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DACUM…A Tool for Documenting Industrial Involvement in Curriculum Design

Deborah J. Hochstein and John I. Hochstein
The University of Memphis

Abstract

The DACUM process is a formal procedure for identifying the competencies, skills, and attributes required of employees in an occupation and organizing that information into a form useful for the design of educational programs to prepare individuals for entry into, and advancement within, that occupation. A brief definition of the DACUM process, and the historical context within which it has evolved, is presented with an emphasis on how this process may be of use in the design of an undergraduate engineering curriculum. As an example, a detailed description of a DACUM workshop recently conducted for a Department of Mechanical Engineering seeking information to help redesign an undergraduate program to better prepare its graduates for entry into a manufacturing environment is presented.

Introduction and Motivation

Engineering programs are continually striving to produce graduates well prepared to enter the job market. The dilemma educators face is one of determining what knowledge base, skill set, and personal traits are currently required to be successful in a particular industrial environment. This information is typically acquired from industrial advisory committees, alumni surveys, and employer surveys. The Department of Mechanical Engineering at The University of Memphis has decided to use the DACUM (Designing A CurriculUM) process as one of the major sources of industrial input to modification of the undergraduate program to better prepare graduates for immediate entry into a manufacturing environment. The DACUM process captures this information and documents it in a structured format called a DACUM chart. DACUM is an innovative approach to occupational analysis. It is an effective method of determining the competencies needed for tasks that must be performed by persons employed in a given occupational area that is based on the following premises:

- Expert workers are able to describe/define their job better than anyone else.
- Any job can be effectively and sufficiently described in terms of the tasks that successful workers in that occupation perform.
- All tasks have direct implications for the knowledge and attitudes that workers must possess to perform the tasks correctly.

The chart that results from the DACUM analysis is a detailed and graphic portrayal of the skills/competencies involved in the occupation being studied. It can be used for curriculum identification and design. It is an outcomes assessment tool that can be used to perform a gap analysis between an engineering program's curriculum and industry's need for a well-trained workforce.

Overview of the DACUM Process

DACUM is an acronym for **D**esigning **A** Curricul**UM** and as such represents a process or methodology that can be followed in performing an occupational analysis; in this project, an engineer in a manufacturing environment. It has proven to be an effective method of efficiently determining the competencies needed for tasks that must be performed by persons employed in a given occupation. Specifically, "What must an engineer in a manufacturing environment know? What must a manufacturing engineer be able to do?" It is an innovative approach that facilitates industrial input into curriculum development and helps to define what students must know and be able to do to be successful in the workplace. A panel of expert workers, in this case engineers working in a manufacturing environment, participates in discussions where they describe their particular job function and reach a consensus as to the most important components of the occupation. An underlying premise is subject matter experts are best able to describe their occupation and the changes that continuously affect their work. It is believed that students are best served by tapping the expertise of incumbent workers and supervisors. DACUM provides an efficient avenue for assessing the knowledge and skills sets required for successful employment today and in the future.

The origin of DACUM can be traced back to the 1960s at the Clinton, Iowa Job Corps program. It has been used at the professional, managerial, technical, skilled, and semi-skilled levels. It has been used by educational agencies, business/industry, and government agencies, both in the United States and abroad[1]. It has proven to be effective in the: development of new programs; revision of existing programs; evaluation of worker performance; creation of job descriptions; development of process descriptions (ISO9000); and conceptualization of future jobs. There are several advantages of using the DACUM process. It is a team-based project where members freely share ideas and hitchhike on each other's contributions. People enjoy talking about their work with others in similar careers. As a result, a synergy develops and members empower each other to arrive at a consensus as to the duties and tasks that accurately describe the occupation. It is oriented toward the future. The facilitator guides the discussion to how tasks are performed today and how they may be performed in the future. The facilitator guides discussion away from the "good old days". When people feel that they have actively participated in the development of a curriculum, they take ownership in it. This produces industrial buy-in for the program in general. Finally, this method is very efficient. It would be very difficult to develop objective employer/employee surveys to capture this type of information. It would be very time consuming to interview expert workers individually. In short the DACUM methodology is highly effective, quick, and low cost.

Robert E. Norton of the Center on Education and Training for Employment at The Ohio State University has developed a Systematic Curriculum and Instructional Development (SCID) model that can be followed in program/process design[1]. The process can be organized into five phases: Curriculum Analysis, Curriculum Design, Instructional Development, Training Implementation, and Program Evaluation. The DACUM process is used in the analysis phase and is composed of three parts, 1) the occupational analysis workshop, 2) the task verification process; and 3) the task analysis process.

The occupational analysis workshop is the most outwardly visible component of the SCID model. The workshop runs for two days and is attended by a panel of 5-12 subject matter experts, at least one trained facilitator, and a recorder. The charge is to develop a DACUM Chart by the end of the second day. Figure 1 displays the essential components of a DACUM Chart using home maintenance as the subject occupation. The first step is to identify all the duties associated with this job. A duty is defined as a large area of work and must be specified with one verb, an object, and usually a qualifier. A typical job has between 6 and 12 duties. These are the main items you would include in a one-line job description. Next, task statements are developed for each duty. A task is defined as specific meaningful unit of work. It has a definite beginning and end. It can be assigned to someone else to perform. There are usually 6-20 tasks per duty. Therefore, a typical DACUM Chart will organize 100 tasks into 10 duties.

Job Title:	Homeowner		
Duties	Tasks		
Maintain the yard	Mow lawn	Edge lawn	Fertilize lawn
Maintain house exterior	Wash windows	Clean out gutters	Paint wooden surfaces
Maintain house interior	Vacuum floors	Replace burned-out light bulbs	Unclog drain

Figure 1: Sample DACUM Chart

One might ask, "Why wasn't wash windows included as a task under Maintain house interior?" If a task falls under two or more duty statements, it should only be included once if the steps in completing the task are the same. The goal of the chart is not to provide instructions for an employee but rather to identify the knowledge and skills required of an employee to successfully perform the job. The quality of the chart depends upon the ability of the facilitator to guide the discussion along a productive path and the willingness of the panel members to participate openly. Ground rules must be set at the beginning involving courtesy and all must agree to adhere to the schedule. Assembling a DACUM chart is like trying to complete a jigsaw puzzle without having seen a picture of the final product on the lid of the box. Tasks are the puzzle pieces and a duty is a collection of pieces of the same color.

While the DACUM Chart emphasizes what a worker needs to be able to do, discussions often lead in other directions such as: What does the worker need to know? What equipment or supplies are to be used? What worker attitudes are preferable? What are the future trends? This information is valuable and needs to be captured in the form of lists to be included with the chart.

The second step in the process is verification of the chart. The chart is distributed to between three and one hundred subject matter experts for review. They are asked to confirm the duty and tasks statements. They are also asked to rate the tasks in terms of their importance.

The third step in the process is the task analysis. This is the most labor intensive, time consuming, part of the process. With the most critical tasks identified, a curriculum-writer interviews a subject matter expert asking very specific questions regarding how the task is performed. The information obtained in this step is very important because it identifies performance steps, decisions, essential knowledge, industry standards, etc. needed to develop accurate and relevant teaching and learning materials. This information can be summarized in a chart similar to the one shown in Figure 2.

Task Analysis Form										
Curriculum Writer				Subject Matter Expert					Date	
Duty										
Task										
Steps	Performance Standards	Tools Equip. Mat'ls	Related Knowledge			Safety	Attitudes	Decisions	Cues	Errors
			Verbal/ Written	Math	Technology					

Figure 2: Task Analysis Chart

These two charts do not tell educators how to teach, or exactly what to teach; it provides and organizes documentation of industry's expectations of engineering graduates. It can be useful is deciding which CAD software to teach or which brand of PLC to use in the lab, as well as defining which soft skills should be acquired by potential employees to help them succeed.

III. Mechanical Engineers in a Manufacturing Environment

The Department of Mechanical Engineering at The University of Memphis is in the midst of a major curriculum review/redesign and has decided to use the DACUM process as one of the major sources for industrial input to that process. In the past, the primary sources for such input were discussions with advisory board members, personal contacts in industry, and alumni. One of the attractions of the DACUM process is that panel members need not belong to one of these groups and a special effort has been made to have a significant percentage of panelists who were not a member of these groups. Another attraction is that the formal structure of the process should provide excellent documentation to help satisfy the new Engineering Criteria 2000 (EC2000) accreditation guidelines published by The Engineering Accreditation Commission of The Accreditation Board for Engineering and Technology (ABET). One component of the curriculum development plan is to perform several DACUM workshops focused on different industries that hire significant numbers of our graduates. Over the past few years the department has recognized that an increasing number of our graduates are being hired by local manufacturing companies. Although several members of the faculty have industrial experience, most have little experience with the small to medium size manufacturing concerns that are prevalent in Memphis. Given the limited experience base, and the recognized need for increased curricular content in this area, the first DACUM panel was targeted at "Mechanical Engineers in a Manufacturing Environment."

The first step in assembling the DACUM panel was to identify local companies for which a primary source of income is the production of a machine, component, or system. Manufacturing in the metropolitan Memphis area includes a very wide variety of products, which range from relatively low-tech products, (wallboard), to extremely sophisticated high-tech products, (artificial knee joints). One of the objectives in DACUM panel assembly was to obtain a representative sampling from as many different market segments as possible. Initial conversations with company representatives included an explanation of the purpose of the panel and a clear statement that participants would be committed to two full days of work on the panel. Attempts to contact 17 companies that fit the desired profile yielded a commitment of eight individuals to serve on the panel; seven actually participated. The objective of diversity in market segment representation was achieved with panelists involved in the manufacture of HVAC equipment, over-the-road trailers, automotive air-conditioning components, artificial knees and other joints, wall-board, sporting goods, and one panelist who works as a consultant to a variety of small manufacturing concerns. The panelists were diverse in educational background, industrial experience, and age. However, all participants satisfied the single most important criteria for serving on the panel; they were all intimately involved in the production of tangible goods.

The “Mechanical Engineers in a Manufacturing Environment” DACUM panel was convened on September 14 and 15, 1999. Seven panelists and two facilitators were present for the entire process. A variety of visitors, including facilitators-in-training, M.E. faculty, and other guests, drifted in and out. The one ground-rule for all visitors was absolutely NO participation in the process. For a member of the faculty, this was harder than you might expect! Over a period of approximately 16 hours the panelists and facilitators identified 108 discrete and unique tasks that were organized into the 7 duties that eventually became the draft DACUM Chart. During the process there was considerable give-and-take with panelists debating the relative merits of how each task was defined as well as the organization of the tasks into duties. The facilitators did not provide any content but rather provided guidance to the panel as to what kind of information was desired and how it could be organized to conform to the DACUM process. A recorder preformed the clerical tasks required to document the process.

The draft DACUM Research Chart produced by this panel identifies seven main duties performed by engineers in a manufacturing environment: A) Manage Projects, B) Troubleshoot Fabrication Problems, C) Troubleshoot Assembly Problems, D) Troubleshoot Finishing Problems, E) Troubleshoot Inspection/Testing Problems, F) Troubleshoot Material Handling Problems, and G) Troubleshoot Packaging/Warehousing/Shipping Problems. Because the phraseology is somewhat non-standard, the facilitators repeatedly questioned the panelists on the repeated use of the word “Troubleshoot” in almost all of the duty titles. The panelists would discuss the issue and consistently recommended retaining that phraseology, so that is how it has been recorded. Per the formal DACUM process definition, verbs used in the title of a duty cannot be repeated in the task titles. This proved to be surprisingly challenging for the panelists. As specified in the DACUM process, the task statements associated with each duty identified a clearly defined unit of work. For example, Prepare Project Investment Proposals, Prepare Bid Packages, and Conduct Project Status Meetings, were a few of the task statements that evolved as panelists sought to define what it meant to Manage Projects, (duty A above). Because the task statements only contain verbs, three list were developed as the discussion progressed to describe what an engineer needs to know, (Prerequisite Knowledge and Skills), to describe what equipment is currently used, (Tools, Equipment, Supplies, and Materials), and to define common terminology a practitioner is expected to know, (Terms and Acronyms). After the draft chart was organized, the panel made a final pass through the tasks to categorize each as either an entry-level task or an advanced-level task requiring experience and/or training.

As of the writing of this paper, this particular DACUM process had proceeded as far as production of the draft chart. As previously described, the next step in the DACUM process is chart verification. A copy of the draft DACUM chart will be sent to a cross-section of practitioners and to solicit feedback on task prioritization and opinions about the accuracy and completeness of the chart. In a formal DACUM process verification would be followed by a task analysis step in which curriculum-writers would interview subject matter experts to obtain additional detailed information about each task. Although this step would probably yield additional useful information, it is extremely labor intensive. Faculty members are already overloaded with other commitments and the financial resources for the dedicated personnel required to accomplish this step in a reasonable time frame are not available. Instead, members of the faculty will perform a “gap-analysis” that compares the tasks identified by the DACUM panel to the current content of the curriculum. The faculty, (11 members of the department), will then meet to review items identified as falling within the gap and decide what changes should be made in the program curriculum to better serve our students.

Summary and Future Directions

As engineering programs continually strive to provide the best possible education for their graduates, and to meet evolving accreditation requirements, they must ascertain the knowledge and skills that prospective employers expect program graduates to possess. The DACUM process has proven to be a very useful tool for acquisition of such information for other occupations and can become a valuable asset for engineering departments implementing continuous improvement programs. An overview of the DACUM process has been presented to inform the reader of the major components, features, and outcomes of the process. The impetus for the present work was an ongoing curriculum development project underway at The University of Memphis and the progress to date in that effort has been presented as an example of how the DACUM process can provide an important contribution to the design of an engineering curriculum.

The verification step of the current DACUM workshop is underway and will be followed by a “gap-analysis” that will lead to modification of the existing mechanical engineering program to better prepare graduates for immediate entry into a manufacturing environment. Plans have been made to conduct additional DACUM workshops to identify curricular content that will prepare graduates to pursue career paths in other environments such as consulting and research. The outcome of this sequence of workshops will be a set of DACUM Charts that will provide valuable guidance in the evolution of the undergraduate program in mechanical engineering.

References

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DEBORAH J. HOCHSTEIN

Deborah J. Hochstein is an Associate Professor of Engineering Technology in the Herff College of Engineering at The University of Memphis. She obtained a Bachelor of Science degree from Georgian Court College and a Master of Science in Engineering from the University of Akron. Prof. Hochstein's present research interests focus on outcomes assessment in higher education, DACUM, and development of seamless curricula to facilitate professional development.

JOHN I. HOCHSTEIN

John I. Hochstein joined the faculty of The University of Memphis in 1991 and currently holds the position of Associate Professor and Chair of Mechanical Engineering. In addition to engineering education, his research interests include simulation of microgravity processes and computational modeling of fluid flows with free surfaces. He is a co-author of a textbook, Fundamentals of Fluid Mechanics, with P. Gerhart and R. Gross. Dr. Hochstein received a B.E. degree from Stevens Institute of Technology (1973), an M.S.M.E. degree from The Pennsylvania State University (1979), and a Ph.D. from The University of Akron (1984).