LESSONS LEARNED USING THE MODIFIED DACUM APPPROACH TO IDENTIFY DUTIES AND TASKS FOR CADD TECHNICIANS IN NORTH CENTRAL IDAHO

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Abstract

Objective: We conducted a job analysis to identify the competency profile of an entry level CADD technician in North central Idaho. B**ackground:** In 2011, the Clearwater Economic Development Association and NIMA collaborated with Lewis-Clark State College and the University of Idaho in a project to strengthen the capacity of Career and Technology Education (CTE) teachers to teach computer aided drafting and designing (CADD). An application to the National Science Foundation, Advanced Technology Education (NSF ATE) program was made and funding began July of 2011. **Method**: A modified DACUM was used. A total of seven expert workers from six companies participated. **Results**: The DACUM research chart created consisted of 8 duty statements and 54 task statements. **Conclusions:** Effective facilitation helps to reduce self-serving biases. The panel of experts believed the modified DACUM expedited the development of a new DACUM Research Chart that is reflective of what is done in the region.

Introduction

The gradual re-emergence of manufacturing from the recent recession has brought to the fore the troubling concern that many high school and college graduates do not have the technical skills required to perform as an entry level employee in many of these companies. Even amidst the present high unemployment rate, manufacturers are still experiencing difficulty finding employees with required technical skills (Department of Labor, 2012). In fact, according to White (2012), although 30.4 percent of U.S. adults have a bachelor's degree or higher, there's a mismatch between the skills many students acquired in those four years and what employers say they need to fill jobs. Nash-Hoff (2011) explicated the main reasons for lack of workers with specific skills needed by today's advance technology manufacturers. These include:

- unemployed workers mainly coming from industries that have been decimated by offshoring
- fewer people choosing manufacturing as a career choice because of poor image and
- attrition from retirement that is worsening as baby boomers begin to retire.

Manufacturers in North Central Idaho face similar challenges in filling requirements for skilled positions. North Central Idaho is comprised of Idaho, Lewis, Latah, Clearwater and Nez Perce counties. This rural region of 13,500 square miles of forest, high prairies, and river basins is home to 104,000 people living within 29 incorporated communities and in unincorporated areas scattered along the Clearwater River valley, Salmon River canyon and on the Palouse, Weippe, and Camas prairies. Sixty percent of the population lives in the most urban communities of Lewiston and Moscow. In the past this region's economy was heavily dependent on agriculture and timber industries. Over time, North Central Idaho has lost agricultural, lumber and wood products jobs. Since 2006, the region has been involved in an aggressive pursuit of economic development planning and implementation through high technology business and industry as a road to economic diversity and regional prosperity (Clearwater Economic Development Association, 2009).

The region's workforce is growing slowly and is notably older than the rest of the state or nation. Between 1978 and 2008, the region's civilian labor force grew 11.8 percent from 43,200 to 48,300. In the same 30-year period, the U.S. civilian labor force grew 50.9 percent and Idaho's grew 82.7 percent. In 2008, 17.9 percent of the U.S. labor force was over 54 years of age; 19.2 percent of the region's labor force was in this age category. These statistics indicate the region will be facing a high number of retirements in the coming years. With a slowly growing regional youth population, the region will face further challenges replacing retirees unless graduates can be attracted to the manufacturing industry and remain in the region. In 2007, these workforce challenges were documented in a comprehensive manufacturer needs assessment performed by the Northwest Intermountain Manufacturers Association (NIMA) through a Federal Economic Development grant. Development and retention of a quality workforce was identified by 100 regional manufacturers as the most critical industrial need (North Western Intermountain Manufacturers Association, 2008).

NIMA's needs assessment survey also identified a negative perception amongst local school district administrators, youths, parents, and teachers regarding the potential for rewarding and livable wage jobs in the manufacturing sector. Because of this negative perception, manufacturing often is not promoted as a quality career possibility and some school district personnel were completely unaware of job opportunities in regional manufacturing (North Western Intermountain Manufacturers Association, 2008).

In 2011, the Clearwater Economic Development Association and NIMA collaborated with Lewis-Clark State College and the University of Idaho in a project to strengthen the capacity of Career and Technology Education (CTE) teachers to teach computer aided drafting and designing (CADD). This initiative arose out of direct consultations with manufacturers in the region to identify the skills that are urgently required for manufacturing in the region. An application to the National Science Foundation, Advanced Technology Education (NSF ATE) program was made and funding began July of 2011.

There was no competency profile that describes comprehensively the duties and tasks of an entry level computer aided drafting and designing technician (CADD) in North Central Idaho. This information was necessary because of a desire to design training in CADD skills to be as prescriptive as possible so as to reduce the gap between what is actually performed in manufacturing enterprises and what is taught in technology education classrooms. The decision was made to conduct a job analysis. The purpose of this job analysis was to use subject matter experts (SMEs) in computer aided drafting and designing to answer the following questions:

- What are the main duties and related tasks that characterize the function of an entry level CADD technician in North Central Idaho?
- What are the skills, general knowledge, and dispositions that an entry level CADD technician in North Central Idaho needs to possess?

Job Analysis

Job analysis is a systematic process in which individuals make judgments and collect data to document the requirements of a job and the work performed (Brannick & Levine 2002; Clifford, 1994). It "provides a detailed description of particular job duties, responsibilities, necessary skills, requirements, and the work environment of a given job"

(Morganson, Major, & Bauer, 2009, p. 252). Job analysis is often the first step in a series of actions to create job descriptions, redesign jobs to promote efficiency, and determine training needs (Morganson et al., 2009). According to Cucina, Martin, Vasilopoulos, and Thibodeuax (2013), there are two broad categories of job analysis methods, job-oriented and worker-oriented. Job-oriented methods focus on the job itself and the work or tasks performed by incumbents, whereas worker-oriented methods focus on collecting information regarding the competencies required in performing a job. Different techniques are used to conduct job analysis. They include observations, surveys, worker diaries, questionnaires, critical incidents, interviews— both individual and focus groups (Chang, & Kleiner, 2002; Shetterly, & Krishriamoorthy, 2008).

Job analyses generated by workers who are viewed as subject matter experts (SMEs) by their employers tended to display high consistency in the type of information revealed (Goffin, et al., 2011). The unique type of manufacturing entities in a particular region often necessitate identification of duties and tasks that are reflective of the nature of work in these specific industries. Using expert employees from specialized industries to perform job analysis of their work can result in competency profiles that are highly reliable. After consultations with various stakeholders, the decision was made to use the DACUM process to determine the competency profile for CADD technicians. It was determined that because this process was more expedient and less likely to infringe on the time of the manufacturers, it had the likelihood of eliciting more support from the mainly small manufacturing companies in the region. It addition, the DACUM process was never used in this region before, so the economic development association and the project team saw an opportunity to explore how efficient the process would be to answer the questions posed and its potential to be used in the future for other job and occupational analysis.

The DACUM Approach

DACUM (Developing A Curriculum) is a job-oriented task analysis process which seeks to answer what skills and knowledge are required to perform a particular job at a certain proficiency level. The DACUM process provides information about theoretical knowledge, practical skills, and personal attitudes or dispositions needed to equip a person to perform at a particular level. The process was first conceptualized in the United States and Canada as a joint effort of the Canadian Department of Manpower and Immigration's Experimental Project Branch and the General Learning Corporation of New York as a means of designing and developing curricula that would be relevant to work place training (Zanella, 1999). It is the first stage of the Systemic Curriculum and Instructional Development (SCID) process (Cooper, Aherne, & Pereira, 2012; Finch, & Crunkilton, 1999; Norton, 1997).

The DACUM method has been used extensively in industry, military, government, and a wide range of professions to develop workplace-relevant training programs. Research shows it is a valid, cost effective, efficient means of executing functional, occupational, job and process analysis (Halasz, & Reid, 2003; Norton, 1997). DACUM charts "permit a ready appreciation of major areas of responsibility and related major tasks for any role" and they are often used to provide information for the development of curricula and learning resources, skills certification, writing of formal job descriptions, and workplace performance evaluations (Cooper et al., 2012, p. 871). Norton (1997) stipulated that the DACUM process is based on three premises: 1) expert workers can

better describe their job than anyone else 2) any job can be effectively described in terms of the competencies or tasks that successful workers in that occupation perform, and 3) the specific knowledge, skills, attitudes, and tools required by workers in order to correctly perform their tasks can also be described.

A DACUM workshop typically involves a trained DACUM facilitator and a committee of 5-12 experts from the job or occupational area that is being analyzed. The workshop usually lasts for two to three days, under the guidance of the trained facilitator. Through a process of brainstorming, group interaction, synergy, and consensus building, a DACUM research chart is produced which consists of the duties, tasks, general knowledge skills, disposition, tools, and future trends for the particular job or occupation (Halasz, & Reid, 2003; Norton, 1997). According to Norton (1997) the DACUM workshop typically includes:

1. a formal orientation of the committee to the DACUM process
2. an initial brainstorming of the entire job/occupation
3. development of an organizational chart
4. identification of all the job/occupational duties
5. brainstorming of each duty to identify specific tasks
6. identification of all job/occupational task
7. obtaining a clear consensus of the committee on duties and tasks
8. review and refinement of all the duties and tasks
9. sequencing of all the duties and tasks
10. identification of general knowledge and skills
11. identification of tools equipment, supplies and materials
12. listing and refining of all acronyms and any unusual terms used in the research chart.

Method

A modified DACUM workshop was conducted (Norton, 1997). This process required a one-day workshop instead of the normal two to three days. The rationale for limiting the workshop to one day was based on the recognition that it would be too costly for small manufacturers to allow their expert employees who perform CADD functions to participate in a workshop for two or more days—most small manufacturers had only one or two workers who performed CADD functions. It was also deemed unproductive to create a DACUM research chart from scratch when DACUM charts for CADD technicians were already developed for other regions and some were available on the internet.

Participants

Letters were sent to owners and human resource managers of several manufacturing companies identified by NIMA, inviting them to identify for participation in the modified DACUM workshop, a worker whose job function involves drafting and designing, and who they recognize as an expert worker. A total of six companies agreed to participate and seven SMEs were recommended. Their years of experience ranged from five to twenty. An additional participant who has more than ten years experience working as a mechanical designer and who was presently working as a professor at a technical college was also invited to participate. Companies represented were Renaissance Marine Groups,

Schweitzer Engineering Labs, Decagon Devices, ATK-CCI-SPEER, Hillco Technologies, and American Turbine.

Procedure

A modified DACUM process was used because the expert panel was not required to build a DACUM research chart from scratch, but was asked to modify an existing DACUM research chart. A trained facilitator in the DACUM process led the workshop. He was assisted by a recorder who recorded the tasks and duties that were obtained by consensus from the SMEs. The participants were given an overview of the DACUM process. The differences between a duty and a task were explained and examples given. The facilitator then asked the participants to review each duty and tasks of an existing DACUM research chart for CADD technicians and determine if they accurately represents what an entry level CADD technician does in their company. Through a process of consensus building, the panel decided which duty and task accurately represented the work of an entry level CADD technician in North Central Idaho. Some duties and tasks were changed and new duties and tasks added. The same procedure was followed for the general knowledge, skills, disposition, tools, and future trends.

To ensure validity, member checks were done in two stages. According to Marshall and Rossman (2011, p.42), "through member checks, the participants can correct the researcher's representation of his world." The first member check took place near the end of the workshop. The facilitator went through the chart with the participants and asked if it accurately represents what an entry level CADD technician does in their company. The second member check took place several days after the DACUM research chart was completed. A draft was sent to each participant for them to comment on how accurately it reflected their input during the DACUM workshop. In addition, the chart was sent to two engineering technologists who were not a part of the DACUM panel to verify if it accurately reflects what an entry level CADD technician does in North Central Idaho.

Results

The DACUM research chart created consisted of 8 duty statements and 54 task statements. A duty statement describes a large area of work in performance terms and is a title for a cluster of related tasks (Norton, 1977). A task statement describes a work activity that is discrete, observable, performed within limited periods of time, and leads to a product service or decision (Norton, 1997). The duties and tasks are shown in Table 1. The research chart also included general knowledge and skills; worker behavior or disposition; tools, equipment, supplies and materials; future trends and concerns (see Table 2). When compared with the reference DACUM research chart for CADD technicians, the results represented a reduction of one duty and sixteen tasks. Qualitatively, there are some notable differences in the duties and tasks from the reference chart and those on the developed chart. The duties and tasks for the developed DACUM chart represented the job performed by an entry level mechanical CADD technician. This represents the predominant CADD functions taking place in the manufacturing companies in North Central Idaho. In contrast, the chart used as reference represented duties and tasks for a CADD technician working in the construction industry.

Table 2
DACUM Research Chart for Mechanical CADD Technicians in North Central Idaho

Duties and tasks

A. Perform project research
- **A-01** Gather reference documents and drawing
- **A-02** Review project scope
- **A-03** Review project specifications
- **A-04** Review relevant standards
- **A-05** Coordinate with project team
- **A-06** Request additional project information
- **A-07** Support schedule development
- **A-08** Conduct job site review

B. Create preliminary designs
- **B-01** Convert external files (e.g. images, models)
- **B-02** Create 3D models
- **B-03** Update engineering data
- **B-04** Create preliminary layout
- **B-05** Incorporate external drawings and models
- **B-06** Create first draft of drawings
- **B-07** Create drawings' dimensions
- **B-08** Add notes and annotations to drawings
- **B-09** Create drawings bills of material
- **B-10** Print (plot) drawing files
- **B-11** Use CADD software analysis tools

C. Participate in project review
- **C-01** Review design with project team
- **C-02** Check for design issues
- **C-03** Specify design changes (e.g. redlines, markup)
- **C-04** Obtain owner approval of design
- **C-05** Review project schedule

D. Create final drawings
- **D-01** Revise drawing based on reviews
- **D-02** Rename and register project files
- **D-03** Check drawings for quality (e.g. appearance & legibility)
- **D-04** Print final drawings
- **D-05** Create closeout documents (e.g. CNC, purchasing, specification, work order, transmittal form)

E. Assist with project management
- **E-01** Monitor project schedule/progress
- **E-02** Respond to vendors contractors phone calls
- **E-03** Determine project issues
- **E-04** Resolve project issues (e.g., drawing, revisions)
- **E-05** Conduct site review

F. Produce project documentation (technical, marketing, safety)
- **F-01** Create as built drawings
- **F-02** Obtain approval of project official (e.g., stamp, signature)
- **F-03** Assist with project cost/time analysis
- **F-04** File project documents
- **F-05** Collaborate with other departments to produce technical marketing document

G. Perform administrative tasks
- **G-01** Perform software upgrades
- **G-02** Assist with CADD library maintenance
- **G-03** Assist with CADD standards manual maintenance
- **G-04** Request equipment and supplies
- **G-05** Maintain personal/job time record
- **G-06** Process electronic communication (e.g., fax, email, pdf)
- **G-07** Participate in personal performance review

H. Participate in professional development
- **H-01** Read professional literature
- **H-02** Participate in internal training (e.g. procedures, software, safety)
- **H-03** Network with professionals
- **H-04** Participate in external training (e.g., seminars, online, workshops)
- **H-05** Provide on-the-job training to colleagues
- **H-06** Provide employee technical assistance
- **H-07** Provide feedback to supervisors

Figure 1 compares the duties from the reference chart to the duties developed by the expert workers. There were three duties that remained the same as the reference chart: "Perform project research," "Assist with project management," and "Perform administrative tasks." One difference was the reference chart documented a CADD technician would "Coordinate project review" while the developed chart documented entry level CADD technicians "Participate in project review."

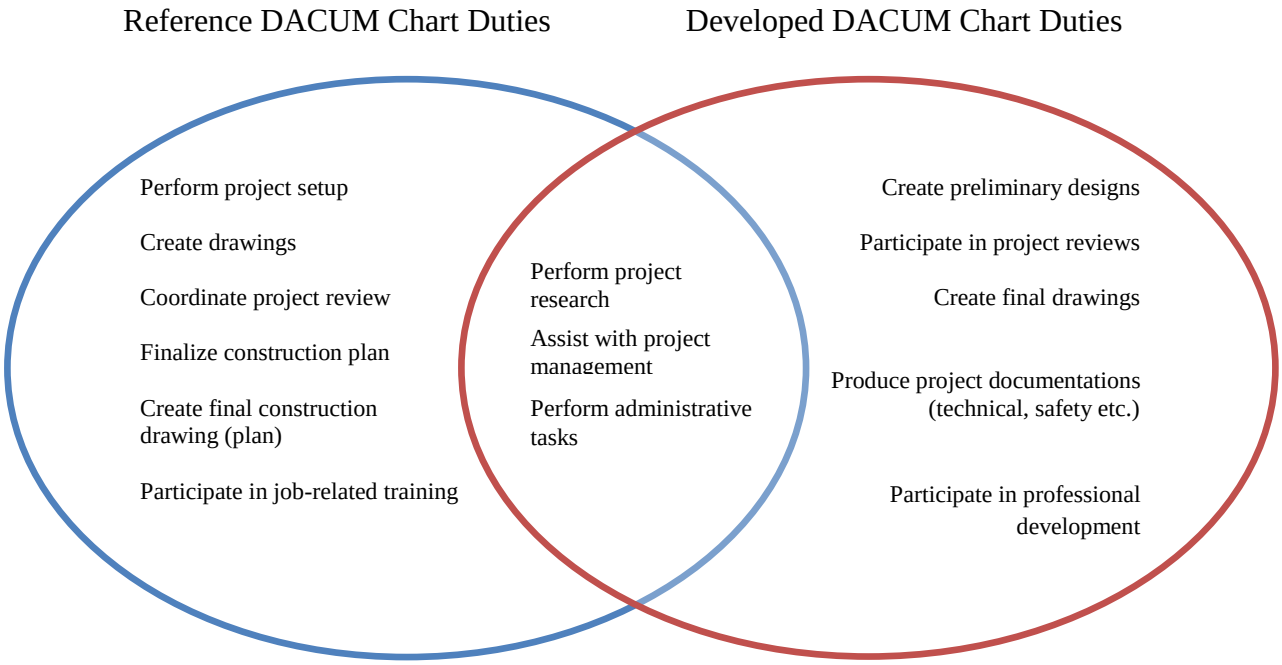

Figure 1. Duties from referenced and developed DACUM charts

Table 3
General knowledge skills and dispositions identified by expert panel

General knowledge and skills	
Industry drafting standards	Licensing laws
ANSI drafting standards	Quality control
Company standards	File management
Detailing standards	Task management
Mathematics	Time management
Interpersonal skills	Leadership skills
Construction terminology	Laws & regulations
Communication skills	Problem-solving skills
Sketching and drafting	Project team skills
Electronic communication	Manufacturing process
Read and comprehend drawings	Geometric tolerance
Word processing and spreadsheet	
Worker dispositions	
Team player	Energetic
Flexible	Good hygiene
Work unsupervised	Confident
Attentive to detail	Honest
Appropriate dress	Positive
Personable	Efficient
Dedicated	Motivated
Willing to ask questions	Punctual
Common sense	Thorough
Willing to change	Resourceful
Proactive	Trustworthy

Respectful enthusiastic learner	
Future trends	
Lack of qualified workers	Online classes
Changes in software	Changing technology
Higher math skills	Changing government regulations
Outsourcing	Continuing education after work hours
Globalization	
Low wages	
Graduates leaves the profession	
Industry relevant curriculum	

It should also be noted even when duty statements were the same on both charts some of the task statements identified by the expert panel differed for that particular duty. The developed DACUM research chart identified specific duties, tasks, general knowledge and skills that need to be addressed through future training and development initiatives, similar to the one presently undertaken through the NSF ATE grant. Competencies identified that might be targeted for future training and development were:

- Relevant manufacturing process
- Leadership skills
- Project team skills
- Communication skills

These competencies included both technical and soft skills an employee needs to possess in order to successfully function as a team member.

Discussion

Some important lessons were learned using the modified DACUM process. First, a modified DACUM workshop can be used to meet the needs and special circumstances of the SMEs and their employers who choose to participate in the DACUM process. Small manufacturers function in a very competitive environment, so whenever a key worker is absent for two or more days, it is extremely costly in terms of lost time and productivity. Most of the manufacturers in North Central Idaho, however, were not hesitant to allow their expert employee(s) to be involved in a one day workshop. They were more than willing to cooperate in a process that did not require their workers to be absent from their work for longer than one day. The panel of expert workers was also appreciative of a process that was not lengthy. Stakeholders from manufacturing and economic development associations can provide insight into sensitivities and constraints that may hinder a manufacturer from permitting one or more expert employees to participate in a DACUM process.

Secondly, whenever a modified DACUM process is used, sufficient preliminary research must be performed to identify enough information regarding duties and tasks of the job or occupation that is being examined. In our research, we successfully identified a recent DACUM research chart from another state. The expert panel was appreciative of the use of a previously developed DACUM chart and was of the opinion that it expedited the process. This is indicated by the following comments:

"Glad we used existing MT. DACUM."
"Was a forum that kept moving forward."
"Good-it was a relatively fast way to lay out job duties and tasks and what is needed…."
"It is a very streamlined process"

The importance of having a trained and experienced facilitator of the DACUM process cannot be overemphasized. Such facilitation skills are integral to ensure suitable composition of the expert panel; guide the process of identifying quality, reliable duty and task statements; and ensure proper identification of worker behaviors, general knowledge, skills, tools and equipment (Norton, 1997).

Third, we found that the DACUM workshop served as a platform for communicating to the experts about the breadth and depth of the NSF ATE project. This promoted a sense of pride in being able to contribute to a major deliverable associated with the project. The DACUM experience motivated some participants to offer other types of assistance in the form of educational tours of their facilities for teachers and students and participating as mentors to students. The experts also verbalized satisfaction over the opportunity to contribute their viewpoint and opinions in the development of a competency profile that will be used to address the development of skills for their profession. Several favorable comments about the process were made. Two of these were:

"It is important for the schools to understand what is used/not used in real practice so they can teach what needs to be learned and just touch on the others."
"Very worthwhile, would love to do it again sometime."

They also welcomed the opportunity to meet with their peers from other companies to discuss what the dos and don'ts of their jobs are. This is reflected in the level of collegiality displayed to each other and comments made about the strength of the modified DACUM process.

"Strength of the workshop is learning how other people in my field function in their job what are the differences/similarities."
"Atmosphere of respect and teamwork was created."

These comments are consistent with the overall benefits of the DACUM process (Halasz, 2003; Norton, 1997).

Fourth, the DACUM research chart captured for future reference technical and soft skills that are to be addressed in future training and professional develop. Attending to these competencies through professional development for high school teachers and complementary curricula and resources for students, will ensure that students are prepared in a more holistic manner to address demands for entry level mechanical CADD technicians in North Central Idaho.

Fifth, the relevance of performing a job analysis rather than solely depending on a job analysis for other regions is reflected in the quality of the DACUM research chart produced. For example, while the reference DACUM chart stated that an entry level CADD technician "Coordinate project review," the DACUM panel agreed that such duty was reflective of someone in a supervisory position. CADD technicians were required to

participate or contribute to the project review process. So, on consensus this duty was replaced with "Participate in project review." Another difference was the reference chart identified one duty as "Finalize construction plans." The expert panel again deliberated and indicated that the CADD technician's function in this region does not include making the final decision about constructions plans. This was replaced with the duty statement "Produce project documentation (technical, market, safety)." These subtle variations in duty and task statements from region to region are very informative when designing training and development programs to address the needs of manufacturers in a specific region.

In processes like DACUM, there is the challenge of reducing self-serving biases of participants on the expert panel. Self-serving bias "occurs when an individual indicates that a trait they have is important for successful performance, regardless of the actual importance of that trait to performance" (Cucina, Martin, Vasilopoulos, & Thibodeuax, 2012, p.513). The consensus building process encouraged by the facilitator to determine these competencies has the potential to reduce the self-serving bias effect. Not allowing one participant to dominate the discussion, encouraging participants who are inclined to be more reserved to contribute to the discussion, and engaging the SMEs in consensus building reduces the potential of a few outspoken panel members insisting on inclusion of duties and tasks, knowledge, skills, and attitudes that are not essential for a particular job, but rather is reflective of a competency in which they excel.

Conclusions

This paper describes the use of the modified DACUM process to identify duties and their related tasks, general knowledge, skills, and dispositions that an entry level CADD technician in North Central Idaho needs to possess. In the past, regional manufacturers indicated a lack of adequately prepared employees as a critical need. Furthermore, the populace of North Central Idaho is older than average in Idaho and the United States. As workers begin retiring, it is predicted the current shortage of employees will worsen unless regional youths are attracted to manufacturing positions. The modified DACUM workshop was part of a larger effort to equip high school students with the skills necessary for them to find employment in manufacturing companies in North Central Idaho. A modified DACUM process was used because it was too costly for small manufacturers to allow their expert CADD employee(s) to be away participating in a workshop for more than one day. It was also deemed unproductive to create a DACUM research chart specific to North Central Idaho from scratch when DACUM charts for CADD technicians in other states were easily accessible and modifying an existing DACUM chart would be more efficient.

Several lessons were learned from the modified DACUM process. The panel of experts was appreciative of the use of a reference chart. They believed this process expedited the development of a new DACUM Research Chart that is reflective of what is done in the region. The participants expressed gratitude for the shortened process. Furthermore, the opportunity to share information about the NSF ATE project with the experts promoted pride in participation and broadened the manufacturers' engagement. The SMEs also welcomed an opportunity to meet with their peers to discuss job performance and best practices. Collaboration with economic development associations

and regional manufacturer's associations improves communication and increases the awareness of the project team of constraints and barriers to participation.

The modified DACUM process required exploratory research to gather enough information on the relevant job that was being analyzed. The use of an existing DACUM chart that describes a similar job function helped to expedite the process. Additionally, in order for the modified DACUM process to produce valid and reliable results it was necessary to have a facilitator who was trained and knowledgeable of the process. Without a trained facilitator, the resultant DACUM research chart may be influenced by self-serving biases of the participants. Member checking by the panel of experts and validation by SMEs who were not a part of the DACUM workshop panel helped to add credibility to the chart. The modified DACUM process was successful on many levels. Participants found value, educators gained information on which to design relevant training, and information was gained on which to base future activities. As the region moves forward to address skills and technical development in the region, there is a common consensus that this strategy can be a useful tool to analyze job and occupational areas.

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