Project Management Education and Training Process for Career Development

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Abstract: The overall goal of this research project was to improve an organization's core competency in construction project management in a focused and systematic manner, with the help of a formalized education and training model. This paper describes the development of such a model for education and training standards for career development at Sandia National Laboratories (SNL) in Albuquerque, New Mexico. The need for this model was driven by the tremendous increase in the volume of construction work at SNL (post 9/11) along with several other factors [i.e., self-governance, customer feedback, and a new Department of Energy Order (413.3) for the handling of program and project management capital assets acquisition]. The goal of this research was to create a defined procedure to identify and quantify project management gaps and strengths, and then to develop a process to succinctly characterize each Sandia model participant's background qualification. This was achieved by administering a survey followed by a questionnaire whose results led to a customized training and development path, tracked both by individual and by department. Tools to address gaps were then identified and a role-task-competency hierarchy was created called the Sandia Project Management Career Development Academy model.

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Introduction and Background

As project management technology has evolved, the industry has developed better computerization tools to control project budgets and schedules (Yamín and Harmelink 2001). With this development of better project management methods and supporting tools for professional project managers, the ability to manage projects has vastly improved. However, what specific educational tools or knowledge are needed by a successful project manager to further enhance their success has not been quantified extensively, especially when it comes to managing construction projects. This study systematically addresses this issue. Because the model is centered around a government agency, it was impossible to avoid a plethora of acronyms. A list of these used in the model is provided in the Appendix of this paper.

Literature Review

The primary deliverable resulting from this research study was the development of a systematic method/model known as the Sandia Project Management Career Development Academy (SPMCDA). This model is being used for advancing construction project management skills at Sandia National Laboratories (SNL). This model began with the investigation of existing success models, human factor studies, Sandia's current career structure, and other project management career development models, as described below. With regard to project management skills, most of what has been accomplished to date has been in the area of general project management, as conducted by the Project Management Institute (PMI) (Rush 1992; Higgins 1993). A review of the ASCE literature indicates that there is less knowledge in project management education and a training process for career development, specific to the construction industry. Other models that were considered in the development of SPMCDA were the Construction Industry Institute's (CII's) research and the Department of Energy's (DOE's) Project Management Career Development Project (PMCDP), described as follows.

Construction Industry Institute

CII is a research organization focused on improving the competitiveness of the construction industry through improved planning and execution of capital construction programs. CII found that the top project management input factors that correlated most significantly with outstanding project performance were as follows (CII 2001):

- Project manager's goal commitment,
- Project manager's experience,
- Project planning effort,
- Team building, and
- Scope definition.

As a result of these findings, it was important that these factors were incorporated into the SPMCDA model.

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Table 1. Ten Knowledge Areas Divided into 77 Subcategories (Fisher 2003)

1 Industry specific	
1.1 Construction principles and techniques	1.8 Trade-off analysis
1.2 Value engineering	1.9 Managing multiple small projects
1.3 DOE order 413.3	1.10 Systems engineering
1.4 DOE program management	1.11 Issue identification/conflict resolution
1.5 ESAAB process	1.12 Electronic project mgmt.
1.6 Writing a project execution plan (PEP)	1.13 Writing an ORR plan
1.7 NEPA/environmental regulations	
2. Leadership/team building	
2.1 Leadership/team building	2.5 Effective meeting facilitation
2.2 Negotiation strategies/techniques	2.6 Congressional hearing process
2.3 Supervision/motivation techniques	2.7 Strategic planning
2.4 Conflict mgmt. (stress disagreement/ resolution)	2.8 Writing a strategic plan
3 Scope management	
3.1 Project scope baseline/WBS development	3.3 Writing a statement of work (SOW)
3.2 Pre-project planning/project alignment	3.4 Feasibility study
4 Communication management	
4.1 Technical writing	4.8 Assertiveness techniques
4.2 Interpersonal communication	4.9 Lessons learned
4.3 Writing decision memoranda	4.10 Implementing change
4.4 Writing project reports/studies	4.11 Strategic thinking
4.5 Formal Presentation Skills	4.12 Media relations techniques
4.6 Effective Briefing techniques	
5 Quality/safety management	
5.1 Facility operations/maintenance orders	5.6 Conducting inspections/walk-downs
5.2 Quality management and QA/QC	5.7 Total quality management (TQM)
5.3 Integrated safety management	5.8 Design for surety
5.4 Contractor validation, ES&H compliance	5.9 Constructibility review
5.5 Conducting effective design review	
6 Cost management	
6.1 Federal/Sandia budget process	6.6 Productivity measurements
6.2 Budget document preparation	6.7 Lean production
6.3 Cost estimating	6.8 Cost review/validation
6.4 Contingency development	6.9 Changes to funding levels
6.5 Cost/benefit analysis	6.10 Briefing on project budget issues
7 Time management	
7.1 Planning/scheduling theory	7.4 Top-level milestone schedule
7.2 Scheduling software	7.5 Resource loaded, baseline schedule
7.3 Jobsite schedule assessment	
8 Risk management	
8.1 Probability and statistics	8.4 Project risk assessment
8.2 Project risk mangement	8.5 Risk management plan (technology development)
8.3 Risk management software	
9 Contract management	
9.1 Contract types, bid evaluation/award process	9.5 Best value process
9.2 Develop RFP, RFQ, IFB documents	9.6 Performance based contracting
9.3 SDR training and requirements	9.7 Acquisition strategies/planning
9.4 Technical evaluation of change order	9.8 Acquisition execution plan (AEP)
10 Integration management	
10.1 Earned value management systems/reporting	10.3 Configuration management
10.2 Project status reporting	10.4 Strategic, comprehensive site planning

Note: See Appendix for definitions of acronyms.

Table 2. Comparison of Results of Benchmark Studies (Fisher 2003)

Topic number	Topic description	DOE survey (% responding affirmatively)	UNM survey (% responding affirmatively)
1	Felt impacts from September 11th terrorist attacks	(Prior to events)	80
2	Felt impacts from Enron fraud scandal	(Prior to events)	75
3	Held certifications in project management	(Not asked)	67
4	Required mandatory certifications	33	16
5	Implemented a formal mentoring program	33	62
6	Implemented a formal knowledge management program	11	50
7	Had project management tools and techniques	11	
8	Received executive management support	78	
9	Used competency models and knowledge areas	56	
10	Granted equivalencies and waivers	56	
11	Integrated models in human resources processes	56	
12	Used a systems approach	56	
13	Utilized external resources	44	

Note: DOE = Department of Energy; and UNM = University of New Mexico.

Department of Energy Report

The DOE initiated the new PMCDP for its project managers. The PMCDP model has four project management levels (GS grades) based on education, training, experience, and total project costs managed. A final report, *PMCDP Gap Analysis*, was published in January 2002 (U.S. DOE 2002). Because of the close working relationship between the DOE and SNL, this model was used as a starting point for developing SPMCDA.

Sandia National Laboratories Integrated Job Structure

Sandia's integrated job structure (IJS) describes Sandia's career advancement system in which all elements (i.e., career ladder, occupation description, and level) support each other. Sandia's IJS helps Sandia managers to evaluate employees against their level criteria and their occupational descriptions. Assessment is conducted annually using Sandia's Performance Measurement Form system. Sandia's IJS was utilized as a starting point for articulating levels and criteria within SPMCDA.

Model Development Methodology and Results

The SPMCDA model was developed from the following 5 steps:

- Step 1: Investigate current project management competencies,
- Step 2: Benchmark industry standards,
- Step 3: Finalize qualification matrix,
- Step 4: Conduct gap analysis, and
- Step 5: Recommend education/training and develop plan.

Both the competency measurement and the gap analysis steps were conducted by an assessment method to quantitatively determine which knowledge areas were weak for each individual, while taking into account their level and the importance the topic had in their job or role. Because Steps 1 and 4 were conducted simultaneously, they will be discussed concurrently in the next section.

Steps 1 and 4: Investigate Current Project Management Competencies and Conduct Gap Analysis

The first step in this research process was to identify and quantify Sandia Model Participant (SMP) competencies using a written questionnaire and oral interview sessions to determine current qualifications and competency levels in two project management departments within SNL (Corporate Projects Department and Customer-Funded Department). A total of 29 out of 35 SMPs were surveyed (83% participation). This survey contained a broad compilation of not only educational backgrounds and training certifications, but an in-depth probing to uncover other skills and competencies that would have relevancy to job functions, such as leadership and mentoring skills, and other engineering and construction abilities and experience. The survey contained questions over three parts. Part 1 was on background, Part 2 was on knowledge areas, and Part 3 was on career development.

Part 1, background, was collected by taking information from the human resources resumes on each participants education, experience, professional affiliations, community service, and other potentially job-relevant skills. Part 2, knowledge areas, came from a questionnaire containing 10 project management topics. The 10 knowledge areas originated from the DOE's PMCDP model. These knowledge areas were further divided into 77 subcategories, which would form the backbone of the SPMCDA model. These knowledge areas are contained in Table 1.

In Part 2 of the survey, SMPs answered each subcategory by rating their knowledge from 0 to 5, where 0 = no knowledge and 5 = very knowledgeable. They also rated the importance of the topic to their current job function on the same scale. Finally, they listed the source(s) where they obtained the knowledge, such as formal education, on-the-job training, formal training, or other. These sources were used later in the qualifications matrix development in Step 3.

The gap for each subcategory (Step 4) was calculated based on the respondent's knowledge of the subject (K) and the importance it had to their job (I), ranging from 0 to 5 where 0 is "not important at all" and 5 is "very important

$$\mathbf{Gap} = \mathbf{I} - \mathbf{K} \tag{1}$$

As these numbers were developed from the SMP's self-assessment, the researchers wanted to include a more objective quantitative metric. SMPs were given the option to take a *PMAppraise* exam online. This was an exam funded and sponsored by DOE/NNSA headquarters that tested their actual skills. Only eight of the 35 project managers (23% participation) took the online exam, but results for this exam aligned almost identically with the self-assessment results, validating the self-assessments that the project managers made of their skills.

Gaps were identified and quantified for each individual and for the two departments (Corporate Projects and Customer Funded) measured. The top departmental gaps for Corporate Projects (department of large capital projects and line item projects) were project risk management, stress, and conflict management, Project Management Professional certification, internal mentoring, imple-

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Table 3. Comparative Topic Results for Training and Certifications (Fisher 2003)

Organization	Certification(s)[a]	Pros	Cons
Alliance for Construction Excellence (ACE)	*None*	High quality training with current topics	No certification
American Institute of Constructors (AIC)	CPC, AC	Construction focus; exam offered by UNM (local)	Only recently endorsed nationally; more of contractor's certification
American Society of Professional Estimators (ASPE)	CCE	Established national program	Narrow focus on cost estimating
Associated General Contractors (AGC)	STP	Established national program	No certification
Assoc. for the Advancement of Cost Engineering (AACE)	CCE, CCC	Industrial construction roots; established national program	Narrow range of subjects in cost/schedule control
Construction Advancement Institute (CAI)	CCM	Patterned after AGC's national STP program	Relatively new and unproven program
Construction Industries Division (CID)	GB98	Established state program 3 GB98s already exist in "Customer-Funded" Department	More of a contractor's license
Construction Industry Institute (CII)	*None*	High quality with current topics	Training program with no certification
Construction Specifications Institute (CSI)	CDT, CCS, CCCA, CCPR	Established national program; 1 CDT already exists in Corporate Projects Departments	Narrow focus on construction documents only
Lean Construction Institute (LCI)	*None*	Potential for very high return on investment (ROI)	Narrow focus on lean construction production; new and unproven; no certification
Mechanical Contractors Assoc. (MCA)	*None*	Established national program	No certification
National Council of Architectural Registration Boards (NCARB)	RA	Nationally recognized	More of a design license
National Electrical Contractors Association (NECA)	*None*	Established national program	No certification
National Society of Professional Engineers (NSPE)	P.E., EIT	Nationally recognized; 19 P.E.s & 2 EITs already exist in "Corporate Projects" and "Customer-Funded" Departments	More of a design license
Project Management Institute (PMI)	PMP, PMA	Nationally recognized; comprehensive subjects; Endorsed by DOE; offers common PM language; offers other certification for less experienced	Roots in information technology (IT) and pharmaceutical type projects, needs additional Sandia-specific construction topics

[a]See Appendix for acronyms.

mentation of DOE Order 413.3, and preparing Project Execution Plans and Acquisition Execution Plans. The top departmental gaps for Customer Funded (smaller, internal projects) were Cost Estimating and Contingency Management.

Part 3 of the questionnaire on career development inquired about each SMP's plans and desires for the type and quantity of his or her own future career development, as opposed to what they actually did in the past year. Data generated from this section were used later in Step 5, recommending an education and training plan.

Following the survey, a follow-up oral interview of SMPs was given to 27 of the 35 SMPs (77% participation). During this time, individual and departmental gaps were discussed, with no surprises among participants. Comments revealed the need for both individual and group training in the identified gap knowledge areas, as well as the need for process improvement.

Step 2: Benchmark Industry Standards

The second step in this research process was to benchmark industry standards that were being used, in order to compare the SP-MCDA model project management elements with that of other world-class organizations in the private and public sectors. In this research, three methods were used to benchmark industry standards.

The first method was a review of an earlier DOE benchmarking study (DOE 2001). In this study, six private organizations (3 owners and 3 contractors) and five public organizations [Department of Defense, General Services Administration, Naval Facilities Engineering Command (NAVFAC), U.S. Army Corp of Engineers (USACE), and National Aeronautics and Space Administration] were surveyed with regard to best practices when it came to project management education and training. Some of these issues included certification/equivalencies, mentoring, knowledge management, knowledge areas, tools/techniques, resources/executive support, systems approach, and integrated human resource processes.

A follow-up benchmarking study was conducted as a part of this research project (Fisher and Wade 2002). This study included responses from 16 organizations broken down as follows:

- 4 public agencies—DOE, NAVFAC, SNL, and USACE,
- 3 private organizations—1 owner and 2 contractors,

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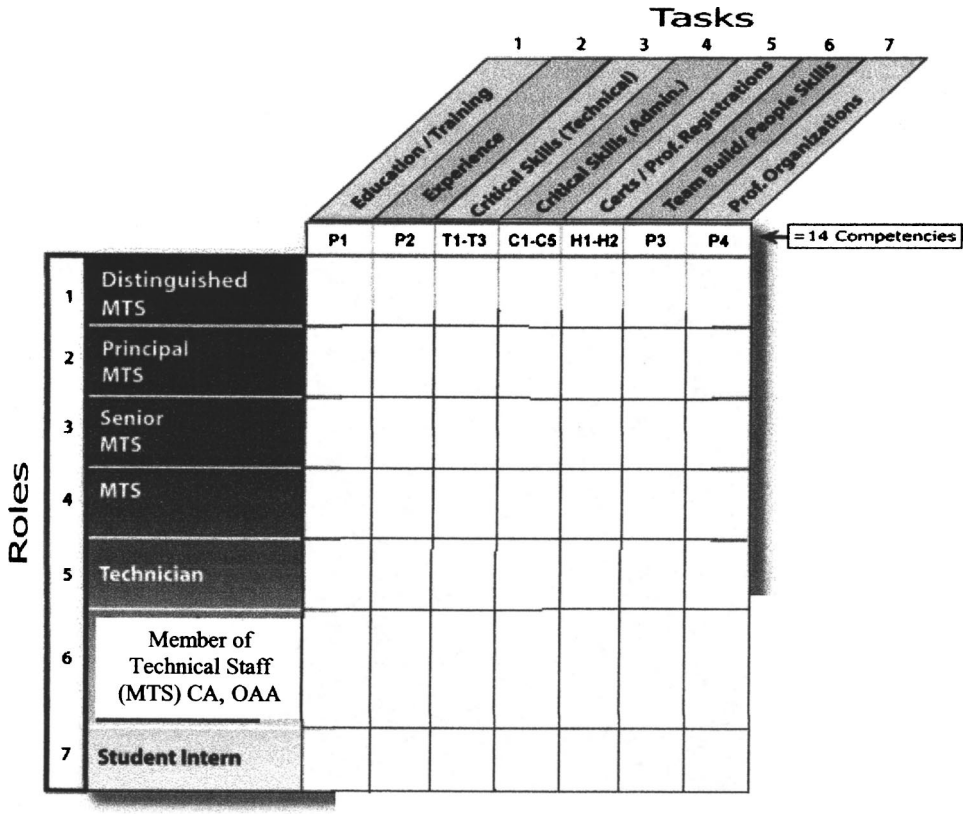

Fig. 1. Qualifications matrix

Table 4. Competency Guidelines for Sandia Project Manager Career Development Academy Model (Fisher 2003)

		Staff levels (roles)			
Competency no.	Competency description	Student interns	Support staff/ new hires	Middle project manager	Senior project manager
P1	Education	Junior standing	Bachelor of Sciences	Master of Sciences	Master of Sciences
P1	Training	N/A	40–80 CUs/yr	40–80 CUs/yr	40–80 CUs/yr
P2	Experience[a]	N/A	0–6 yr total	5–8 yr total	>5 yr
T1	Technical management	N/A	Gaps>2	Gaps1–2	Gaps<1
C1	Controls management	N/A	Gaps>2	Gaps1–2	Gaps<1
H1	Human management	N/A	Gaps>2	Gaps1–2	Gaps<1
P3	Professional reorganization	N/A	Encourage PMA Certification	Encourage PMA Certification	Require PMA Certification
P4	Service/outreach[a]	N/A	N/A	Present papers	Serve in technical society as mentor
O4	Success development[b]	N/A	Stage I	Stage I/II	Stage II/III
O4	Skills and interests	N/A	Gap<0.5	Gap<0.5	Gap<0.5
P5	Process development	N/A	Map processes	Map and/or identify recommended process development	Identify/recommended and/or implement process improvement

Note: N/A=not applicable; CU=course unit; PMA=project management associate.

[a]From Sandia integrated job structure (IJS) resume database.

[b]From Sandia's success profiles-competency based development. Stage III is designed for manager, project leaders, and staff in premanagement curriculum (Mulligan 2002).

- 5 institutes—Alliance for Construction Excellence at ASU, Construction Advancement Institute at UNM, CII at the University of Texas—Austin, Lean Construction Institute, and PMI, and
- 4 professional associations—National Electrical Contractors Association, Association for the Advancement of Cost Engineering, Associated General Contractors, and Mechanical Contractors Association.

In addition to asking about the issues from the DOE study, this study included questions about the impacts on project management education and training as a result of the 9/11 terrorist attack and the Enron fraud scandal. Table 2 contains a comparison of results of these studies. These 13 topics summarize the best practices in benchmarking education and training. Note that the addition of Topics 1 and 2 beg the need for design for "Surity" and "ethics" topics among the knowledge areas.

Because certification of project managers is a new trend and was present in both benchmarking studies (Topic Nos. 4 and 10), a third benchmarking method was used. This step looked at the "pros and cons" of various existing training and certifications offered by 15 construction-related organizations. Table 3 contains a summary of these results. The closest comprehensive certification to project management that exists is from the PMI. At the time of this research, the PMI was looking into a specialized construction project management certification evolving from their "Design Procure Construct Special Interest Group."

Step 3: Finalize Qualification Matrix

As part of the research steps, a qualifications matrix was developed as a precursor to the SPMCDA model and was based on the DOE's PMCDP model. The purpose of developing a qualifications matrix was to create a matrix of knowledge areas and skills that would include mechanisms and tools to achieve these qualifications. These mechanisms came from the sources that were given by the SMPs in Part 2 of the questionnaire for each knowledge area (see Steps 1 and 4). The qualifications matrix, illustrated in Fig. 1, contains seven roles, seven tasks, and 14 competencies. Competencies are divided into professional (P1-P4), technical (T1-T3), control (C1-C5), and human (H1-H2) areas.

It was decided that assigning target values for each cell in Fig. 1 (competency based on role) was too prescriptive. Instead, a guidelines table (see Table 4) was developed, indicating ranges in each cell. These ranges give broader parameters to assess the level and type of skills and experience that could meet the competency. This table contains four roles (a reduction from seven), and seventeen competencies (an increase of three). Guidelines for P1 (education), P2, and P4 came from Part 1 of the survey/questionnaire discussed under Steps 1 and 4. Guidelines for P1 (training) came from Part 3 of the survey/questionnaire. Guidelines for T1, C1, H1, and O4 (skills and interests) came from Part 2 of the survey/questionnaire. Guidelines for P3 came from Step 3, the benchmarking study. Guidelines for O4 (Success Development) came from Sandia's Success Profiles-Competency Based Development program (Mulligan 2002). Finally, guidelines for P5 came from the oral interviews in Steps 1 and 4 that followed the survey/questionnaire.

The qualifications matrix (Fig. 1) was merged with the guidelines table (Table 4) and eventually refined into the SPMCDA model (Fig. 2). This model contains a hierarchical list of four roles, six tasks, seventeen competencies, and 24 tools.

Step 5: Recommend Education/Training and Develop Plan

As part of the study process for career development, the final step in this research project was to recommend training to fill gaps and develop an implementation plan. Development of an implementation plan proceeded in three substeps:

1. Identify Project Management tools: Tool identification was an important step in the final development of the SPMCDA model. In developing the SPMCDA model, guidelines were suggested by Dr. Fisher with multiple gap filling avenues (shown in Table 4). These guidelines were consistent with Sandia's existing IJS.
2. From alliances through interorganization interfaces: During this study, many interorganization alliances were formed in the areas of education and training. For example, DOE personnel were included in Suretrak and PMP training sponsored by corporate projects. These alliances helped in payoffs of significant dividends to Sandia in the form of efficient, local, and cost savings education and training opportunities.
3. Estimate training cost and schedule implementation activities: A final part of this study reviewed education and training programs and the related cost and schedule implementation activities. The results of the study that came from Part 3 (career development) of the questionnaire/survey in Steps 1 and 4 are summarized as follows:
   - Managers complete double (or more) the training hours (80 to 100 average annual hours) than the group average (40 to 50 average annual hours). This is to be expected, due to the added requirements for Management training that SNL requires.
   - There is close agreement between departments and managers as to what should be achieved *external* to Sandia (1 week per year).
   - Most respondents agree that the amount of annual training time devoted *internal* to Sandia should be two weeks per year (it is currently 1 week per year). Internal Sandia training hours should double for both departments
   - External training hours should be cut in half (from 50 to 70 average annual hours to 20 to 40 average annual hours)
   - According to the DOE gap analysis study (DOE 2002), the average cost of education and training per person is $300 per day for in-class training and $50 for online training.

Overview of Sandia Project Manager Career Development Academy Model Development

Based on the literature from existing models and from the results of the five research steps, the SPMCDA model was finalized. The model contains a comprehensive hierarchical structure for defining project management competencies and tools. The model is compatible and integrated with Sandia's existing Human Resources and Corporate Training and Education systems, a best practice in the industry. It consists of four roles and six tasks. A total of 17 competencies were selected for the model. This is an increase from the 10 knowledge areas contained in DOE's PMCDP model. Although the concept of project management tools and techniques is not new, the addition of 24 tools (see Fig. 2) to the model that are specific to particular competencies is new.

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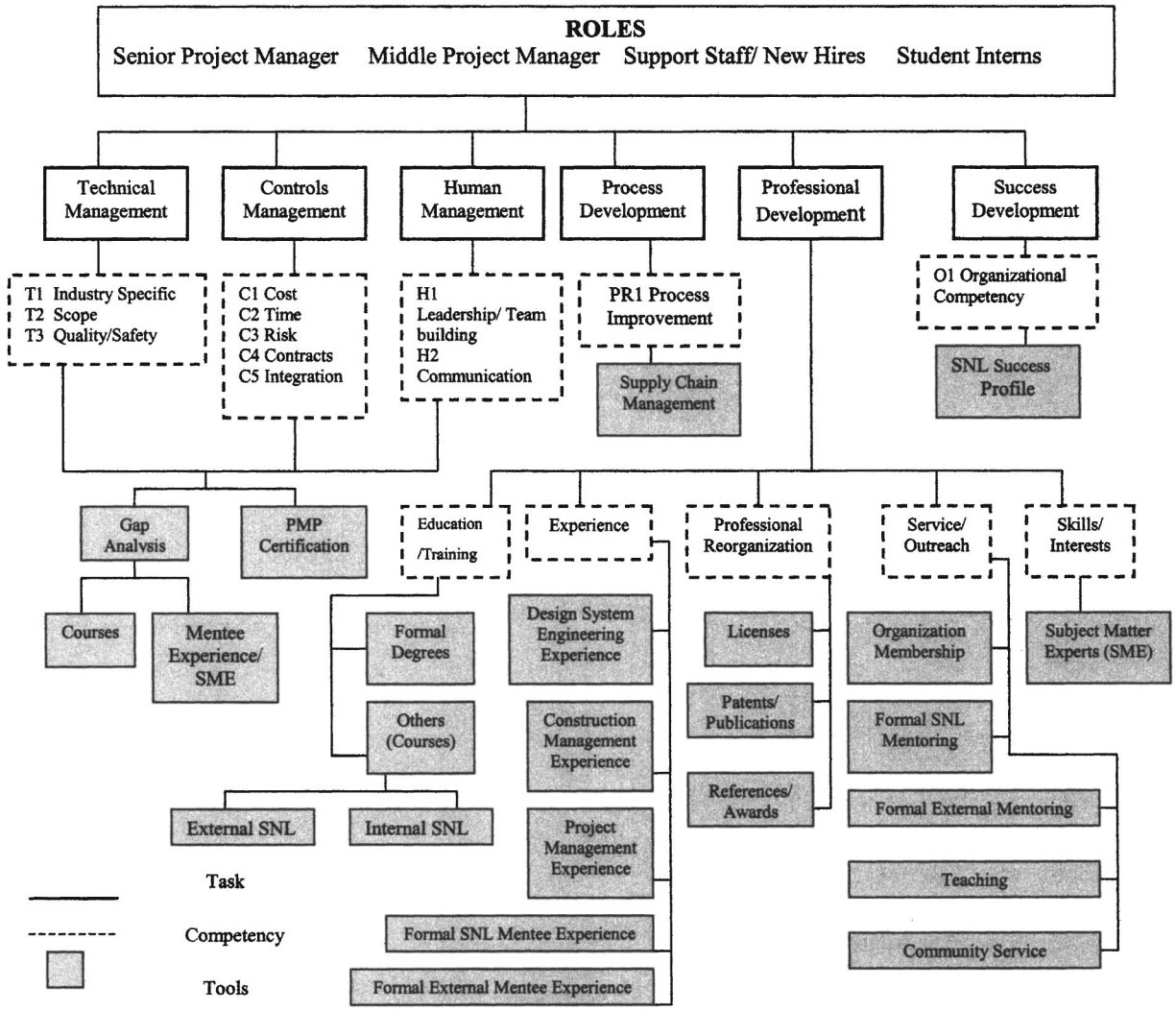

Fig. 2. Sandia project manager career development academy model

Finally, the development of two prototype databases (Fisher 2003) paves the way for fully implementing a quantitative assessment process that will identify gaps, track career progress, and calculate an assessment score for Sandia's construction project managers and construction support staff. Fig. 2 illustrates the completed SPMCDA model showing the role-task-competency-tools hierarchy.

Conclusions and Recommendations

This study documents the development of construction project management education and training for the project mangers and construction support staff at SNL, Albuquerque, New Mexico. The results of the study culminated in the development of the SPMCDA model. The SPMCDA model can be easily applied to other design and construction firms with only minor adjustments to only two or three of the seven category T1 (industry specific) subcategories listed in Table 1. These are unique to the management of DOE projects.

The SPMCDA model goes beyond many of the project management career models that currently exist in industry and government. The model provides a quantifiable process involving a systems approach to clearly identifying knowledge/skill area gaps, quantify the gaps, and provide specific methods to fill those gaps. It does not prescriptively test, grade, or mandate to project managers, based on a static assessment system or matrix, but allows them to assess themselves by comparing their knowledge of a subject and the importance of that knowledge to their job function. The process directly involves each project manager and construction support staff in their own career development since they identify their own gaps. In this way, they can effectively budget their training time toward the most relevant courses. It also allows a department manager to monitor its department's overall gaps and strengths and strategically plan accordingly for annual education and training budgets.

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Appendix. Acronyms

AC = Associate Constructor (AIC);
ACE = Alliance for Construction Excellence (Arizona State University);
AEP = Acquisition Execution Plan;
AGC = Associated General Contractors;
CA = Construction Associate;
CCC = Certified Cost Consultant (AACE);
CCE = Certified Cost Estimator (AACE);
CCE = Certified Cost Engineer (ASPE);
CCCA = Certified Construction Contract Administrator (CSI);
CCM = Certified Construction Manager (UNM's School of Engineering);
CCPR = Certified Construction Production Representative (CSI);
CCS = Certified Construction Specifier (CSI);
CDT = Construction Document Technologist (CSI);
CPC = Certified Professional Constructor (AIC);
CU's = Course Units;
DOD = U.S. Department of Defense;
DOE = U.S. Department of Energy;
EIT = Engineer in Training (NSPE);
ESAAB = Energy Systems Acquisition Advisory Board;
GB98 = General Building (a General Contractor's license);
GSA = General Services Administration;
IFB = Invitation For Bid;
MTS = Member of Technical Staff;
NASA = National Aeronautics and Space Administration;
NAVFAC = Naval Facilities Engineering Command;
NEPA = National Environmental Policy Act;
OAA = Office Administrative Assistant;
ORR = Operational Readiness Review;
P.E. = Professional Engineer (NSPE);
PEP = Project Execution Plan;
PMA = Project Management Associate (PMI);
PMCDP = Project Management Career Development Program (DOE model);
PMP = Project Management Professional;
QA = Quality Assurance;
QC = Quality Control
RA = Registered Architect (NCARB);
RFP = Request for Proposal;
RFQ = Request for Quotation;
SDR = Sandia Delegated Representative;
SME = Subject Matter Expert;
SMP = Sandia Model Participant;
SOW = Statement of Work;
SPMCDA = Sandia Project Management Career Development Academy;
STP = Superintendent's Training Program;
TQM = Total Quality Management;
SNL = Sandia National Laboratories;
UNM = University of New Mexico; and
USACE = U.S. Army Corps of Engineers.

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