DOCUMENT RESUME

ED 386 969 HE 028 550

AUTHOR	Zeglen, Marie E.; And Others
TITLE	Error-Proofing Work Processes in Institutional Research Offices. AIR 1995 Annual Forum Paper.
PUB DATE	May 95
NOTE	23p.; Paper presented at the Annual Forum of the Association for Institutional Research (35th, Boston, MA, May 28-31, 1995).
PUB TYPE	Viewpoints (Opinion/Position Papers, Essays, etc.) (120) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Accountability; College Faculty; Computer Oriented Programs; Enrollment Projections; *Error Correction; Higher Education; *Institutional Research; Organizational Climate; *Program Effectiveness; Program Improvement; *Quality Control; Standards; Student Costs; Teacher Salaries; Total Quality Management
IDENTIFIERS	*AIR Forum

ABSTRACT

A framework is presented for understanding how errors arise in institutional research, and principles are suggested to avert errors in work processes of institutional research offices. Error is defined as a product which fails to meet professional standards, has unacceptable process limitations, or is unacceptable to a client. The following four principles are suggested to make work processes more error-sensitive and error-free: (1) clarifying environmental constraints and redesigning how work is done; (2) empowering agents to overcome organizational, perceptual, or knowledge-base limitations in defining, managing, or interpreting the results of work processes; (3) designing heuristics which emphasize openness of information and feedback loops; and (4) using technologies which generate intraprocess feedback. Environmental constraints include the organizational climate for work as well as political, legal, professional, and other external constraints. Four examples of project redesign are discussed: a survey on student charges, a comparative analysis of faculty salaries, an enrollment planning process, and redefinition of a comparator group. (Contains 12 references, 4 tables, and 2 charts). (SW)

Error-Proofing Work Processes in Institutional Research Offices

by

Marie E. Zeglen, Ph.D.
Director of Policy Analysis

Mark A. Hughes
Policy and Planning Analyst

Paula R. Hollis
Policy and Planning Analyst

University System of New Hampshire
Myers Financial Center
27 Concord Road
Durham, New Hampshire 03824-3546

(603)868-1800, ext. 166
M_ZEGLEN@UNHE.UNH.EDU

(603)868-1800, ext. 159
M_HUGHES@UNHE.UNH.EDU

(603)868-1800, ext. 165
P_HOLLIS@UNHE.UNH.EDU

Paper Presented at the Thirty-Fifth Annual Forum of the
Association for Institutional Research
May 28-May 31, 1995
Sheraton, Boston, Massachusetts

AIR

for Management Research, Policy Analysis, and Planning

This paper was presented at the Thirty-Fifth Annual Forum of the Association for Institutional Research held at the Boston Sheraton Hotel & Towers, Boston, Massacusetts, May 28-31, 1995. This paper was reviewed by the AIR Forum Publications Committee and was judged to be of high quality and of interest to others concerned with the research of higher education. It has therefore been selected to be included in the ERIC Collection of Forum Papers.

Jean Endo
Editor
AIR Forum Publications

Abstract

The cost of error is high in the institutional research environment in terms of time, resources, and credibility. Therefore, institutional research professionals strive to produce work which is timely, error-free, accurate, and informative. A theme common to both total quality management and business process design is to replace inspection or error checking activities with improved work processes. This paper presents a framework for understanding how errors arise in work and suggests principles for creating error-sensitive work processes. To illustrate these principles, four redesigned projects will be described and demonstrated, including a survey, spreadsheet, simulation, and policy analysis.

Error-Proofing Work Products and Processes in Institutional Research Offices

INTRODUCTION

Institutional research professionals are familiar with the mandate to produce error-free work under tight deadlines with few resources. The pressures for error-free work and the consequences of error are well known. A misplaced decimal point, ill-conceived analysis, or unrecognized concept can wreak havoc with the reputation and credibility of professionals. However, despite the importance of avoiding errors, there are few practical guidelines available to professionals on how to do so.

A theme common to total quality management and business process design is to reduce inspection or error checking activities by better product design and improved work processes. As Stratton (1991) has pointed out, finding, fixing, and fighting errors is very wasteful compared to preventing errors. There are clear payoffs in both quality and efficiency by dedicating more time to product design than to product checking. Better work processes can also lower waste, restarts, and rework. In a recent study of errors committed by institutional researchers, the authors found that nearly 60% of all reported errors were not discovered until well beyond the time or stage of work at which the errors had been produced. The average lag for detecting errors was nearly 25 days. Clearly, successful re-design of work products and processes in institutional research offices could close the gap between error production and error discovery. This paper proposes some principles for designing work products and processes less likely to result in errors, and shows how these principles were successfully applied on four different projects.

UNDERSTANDING ERRORS

It is almost as difficult to define "error" as it is to define "quality." Definitions of quality have focused on two main ideas: (1) product performance or "fitness for use" (Juran, 1989, p. 15); and (2) customer satisfaction or "meeting customers' needs and reasonable expectations" (Berry, 1991, p. 3). Quality processes are also important in evaluating a product. According to Chafee and Sherr (1992, p. v), "a quality process means that all the steps within the organization's functioning, from beginning to end, work effectively toward the desired goals, with each step adding value."

If quality can be defined in terms of product fitness, product process, and client satisfaction, what then are errors? In this paper, an error is a product which fails to meet professional standards, has unacceptable process limitations, or is unacceptable to a client for one of four reasons: (1) inadequate conceptualization (understanding of the project goals or research question was flawed); (2) poor design or method (an ineffective approach was taken to answering the research or project question); (3) flawed process (the strategies, tactics, or procedures chosen to implement the design for the product were flawed); or (4) poor presentation (the presentation or packaging of the product was ineffective).

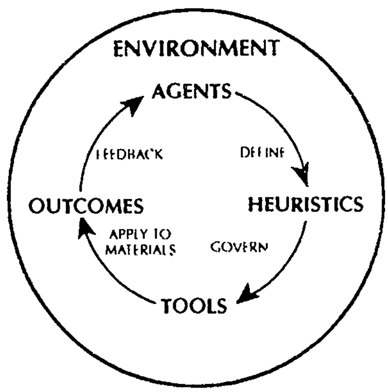
In stating that a product may be in error simply because it is unacceptable, we are implicitly recognizing that errors are not always objectively identifiable. Errors are not always as easy to identify as a mistake in addition or a transposed number. Senders and Moray (1991, p. 19) claim that human error "does not refer to something observable, in the same sense as decision-making does." Errors are always inferred from the results of processes. Errors can be matters of judgment, based upon the meanings attributed to data or reports or other products. A report may be accurate, for instance, but irrelevant to the need at hand. Such subtleties are not unusual especially in reference to policy analysis. A given policy analysis may fail as a product in many subtle ways. The analysis may be correct but not politically operable. The proposed policy may speak correctly - to the wrong issue. The policy solution may work - but not in the environment where it has been proposed.

HOW ERRORS ENTER INTO WORK PROCESSES

Understanding how errors enter into work processes is the first step to making significant improvements. There are four interactive components to any work process: (1) the **environment** in which the work process operates; (2) the **agents** implementing the process; (3) **heuristics** or the written and unwritten rules governing how the process operates; and (4) the **tools** which are applied to materials to produce work. Consider a study of tuition and fees as an example of a work process. The **agents** in the institutional research office are the staff trying to collect the tuition and fee information, and those with whom the staff interact to do so. The **heuristics** are governed by a pre-defined form for collecting the information, an unwritten "script" for asking the questions, and a set of procedures for checking and producing the final analysis of data. The **tools** used range from language to paper and pencil to a computer spreadsheet. The materials are the data received from the other offices, and the outcome is a report. **Feedback from the environment** about the report eventually flows back to the agents, who can then modify the process in response to the feedback.

Chart 1 shows the relationship between each of these factors in influencing process outcomes:

Chart 1: System View of Work Processes



Under this model, agents work within an environment to define the rules of the game for using tools to produce outcomes or results. Feedback about the outcomes of the work process form the basis for future work.

Errors can arise at any of the stages shown above:

Environment. All work occurs within a particular environment. The environment is often given names like "campus climate," "work climate," "home team advantage," or "office politics." The environment circumscribes all of the internal and external factors which can influence how work is done or received. Examples of internal factors include resources, work values, the time available to do the work, and training. Many external factors, such as politics, audit standards, or legal considerations, may also influence the environment or expectations for work.

Agents. Every person has a unique perception of the world arising from different cultural, social, psychological, and personal experiences. In addition, each person's base of knowledge and contextual understanding will differ. For all of these reasons, agents may contribute to errors in numerous ways. Earl Babbie (1990) lists several ways in which agents can err, including inaccurate observation, over-generalization, selective observation, made-up information, illogical reasoning, ego-involvement in understanding, premature closure of inquiry, and mystification.

Heuristics. Heuristics describe the way in which a process, activity or task will operate. The process may be rational or irrational. The "rules of the game," "standard operating procedures," "decision rules," "rules of engagement," and "office protocols" all convey some sense of the broad range of heuristics. The way in which the heuristics operate for a task may contribute to errors or reduce the usefulness of work products. For instance, estimating annual enrollments at an institution by multiplying IPEDS fall enrollment data by a factor of two will fail if an institution's pattern of enrollments does not fit a standard academic semester calendar.

Tools. The term "tools" is used in its broadest sense to describe the means by which the work inputs for a project are translated into an outcome or product. The means can be a mind, a pencil, a calculator, or an electronic tool like a computer. Tools can produce an error primarily if misused or misinterpreted by the agent. Tools can also represent inadequate approaches to accomplishing a task. A needle and thread will not bind together a book, any more than a policy without support will govern behavior.

STRATEGIES /TECHNIQUES FOR CREATING ERROR-SENSITIVE WORK PROCESSES

Four principles are suggested in this paper for making work processes more error-sensitive and error-free: (1) clarify environmental constraints as part of the work process and use this understanding in designing the work to be done; (2) empower agents to overcome organizational, perceptual, or knowledge base limitations in defining, managing, or interpreting the results of work processes; (3) design heuristics which emphasize openness of information and feedback loops; and (4) use technologies which generate intraprocess feedback.

Clarifying Environmental Constraints

Errors arise from internal and external environmental constraints. Internal constraints have sometimes been called the "organizational climate for work". Tagiura and Litwin (1968) define organizational climate as "the relatively enduring quality of the total internal environment of an organization that (a) is experienced by the members, (b) influences their behavior, and (c) can be described in terms of the values of a particular set of characteristics (or attributes) of the environment" (Tagiura and Litwin, 1968, p. 27).

Litwin and Stringer (1968) identified several key components of organizational climate which can impact performance: (1) responsibility (degree of delegation experienced by employees); (2) standards (expectations about work quality); (3) reward (recognition for good work versus disapproval for poor performance); (4) organizational clarity (orderliness versus disorderliness); and (5) team spirit (fellowship and trust within an organization). Performance can be stimulated (and errors minimized) in organizations which stress meaningful delegation to employees (Chaffee and Sherr, 1992), emphasize the importance of quality in every part of the organization (Berry, 1991), recognize and reward quality (Winter, 1991), show constancy of purpose (Deming, 1986), and encourage teamwork (Chaffee and Sherr, 1992).

External environmental constraints help to define the "acceptability" of work products. These constraints may be political, legal, professional, or arise from other sources. For instance, a policy paper aimed at restructuring compensation practices will need to take into account the effect of changes on a broad range of actors, including staff (who would be directly affected by any change), individuals in the larger job market (who will respond to future changes), the general public (who may bear the costs for the changes in a public system), the legislature (who may have other approaches or priorities), other employers (who may resent increased competition if wages increase), or other institutions (which may respond in kind to policy changes, thereby changing competitive dynamics in the market). An analysis which focuses only on cost or form of change in compensation practices may result in too limited a view, and underestimate the reaction to a policy change - which may ultimately doom the proposed policy to failure. It may not be possible to take into account all external constraints impacting a work product, but at least, clarifying the constraints can help avoid serious problems. Recognizing and assessing constraints early in the work process also allows time to handle and manage the expectations concerning the work more effectively.

Empowering Agents

Traditional hierarchical organizations focus most resources for professional development on the top of the organization, hoping for "trickle-down" effects for other staff. Gilbert and Nelson (1991) have urged those concerned with quality in organizations to focus instead on empowering employees throughout the organization.

"The quality approach assumes the people closest to the process know what the problems are . . . . They have good ideas about how to improve things so they can do their jobs better. They are encouraged to discuss them and be heard by others with whom they work, and they are able to improve things in collaboration with others on their teams. They do not need heroic leaders to solve their problems. They are partners in problem solving with their customers, suppliers, and others in their teams who can help (Gilbert and Nelson, 1991, p. 132)."

Gilbert and Nelson suggest that the emphasis in organizations needs to be on "followership" not leadership; the qualities associated with followership are partnership, motivation, technical competence, dependability, professional comportment, sense of humor, positive working relations, and willingness to speak up (Gilbert and Nelson, 1991).

Peter Senge carries the concept of followership further in advocating the need for learning organizations, or "organizations where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together (Senge, 1990, p. 3)." Such organizations provide the climate for empowering employees to create higher quality, more error-free work. Learning organizations are organizations which are open, or characterized by a high degree of information sharing, and which nurture the freedom to interpret information in novel ways. In such organizations, employees are empowered by access to information and lack of constraints on discussing its meaning for the organization.

Many total quality management perspectives stress that most errors are due to management decisions about how to organize work rather than worker mistakes (Deming, 1986; Stratton, 1991). Organizational structures or climates may also contribute heavily to the production of errors or of low quality work. However, human agents are very well positioned to discover and correct errors, irregardless of the real causes of the errors.

Most of the errors which can be attributed to people, arise because of organizational, perceptual, or knowledge base limitations in defining, managing, or interpreting the results of work processes. Empowering staff to do better work may require additional training opportunities, better tools, or better access or understanding of the context for the work being done. Training can address knowledge base limitations. Tools can aid employees in many ways, but can be especially valuable in overcoming perceptual limitations in spotting or detecting errors. The most effective way to help staff overcome contextual limitations is to create more openness in the work organization, thereby allowing staff to better understand the context in which work is performed. Effective policy analysis, for instance, can not occur in a vacuum; policy studies are hampered by lack of access to decision makers and other stakeholders in the external environment.

Re-designing Heuristics

Heuristics govern a wide range of behaviors related to how organizations, and the people in them, function. Heuristics are the rules, explicit or implicit, which set expectations for behavior in given situations or contexts. The rules are given many names - laws in science, norms in sociology, mores in anthropology, etiquette in social relations. Senge (1991, p. 174) has called these types of rules mental models, or "deeply held internal images of how the world works." The mental models are important in that they not only constrain or limit ideas, but they also color perceptions. Not only may individuals favoring a particular mental model not consider other approaches but they may also fail to perceive their existence.

On an organizational level, heuristics can be instrumental in determining patterns of openness for information and exchange of ideas. Openness is one of the critical characteristics of a learning organization (Senge, 1991); in such organizations members are not only free, but are actively encouraged, to explore novel solutions to problems and to improve the ordinary ways of doing the work of the organization. Hierarchy can have the opposite effect. Hierarchical relations constrain information access and limit the ability to re-think work based on one's position within the organization. At the project or task level, heuristics based on hierarchy limit feedback on work. For example, it is important for staff who produce reports or analyses to have a clear understanding of the use of those products in order to make the work accurate and relevant. Yet, in a hierarchical organization, staff may not be invited to meetings where their work products are used or discussed. In such circumstances, staff may receive indirect feedback from those in attendance, but lack direct insights into how their work met the needs of their client.

It is important to challenge and re-define the heuristics governing how work is done in a given setting if those heuristics do not foster openness and a rich environment for feedback about the work being done. As Peter Senge (1991) has noted, it may be necessary to challenge the prevailing mental model governing a task or activity before any improvements can be made in the task.

Using Technologies to Emphasize Feedback

Feedback is especially critical to the improvement of work processes - whether in industry or institutional research. Feedback which occurs after the product is already developed is useful for future improvements, but feedback obtained during the work process, or intraprocess feedback, can help to avoid errors or improve quality.

Technology can effectively provide intraprocess feedback. The instant replay is an example of feedback obtained during a sports game which is used to promote quality of decision making. Referees can use the replay to make better decisions during the game rather than waiting for appeals or rulings after the game. Another example is a smoke detector. Smoke detectors provide feedback early in the fire process with the aim of alerting people to the fire before the situation becomes dangerous. The yellow light at a street crossing is another example of a technology designed to aid decision-making in the middle of a process (crossing an intersection) rather than at the beginning (green light) or the end (red light).

In institutional research, it is desirable to detect errors while the work is in the office rather than in the client's office, or in a publication. Frequently an error is not discovered until the intensive error-checking just prior to the release of a study or report. At that point, more effort is required to fix the error than if the error had been identified soon after it was made.

RE-DESIGNING WORK PROCESSES

The principles of clarifying environmental constraints, empowering, re-designing heuristics, and using tools which emphasize feedback can be used in institutional research tasks to improve work processes. Four examples of project re-design are given in this paper: (1) a survey on student charges; (2) a comparative analysis of faculty salaries; (3) an enrollment planning process; and (4) re-definition of a comparator group.

Example 1: Student Charges Survey Re-design

The University System of New Hampshire (USNH) is composed of four institutions and a branch campus. The main institutions, the University of New Hampshire, Keene State College, and Plymouth State College, have long operated as "privatized" publics, or institutions whose state funding is modest and whose primary source of revenue is tuition. As such, it is important to regularly monitor tuition, fee, and other student charges for USNH institutions compared with those of other institutions with whom there is competition for enrollments. To this end, the Office of Policy Analysis conducts a survey of the tuition and fees of roughly thirty institutions twice a year. The information from the survey is used by the Board of Trustees in setting and in approving tuition and fee charges. Published sources can not be used for this purpose because such sources are generally retrospective and do not provide information for charges for the coming academic year.

In the past the survey was done using paper survey forms to record the results of telephone conversations with staff from other institutions. Table 1 contains a copy of the form which had been used. Fax transmissions were used both to obtain and confirm data from the participants in the survey. The data gathering form was re-designed several times and the survey questions refined, yet survey results often did not track with data from other sources. Analysis of outcomes indicated the errors resulted from an inability to translate questions into the "jargon" of particular institutions or for the surveyer to remember details about the way each institution handled and reported student charges. Sometimes several offices within an institution had to be contacted to obtain the needed information (for instance, the registrar's office for tuition and the housing office for dormitory fees). It was not always possible to survey the same individual in a given office from year to year. Finally, it often took several iterations of telephone calls to obtain, clarify, troubleshoot, and correct information. One reason for the need to revisit information initially obtained during a survey interview was that it was difficult to identify an error until the information obtained had been summarized and compared to responses from prior years.

A new approach was developed which focused on empowering the surveyer in several ways: 1) to request and clarify information using the institution's terms and "jargon"; 2) to have information available while asking questions which would describe any special circumstances or nuances which the surveyer should address; 3) to get immediate feedback showing how the information received during the survey interview compared to prior historical data from the institution; 4) to automatically calculate and annualize the data obtained so that information could be reflected to the person being interviewed for purposes of clarification or confirmation; and 5) to record clarifying information received during the interview for future use. The goal of the re-design of the survey process was to enable the surveyer to obtain as much accurate information as possible from each telephone call made and to reduce the number of call backs needed for correcting or clarifying information.

The re-design was accomplished by using a computer to enter and get feedback on information as it was received on the phone. An ORACLE data structure was created to accept the data as they were obtained on the telephone. SQL Forms were used to provide contact information, create data entry screens, initiate programs for processing and presenting the information, and generate feedback to the surveyor on the information received. Contextual information needed to frame questions, enable immediate data entry, show the

TABLE 1. Initial Student Charges Survey Form

FY95 FULL-TIME UNDERGRADUATE STUDENT CHARGES
UNH AND COMPARATORS

TELEPHONE NO.:______________

NAME OF INSTITUTION:

FALL___ & SPRING ____

CONTACT PERSONS:

TOTAL STUDENT CHARGES:
Resident: ______________
Non-Resident: ______________

DATE OF SURVEY:_____ ____ STAFF________

☐ ESTIMATED AS OF________

☐ FINAL AS OF ________

What was the percent increase in student charges over the previous year?__________________

Are there any unusual increases or additional student charges compared to the previous year?_______

How many semesters/quarters/other make up your academic year:______________

Data for collection represents fulltime, undergraduate resident and non-resident student charges for one academic year.

CATEGORY	$ Per semester/quarter/ other		Total for Category per Academic Year
FULL-TIME Undergraduate RESIDENT TUITION (tuition only; <u>Do Not</u> include mandatory fees) How many hours per semester are you using to calculate the tuition charge? Hours per semester ____	______________	X	______________
FULL-TIME Undergraduate NON-RESIDENT tuition (tuition only; <u>Do Not</u> include mandatory fees)	______________	X	______________
Standard Double-Occupancy Dorm Room:	______________	X	______________
Meal Plan: Standard 19 meals per week. Or your plan that comes closest ____ (meals per week)	______________	X	______________
TOTAL MANDATORY FEES: (fees that all students must pay in order to attend classes) <u>Do not</u> include tuition.	______________	X	______________

Mandatory Student Fee Breakdown (Please show subtotal of mandatory student fees by category. Add categories if needed)

	Per Semester	Per Year
STUDENT ACTIVITIES:		
STUDENT SERVICES:		
STUDENT HEALTH/ACCID.		
STUDENT REC.		
STUDENT UNION		

	Per Semester	Per Year
EDUC. TECH.		
REGISTRATION		
INTERCOL. ATH.		
COMPREHENSIVE FEE		
TRANSPORTATION FEE		
STUDENT GOVT FEE		
Other categories specific to your institution		

University System of New Hampshire Office of Policy Analysis

reasonableness of data received in light of historical data, and provide error-trapping with range edits was included on the screens for data entry. Table 2 contains an example of the main data entry screen from the program. The new approach is being pilot tested to see if call-backs are reduced and the survey completed more efficiently.

TABLE 2. Screen From Interactive Survey Form

STUDENT CHARGES

UNITID	Institution Name	C	AY	Code	ENTRY DATE
183044	UNIVERSITY OF NEW HAMPSHIRE-MAIN CAMPUS	U	95	F	01-MAY-94

	Amount	Mult	Annual	HR	Per HR	NOTE
RES:	1835	2	3670	12	152.9	
NRES:	5995		11990	12	499.6	
ROOM:	1163		2326			
BOARD:	856		1712			

PRIOR YEAR

UNITID	AYR	Code	COMP	ENTRY DATE
183044	95	F	U	01-MAY-94

MOST RECENT TERM

AY	Code	ENTRY DATE
95	F	01-MAY-94

	Amount	Mult	Annual	HR	Per HR	NOTE
RES:	1835	2	3670	12	152.9	
NRES:	5995		11990	12	499.6	
ROOM:	1163		2326			
BOARD:	856		1712			

CURRENT YEAR

TUITION					ROOM		BOARD		FEES			
	$ Dif	% Inc	$ Dif	% Inc	$ Dif	% Inc	$ Dif	% Inc	OldTOT	NewToT	$ Dif	% Inc
RES: / NRES:	0	0	0	0	0	0	0	0	890	352	-538	-60

Example 2: Salary Study Process Re-design

Every year, the Office of Policy Analysis produces a book summarizing the salary market position of faculty within the University System of New Hampshire by discipline. To do so, survey data are obtained from the Oklahoma State University study of faculty salaries by discipline. The study provided by Oklahoma State University is a summary of the responses of institutions designated as comparators for the University of New Hampshire (one database) and for the State Colleges (a second database). Not all comparator institutions respond to the Oklahoma State University survey. Special surveys requesting similar data are sent to non-responding comparator institutions. In the past, processing of the data from the surveys occurred in several steps: 1) the Oklahoma State University and special survey data are combined into a single database on a VAX platform, by CIP code; 2) the data are analyzed to extract only those CIP codes for which there are programs at the University of New Hampshire or the State Colleges; 3) the CIP codes are analyzed and re-grouped where necessary to assure adequate numbers of cases in each grouping to be studied; 4) salary data are sorted and organized by CIP code for the University of New Hampshire and State College data and the relevant comparator databases; 5) two files are extracted with the salary data (one for the University of New Hampshire comparator data and one for the State College comparator data) and transferred into a MacIntosh microcomputer environment; 6) calculations are made on salary deficiency and position to market using an Excel spreadsheet on the MacIntosh; 7) data from the Excel spreadsheet are imported into Pagemaker and are used to produce the final report (which uses multiple graphs and tables per page in the report to summarize the comparisons.) Table 3 contains a sample page from the salary book report.

The complex process described had shortcomings in two main areas. The first was the study data from Oklahoma State University could not easily be checked for accuracy until combined and then processed into CIP groupings. Any population errors or discrepancies persisted well into the processing of data. The second, and more serious problem, was that it was difficult to spot errors or inconsistencies concerning the results of the salary analyses until the last two stages of work, when calculations and visual summaries were available. Any redo of work which had progressed to the last stage meant considerable effort to fix the problem and then re-import the new data streams to produce graphics in Pagemaker. Not atypically, the error capture process was most effective in the very last stages of work, rather than in the early work processes. The third shortcoming was that using multiple platforms to process and package the data resulted in a complex process for correcting errors when identified.

An early attempt to re-design the work process addressed the issue of multiple platforms. The process was re-designed so that all database creation, processing, and report preparation was done on a single platform, the VAX. A pilot project was undertaken to produce the salary study for the 1991 year. While the salary book was successfully produced using a combination of 1032 and Interleaf software, the pilot was not repeated. The process did not improve the ability to trap errors earlier in the work process, and data transfer into the final production product, Interleaf, required considerable programming effort. Interleaf proved to be a highly specialized product which was difficult to use without extensive training. Production of the report under this approach would have required too much external computing support and allowed too little control of the production process by the Policy Analysis staff.

Re-design of this work process incorporated two principles. The first principle was to use technology to front-load error-trapping earlier into the processing of data from Oklahoma State University and from external surveys. For this purpose, one program was developed on the VAX to compare data received from the external sources with past year data. Total counts were analyzed, allowing for a quick assessment of the reasonableness of the study population.

TABLE 3: Sample Page from USNH Salary Study Report (Mock Data)

UNH
Discipline: Mathematics

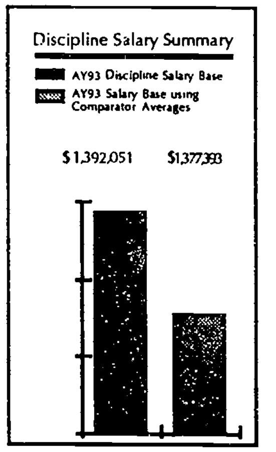
CIP Code: 270000

AY93 Salary Averages

	UNH Average	Number of Faculty	Average of Comparators	Number of Faculty	% Above/Below Comparator Average
All Academic Year Faculty					
Full Professor					
Associate Professor	$70,973	12	$70,031	193	1.34%
Assistant Professor	$53,483	6	$52,322	95	2.22%
	$43,896	5	$44,618	58	-1.62%
All Fiscal Year Faculty‡					
Full Professor					
Associate Professor	$0	0	$70,031	193	0.00%
Assistant Professor	$0	0	$52,322	95	0.00%
	$0	0	$44,618	58	0.00%

Salary Catch-Up Needs

	AY93 Discipline Salary Base *	AY93 Salary Base Using Comparator Averages **	Percent Change Needed For Salary Base Catch-Up
All Academic Year Faculty			
Full Professor			
Associate Professor	$851,675	$840,375	-1.33%
Assistant Professor	$320,895	$313,930	-2.17%
	$219,481	$223,088	1.64%
All Fiscal Year Faculty‡	$0	$0	0.00%
AY93 Totals	$1,392,051	$1,377,393	-1.05%



*Salary base estimated as number of UNH faculty times salary average for each rank.
**Salary base estimated as number of UNH faculty times comparator salary average for each rank.
‡AY93 estimate of fiscal faculty based on .857 of actual FY93 salary.

3

This process identified errors due to the composition of external data, which had proved a problem in the past. Table 4 contains an example printout from this program. Another program was written to compare counts by CIP code and CIP groupings for the current and past year in order to quickly identify potential problems with the external data. A final program produced the actual deficiency calculations on the VAX, rather than within the MacIntosh Excel software. All of this programming enabled efficient assessment of the accuracy of the data well before any graphics were produced.

The second principle was to improve the heuristics governing the data handling process. Current practice was to create a speedy mockup of the study report so that data checking could begin. Deadline pressure was on the office to produce the report quickly in support of collective bargaining efforts. The report is routinely audited by an external agency, such as Coopers and Lybrand, so accuracy was also critical. The new heuristics called for extensive error and reasonableness checks of the data prior to any mockup of the report pages. The Excel spreadsheet became the main tool for this part of the process. A new master spreadsheet was designed so that information was categorized and highlighted by visual clues. Data summary columns were added to the spreadsheet which calculated percent totals and percent increases. The summary columns gave immediate feedback on keyboard inputting accuracy and were highly visible flags for out-of-range data. Additionally, color text was used to highlight CIP codes that required a calculation outside of the normal parameters. Embedded spreadsheet notes were added (a feature of Microsoft Excel which allows for voice and written notes to be assigned to specific cells). The notes were used to annotate key formulaes, explain important exceptions to data handling rules, and point out potential pitfalls in certain areas of the analysis. Cells with notes are automatically marked with a red dot signal to alert the staff member to potential problems and provide specific information.

TABLE 4: Excerpts from Out;ut of Population Assessment Program

CIP Major Group	Faculty Rank	FY93 Totals	FY94 Totals	Difference FY94-FY93 Totals	%Incr. FY93-FY94
45	00170	151	194	43	28.5%
	00171	107	115	8	7.5%
	00172	87	96	9	10.3%
	00173	6	3	-3	-50.0%
Total		351	408	57	16.2%
50	00170	122	124	2	1.6%
	00171	83	76	-7	-8.4%
	00172	80	87	7	8.8%
	00173	15	11	-4	-26.7%
Total		300	298	-2	.0%
51	00170	10	16	6	60.0%
	00171	36	30	-6	-16.7%
	00172	33	33	0	.0%
	00173	14	8	-6	-42.9%
Total		93	87	-6	-6.5%
52	00170	70	109	39	55.7%
	00171	88	101	13	14.8%
	00172	67	76	9	13.4%
	00173	1	1	1	.0%
Total		226	287	61	27.0%
ALL CIPS Grand Total 10 to 52		2507	2589	82	3.3%

This effort to re-design the work process on the faculty salary study has been successful. Data errors are identified earlier in the process and corrected before extensive investment of staff time occurs. More improvements will be made. For instance, it may be possible to eliminate the step of exporting data into Pagemaker for final report production by making full use of the graphic capability of Excel.

Example 3: Enrollment Modeling Re-design

Enrollment planning has a strong flavor of "demographic determinism" at most institutions. This doesn't arise out of any conviction that such forecasts are very accurate. Carol Frances (1989) has explained at length why such forecasts are often misused and later found to be inaccurate in higher education planning. Reliance on demographic forecasts arises more from a lack of proven alternatives than from dogmatism about the method. A departure from the common heuristics underlying enrollment planning, however, has its risks. New methods which are not widely familiar or accepted can be difficult to "sell" as creditable.

Similar to other institutions, the University System of New Hampshire maintains and publishes a set of enrollment projections based upon college-going rates of traditional age high school graduates. In 1994, these projections indicated that significant increases in demand from New Hampshire students could be expected from the mid 1990s through the early years of the next century. Recognition of this challenge spurred a major enrollment planning effort in the system.

No one involved in the planning process was entirely satisfied that simple linear demographic projections could show enough detail about future demand patterns to be useful. There was scepticism about the accuracy of the projections and a desire to incorporate, or at least recognize, some of the other factors which would ultimately influence enrollments. Capacity, the economy in New Hampshire and New England, competition from other institutions, and the demand from nontraditional students are a few examples of such factors. Consequently, one of the first steps taken in the planning process was to adopt an ambitious new approach to refining the understanding of potential demand for New Hampshire public higher education. This break in heuristics culminated in the hiring of a consulting firm, Cambridge Decision Dynamics, to work with staff from the Office of Policy Analysis in using a new technology for support of planning, a system dynamics model of enrollments.

Moving to a new approach presented three challenges. First, the creditability of the model would be challenged since the technique was new and would not mirror previous work. Second, a new knowledge base was needed on the part of those using the model if it was to serve as a viable policy simulator. Third, the model itself was sufficiently complex that new communication and teaching tools were needed if policy makers were to become fully engaged in its use.

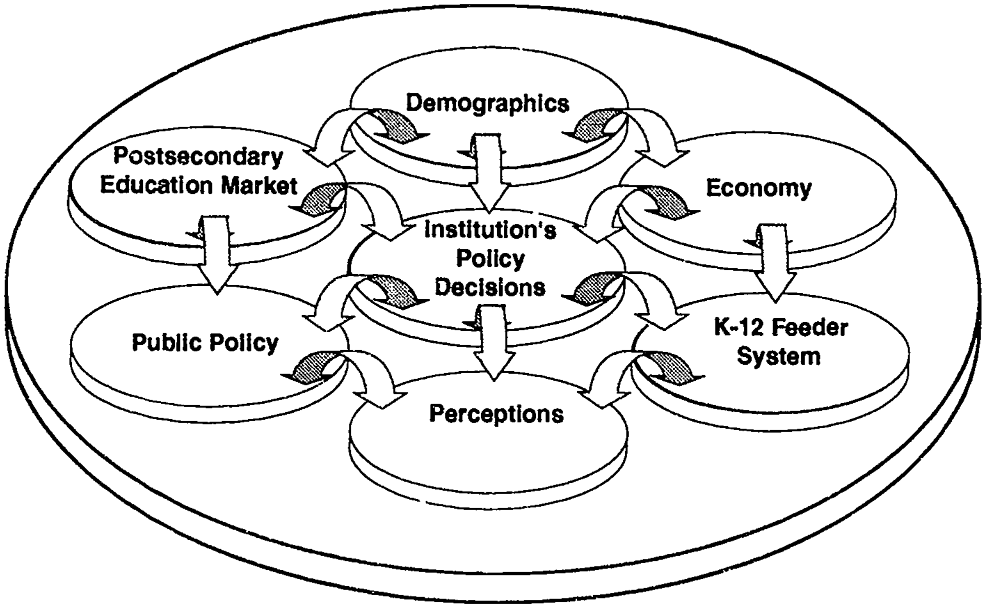
The process design for implementing the model used all of the principles for designing error free work processes. The technology change was the key to changing the mental model or heuristics for enrollment planning. System dynamics modeling is a relatively new planning technique for higher education, although it has been used in other fields for about three decades (Senge, 1991). The model developed is a microworld, or computer replica of the many external and internal factors affecting the University System of New Hampshire and its institutions. This microworld contains quantitative as well as qualitative, or "soft" variables reflecting the best judgments of professionals in institutional operational areas such as admissions, student services, and financial aid. The scope of the model is broad, with major subsystems covering institutional policy and data (finance, space, admissions, academic policy, financial aid, personnel, students), market share (college-going rates in local and regional markets), enrollments (admissions patterns, academic aptitude, numbers of students, transfer patterns, retention patterns, exit and graduation patterns), demographics, K-12 sector, economy, and state policy. The model was fully arrayed by both race and residency of students. A diagram showing the many factors incorporated in the system dynamics model by Cambridge Decision Dynamics is included as Chart 2.

The change in heuristics was supported by meetings and demonstrations at each campus. The new technology was explained and participation was encouraged in a broad data gathering effort to support the creation of the system dynamic model. An additional consultant was hired specifically to support campus use of the model and other planning tools in developing strategies to deal with the foreseeable enrollment demand. Feedback from the model was an integral part of the planning process. The ultimate goal of the project was to put into place a model at each campus to be used as a planning tool both for the enrollment planning project as well as for future planning.

The structure of the model helped to clarify environmental constraints on solutions to the enrollment problem. Using prior methods, policy makers were left to speculate on the potential impact of both external and policy choice factors on enrollment demand. A recession, change in federal financial aid policy, or migration trends could all affect enrollments, but there was no clear method for identifying and quantifying the impact. Under the new technology, the effect of such factors on enrollments could be estimated with greater precision.

The model serves to empower decision makers by creating an environment for policy simulation. As was the case with external factors, decision makers could only guess at the likely impact of internal policy choices such as changes in the amount of institutional aid provided to students or changes in admissions standards under the previous enrollment planning method.

Chart 2. Overview of Model System Dynamic Model Subsystems



Source: Cambridge Decision Dynamics

With the new technology, the effect of internal policy changes in areas such as admissions, financial aid, retention, transfer, and academic standards can be modeled. The simulation environment helps uncover consequences of policy choices which were either unrecognized or counter-intuitive.

The results of this process re-design will take some time to assess. The initial model development for the planning process (a systemwide model) is being followed by creation and equilibration of models for each campus (spring-summer, 1995). The real test of success of the re-design will be whether or not campus executives use the models as part of their internal planning processes.

Example 4: Comparator Group Re-design

In the late 1980's, the University System of New Hampshire Board of Trustees formally adopted comparator groups for both the University of New Hampshire and the State Colleges. The comparator groups were identified using consultants to guide the process. The process was highly participative, with involvement from the administration and academic senate of each institution, as well as staff from the Chancellor's Office. However, by the early 1990's, it was clear that the composition of the groups was very controversial, and had become a subject for discussion in the collective bargaining sessions with faculty at two of the institutions within the system. The main use of the comparator groups was the establishment and tracking of salary benchmarks, so there was a renewed interest on the part of faculty in the process. While it was certainly debatable whether or not the groups could be considered somehow "in error", it was clear that the current groups were not of positive benefit in promoting shared goals or understandings on salary deficiencies. Eventually, leadership in the Chancellor's Office and the institutions agreed that it was pointless to take a defensive stance with regard to the current comparator list and that it was desirable to try a new approach. The approach was to initiate a collaborative effort to redefine comparators. The change in heuristics is underway and seems to be leading to a successful redefinition of the comparator group for the State Colleges.

Analysis of the conflict over the established comparator group revealed several common complaints. First, despite the clear documentation that showed extensive participation by faculty in selecting comparators, faculty denied that adequate consultation had occurred. Second, faculty did not believe that the group had enough representation from New England and/or the Northeast. Third, faculty believed that some factors which had not been considered in the initial process were important (for instance research productivity) and that other factors were given undue importance (size of institution). Finally, faculty desired input into the actual uses of the information from comparators such as in setting salary benchmark goals. Faculty complained they had never really understood how the comparator group would be used and thus had offered earlier feedback based on different perceived goals for the group.

The underlying heuristic changes made as part of the re-design process are important to clarify. The basic change was a move from seeing faculty as participants in the process to seeing faculty as collaborators in the process. Under the participation model, faculty could offer advice and counsel, but for faculty to have any decision-making role in selecting a group against which their performance and salaries would be judged was seen as inappropriate. In seeing faculty as collaborators, administrators were recognizing that shared ownership of salary goals was more important than maintaining a hierarchical stance with regard to faculty.

The emphasis on re-designing the process to select comparators was on creating the opportunity for full engagement of faculty representatives in the process. To this end, a study group was formed with representatives of the Chancellor's Office, Keene State College, and Plymouth State College to select new comparators for the State Colleges. The group was composed of faculty from both institutions, and administrators representing finance, planning, human resources, and policy analysis. To foster trust, a partnership was formed between the

Director of Policy Analysis and a faculty representative. All data and information supplied to the group are jointly created and endorsed by these two individuals.

Another emphasis in the new process is to clarify expectations concerning comparisons in order to create more viable reports for use in the bargaining process. Issues about the processing and use of any salary information gathered from comparators are discussed openly in group meetings.

The study group has proceeded on its task with the following steps: 1) define the criteria for selecting comparators; 2) weight the criteria; 3) collect information from candidate institutions; 4) identify the best matches to the criteria; and 5) make recommendations on a final list of comparators. At the time of this writing, the study group has recently issued a report recommending composition of a new comparator group. This report will be sent forward to the Chancellor and eventually to the Board of Trustees Capital and Strategic Planning Committee.

The ultimate test of whether the re-design of process has succeeded will be whether or not the faculty support the salary goals and related benchmarks developed in the future by the Board of Trustees. It is likely that success in collaborating on the new comparator set may open the door to further collaboration on other issues and goals in the future. Another success measure will be whether or not the overall methodology used to study salaries will be accepted by faculty, given that they will now have had input and discussion of the processing and use of the data.

CONCLUSIONS

Institutional research professionals are adept at producing work under time pressures with relatively light staff support. Errors, when they occur, are understandable, yet have important consequences for institutional research offices. Sensitivity to how errors enter into work processes can help professionals re-think and re-design how work is done within their office. The principles of empowering agents, re-designing heuristic rules, using tools to create process feedback during work, and clarifying environmental influences can be used to minimize work errors and enhance work quality. Institutional research professionals should look beyond common conceptions of errors to strive to produce work which better meets the needs of both operational units and policy makers. In this paper, four practical examples of institutional research work process improvements were described. The creation of error-sensitive work processes helps institutional researchers reduce errors, redos, restarts, and other inefficient activities in our resource-constrained environment.

REFERENCES

Babbie, E. R. (1986). *The Practice of Social Research.* CA: Wadsworth Publishing Co.

Berry, T. H. (1991). *Managing the Total Quality Transformation.* New York: McGraw-Hill, Inc.

Chaffee, E. E. and Sherr, L. A. (1992). Quality: Transforming Postsecondary Education. *ASHE-ERIC Higher Education* Report No. 3. Washington, DC: The George Washington University, School of Education and Human Development.

Deming, W.E. (1986). *Out of the Crisis.* Massachusetts Institute of Technology, Center for Advanced Engineering Study. Cambridge, MA.

Frances, C. (1989). Uses and Misuses of Demographic Projections: Lessons for the 1990s. In Arthur Levine and Associates (ed), *Shaping Higher Education's Future: Demographic Realities and Opportunities, 1990-2000.* San Francisco: Jossey-Bass Inc.

Gilbert, G. R. and Nelson, A. E. (1991). *Beyond Participative Management: Toward Total Employee Empowerment for Quality* . New York: Quorum Books

Juran, J. M. (1989). *Juran on Leadership for Quality: An Executive Handbook.* New York: Free Press

Senders, J. W and Moray, N. P. (1991). *Human Error: Cause, Prediction, and Reduction.* Hillsdale, NJ: Lawrenceerlbaum Associates

Senge, P. M. (1990). *The Fifth Discipline.* New York: Doubleday

Stratton, A. D. (1991). *An Approach to Quality Improvement That Works.* Milwaukee: ASQC Quality Press.

Tagiuri, R. and Litwin, G. (1968). *Organizational Climate: Explorations of a Concept.* Boston: Harvard University.

Zeglen, M. (1994). *The Error of Our Ways: Using TQM Tactics to Combat Institutional Research Bloopers.* Forthcoming AIR Professional File.