICS EDUCATION INDICATORS PROJECT

IV. INSTITUTIONAL AND SYSTEMIC ISSUES

Peter Ewell (with the assistance of Janet Ray)

ABSTRACT

This chapter proposes a number of indicators designed to provide information about elements of the institutional and departmental environment that may significantly affect the delivery of mathematics instruction. These indicators are contextual and must always be used in conjunction with the more direct measures of curriculum, experience, and attainment covered elsewhere in this volume. Indicators are proposed at both the institutional and departmental level that address; a) key aspects of organizational climate, culture, and incentives that shape individual behavior that are present; b) key organizational, structural, or resource conditions affecting the delivery of instruction; and c) factors in the external environment that may significantly condition these institutional characteristics. Possible data sources for constructing indicators of institutional and departmental context include, a) published statistics available nationally or at the state level, b) institutional or unit-level questionnaires, c) institutional records and documents, d) surveys administered to faculty and staff, e) student and graduate surveys, and f) site visits and interviews. A review of the current feasibility and the applicability of each data source to the domains of interest suggests that the greatest potential for developing such indicators lies in faculty / student surveys undertaken on a national basis, combined with site visits.

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Collegiate mathematics is taught and learned by students in the U.S. across an enormous range of institutional settings. Some encounter mathematics as college students traditionally have done so--as part of a defined set courses taken in sequence as a prelude to in-depth study or to meet the "general education" component of an established four-year undergraduate curriculum. Growing numbers--often in two-year institutions but increasingly in urban four-year institutions as well--enter with deficits in basic mathematical skills, and must engage in remedial work before proceeding further. The institutions delivering mathematics instruction of any kind, moreover, vary from small to large, with faculties whose assignments range from occasional undergraduate contact to full-time lower-division teaching roles. Such differences in clientele and setting will have direct impacts on the effectiveness of teaching and learning mathematics, no matter how well-designed the curriculum or committed and well-prepared the instructional staff. More importantly as already noted by Chapter 1, such differences may decisively affect the **climate** of instruction--rendering the development of improved approaches to instruction more or less difficult, or actively building or inhibiting faculty commitment to effective teaching.

At the same time, the national policy context within which undergraduate instruction in any field takes place is shifting rapidly. Public sector institutions are under increasingly stringent accountability demands, while independents are facing more and more proactive accrediting requirements. Fiscal resources are also increasingly constrained--a condition which is not likely to be reversed in the coming decade. Resulting demands for "consumer responsiveness" and greater efficiencies in delivering instruction at all levels are significantly affecting the ways colleges and universities must do their business.

While knowledge of factors such as these is important for gaining a more extensive national understanding of the nature and effectiveness of undergraduate mathematics instruction (and may be critical in effecting any needed changes in policy and delivery), it must be emphasized that their impact is indirect. As a result, this chapter is intended to be essentially **contextual**, yielding indicators that must be used in conjunction with the more direct measures of curriculum, experience, and attainment proposed in other chapters. In particular, Chapter 1 provides considerable in-depth discussion of the many relationships between departmental contexts and specific aspects of instructional delivery, and references to this material will be made wherever appropriate. The intent here is to capture important elements of the broader institutional and departmental

environment that significantly affect the delivery of mathematics instruction. It is not to comprehensively describe the institution. These elements are located essentially in the area of "intentions" and "transactions" at the institutional and macro-departmental levels, as delineated in Chapter Zero's Figure 1--factors that in turn serve to condition intentions, transactions, and outcomes at the critical classroom and student levels. In discharging this limited intent, however, we suspect that the resulting array of "contextual" indicators may be useful to fields other than mathematics. Indeed, we advance them as a template for other disciplines that wish to travel a similar path.

The chapter is intended to cover two main topics:

_**specific aspects of the institution and department** for which indicators might usefully be developed; in particular here, we suggest indicators of three kinds: a) those that describe key organizational, structural, or resource conditions affecting the delivery of instruction in mathematics across the many settings in which it occurs; b) those that address key questions of the organizational climate, culture, and incentives within which instruction takes place and that may decisively affect the ability to respond effectively to new conditions; and c) factors in the external environment that may significantly affect either or both of the above.

_possible **sources of evidence** for the development of such indicators. As in any comprehensive indicators system, we expect that a given domain may be informed by data drawn from many sources. Conversely, some sources of evidence (e.g. a site visit or faculty questionnaire) may allow information to be efficiently and simultaneously gathered about many different aspects of institutions and departments.

As noted, matters like overall curricular structure and patterns of student experience are covered elsewhere in the volume--especially in Chapters 1 and 3. Because of their substantial potential impact on instructional innovation and delivery, however, issues of institutional academic and curricular policy deserve independent treatment as contextual factors and will be included in the present discussion.

A. A Conceptual Scheme for Developing Contextual Indicators

Pedagogy and instruction are shaped decisively by the environment within which they take place. To respond effectively to new conditions, faculty and administrators need to understand both what works in individual learning situations and also how to cause the adoption of effective practice across the enormous range of settings in which mathematics instruction takes place. If only the first occurs, appropriate practices may occur in particular settings because of the efforts of isolated individuals, but the resulting responses will be both shallow and short-lived.

Given this proposition, information about contexts of the kind addressed in this chapter serves two purposes. First, it enables policy to reflect appropriate variations in setting--and in particular, the fact that what works in one kind of setting may not in another. Many past attempts to improve educational practices have been unsuccessful precisely because they advanced "canned" solutions, unsuited to any particular institutional setting. Second, when collected over time, information about organizational contexts allows policymakers to begin to understand the dynamics of change itself--what particular incentives and structures seem most associated with the adoption of effective practices and attitudes toward teaching. Both will be critical if systemic improvements in mathematics instruction are to occur.

Following this logic, Figure 1 presents a schema for constructing a useful set of indicators on the organizational and systemic conditions affecting the delivery of undergraduate mathematics instruction. The figure's vertical dimension proposes a basic distinction between indicators of two kinds:

> **_variations in setting** refers to important structural, organizational, or resource conditions of an institution, unit or department that have a direct bearing on the delivery of instruction. Such factors are palpable, or are at least readily susceptible to measurement. Moreover, they provide a set of factors in terms of which other obtained measures of performance can be appropriately disaggregated to reflect important distinctions among instructional settings and environments. It may make little policy sense, for instance, to mindlessly combine statistics on instructional delivery or levels of attainment into aggregate indicators of effectiveness, without awareness of the fact that both levels and ranges of variation in these aggregates may differ decisively between two and four-year colleges, between selective and non-selective institutions, or between institutions experiencing very different resource constraints. As a result, classes of indicators proposed under this heading are intended to do "double duty." Because the conditions that they describe may directly or indirectly affect instruction, such indicators are important to monitor and report in their own right. But they are equally useful in delineating the appropriate subgroups for which to collect and report other more direct indicators of structure and performance.
>
> **_climate/culture** refers to some of the more intangible aspects of an instructional setting that may significantly affect how teaching and learning occurs. Such factors are generally not amenable to direct measurement. Despite this difficulty, they are critical to assess for two reasons. First, like structural factors, they may directly or indirectly condition instructional delivery; faculty morale and commitment, for instance, may be at least as important a determinant of the effectiveness of instructional delivery as the presence of up-to-date equipment (and indeed, the two may be related). Equally important, such factors appear

particularly associated with the ability of an institution or department to respond effectively to changes in its environment. Insofar as it is a principal purpose of a national system of undergraduate mathematics indicators to foster such responsiveness in instructional delivery, explicit consideration of the factors affecting innovation and its dissemination may become critical.

Individual entries within each area of the figure represent promising general domains for indicators development, and each will be discussed in more detail. For the moment, though, each can be interpreted as a relatively distinct arena within which a specific cluster of indicators might usefully be considered.

The second dimension of the figure is intended to convey the fact that parallel sets of indicators might be appropriately constructed at several levels within the institution. The two most salient, of course, are the institution as a whole, and the individual mathematics department. But between these two, there may be several additional relevant layers of organization. These may be especially important in two-year college settings, where mathematics faculty may lack a distinct organizational identity because they are members of a larger Divisional faculty. As the double-headed arrow on the horizontal axis is intended to convey, moreover, the **congruence** or **alignment** among factors at varying organizational levels within the institution is critical. An individual department, for example, may be highly flexible and oriented strongly toward student success but be embedded in a wider institutional context that prevents systematic changes from being accomplished effectively or that actively discourages real attention to students through its established structure of incentives. Similarly, individual departments within a resource-rich institution may remain relatively deprived, either through politics or structural isolation.

This last point has two important implications for the development of contextual indicators. First, each domain described for which a specific measure is suggested implies a further need to construct additional measures of **alignment** or **congruence** among organizational levels. In the realm of faculty instructional values, for instance, indicators are needed not just of the content of these values at the institutional and departmental levels, but that also reflect the degree to which these are different. Secondly, it is the overall **pattern** of such contextual factors at each level--and between levels--that is ultimately important. As a result, too much emphasis should not be placed on the individual value of any given indicator, independent of those of its counterparts. It should rather be placed on determining the degree to which many such factors are both simultaneously present in a given institutional or departmental environment, and the degree to which they are mutually reinforcing.

Figure 1's final "dimension" involves the external environment. This refers to factors in the wider society that affect both available resources and the manner in which higher education is delivered. Prominent among these are political factors such as growing "customer consciousness" or demands for efficiency, governance factors such as the

institution's actual decision latitude in making curricular changes, and overall fiscal conditions or the availability of special-purpose funds to support innovation. It is expected that these factors--operating from many directions simultaneously--will affect both the institution's structural and resource condition and its climate and culture.

To close this section, it is important to re-emphasize principal purposes. First, the type of indicators proposed are intended primarily to describe the particular background conditions within which the far more relevant factors described in other chapters occur. As a result, they are far less comprehensive than they might be in describing the underlying domains which they represent. Because the intent is thus auxiliary, efficiency is a primary concern. The objective should eventually be to propose as limited a set of indicators as possible to address an extremely complex set of conditions. While the intent of the chapter is to discuss a wide array of appropriate domains, careful choices among these will eventually have to be made to achieve a workable set of indicators. Second, because they are intended to reflect the variations in context within which more relevant activities take place, a primary use of the indicators discussed in this chapter is to provide an appropriate means to **disaggregate** more relevant data on outcomes, instructional delivery, and student experiences as described in other chapters. Finally, the indicator domains addressed in this chapter have a conscious **action** bias. Consistent with what we take to be NSF's original intent in proposing that national indicators of undergraduate mathematics education be developed, we assume that the resulting data will be used to propose and monitor improvements (Shavelson, McDonnell and Oakes 1989). As a result, in the discussion of organizational climate and culture, there is a strong bias toward describing the particular features of institutions and departments that appear to be associated with the ability to respond effectively to new instructional conditions.

B. Indicator Domains

Following the logic of Figure 1, each of these topics is addressed distinctly in the subsections that follow. The discussion begins with **organizational culture and climate** issues, largely because these are directly related to important domains that directly affect curriculum and instruction as discussed in Chapter 1. Potential indicators discussed here are highly consistent with Chapter 1's recommendations and can be designed to be collected in tandem with such measures. A second subsection treats important **variations in setting**--beginning with structural and resource issues, but with particular emphasis on instructional staff and support. Both these domains are treated at two distinct levels of analysis, the institution as a whole and the individual mathematics department, but it is expected that in large, complex institutions, more than two levels of analysis may be relevant. The final subsection examines **external environmental conditions**, with special emphasis on the availability of resources and changes in technology.

Within each subsection, each domain is first discussed at the institutional level, and then at the level of the individual mathematics department. While an exhaustive list of specific recommended indicators cannot be provided at this point, samples of potentially useful indicators are provided [*enclosed in brackets*] for each domain element considered.

1. **Climate and Culture**

Despite their strong linkage to instructional delivery, explicit investigation of organizational climate and cultural factors is a relatively recent activity in higher education settings. Most systematic work has occurred at the institutional level--attempting for the most part to apply to colleges and universities conceptual approaches initially developed for corporate settings (e.g., Cameron 1978). The majority of these focus on two factors that were part of the mainstream of organizational culture work in the 70s and early 80s--the degree to which belonging to an organization proves satisfying to its individual members, and the degree to which members of the organization share a common view of what the organization is and where it ought to be going (Weick 1978). More recently, attempts have been made to connect such factors with institutional outcomes--in particular, the survival of individual colleges and universities (e.g., Chaffee 1983) and the "effectiveness" with which they are able to garner resources and shape their futures. Even more recent lines of inquiry, borrowing from the "effective schools" literature on elementary and secondary education, have attempted to connect specific aspects of organizational climate and culture with the presence of particular instructional practices and enhanced outcomes (e.g., Krakower 1985, Bergquist 1992).

As might be expected, most such approaches involve far more sophisticated data-gathering methods than simple counts and percentages. Most rely principally on surveys of faculty and staff to draw conclusions about organizational culture, while more recent work emphasizes the use of direct observation--generally employing qualitative or ethnographic techniques borrowed from anthropology (e.g., Chaffee and Tierney 1988). For purposes of this presentation, it is assumed that such sophisticated, qualitative approaches will in part be used. As a result, the domains considered are considerably broader than those proposed to describe structural and resource variations, yielding potential "indicators" of a quite different form.

The majority of past attempts to assess culture and climate in college and university settings, moreover, have been applied to the institution as a whole, rather than to individual departments. An important exception in mathematics, which points a direction for the future, is a set of departmental case-studies recently completed under the auspices of the MAA (Tucker, forthcoming). For the purposes of developing useful indicators of climate and culture for undergraduate mathematics education, we agree strongly that the department provides the most promising unit

of analysis. The emphasis of this section, consequently, centers on the department or division as the principal locus of data-collection and reporting.

1.1 **Shared Purposes.** Most researchers on organizational culture agree that clarity of organizational goals, and the degree to which there is obvious agreement about and commitment to such goals, are at the heart of organizational effectiveness (e.g., Masland 1985). In higher education settings, assessments of shared purposes have been available for some time at the institutional level. The Institutional Goals Inventory (IGI) and Institutional Functioning Inventory (IFI), both offered by ETS for instance, assess the strength of specific goals and the congruence of perceptions about goals by surveying samples of faculty, staff and students. Whatever methodology is employed and regardless of the organizational unit of analysis, however, the principal domains of interest here will likely include the following:

1.1.1 **clarity and consistency of goals.** This dimension refers to the degree to which the specific goals of the department (or, where appropriate, the institution or division) are clearly and visibly established and are regularly communicated to department staff. For two-year colleges or other institutions where there may not be a distinct mathematics department within a larger divisional structure, the clarity and consistency of goals may be a particularly important issue. More specific elements within this sub-domain might include:

1.1.1.1 **the visibility of goals**, through program and curriculum descriptions, established standards for academic achievement or grading policies, newsletters or other periodic devices, or both formal and informal communications to students and the faculty from academic leaders. *[Sample indicator: content analyses of available communications indicating the weight of attention given to teaching and learning issues]*

1.1.1.2 the **degree to which expressed goal elements are relatively limited in number, and consistent with one another** across a range of sources or settings. *[Sample indicator: congruence in the above across different types of formal and informal communications, or for different parts of the department or unit]*

1.1.2 **awareness of goals.** This dimension refers to the degree to which members of the unit or department (or the institution as a whole) are aware of established goals. Where there is unevenness of awareness, the indicator should also reflect the specific populations--types of instructional staff, support staff, students, or administrators, for

instance--where these differences occur. *[Sample indicator: percentage of departmental staff and/or students "strongly agreeing" that a priority of the unit is to provide excellent first-year statistics instruction for students majoring in business or social science fields, (if this is in fact an established priority of the unit).]*

1.1.3 **agreement about goals.** This dimension refers to the degree to which members of the department (or institution) in fact agree with one another regarding priorities. As above, the indicator should reflect not only the absolute levels of congruity or disagreement, but also the specific staff (or student) populations where any disagreements are present. *[Sample indicator: congruence of responses identifying priority goals for the unit among different members of the departmental community, as reported on a common survey]*

1.1.4 actual **alignment of incentives and policies with identified priorities**. This dimension refers to the degree that the unit (or institution) in fact "acts out" its established goals through visible policies, investments, and rewards. This is probably the most revealing indicator of commitment, but will likely be detectable only through careful analysis and inspection of documents or through direct observation. If a primary goal of the department is providing effective undergraduate (and especially lower-division) mathematics instruction, investments in many of the activities and functions noted later under "instructional support" constitute indicators of such an underlying commitment. *[Sample indicator: the degree to which expressed unit priorities are visible in actual or budgeted expenditures of time or other resources consistent with these priorities]*

1.2 **Instructional Philosophy.** This domain of institutional and departmental culture refers specifically to the unit's values about and orientation toward undergraduate teaching. Numerous researchers on teaching and learning in collegiate settings have noted that such values are palpable and observable--and have a direct impact on the delivery and effectiveness of instruction (Astin 1993, Gamson and Associates 1984, Chickering 1989, etc.). Most also agree that these values interact with and are reinforced by the structural conditions of institutions, including small size and clear mission. For two-year colleges, which already have an undergraduate teaching mission, important additional dimensions of instructional philosophy will include faculty orientation toward remedial, transfer, or occupational preparation--and the relative balance among these orientations. Many factors potentially included under this heading, of course, are already observable in specific features of the curriculum and instructional delivery, or as aspects of student experience, that are covered in other chapters. Here, then, the attempt should be to capture broader elements of departmental (or institutional) culture with respect to teaching that are not

necessarily embedded in specific curriculum designs or observable in faculty teaching behavior. Among these elements are:

1.2.1 the **overall salience of teaching as an organizational value**. This dimension is intended to capture the relative degree to which instruction--especially undergraduate instruction--is a dominant object of faculty attention, discussion, and activity independent of any specific structures or incentives that might be present. In many ways, it is captured conceptually by Astin's notion of "student-centeredness" (1993). To what degree do faculty actively discuss teaching issues informally, help one another with teaching problems, or express good teaching as quality worth admiring in a colleague? Specifically within mathematics departments, it is well-captured in the core value of "respect for students" detected by Tucker and his colleagues as a common feature of effective programs (forthcoming). Positive answers to both kinds of questions will very likely be aligned closely with structural and resource factors that reinforce such behaviors, but they are likely important in their own right as indicators that such incentives are working. *[Sample indicators: degree to which faculty report a high level of personal commitment to undergraduate teaching, and report that such an attitude is common and valued among their colleagues; incidence of citing "good teaching" and "commitment to teaching" as reasons for admiring a faculty colleague.]*

1.2.2 **commitment to active learning, frequent feedback on performance and other "principles of good practice" in undergraduate instruction.** Since the mid- eighties, efforts to reform undergraduate teaching have converged on a relatively small number of interrelated principles of "good practice" (Chickering and Gamson 1987). As a result, a number of approaches to developing indicators centered on detecting and monitoring "good practice" as a proxy for instructional effectiveness have been proposed (e.g. Ewell and Jones 1994, 1996). In essence, all such practices can be contrasted with a "traditional" teaching model based on lecture-style or unguided modularized or self-paced delivery modes, where students are in essence considered passive recipients of the knowledge being delivered. Active learning techniques, in contrast, stress student discussion and group work. Another theme is frequent feedback on performance, which emphasizes that students learn better when given prompt responses about their own performance on tests or problems. Again, full investigation of these matters and their potential for indicators development is beyond the scope of this chapter, and readers are referred to the discussions on "Instructional Activities" and "Expectations for Student Capacities" in Chapter 1. Relevant here are

indicators that suggest that such principles are known and actively encouraged as part of the unit's general approach to teaching. *[Sample indicators: frequency with which faculty report using "classroom research" (Angelo and Cross 1993) techniques or other specific tools for assessing and monitoring their own teaching; frequency with which faculty cite the use of active learning or group/cooperative study as valued features of their own and/or their colleague's teaching; presence and attendance at workshops or faculty development activities directed toward fostering such approaches]*

1.2.3 **approaches to grading and the assessment of student performance.** A counterpart to "active learning" in the classroom is the degree to which student performances are assessed individually or cooperatively. Traditional grading policies that emphasize competitive, norm-based approaches represent one extreme on this continuum, while policies stressing cooperative assessment of performance against fixed criteria of competence represent another. The degree to which the department or unit emphasizes or encourages a particular approach provides a useful indicator of commitment to "good practice" principles. *[Sample indicators: the existence of established departmental (or course) grading policies that emphasize a particular approach to grading; incidence faculty citations or reports that cooperative grading approaches are valued and used throughout the department; presence and/or attendance at workshops or activities stressing such approaches]*

1.3 **actively "student-centered" policies, values, and behaviors.** Researchers on college student settings and behaviors have over the past twenty years consistently identified a particular set of attributes of the institutional environment that appear to be associated with high involvement and achievement (Astin 1993, Pace 1990, Pascarella and Terenzini 1991). Astin (1993) labels these environments "student-oriented" and identifies a number of their specific features that can serve as a useful guide for indicators development. As above, many of these are also beginning to be confirmed at the level of the individual mathematics department (Tucker, forthcoming). Among the most salient of these features are the following:

1.3.1 frequent opportunities for **out-of-class contact between faculty and students.** Student-faculty conversation is probably the single most often- cited feature of such environments, and in most studies exhibits strong independent effects on student development. An important qualification on this finding, however, is that such contact must not be purely social, but should involve an element of learning as well (Pascarella and Terenzini 1991). The degree to which a given departmental (or institutional) environment values and encourages such contact may therefore be especially promising as an indicator. It may

also be useful to monitor the extent and quality of such non-face-to-face media for contact as E-mail networks and interactive video. (See also the discussion on "Expectations for Student Capacities" in Chapter 1.) *[Sample indicators: emphasis placed on contact with students outside of class by individual faculty members on a survey or in interviews; observed frequency of such contact immediately before or after class; presence of opportunities for such contact in the form of study groups, informal study sessions, Mathematics Clubs, etc.; overall feelings about faculty contact and accessibility reported by students in a survey or interviews.]*

1.3.2 departmental (and / or institutional) **policies and procedures that treat students as "partners" or "valued customers.**" This dimension refers primarily to the ways in which students are treated in navigating the "bureaucracy" of curriculum and academic policy, or the response they receive when trying to solve an individual problem or difficulty. On the one hand, they can be treated as a "number," and subjected blindly to a set of rigid rules and procedures (e.g. in registering for courses or in attempting to determine whether prerequisites are met through a transfer course). On the other, they can be treated as individual cases, and with the feeling that their needs are important and deserving of prompt attention. Partly such values are a function of unit size, but they appear to some degree to be an independent element of organizational culture. (See also the discussion of the need to provide assistance to non-traditional or underserved student clientele groups in Chapter 3.) [*Sample indicators: student reports on the attitudes of staff in direct contact with them about solving a particular problem or obtaining basic information; readability and general "user- friendliness" of departmental (and institutional) publications describing basic academic policies and procedures; reported incidence by faculty of helping students solve an individual problem]*

1.3.3 the presence and use of **specific mechanisms for regularly identifying student needs and difficulties.** A third important dimension of "student-centeredness" is the degree to which the unit (or institution) has visibly established mechanisms for listening to students--determining their concerns, problems, and needs. Many such mechanisms, as noted, will be informal--arising through direct contacts between faculty and students. Others, though, are more explicit, for example needs assessment or student satisfaction surveys or "suggestion boxes." Active student associations directed toward surfacing and discussing common student concerns may also provide evidence of this commitment. [*Sample indicator*: *presence of, and use of results derived from, student satisfaction surveys or reaction questionnaires; student responses on surveys (or in interviews) that indicate feeling that their needs and opinions are listened to and taken into account]*

1.4 **decisionmaking style.** Institutions and academic units use many forms of internal decisionmaking, and different forms have received considerable treatment in the literature on collegiate culture. Among the most common classification is Chaffee's (1983), which identifies four basic orientations--political, collegial, bureaucratic, and rational--each with a unique view of how conflicts should be resolved and the manner in which information is used for decisionmaking. Other taxonomies concentrate on the specific roles of the organization's members--for instance the degree to which they are explicitly consulted or feel they have a voice in making decisions (Cameron 1978). Based on this literature, the following specific aspects of decisionmaking style appear most related to instructional policies and behavior--and more particularly, to the degree to which these can be changed.

1.4.1 **basic organizational style.** Some organizations are run by rules, some by personal and direct control on the part of those in positions of authority, and some by accommodation and political compromise. Given the decentralization common in institutions of higher education, moreover, different basic styles can coexist alongside one another in different departments or be typical of different organizational levels (i.e. a collegial department may exist within a highly bureaucratic institution). The intent of this dimension, therefore, is to capture in summary fashion the basic culture of the department (or institution), using categories already established in the literature on organizational culture. [*Sample indicator: basic classification of the unit's decisionmaking style based on staff responses to such standard instruments as the Institutional Performance Survey (Krakower and Niwa 1985)]*

1.4.2 **degree of shared information.** A good proxy for detecting centralized decisionmaking is often simply the degree to which members of the unit know what is going on. More specifically, indicators might be constructed that reflect the degree to which departmental (or institutional) staff are aware of the specific decisions that have been taken and the basis on which issues were resolved. [*Sample indicator: reported knowledge on the part of individual members of the department (or institution-wide) regarding why a particular decision, rule, or procedure is the way it is]*

1.4.3 **level and extent of consultation and active participation in decisionmaking.** This dimension refers directly to the "voice" that individual members of the unit feel they have in making decisions. Two sub-dimensions are generally relevant here. The first concerns the **origins** of proposals or alternatives: are they generated by only a limited

set of individuals or do they "bubble up" from individual members? The second addresses the degree to which posed alternatives are **actively discussed** by the affected parties in such forums as department meetings, through designated committees, or through indirect consultation such as written invitations to provide input on potential issues or decisions. (See also the discussions of "Share in Shaping Instructional Mission" and "Communication of Goals and Values" in Chapter 1.) [*Sample indicators: faculty and staff reports on the degree to which they believe they and their colleagues are consulted about major issues or decisions; incidence of full discussion of decisional alternatives in minutes of department meetings; percentage of active participation of the staff in developing recommendations in such processes as accreditation self- studies, program reviews, or budget requests]*

1.4.4 **consideration of the views "outsiders," "partners," or "clients" in the unit's decisionmaking process.** This final sub-dimension refers essentially to the degree to which the unit (or institution) is externally directed. To what extent does it actively solicit the views of others that its activities affect in the process of determining what to do? For undergraduate education at the institutional level, this most commonly includes employers, graduate schools, and students themselves. At the level of the individual mathematics department, it may include both students and the views of "partner departments" for which the unit provides large amounts of service instruction. In occupational instruction--especially in two-year college settings--it may additionally embrace the views of employers or professionals as embodied in technical advisory boards. Finally, in institutions with a prominent transfer mission, it may involve explicit department-to-department informational links with receiving institutions. [*Sample indicators: reports by the chairs of client departments (or their designees) that their opinions were solicited regarding decisions about courses and curricula; existence of explicit reports on the later performance of transfer students in mathematics-related coursework]*

1.5 **climate for change.** While important, this is probably the most elusive domain for the development of specific indicators. Its basic concern is the degree to which the unit or department provides an overall environment that encourages flexibility and nurtures experiments in curriculum, instructional delivery, and academic policy, or on the other hand discourages such risk- taking on the part of its members. Among the specific dimensions that might be considered are:

1.5.1 general **attitude toward instructional innovations**. This dimension refers to the overall climate for instructional experiment provided by the unit (or institution) as felt by its individual members. Do they feel

encouraged and supported by others and by the unit's leadership in undertaking experiments like proposing new courses or new ways of teaching established courses, or do they feel that they are likely to be penalized for doing things differently? (See also the discussion entitled "Are Instructional Missions Changing?" in Chapter 1.) [*Sample indicators: reported latitude given to instructional staff in developing new approaches to teaching; degree to which staff members feel that most members of the unit or department (and its leadership) support and encourage such activities]*

1.5.2 presence of **explicit incentives to promote instructional improvement,** as well as forums to disseminate the results of instructional experiments. The focus here is on mechanisms to explicitly support or encourage instructional improvements or experiment such as mini-grants to be applied toward developing new approaches, colloquia or workshops intended to share experiences with such approaches, etc. From the standpoint of organizational culture, moreover, the active involvement and support of departmental leadership and its senior members in such efforts might specifically be monitored, as this will likely have a considerable bearing on the degree to which innovations are adopted. [*Sample indicators: existence of explicit incentives to innovate as reported by department members or through direct observation; presence and levels of involvement of department heads and senior members of the department in such activities]*

In closing, it is again important to recognize the importance of qualitative data in examining organizational climate and culture. Many of the specific domain areas reported in this section to some extent overlap the "harder" descriptors of organizational structure and resources described in the next subsection. But their intent is different--to provide a more comprehensive in-depth view of the degree to which different settings for instruction support or inhibit the development of curricular and instructional practices deemed important in other chapters. Any attempt to fully operationalize climate and culture must keep this original intent fully in mind, and not de-emphasize such factors simply because information about them is difficult to collect.

2. **Variations in Setting**

Since 1965, a considerable array of standard descriptors of higher education institutions has been developed, primarily for federal and state reporting purposes (NCES 1994), that are useful in identifying variations in setting. At the same time, higher education researchers have developed a number of applicable taxonomies of institutions and of organizational settings within institutions (Boyer 1987, Birnbaum 1989). Though constructed for purposes of basic description, much of the resulting

information is related to instructional conditions. At the departmental or unit level within institutions, in contrast, there is far less standardization in the ways in which descriptive information have been compiled. In general, however, domains of interest at the department or unit level parallel those for the institution as a whole.

2.1 **Basic Characteristics**. This domain is intended to capture the most fundamental differences in organizational settings, including size, type etc., primarily for purposes of disaggregating other information. At the institutional level, the following sub-domains will be relevant:

2.1.1 **size** *[Sample indicators: Total FTE enrollment, total number of full-time faculty]*

2.1.2 basic institutional **type** and **control** [*Sample Indicators*: Carnegie or IPEDS classification, public vs. private control]

At the department or instructional unit level, such basic considerations further include:

2.1.3 **size** *[Sample indicators: total instructional staff, total number of sections offered, number of majors and FTE of course-credits generated by mathematics courses]*

2.1.4 basic **instructional responsibility** with respect to undergraduate teaching *[Sample indicators: proportion of the institution's total offerings and enrollments represented by undergraduate mathematics offerings and enrollments at the lower-division, upper-division, and basic skills (remedial) levels]*

2.2 **Mission and Goals**. This domain is intended to capture fundamental differences in orientation and intent. Such differences profoundly affect both organizational structure and the deployment of resources, as well as conditioning faculty priorities. Among the most important elements to be considered at the institutional level are:

2.2.1 basic **mission differences** including distinctions between:

2.2.1.1 **research/service vs. teaching emphasis** in the mission. *[Sample indicators: percentage emphasis on teaching included in institution's promotion/tenure criteria, percentage of total E&G Revenue represented by sponsored research support]*

2.2.1.2 **length of instructional programs and levels and types of degrees offered**. *[Sample indicators: number of programs by length, highest degree offered, proportion of degrees granted by level]*

2.2.1.3 **mix of program offerings**, including especially the balance between general arts and sciences programs, and technical or career-oriented training programs. *[Sample indicator: percentage of degrees granted by 2-digit CIP code]*

2.2.1.4 established **relationships with other institutions** or postsecondary providers such as transfer / articulation relationships, and / or with external clients such as employers, professional associations, etc. *[Sample indicators: percentage of transferable credits generated, percentage of degree programs accredited]*

2.2.1.5 differences in the **student body** that the institution is charged with serving, including:

2.2.1.5.1 undergraduate student **demographics** *[Sample indicators: percentage black or hispanic, percentage residing within 20 miles of campus]*

2.2.1.5.2 undergraduate student **enrollment behavior** *[Sample indicators: percentage of students attending part-time, proportion of first-time full-time students completing programs, time to degree completion]*

2.2.1.5.3 undergraduate student **preparation levels** *[Sample indicators: percentage of new first-time students assessed as requiring remediation in mathematics on entry; percentage of new first-time students achieving advanced placement in mathematics]*

2.2.1.5.4 undergraduate student **participation modes** *[Sample indicator: percentage of enrolled students completing course requirements through distance-delivery modes]*

2.2.2 specific **perspectives** inherent in the mission that may have an impact on the delivery of undergraduate mathematics instruction, such as:

2.2.2.1 orientation toward **application or practice** *[Sample indicator: percentage of graduates entering employment in a trade or a technology-related field immediately after completion]*

2.2.2.2 orientation toward **research-preparation or application in major field instruction** *[Sample indicator: percentage of institution's total graduates going on for advanced study in their disciplines; percentage of faculty reporting that disciplinary research training is their department's principal emphasis in instruction.]*

2.2.2.3 relationship between the mathematics department and specific **partner disciplines** within the institution *[Sample indicator: number/ percentage of programs requiring two or more mathematics courses beyond the general distribution requirements of the institution.]*

2.2.2.4 relationship with **external clients** (particularly employers) *[Sample indicator: percentage of programs requiring an internship/practicum or other placement in an actual work setting]*

2.2.3 specific **curricular demands for instruction in "mathematics" and how such instructional needs are met.** This dimension is intended to explicitly recognize and document the extent to which programs other than mathematics require mathematics instruction, and the degree to which they in essence "contract" with the mathematics department to provide such instruction through service courses or contrive ways to supply it themselves. In addition, it addresses external "clients" for mathematics instruction, including employers and professional associations or certification bodies. Specific aspects of this area might include:

2.2.3.1 the **basic "demand" for mathematics instruction**. Demand in this context reflects the overall requirements for "mathematics" instruction generated by the institution as a whole, regardless of whether such instruction is in fact delivered by a mathematics department. To be of maximum value, it should be broken down by clusters of "partner disciplines" such as the physical sciences, life sciences, social sciences, engineering, etc., and by the level and types of instruction required (e.g. statistics, calculus, etc.). For institutions with a strong orientation toward providing vocational or technical education, it should also reflect the needs and requirements of specific occupational fields, as expressed by members of external advisory boards. *[Sample indicator: total number of "math" credit hours per term, reported both as an absolute and as a proportion of total credits generated]*

2.2.3.2 current **division of labor among departments in delivering mathematics instruction** as defined above. This is intended to reflect the degree to which the mathematics department is in fact the primary supplier of "math" instruction throughout the institution, and in what particular areas it does so. *[Sample indicator: proportion of total "math" credits generated per year generated by courses offered by the mathematics department]*

2.2.3.3 the **specific clientele** for mathematics instruction. This is intended to provide a basic description of the characteristics of students taking mathematics instruction at various levels. At minimum, it should address gender and ethnicity although other characteristics might be considered. Its intent is to reflect both who is served, and how different student demographic groups are behaviorally "tracked" through the curriculum *[Sample indicator: percentage breakdown by ethnicity of mathematics enrollments at the 200-level].*

Most of the above domains are mirrored completely at the department level. Data sources for constructing goal-related indicators at this level, however, may be considerably more qualitative. In addition, consideration should be given at the department level to the following additional goal-related domains :

2.2.4 the **overall "center of gravity" of the department's teaching activity** with respect to service to other programs and levels of instruction provided. *[Sample indicators: proportion of lower-division mathematics credits taken by non-mathematics majors, numbers and percentages of total mathematics courses and enrollments at each level]*

2.2.5 departmental **commitment to undergraduate teaching** as reflected in the degree of staff interaction on teaching topics, willingness to discuss common instructional problems or issues, or the cases of individual students (see also the discussion in Chapter 1 on "Conceptualizing and Shaping Instructional Missions"). [*Sample indicators: reported levels and frequency of formal or informal discussions about specific pedagogical issues, or about the cases of individual students and their difficulties; existence of requirements for faculty office hours, length of advertised office hours and student utilization of office hours]*

2.3 **Academic Structure, Governance, and Policy**. This domain is intended to capture differences in the ways in which institutions and departments are structurally configured and how academic decisionmaking takes place. At the institutional level, the following considerations will be particularly relevant:

2.3.1 **academic administrative structure**, including:

2.3.1.1 the **types of instructional units** present (e.g. departments, divisions, etc), and the lines of communication among them. Of particular importance here is the administrative organization housing mathematics faculty--for example, whether there is a distinct mathematics department or whether mathematics faculty are housed within a larger divisional structure. *[Sample indicators: total number of instructional units, span of control of academic administrators]*

2.3.1.2 **locus of fiscal and curricular decisionmaking** *[Sample indicator: average proportion of departmental budget under the discretionary control of the department chair]*

2.3.1.3 **organizational support for undergraduate instruction** such as the presence of specific offices or administrators charged with oversight of undergraduate education, multidisciplinary programs, honors programs, etc. In two-year colleges, the presence of similar offices or administrators for coordinating remediation and / or transfer instruction. *[Sample indicator: number and staffing of such offices in relation to institutional size]*

2.3.2 **faculty governance arrangements**, and especially faculty roles in key decision areas such as budgeting, institutional planning, curriculum review, etc. [*Sample indicators:* presence and powers of key academic and budgetary review committees of the institution's faculty governance body; proportion of faculty belonging to a collective bargaining organization and the role of such an organization (if present) in academic and budgetary decisionmaking]

2.3.3 **curricular review and decisionmaking procedures**, including:

2.3.3.1 mechanisms for regularly **reviewing academic programs** and particularly the role of "partner departments" in setting curricular priorities for service instruction, and the level(s) at which this takes place (e.g., entire curriculum vs. individual course). *[Sample indicator: presence of active academic program review procedures and involvement of non-departmental faculty and/or external advisory bodies in reviewing a given department's programs]*

2.3.3.2 mechanisms for **proposing curricular revisions and approving new courses**. *[Sample indicator: proportion of new course proposals*

accepted on initial submission, specific involvement of non-departmental faculty and/or external advisory bodies in this process]

2.3.3.3 the extent and utilization of **outcomes assessment** and **course-evaluation** procedures, and the level(s) at which this takes place (e.g., entire curriculum vs. individual course). See also the discussion of "Internal Monitoring of Curriculum and Instruction" in Chapter 1. *[Sample indicators: presence of explicit policies on assessment and course evaluation; proportion of classes covered by such policies and the frequency of data collection; citations of assessment/evaluation results in curriculum revision or other proposals for change]*

2.3.3.4 the **basic orientation of review and evaluation procedures**-- for example whether they involve a longitudinal / developmental perspective in examining student growth and performance in subsequent courses, or whether they emphasize effectiveness in covering particular content areas *[Sample indicator: use of performance in subsequent coursework as a common evaluative technique in reviewing curricular structure and the effectiveness of pre-requisite courses]*

Again, these domains will be broadly similar at the level of the individual mathematics department, and parallel indicators should be developed at that level. In addition, consideration should be given to:

2.3.4 **formal departmental organizational features affecting undergraduate study**. These might include specific organizational arrangements for handling basic skills instruction (e.g. a developmental studies division), administrative positions assigned responsibility for undergraduate instruction, departmental curriculum committees and their specific approval roles, etc. *[Sample indicators: presence or absence of such features, and their specific reported roles and responsibilities]*

2.3.5 procedures for **curriculum review and approval of new courses** [as above]

2.3.6 the **specific involvement of "partner" disciplines and programs** (i.e. those requiring substantial amounts of service instruction in mathematics as prerequisites or co-requisites of their own programs) in departmental or curricular decisionmaking. *[Sample indicator: reported formal and informal involvement in discussions*

about mathematics offerings on the part of Deans, department chairs (or their designees) in disciplines such as engineering, the sciences, health professions, etc.]

2.3.7 **informal organization features of the department affecting undergraduate study**. These might include established subdivisions of larger "math" departments specifically concerned with applied mathematics or mathematics education, or *ad hoc* networks of faculty interested and engaged in such initiatives as calculus reform. *[Sample indicator: proportion of faculty reporting meeting at least once per week with colleagues to discuss topics related to changing pedagogy in mathematics, calculus reform, or similar topics.]*

2.4 **Fiscal, Physical and Human Resources**. This domain is designed to reflect the varying levels and kinds of resources--and the condition and deployment of those resources-- that are available to institutions and mathematics departments. Indicators of resources are important for two reasons. First, resource levels may substantially condition the delivery of instruction and indicators of resource level are thus useful for disaggregating other more relevant measures of performance. But secondly, investments in varying types of resources (e.g. faculty support and training) may themselves be indicative of instructional quality, and be therefore worth monitoring in their own right.

The resources available to an institution or department are of quite different kinds. At the very least, three types of resources should be considered. **Fiscal resources** condition all areas of institutional operations, but will generally exert this influence at a fairly high level of generality. **Physical resources**--most notably instructional equipment and classroom facilities--though dependent to some extent on fiscal condition, will in general exert a more direct effect on the shape of instruction and its outcomes. Finally, **human resources**--in particular the characteristics, training, and behavior of the instructional staff--will likely be decisive. Furthermore, the continuum of interest from institution to department with respect to resources should probably entail different levels of emphasis among these three basic types. Indicators of fiscal condition will in general be more useful at the institutional than at the departmental level, while indicators reflecting the condition and use of instructional facilities and equipment or the faculty will more fruitfully be deployed primarily at the level of the individual mathematics department.

In developing indicators of resources of all three kinds at any level, moreover, three distinct dimensions should be considered. A first is the absolute **level and condition** of these resources--for example numbers of instructional staff and their educational backgrounds, or amounts, and types of instructional equipment. A second relevant dimension is the **use or deployment** of these resources--for instance the teaching assignments of staff, or the distribution of instructional equipment across different kinds of classes or settings. A final dimension is **investment in the renewal, replacement and support** of these resources--for example, investments in faculty development, policies regarding the depreciation and replacement of instructional equipment, or the provision of technical support to faculty in delivering instruction. Applying this rough taxonomy to the overall question of resources at both the institutional and department level yields the following array:

2.4.1 **fiscal condition**. As noted, indicators of overall fiscal condition are probably most fruitfully developed at the institutional level, to be used in distinguishing what are likely to be vastly different instructional conditions. Potential dimensions of interest include:

2.4.1.1 **available operating funds** *[Sample indicator: Total institutional Educational and General (E&G) expenditures per FTE student and total instructional expenditures per FTE student]*

2.4.1.2 specific **restrictions or specifications affecting the use of operating funds**, such as limits on certain types of expenditures or the degree to which budgets are (or are perceived to be) restricted or enrollment-driven *[Sample indicator: proportion of faculty believing that sufficient resources are available but are not allocated to appropriate educational purposes]*

2.4.2 **characteristics and development of the instructional staff**. Also as noted, these should be developed in greater detail at the level of the individual mathematics department than for the institution as a whole. Nevertheless, at both levels, the following factors are important:

2.4.2.1 **numbers and levels of instructors and instructional positions** broken down by category--including tenure-track, adjunct, part-time, graduate teaching assistants, or paraprofessionals. *[Sample indicator: numbers and FTE of the above, disaggregated by standard categories such as those*

contained in the Conference Board of the Mathematical Sciences (CMBS) survey (Albers, Loftsgaarden, Rung and Watkins 1992), or in the NCHEMS/NCES Human Resources Classification scheme (Jones and Lovell, forthcoming)]

2.4.2.2 **demographic characteristics** of the instructional staff, including gender, age, and ethnicity [as above]

2.4.2.3 **preparation and experience of staff**, including academic background, teaching experience, explicit preparation in pedagogy, number of years at the institution, proportion tenured, experience in current teaching assignment, etc. *[Sample indicator: percentage of core instructional staff with terminal degree; average number of years of teaching experience of instructional staff by level]*

2.4.2.4 **utilization of instructional staff**, in terms of basic assignment and deployment to different types and levels of instruction. This would normally include:

2.4.2.4.1 **basic assignment** of faculty among the roles of teaching, research, and professional service *[Sample indicator: percentage or credit-unit-equivalent assignments of core faculty to specified activities]*

2.4.2.4.2 **actual allocation of faculty time** among various functions, including research, service, direct instruction, class preparation, advising, office hours, etc. *[Sample indicators: percentage of faculty work-hours reported for various activities obtained through faculty surveys; departmental policies on faculty time-allocations to such functions as advising and office hours, as well as direct observation of these activities]*

2.4.2.4.3 **instructional deployment of staff** by type and level of teaching assignment *[Sample indicators: percentage of credits in 100-level courses generated by part-time faculty; percentage of lower-division offerings taught by tenure- track faculty; percentage of credits in remedial courses generated by part-time instructors]*

2.4.2.5 **development of faculty as an institutional or departmental "asset."** Indicators under this heading reflect the institution's or department's commitment to ensuring that appropriate attention is given to renewing and supporting instructional staff. In particular, this dimension should reflect:

2.4.2.5.1 **faculty compensation** and other benefits such as sabbatical policies, use of release time, etc. *[Sample indicator: average faculty salary by rank in comparison with peer institutions]*

2.4.2.5.2 **turnover and rates of replacement** of instructional staff *[Sample indicator: proportion of instructional staff at the institution for five years or less]*

2.4.2.5.3 **professional activity** of faculty as reflected by participation in professional meetings, membership in relevant disciplinary associations or organizations, or other activities reflecting vital contact with colleagues and the discipline. *[Sample indicators: proportion of faculty attending at least two professional meetings per year; faculty participation in electronic discussion groups, journal subscriptions, or similar indicators of continuing disciplinary engagement]*

2.4.2.5.4 **faculty development opportunities** and the use made of these opportunities-- especially in the area of improving pedagogy. *[Sample indicators: numbers and percentage of faculty by level attending at least one teaching workshop per year; reported frequency by faculty of informal "mentoring" activities such as visiting one another's classes, mutual critique of teaching techniques, etc.]*

2.4.2.5.5 **interdisciplinary activities** and encouragement of **contact across departments**--especially when these are intended to foster active linkages between mathematics instructors and faculty drawn from particular

client disciplines. For two-year colleges, contact with counterpart mathematics departments in four-year institutions, as well as with client disciplines in such institutions, should also be considered. *[Sample indicator: number of experiences of this kind reported by full-time faculty members.]*

2.4.2.5.6 attention devoted to the **physical and organizational support of faculty** and their activities-- especially instructional activities. Of particular concern here is the support provided to faculty in directly discharging their teaching responsibilities especially in the area of technology, and administrative support which allows faculty to avoid costly diversions of time to non-instructional activities. Largely appropriate at the level of the individual department, indicators of this dimension might include:

2.4.2.5.6.1 faculty **office space**, including its allocation, configuration, location, and policies governing who gets it and how *[Sample indicator: percentage of faculty with office space suited to meeting with individual students in confidence]*

2.4.2.5.6.2 availability and utilization of **informal faculty gathering-places** such as lounges or dining facilities, particularly as these help to facilitate discussions about students or instructional situations *[Sample indicator: does the department have a faculty lounge or other designated space for faculty to gather in comfort for informal discussion]*

2.4.2.5.6.3 **distribution and configuration** of classroom, laboratory, and other instruction-related space; especially important here is the degree to

which assigned space defines a physical "center" for departmental life and provides multiple opportunities for contact both among faculty and between faculty and students *[Sample indicator: percentage of undergraduate mathematics classes held in a single definable location--e.g., building, floor, wing, etc.]*

2.4.2.5.6.4 **equipment** available to faculty such as computers, access to electronic mail, etc. *[Sample indicator: percentage of faculty with access to Internet through office space on campus and logging on at least once a day]*

2.4.2.5.6.5 **staff support** available to faculty in the realm of technical expertise and support to maintain and set up instructional equipment or to assist in developing course materials and presentations, as well as basic administrative support for such functions as duplicating and secretarial functions. *[Sample indicator: FTE ratio of support personnel to departmental faculty]*

2.4.2.6 special considerations regarding the **use of adjunct or part-time instructors, and/or graduate teaching assistants**. A large proportion of lower- division and remedial instruction in most institutions is delivered by part- time or adjunct staff or by graduate teaching assistants. At the same time, current teaching assistants constitute the future faculty workforce, and indicators of how they are being trained to deliver undergraduate instruction is itself worth monitoring. For both reasons, the full inclusion of teaching assistants and part-time faculty in the instructional life of the department and their own perception of being part of a supportive group are critical. Consistent with this, indicators might fruitfully be developed around the following topics:

2.4.2.6.1 the specific **roles and levels of responsibility** assigned to such personnel-- for instance, full section teaching responsibility, conduct of study sessions or labs, assignment as graders, etc. *[Sample indicators: percentage of sections or review sessions conducted by non-tenure-track faculty; percentage of students taking first-year mathematics courses reporting that their primary contact was with a teaching assistant]*

2.4.2.6.2 **recruitment and selection criteria** for such personnel. *[Sample indicators: average number of years of teaching experience and educational background of adjunct instructors; at two-year colleges, the administrative level at which hiring decisions are made and the actual involvement of mathematics instructors in making such decisions]*

2.4.2.6.3 **supervision and monitoring arrangements** for such personnel. Are there, for instance, explicit mentoring arrangements in place such that the teaching performance of individual adjunct instructors assigned to deliver multi- section courses is regularly assessed, or is the performance of teaching assistants regularly monitored as part of their academic program? *[Sample indicator: average number of meetings with a regular faculty member to discuss teaching performance and to provide guidance and feedback reported by teaching assistants and/or adjunct or part-time instructors]*

2.4.2.6.4 the degree of **formal training in teaching** provided to teaching assistants as part of their academic program. This dimension is intended to capture the overall extent to which teaching assistants are developed as "apprentice teachers" in addition to the emphasis placed on nurturing their disciplinary growth. Specific aspects that might be considered include workshops and other training provided in advance of their employment as TA's, whether participation in

these activities is mandatory and formally evaluated, and whether it is a formal and continuing part of their program. *[Sample indicators: percentage of graduate teaching assistants receiving initial (and ongoing) formal training in pedagogy; student evaluations of the effectiveness of teaching assistants in the classroom]*

2.4.2.6.5 the degree of **training**and **career support** provided to adjunct faculty by the department. This dimension is intended to reflect parallel concerns about formal pedagogical training provided to part-time faculty. In addition, it is intended to reflect the degree to which part-time faculty are supported and mentored as members of the department on an ongoing basis, and their career paths enhanced. *[Sample indicators: average number of years that part-time instructors have been teaching as part-timers; reasons for choosing to teach on a part-time basis; incidence of conversion of part-time instructors to full-time status; average number of institutions at which part-time instructors are (or have been) employed]*

2.4.2.6.6 the degree of **physical support** provided to part-time faculty and teaching assistants to help them discharge their instructional role such as office space, telephone access, access to E-mail, etc. *[Sample indicator: percentage of TA's and/or part-time instructors with sufficient E-mail access to enable them to conveniently respond to student questions or provide feedback to students at least twice per day.]*

2.4.3 **extent, condition, and renewal of equipment and facilities.** Again, indicators listed under this domain will be more directly applicable at the department or unit level than to the institution as a whole. However, it is important to emphasize that due to the increasing prominence of technology in mathematics instruction in the form of computer-assisted instruction, interactive math labs, and the use of graphing calculators, this contextual domain is especially important to monitor. As noted in Chapter 1 ("Are Instructional Missions Changing?"), not only are those

developments important to track for their own sake, but their potential effect in transforming the fundamental nature of mathematics instruction is important to recognize explicitly in any future system of indicators. Specific contextual dimensions related to this area include:

2.4.3.1 the **characteristics and condition of instructional facilities** such as classrooms, libraries, labs, study spaces, etc., including:

2.4.3.1.1 **classroom and laboratory** space and its configuration in relation to instructional objectives. For instance, if small-group problem-solving is an instructional objective, to what extent are existing facilities adapted to this objective *[Sample indicators: average number of stations per classroom by class level; percentage of classrooms with moveable furniture; percentage of classrooms equipped with computer projection or networking capabilities]*

2.4.3.1.2 **library facilities and resources**, including their location and adequacy *[Sample indicator: library holdings in mathematics or mathematics-related topics in comparison to peer institutions]*

2.4.3.1.3 **informal gathering-places** or study areas for student and/or faculty use. Particular emphasis here might be placed on the availability of space suitable for tutoring or out-of-class peer contact. *[Sample indicator: existence of a department-level space allocated to mathematics majors and faculty]*

2.4.3.2 the **characteristics and condition of instructional equipment** including computers, graphing calculators, computer-projection equipment, etc. Specific dimensions might include:

2.4.3.2.1 **availability and distribution** of instructional equipment *[Sample indicators: number and characteristics of computer-equipped classrooms; existence and utilization of institutionally-administered calculator loan or rental programs]*

2.4.3.2.2 **age and technical adequacy** of equipment in relation to instructional objectives *[Sample indicator: proportion of current equipment inventory that is obsolescent by current industry standards]*

2.4.3.2.3 **provision of support** for computing or instructional equipment in the form of troubleshooting and repair/replacement *[Sample indicator: average time required to repair or replace a defective piece of instructional equipment in regular classroom use]*

2.4.3.3 **utilization of and access to instructional facilities and equipment**, including:

2.4.3.3.1 **policies and procedures governing access** to specific facilities or the use of specific types of equipment. This dimension includes the level at which such assets are "owned" within the institution--for instance, can the individual department make decisions about access or must this be requested from higher administrative levels? *[Sample indicator: lead time and procedures necessary to obtain access to a networked classroom for a specific class session]*

2.4.3.3.2 **actual utilization** of specific types of classroom space and specific types of instructional equipment by level and type of class. *[Sample indicator: proportion of first-year calculus courses held in theater-style classrooms without projection equipment]*

2.4.3.4 **renewal** of instructional technology, equipment and facilities, including:

2.4.3.4.1 **policies regarding the replacement and maintenance** of instructional equipment and classroom facilities *[Sample indicator: whether depreciation of plant and equipment is "expensed" in the operating budget or otherwise budgeted for,*

as opposed to simply occurring periodically in a capital request]

2.4.3.4.2 **actual levels of investment made in facilities and equipment replacement and renewal**
[Sample indicator: percentage of overall book value of current instructional equipment holdings represented annually by new equipment purchases]

2.5 **Instructional Support Resources.** Both institutional and departmental investments in instructional support can be identified as subcategories under one or more of the domains already covered. For a variety of reasons, however, they are worth independent treatment. First, commitment to supporting and developing undergraduate instruction tends to be pervasive: actions taken in one arena tend to correlate highly with those taken in others. Such actions also are important not only for what they constitute in themselves, but as evidence of the presence of a wider set of institutional or departmental values. Thus it is useful to think of such indicators as a body, as their alignment or congruity in a given setting may communicate something powerful about what is happening. Secondly, there are a variety of actions that institutions or departments may take that do not fit neatly into the categories outlined earlier. Among these are specific policies governing the development of new courses, or resources invested in instructional development (for instance, resources associated with supporting the introduction of new technology into the classroom).

As in the case of human and physical resources, the center of gravity for indicators development in this domain is properly placed at the level of the individual department. At the same time, some information about general institutional investments in instructional support may be useful in providing a broader picture with which the department is either consistent or at odds. To the extent they are at odds, of course, the chances of the department being able to sustain such activities in the long run are diminished.

Specific dimensions of interest within this domain include:

2.5.1 **support for curriculum development**, such as:

2.5.1.1 departmental (and to some degree, institutional) procedures for **encouraging the development of new courses or for proposing changes in existing courses**
[Sample indicator: proportion of total course inventory

formally and comprehensively reviewed or evaluated in a three-year period, and by whom]

2.5.1.2 **support provided to faculty for developing courses or revising curricula** through release time, additional compensation, travel to institutions offering "best practice" in a particular type of instruction, etc. *[Sample indicator: proportion of faculty receiving some form of compensation or release for purposes of curriculum or instructional development]*

2.5.1.3 specific mechanisms for **ensuring coherence and quality in multi-section courses**, such as course team reviews, policies on common texts or examinations, or similar activities across courses in prerequisite sequences. *[Sample indicator: percentage of sections in which cross-grading or team- grading "rangefinding" sessions occur to ensure consistency in grading]*

2.5.1.4 specific mechanisms for **ensuring consultation with the instructional needs of "partner" disciplines** to ascertain their needs, build partnerships, determine satisfaction, and explore opportunities to develop interdisciplinary instructional approaches. *[Sample indicator: occurrence of at least one face-to-face meeting between mathematics course-team representatives and representatives of specific client disciplines such as engineering, sciences, health professions, business, etc.]*

2.5.2 **support for instructional development**, such as:

2.5.2.1 departmental (and to some degree, institutional) resources for **assisting faculty to develop their proficiency in classroom instruction** such as formal faculty development programs, seminars, colloquia, visiting speakers, etc. (See also the discussion in Chapter 1 on "Methods of Supporting Instruction.") *[Sample indicator: numbers of such opportunities/activities offered annually in relation to the total size of the instructional staff]*

2.5.2.2 **levels of utilization** of such opportunities by type of staff member *[Sample indicator: participation rates by category and level of instructional staff]*

2.5.2.3 **coverage** of such activities in terms of such issues as the relative attention dedicated to disciplinary content vs. approaches to pedagogy [*Sample indicator: reports of faculty engaging in such activities about their relative coverage and emphasis]*

2.5.2.4 **length of time** that the department (or institution) have been engaging in such activities *[Sample indicator: total number of terms in which the number of faculty served by formal instructional development activities exceeded 25% of the total number of faculty]*

2.5.2.5 specific mechanisms for **determining what kinds of instructional development activities are needed** and who should be exposed to them *[Sample indicator: existence of an explicit connection between the results of student course evaluations or classroom observation visits and the content or emphasis of subsequent instructional development efforts]*

2.5.2.6 departmental (and to some degree, institutional) **incentives affecting staff participation in such activities** *[Sample indicator: existence of departmental policy that participation in workshops is expected of all new instructional staff]*

2.5.2.7 **access to student records and other materials** directly related to advisement or the support of teaching *[Sample indicator: percentage of instructional staff able to call up individual student records in easily-interpretable form from their office computers]*

2.5.2.8 presence, adequacy, and utilization of **instructional technology or media services** at the departmental (and to some extent, the institutional) level *[sample indicator: proportion of instructional staff using such services to assist in the presentation of at least one class per term]*

3. External Environment

Many of the things that colleges and universities do, and are able to do, are strongly conditioned by factors outside their control. While far removed from the instructional action, such factors may exert a strong indirect influence on both instructional delivery and the ability of an institution or

department to innovate. Full coverage of such factors is by nature well beyond a project such as this. But three aspects of the outside environment may exert sufficient influence on institutional behavior to merit explicit consideration in the process of developing indicators.

3.1 the **governance context of the institution**. Currently, some sixty-five percent of undergraduate students attend institutions that are part of public multi- campus systems (McGuinness 1996). Other institutions are directly linked with one another through articulation agreements or are affected by statewide academic policies that can exert a considerable influence on their discretion with respect to curricular structure and course content. Finally, public institutions are required to meet growing accountability requirements centered on student outcomes and, increasingly, are assessed in terms of standard indicators of performance (Ruppert 1994). Given these trends, specific dimensions of this domain that might be relevant for indicators development include the following:

3.1.1 whether the campus is **part of an integrated multi-campus system**. One end of this continuum is represented by such states as Florida in which common course numbering is used by all public institutions; the other is Michigan, where public institutions are largely autonomous. Regardless of structure, the essential domain of interest is the degree to which curricula and / or academic policies must be approved by higher authorities outside the institution itself. [*Sample indicator: numbers of external approvals necessary to make curricular modifications and average time to receive such approval]*

3.1.2 **actions of state governments, agencies, or governing boards to sanction or provide incentives for specific initiatives affecting undergraduate and technical education.** Since the early 80's boards and state governments have exerted a growing influence on public institutions directed toward the "reform" of undergraduate instruction. Examples include the availability of incentive grant dollars to support new forms of teaching or curricular designs, assessment of outcomes, and statewide or multi-campus technical assistance efforts aimed at faculty development. While the effects of such efforts rarely directly affect the individual department of classroom, their presence may strongly condition the actions that an institution chooses to take consistent with these objectives. It is important to note, moreover, that this conditioning is not always positive; in some state contexts, government action has actively stimulated

institutional change while in others it has heightened faculty resistance to change because it raises wider concerns about inappropriate interference. As a result, institutional reactions to such external stimuli should also be considered. [*Sample indicator: presence or strength of legislative, agency, or governing board mandates on undergraduate assessment or teaching policies, and/or the identification of undergraduate education as a "priority" area for investment or reform.]*

3.1.3 the presence and strength of **articulation agreements or similar academic "client" relationships with other institutions.** The actions of large numbers of institutions in the arena of undergraduate mathematics instruction--especially in the community college sector--are strongly influenced by the academic policies and requirements of others. As a result, the ability of departments within such institutions to introduce curricular innovations and academic policies entirely on their own is substantially constrained. Where such constraints are present, an effective indicators system ought to reflect them. Of particular importance here, moreover, are the origins and character of such agreements--for instance, whether they are a result of a bureaucratic mandate applied uniformly to all coursework or whether they are developed and administered in a participatory fashion that features the active involvement of mathematics faculty from the institutions affected. [*Sample indicator: percentage of mathematics courses at the institution that are part of formal articulation agreements with other institutions]*

3.2 **external resource conditions.** Since about 1990, overall fiscal conditions in higher education have been severely constrained, but these conditions have affected states differentially. At the same time, a variety of external sources of special-purpose funding have arisen that may allow institutions that have access to them substantial advantages in making improvements. While it is beyond the scope of the intended indicators system to fully describe these trends, the final scheme should broadly reflect these constraints and opportunities. Specific dimensions that might be considered include:

3.2.1 general **fiscal conditions** for higher education in the state. While largely limited to the public sector, this factor will exert a powerful constraining influence on the overall capacity of the institution to deliver instruction. On the other hand, recent experience is suggesting, severe financial constraints may induce institutions (and systems) to engage in more extensive levels of

curricular experimentation and innovation as they search for greater efficiencies. [*Sample indicator: three-year trends in the percentage change of overall allocations to public higher education in the state in which the institution is located (in constant dollars)]*

3.2.2 the presence of, and the institution's access to, **external sources of funding and other support consistent with the improvement of undergraduate education**. National agencies such as NSF and FIPSE have recently made substantial investments in projects aimed at improving undergraduate instructional delivery, as have a few private foundations (e.g. the Busch grants in Minnesota and the Dakotas, and the Pew Charitable Trusts). In addition, as noted, a number of states have established categorical funding programs aimed at such objectives. Insofar as the institution is able to access such external sources of support, its ability to undertake improvements in instruction is enhanced. [*Sample indicator: total amount of support received from such sources for purposes of instructional improvement over the past three years, both in absolute terms and normalized by FTE enrollment]*

3.3 **other external influences.** Several additional external conditions are worth some consideration for the development of indicators because of the influence they may exert on the delivery of undergraduate mathematics instruction. They include:

3.3.1 **trends in technology,** and especially its pricing. Technological improvements that affect the delivery of undergraduate mathematics instruction range from the development of compact graphing calculators to fiber-optic distance delivery, and the economics of these developments is changing rapidly. Many observers maintain that technologies now too costly will be quite affordable in the future. As a result, the institution's access to such solutions may be strongly affected. As noted strongly in Chapter 1 ("Impacts of Technological Innovation"), these trends are not auxiliary to mathematics instruction but have the potential to transform its nature entirely. The use of appropriate technology, for instance, is integral to the emphasis on visual representation prominent in reform calculus, and the use of technology in the form of computer-assisted instruction may enable for higher levels of active engagement than traditional methods of delivery. As a result, the institution's (and department's) access to such technology may decisively affect the character of instruction it is capable of providing. [*Sample indicator: average unit price of commonly-used pieces of instructional*

equipment in relative to household income for the community or state in which the institution is located]

3.3.2 **actions of disciplinary associations and other external bodies** in encouraging the discussion of instruction and the dissemination of new instructional approaches. Increasingly, disciplinary associations in mathematics have become more actively involved in encouraging discussions of instructional improvement, and have provided a forum for such activities. These include, principally, the Mathematical Association of America, the American Mathematical Society, and the American Mathematical Association of Two-Year Colleges. Overall, trends in the actions of these bodies are important to monitor because of the influence they may exert on the success of individual reform efforts on campus. Similarly, the institution's access to and contact with such discussions might be monitored. [*Sample indicators*: *proportion of sessions at AMA, AMATCC, ASA, and AMS meetings devoted to issues of curriculum and pedagogy; participation of those attending such meetings from a given institution in at least one such session]*

3.3.3 **trends in accountability.** Some two-thirds of the states now require institutional assessment of undergraduate outcomes from all public institutions as an element of accountability reporting. All six regional accrediting organizations do so as well. Recent federal actions calling into question the effectiveness of such requirements have stimulated considerable action on the part of both to make these mechanisms stronger and more uniform. Both the presence of and the specific institutional reactions to these developments may be important as such actions may actually increase faculty resistance to change and thereby inhibit reform. [*Sample indicator: presence and institutional reactions to external accountability mandates as reported by institutional leadership]*

Many additional elements of the external environment may be of interest, but it is important to the development of a viable indicators approach not to allow this list to get too long. The above topics appear minimal for such a scheme.

C. Sources of Data for Indicators Development

While it is beyond the scope of this chapter to operationalize the types of indicators proposed, some consideration of sources of evidence is warranted.

Consequently, this section is intended to briefly review the most promising such sources, outline their suitability for the development of indicators in particular domains of interest, and sketch their feasibility given currently available approaches and methodologies.

1. Available Methods and Approaches

Adequate indicator systems demand data drawn from a number of sources, and a large variety have been used to investigate one or more of the domains reported in the previous section. The most prominent such sources are briefly presented below.

1.1 **published statistics available nationally or at the state level.** These will be most useful in the development of basic institutional descriptors of size, enrollment characteristics, fiscal resources, faculty, research activity, and program array. The principal sources available are the annual surveys conducted by the National Center for Education Statistics (NCES) under the auspices of the Integrated Postsecondary Educational Data System (IPEDS). Additional information on such topics as overall research activity is available from the National Science Foundation. In addition, individual state systems of higher education typically maintain more detailed institutional surveys covering curricular and program offerings. Occasionally these will include the activities of independent as well as public colleges and universities. And more than two-thirds of the states have established (or in the process of implementing) student unit-record information systems at the postsecondary level which contain highly-detailed information on student enrollments and characteristics (Russell and Chisholm 1995). Occasional national studies conducted by OERI or NCES can provide a few additional general indicators of importance. Examples include the transcript studies included as part of the National Longitudinal Study (NLS-72) and High School and Beyond (HS&B), which might be employed to construct indicators of the proportion of "math" content actually delivered by mathematics departments, or of the national proportion of students engaging in remedial mathematic in postsecondary institutions.

1.2 **institutional or unit questionnaires.** A standard procedure for obtaining indicative data on institutional and/or departmental contexts is to survey institutions or departments. Generally in such work, designated individuals such as academic vice-

presidents or department chairs are considered "expert witnesses" who are in a position to provide the required information--or who can delegate response to someone who has it. Where this approach is used, the respondent is generally identified, with provisions made for telephone or other follow-up. Because a single individual is generally used as an informant, however, results of such surveys should be treated with some caution. Prominent examples of this approach at the institutional level relevant to the goals of the NSF Mathematics Indicators Project are the Academic Management Practices Survey developed by the National Center for Research on Postsecondary Teaching and Learning (NCRPTL) at the University of Michigan and the Institutional Inventory associated with the "Seven Principles of Good Practice in Undergraduate Education" developed by the Johnson Foundation (Gamson and Paulsen 1989). The National Study of Postsecondary Faculty (NSOPF) administered by NCES also contains an institutional survey that might be modified to contain appropriate items on faculty support and development policies. Such instruments typically devote considerable attention to issues noted under "climate and culture" in the previous section. Alternatively, such instruments may serve as excellent protocols for site visits or interviews conducted by a visiting data-gathering team. For mathematics departments, an excellent vehicle of this type already exists in the form of the "Survey of Undergraduate Programs in the Mathematical Sciences and Computer Science" conducted every five years by the Conference Board of the Mathematical Sciences (CBMS), which already addresses matters of curricular coverage, faculty characteristics and preparation, and instructional support. Regular "Notices" surveys of Mathematics departments also conducted by the American Mathematical Society could also be tapped to gather such information.

1.3 **institutional records, documents, and publications.** These include such diverse sources as catalogues documenting academic policies, budgets indicating investments in particular types of activities, or faculty handbooks outlining roles and responsibilities. Typically, these are used in conjunction with site visits or interviews to more fully examine such questions as the level of attention that the institution or department dedicates to faculty development or the existence of special offices intended to support undergraduate teaching and learning. Occasionally, a sample of documents such as undergraduate catalogues can yield

simple but valuable indicators of institutional effort--for example the percentage of institutions with common general education competency requirements or the number of articulation agreements of various kinds in place with other institutions. In general, however, it is expected that this source will be used in conjunction with other approaches.

1.4 **questionnaires or surveys administered to samples of faculty and staff.** This method constitutes the modal approach now used for studies of campus and organizational culture. Prominent examples include the established Institutional Goals and Institutional Functioning Inventories (IGI, IFI) developed at ETS to examine mission solidarity and patterns of perceived resource allocation, the Institutional Performance Survey (IPS) developed at NCHEMS to examine perceptions of institutional priorities and overall institutional culture and decisionmaking style, and the faculty questionnaires developed by Astin (1993) for use in the Exxon study of general education focusing on such elements of culture as "student-orientation" or for instructional philosophy. Many similar approaches have been used in single-institution studies and in comparative assessments of organizational culture. All such approaches survey a cross-sectional sample of respondents at each institution in order to arrive at a reliable estimate (Krakower and Niwa 1985). While applied typically to the institution as a whole, this approach represents a reasonable method for obtaining information about individual departments--especially in more elusive domain areas--and is considerably more reliable than relying on single informants.

1.5 **national surveys of faculty and students.** This approach is predominantly used to document faculty and student attitudes, experiences, and activities. As such, it is particularly suitable for examining overall faculty values toward teaching, reported emphasis on teaching in processes like promotion and tenure, and overall levels of faculty participation in activities intended to improve instruction. Primary examples of current instruments include the faculty questionnaires associated with the Astin/Exxon general education study (Astin 1993) and the National Study of Postsecondary Faculty (NSOPF) administered by NCES. Student surveys administered on a national basis will be primarily useful in tracking key student experiences as noted in Chapter 3. Within the domains of institutional and department context, however, such instruments can be useful for collecting

data about the effectiveness of teaching assistants or the degree to which students perceive that their concerns are listened to, as noted under the heading of "student centeredness" above. Examples here include the nationally-administered Cooperative Institutional Research Program (CIRP) freshman and follow-up surveys and the College Student Experience Questionnaire (CSEQ) developed by Robert Pace and now available through the University of Indiana. With limited national sample sizes, indicators of such factors could be obtained reliably for different institutional types. Far higher numbers of respondents, of course, would be required to obtain reliable indicators at the institutional level--though this approach might be used to gather data from a limited number of "indicator" institutions.

1.6 **site visits and interviews.** A large proportion of the items listed under "climate and culture" in the previous section are best obtained directly through site visits to campuses and departments or through in-depth interviewing. Indeed, such "ethnographic" approaches have gradually become the method of choice for those investigating matters of culture and climate. In general, of course, such methods will not typically result in single quantitative indicators of performance or condition. Rather, the "indicators" obtained through this method will constitute overall judgements by trained observers using standard observational protocols (Guba and Lincoln 1981). Obviously, such a method is expensive and can only be applied to a limited number of institutions. Given this constraint, consideration might be given to designing such site visits to verify or validate information collected through survey or "expert witness" formats rather than to provide indicators data directly.

2. Current Feasibility and Applicability to the Domains of Interest

Data sources noted in the subsection above have varying levels of applicability to the specific aspects of institutional and departmental context noted in section B. Figure 2 attempts to summarize their relative suitability for development as indicators for each major domain dimension at three levels. "Not Suitable" indicates that the method will not provide the required information in any form. "Somewhat Relevant" indicates that the method will provide some information relevant to the domain of interest, but that better methods are available or might eventually be developed. Nevertheless, a case could be made for using such methods for these purposes if the data are relatively easily obtained, or if other methods are unavailable. "Highly

Suited" indicates that the method is particularly adapted to collecting data relevant to the specified domain, though it may of course be excessively costly or simply unavailable.

Figure 3, in turn, presents in summary form the current state of data-collection technology with respect to each method. This review is provided in several ways. The first column in the figure presents a classification of the current status of each method as a potential source of national indicators data according to the following taxonomy:

C - National and/or institution-specific data compiled according to this method currently exist in a readily-accessible form.

D - Data currently exist, but will need to be compiled across sources, aggregated, or otherwise manipulated to create a useful national indicator.

M1 - Such data do not currently exist, but methods are easily available to obtain such data on a national basis (e.g. valid survey instruments already contain relevant items or could easily be modified to obtain them).

M2 - Such data not currently exist, but methods exist to collect them--though such methods have not been applied nationally or for these purposes.

N - Such data do not currently exist, and new technologies will be needed to obtain them.

Figure 3 also indicates in summary form assessments of the estimated cost to collect data on a regular basis using each approach and, where appropriate, how costly it would be to develop the required capability. A final column of the figure presents a rough assessment of the level of validity or precision associated with the method in question, when applied to the domains for which it is deemed "highly suited" in Figure 2. Note here that a low rating does not mean that the method should under no circumstances be used. Rather it suggests that it be used with caution and generally in conjunction with other approaches.

Examination of Figures 2 and 3 suggests that a combination of institutional/unit inventories and questionnaires on climate and culture, occasionally validated through site visits, might be the most appropriate general approach. If site visits are contemplated as part of the data-gathering

strategies of the domains addressed by other chapters, however, it would be wise to include appropriate coverage of institutional and department context as part of the overall design of such visits. Certainly, experience has shown, direct observation is the most appropriate technique for discovering and documenting many of the domains treated in this chapter--especially those associated with climate and culture. This recommendation applies also to the kinds of questionnaires and surveys of faculty and/or students discussed as potential data-collection mechanisms in Chapters 1 and 3. If such surveys are eventually designed and deployed, the opportunity should be taken to include additional appropriate items on departmental and institutional context.

Examination of these two displays also allows consideration of some "low-end" and "high-end" options for indicators construction. At the low end, a feasible national approach could be developed that emphasizes, a) national statistics on institutions and contexts available through such sources as NCES and, b) items on organizational climate and teaching practices incorporated into regularly-administered national surveys of postsecondary faculty (e.g. NSOPF). This option would involve low expenditure on new data collection, could be implemented relatively quickly, and would be relatively unobtrusive. Principal costs are the staff time associated with conducting additional analyses of these existing data. Such an approach would provide indicators of visible institutional attributes that would be principally useful in disaggregating the results of other types of outcomes and process measures. But this approach would contribute little to an understanding of the departmental or unit level, or to the impact of extremely important climate and culture issues on instruction.

The "high-end" option involves a combination of specially-designed faculty and student surveys administered periodically to a broad national sample, together with site visits to a selected cross-section of mathematics departments located in a range of institutions intended principally to verify and further illuminate the findings of prior surveys. Site visits of this kind would be designed to interview selected faculty members and administrators, and to allow direct inspection of such materials as course descriptions, course and curricular review procedures, planning documents and other relevant publications, etc. consistent with the recommendations of Chapter 1. This approach, supplemented by available published statistics, would provide a rich array of contextual material in terms of which to interpret the results of other indicators described in this volume. It would, however, be relatively obtrusive and expensive, and should only be undertaken in conjunction with procedures for data collection already recommended by Chapters 1 and 3.

In making a decision about how much to invest in data- collection efforts of this kind, moreover, care should be taken to balance the real need for context

with the fact that information about domains such as instructional delivery and outcomes is considerably greater salience for policy. As a result, we suggest that expenditures for collecting indicators aimed principally at understanding institutional and departmental contexts such as those described in this chapter should be limited to no more than ten percent of the entire developmental effort.

REFERENCES

Albers, D.J.; Loftsgaarden, D.O., Rung, D.C., and Watkins, A.E. (1992). *Statistical Abstract of Undergraduate Programs in the Mathematical Sciences and Computer Science in the United States: 1990-91 CMBS Survey*, MAA Notes #23. Washington, D.C.: The Mathematical Association of America.

Angelo, T. A. and Cross, K. P. (1993). *Classroom Assessment Techniques: A Handbook for College Teachers.* San Francisco: Jossey-Bass.

Astin, A. W. (1993). *What Matters in College?* San Francisco: Jossey-Bass.

Bergquist, W. (1992). *The Four Cultures of the Academy*. San Francisco: Jossey-Bass.

Birnbaum, R. (1989). *How Colleges Work.* San Francisco: Jossey-Bass.

Boyer, E. L. (1987). *College: The Undergraduate Experience in America.* New York: Harper and Row.

Cameron, K. S. (1978). Measuring Organizational Effectiveness in Institutions of Higher Education. *Administrative Sciences Quarterly*, 23, 604-632.

Chaffee, E. E. and Tierney, W. G. (1988). *Collegiate Culture and Leadership Strategies.* New York: Macmillan.

Chaffee, E. E. (1983). *Case Studies in College Strategy*. Boulder, CO: National Center for Higher Education Management Systems (NCHEMS).

Chaffee, E. E. (1983). *Rational Decisionmaking in Higher Education.* Boulder, CO: National Center for Higher Education Management Systems (NCHEMS).

Chickering, A. W. (1969). *Education and Identity*. San Francisco: Jossey-Bass.

Chickering, A. W. and Gamson, Z. F. (1987). *Seven Principles for Good Practice in Undergraduate Education.* Racine, WI: The Johnson Foundation.

Ewell, P. T. and Jones, D. P. (1994). *A Preliminary Study of the Feasibility and Utility for National Policy of "Good Practice" Indicators in Undergraduate Education.* Washington, DC: National Center for Education Statistics, U.S. Department of Education.

Ewell, P. T. and Jones, D. P. (1996). *Developing Indicators of "Good Practice" in Undergraduate Education: A Guide to Implementation.* Boulder, CO: National Center for Higher Education Management Systems.

Gamson, Z. F. and Associates (1984). *Liberating Education.* San Francisco: Jossey-Bass.

Guba, E. G. and Lincoln, Y. S. (1981). *Effective Evaluation: Improving the Usefulness of Evaluation Results Through Responsive and Naturalistic Approaches.* San Francisco: Jossey-Bass.

Jones, D. P. and Lovell, C. D. (forthcoming). *Handbook on Human Resources: Record-Keeping and Analysis, Technical Review Draft.* Washington, DC: National Center for Education Statistics (NCES), U.S. Department of Education.

Krakower, J. Y. (1985). *Assessing Organizational Effectiveness: Considerations and Procedures.* Boulder, CO: National Center for Higher Education Management Systems (NCHEMS).

Krakower, J. Y. and Niwa, S. (1985). *An Assessment of the Validity and Reliability of the Institutional Performance Survey.* Boulder, CO: National Center for Higher Education Management Systems.

Masland, A. T. (1985). Organizational Culture in the Study of Higher Education. *Review of Higher Education* 8: 157-168, Winter, 1985.

McGuinness, A. C., Jr. (1996). A Model for Successful Restructuring. In T. MacTaggart (ed), *Restructuring Higher Education: What Works and What Doesn't in Reorganizing Governing Systems.* San Francisco: Jossey-Bass.

National Center for Education Statistics (1993). *Integrated Postsecondary Data System, Institutional Characteristics Survey, 1993-94.* Washington, DC: National Center for Education Statistics, U.S. Department of Education.

Pace, C. R. (1990). *The Undergraduates: A Report of Their Activities and Progress in College in the 1980's.* Los Angeles: Center for the Study of Evaluation, University of California, Los Angeles.

Pascarella, E. T. and Terenzini, P. T. (1991). *How College Affects Students: Findings and Insights from Twenty Years of Research.* San Francisco: Jossey-Bass.

Ruppert, S. S. (ed) (1994). *Charting Higher Education Accountability: A Sourcebook on State-Level Performance Indicators.* Denver, CO: Education Commission of the States.

Russell A. B. and Chisholm, M. P. (1995). Tracking in Multi- Institutional Contexts. In P. T. Ewell (ed), *Student Tracking: New Techniques, New Demands.* New Directions for Institutional Research #87. San Francisco: Jossey-Bass.

Shavelson, R. J., McDonnell, L. M. and Oakes, J. (1989). *Indicators for Monitoring Mathematics and Science Education: A Sourcebook.* Santa Monica, CA: The RAND Corporation.

Tucker, A. and Associates (forthcoming). *Models That Work: Case Studies in Effective Undergraduate Mathematics Programs.* Washington, DC: The National Science Foundation.

Weick, K. (1978). Educational Organizations as Loosely- Coupled Systems. *Administrative Science Quarterly* 23: 541- 552, December, 1978.