AC 2007-83: THE ROLE OF EDUCATION IN THE PROGRESSION FROM TECHNOLOGIST TO GENERAL MANAGER

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The Role of Education in the Progression from Technologist to General Manager: A Qualitative Study

Abstract

A qualitative research study addressing looking at educational interventions in the career development of engineers moving from technologist to general manager. For this study "education" is defined on a four-part continuum of formal, non-formal, informal, and incidental/experiential. Formal and non-formal education is an intentional and systematic enterprise while informal and experiential education results in learning but learning is not the basic purpose of an activity.

This research revealed 1) the pattern of learning interventions along the educational continuum is different for those engineers that made a successful transition versus those that did not. The learning for a successful transition was weighted toward the experiential end of the continuum. 2) The key educational content for those engineers who made a successful transition is multidisciplinary. And 3) this multidisciplinary education takes place early in a career. When looking at the ABET criteria 3d, "ability to function on multidisciplinary teams," this career path and educational study indicates that we should define multidisciplinary as integration along functional areas of engineering, marketing, sales, finance, manufacturing, purchasing, etc.

Introduction

Prospective engineering students and their parents visit colleges and universities trying to determine the best place for the student to attend and how to prepare that student for a career. It is common to hear questions such as: Will my child receive a good education here? What is the job market like? Will there be jobs available when they graduate? How will engineering careers be impacted by international outsourcing?

As students graduate they often add additional questions: Will I enjoy my job? Will I do well in my job? What kind of career progression should I expect? Will I always be an engineer or should I consider moving into management?

History has shown that many of engineering students will take a career path that begins in a technology position and moves into a general management position. Engineering educators should be interested in the role that education plays in that transition. Therefore, this paper addresses the research question: What role does education, in its various forms, play in the successful transition of an individual from technologist to general manager?

This paper will: provide definitions for general management and educational learning continuum that bounded the research, outline the research process, summarize the results, identify the emergent theory, and finally state areas of application and continued research.

General Management

As graduates, engineering students are typically hired into a starting, junior engineering position within a company. Career progression from that point often proceeds along one of two paths. The engineer can remain in a technical position and be promoted into more senior technical positions. The most senior position in companies may be as a technical fellow or Vice President of Engineering or Technology. The second path would be to move into a general management position. As a general manager, the individual would be responsible for multidisciplinary operations along functional areas such as engineering, marketing, sales, finance, manufacturing, purchasing, legal and other corporate disciplines. From this perspective, the individual will not only be able to function on a multidisciplinary team as required by the ABET outcome criterion 3(d)[1], but they will also be managing and leading those teams. Progression along this second path was the focus of this research.

Educational Continuum

ABET engineering outcome Criterion 3(i) states "a recognition of the need for, and an ability to engage in life-long learning."[2] To understand the relationship between life-long learning and educational interventions, it is first necessary to understand the various roles of education. Education and learning take place along a four-part continuum with formal, non-formal, informal and experiential interventions. Table 1 shows many of the characteristics of these interventions.

	Formal	Non-Formal	Informal	Experiential
Structure	High	Medium to Low	Minimum to No	No
Maintenance	High	Minimal	Almost None	None
Format	Lecture/class	Small Group	One-on-One	One
Control	Professor	Speaker	Relationship	Student
Student Control of Content	Limited to None	Limited to None	Increase	High
Time	Set by Degree Requirements	Days or Weeks	Short Encounters Over Long Time	Dependent on Task
Reward	Grades/Degree	Certificate	Dinner/ Promotion	None/Job Completion

Table 1. Educational interventions on a continuum.

Universities exist in the realm of formal education with very intentional learning, grades, high structure, limited student control of content, and the outcome of a degree. New philosophies move the format from the lecture to more active learning techniques, but the classical lecture

continues for many. Non-formal interventions are characterized by seminars: much less structure, still intentional learning, no grades, limited student control of content, and certificates. Informal interventions are characterized in the mentoring or peer team activities: one-on-one relationship encounters, minimal to no structure, increased student control, learning by doing, and more intrinsic reward of accomplishment. Experiential learning is the least structured form of educational intervention and is sometimes termed as incidental or consequential in nature. It is characterized by: the highest student initiative expressed in total control of the learning content, process, length, and depth; lasts only long enough to complete a given task or solve a specific problem; no perceived resultant reward or only the intrinsic satisfaction of knowing that a task is completed. The experiential process of education and learning may not be specifically recognized since it takes place as a part of other activities that are not normally associated with learning. Research has shown that informal and experiential learning are dominant as an individual proceeds through a career.[3]

Research Process

For this study qualitative research methods were utilized. The study evaluates career changes that take place over an extended period of time. Qualitative methods allow for purposive sampling of individuals that have fulfilled the career outcome requirements of the research question. By utilizing interviews and case studies, the careers of each participant were evaluated retrospectively and the data emerged for the independent variables. A detailed evaluation of multiple participants and triangulation yielded data on relative importance of the types of educational intervention, the content of the educational interventions, and the timing of the intervention critical to successful transition. The study incorporated the key qualitative concepts of: natural setting, tacit knowledge, qualitative methods, iterative research, negotiated outcomes, and case report and trustworthiness as summarized by Lincoln and Guba[4].

Natural Setting. The first demand of this inquiry is using the natural setting. Whatever the phenomenon being studied, meaning comes as much from the context and setting of the study as from responses of the research participants. The researcher is not just looking for answers to a series of interview questions, but is also attempting to understand why actions take place, to assess the participants' reactions to questions and to explore how environment impacts behavior.

Due to the longitudinal nature of this study, there was not the opportunity to follow participants throughout many years of multiple careers and record observations. Alternatively, research participants were chosen as individuals who had attempted the career transition to general management. Interviews probed retrospectively at the career development of each participant and extracted information relevant to the research question.

In addition to direct interview responses, attitudes and reactions to interview questions were observed and recorded, their recalled feelings were probed with respect to key career points, company environments and cultures were studied, and some artifacts from personnel files were available for evaluation.

Tacit Knowledge. Qualitative inquiry also builds on the tacit knowledge of the researcher. Tacit knowledge comes from experience, and can be built upon to gain greater depth of understanding

and inquiry. It relies on the ability of the interviewer to recognize key triggers for probing and understanding. Recognition of body language, nervous idiosyncrasies, or similar nonverbal cues can key the researcher to important areas that require better understanding. Does the tone of a meeting change significantly due to the presence of one individual? Is there an unspoken "pecking order?" What cues or critical incidents should be looked for and trigger the researcher to explore deeper? Everyone has some level of tacit knowledge that allows recognition of such cues.

The researcher's background of over 20 years in both broad-based technologies and general management provided a tacit knowledge base that was particularly suitable to researching this question. His vocabulary and experience gave credibility to probing, promoted rapport, provided a communications base between interviewer and interviewees, provided ability to recognize and respond quickly to statements, and focused inquiries for revealing data.

This background could also have been a detriment. When an interviewee responded to a question, the researcher could not assume to understand the answer in the context of his own experience. Responses had to be recorded with sufficient depth so that the interviewee's context and background was captured.

Qualitative Methods. The interview guide approach was used for conducting this research. This method provided an excellent mix of structure and flexibility. The key topics and issues are specified in interview questions prepared in advance of any meetings to assure that all areas are identified for exploration, but sequencing and wording could change depending on specific situations. Questions were inserted as required for clarification. As new issues arose during the course of the interview, this method allowed pursuit of inquiries to gain a greater depth of understanding.

In general, the interview discussion began with the decisions that the participant made in choosing a technical beginning. Then the interview probed career learning and development beginning with the first position in each career and proceeding through all career positions. This sequence allowed for determination of both the learning experiences that played a role in the participants' career development and the transition points in the career path. Development of the interview questions was influenced by the findings of McCall, Lombardo and Morrison[5], in which they documented the impacts of key events on management development.

Iterative Research. Qualitative research methods include the iterative process of purposive sampling, data gathering and analysis, and finding convergent results that yield grounded theory and emergent design. Participants are chosen with a purpose. Sampling is focused to the context of interest. Patton (1990) identifies sixteen types of purposive sampling. For this research study, I chose a combination of typical case sampling and stratified purposeful sampling.[6]

To obtain data that could draw a line between successful and unsuccessful transition, the research selection process began by selecting typical participants that had a common background of careers that began in a scientific or engineering activity. The stratified purposeful sampling was utilized to choose both individuals that have successfully moved into general management and those that remained in technical positions either by choice or failure in career progression.

Fifteen participants had made a successful transition to management while 5 participants remained in technical positions throughout their career.

Participants were identified with diverse background. Participants came from a mix of small (4), medium (7), and large (7) organizations; and geographical distribution was from eight states spread from Florida north and from the East Coast to the Midwest. They were also from various industrial backgrounds of electrical power, telecommunications, biotechnology, research/consulting, medical technology, electronics, nuclear, and entertainment. Although this mix was not a prerequisite, it was anticipated that a broader base of participants might suggest some differential influences, leading to broader outcome transferability.

Data accumulated from the study were analyzed inductively and placed into various subsuming categories. As information became redundant and convergent, theories and designs emerged. Note that a qualitative study does not necessarily begin with a priori theory or hypothesis testing. The theory emerged from the data and became grounded in the data[7].

The primary data analysis of these studies followed the constant comparative analysis method[8]. In this method, analysis began during the data-gathering phase, preliminary results began to emerge, multiple cases were studied in an effort to establish these results as a repeated outcome, and differences were also evaluated on a constant comparative basis. Second, the case-cluster method[9] was used as each case is treated as a single unit of analysis, and a grouping of common results from each case is then employed.

The emergent results were not just the opinions of the participants regarding the role education played in their career transition. Most of the interview time was spent looking into the experience and key events in the individual's career from the beginning to their current positions. This time span covered what is referred to as the transition period of the participants' careers. A thorough and in-depth understanding of the intentional interventions, mediating factors, and learning, that affected the career movement of each participant was gained and, wherever possible, the elements of education emerged from the data. Each participant directly addressed the research question, but only toward the end of the interview after sufficient data had been gathered to ensure the validity of answers to actual experience.

The data were carefully analyzed to (1) rank the learning interventions according to their greatest impact on career transition, (2) learn how content impacted transition and (3) determine when key learning took place.

1) Ranking. The task of ranking the learning interventions on the educational continuum involved documenting the intervention priorities and establishing ordinal values for graphic portrayal of the results. During the latter stages of the interview, the participants were asked to rank the importance of the learning interventions for greatest impact on career development. These rankings were also compared to extensive amounts of additional interview data to verify consistency of ranking. This analysis integrated case cluster and comparative pattern analysis to discover where educational activities took place that impacted career transition.

To facilitate graphic portrayal, ordinal values were place on the rankings. The top ranked learning intervention was given a value of "4", with the second priority receiving a value of "3", the next rank a value of "2", and the lowest rank a value of "1." In some cases there was no evidence of learning via a particular intervention. These modes were ranked as NA and given a value of "0." These results are shown later.

2) Content. As data were analyzed, coded and searched for patterns[10], it became apparent that the learning content for successful participants was definitely different than those that remained in technology. As the data was analyzed, it was found that a job title or functional responsibility change could indicate new learning content being applied to a career. But job titles were not the only indicators. Skills and experiences were discovered where a participant recognized that he/she learned something new, brought success in a current task or position, or was important in continued growth and development, but career development did not always result in a job title change. These experiences involved contact and involvement with others and a learning and action that went beyond the participants' current technical job assignments. These results are addressed later.

Recognizing the various skills was sometimes quite simple as the interviewee would directly relate experience in a particular area such as contract management. Other times, tacit knowledge was used to extract the skill from the supporting data. For example, the research participants would relate experience in binding agreements, terms and conditions, negotiations, proposal evaluations, and similar terms that indicated experience in contract management.

3) Timing. The final variable analyzed was the relationship between the time when educational interventions took place and their relative impact on career transition. It was found that time into a career for a content learning activity was a stronger indicator than time relative to a particular career transition point. Therefore, the number of years into a career was measured to when the initial skills determined in the "content" area were learned. This measurement does not relate to when the actual transition took place. As careers developed, it was obvious that in order to sustain general management capability learning continued with greater depth and complexity. Research was limited to the transition, not sustainability, and therefore data were analyzed when skills were first learned to impact that transition.

Negotiated Outcomes. This is a point of testing and credibility from the eyes of the participants. In this study, all interviews were recorded and tapes transcribed by the researcher for documentation and analysis. Each participant received a copy of their interview transcript so that the participant could review the data; correct any errors, clarify issues, or supply additional data that may yield a more accurate understanding. The corrected transcripts were used for the final data analysis and writing the results.

Case Report. The final step of the qualitative process is writing the case report. The results that follow were integrated for a single report. Sections of the results contain quotes from the various interviews to contribute to the clarity of understanding of the findings and discussion. The transcribed data frequently contained grammatical errors as it was generated directly from the recorded conversations. In agreement with the interviewees, any quotes that have been used in this report have been corrected for grammar errors and readability.

Trustworthiness. The qualitative research process has been proven to maintain trustworthiness of results. Conventional quantitative criteria for trustworthiness are internal validity, external validity, reliability, and objectivity. Qualitative research poses different terms of 1) credibility, 2) transferability, 3) dependability and 4) confirmability.

1) Credibility is achieved through five major techniques. First, prolonged engagement/interviews, observation, document analysis and triangulation make it more likely that credible findings and interpretations will result from the study. As stated earlier the prolonged interviews were accomplished through multiple case studies and case cluster analysis. Second, peer debriefings were completed throughout the study to allow for an external check on the inquiry process. Third, negative case analysis (technical track participants) was performed as required in order to refine working and emerging hypothesis as more and more information became available. Fourth, accurate records were maintained and referential adequacy allowed the checking of preliminary findings and interpretations against raw data. And fifth, there was direct checking of results as participants become evaluators during negotiated outcomes.

2) Transferability is the equivalent to external validity or generalizability. Transferability (generalization) is a step-by-step process building through multiple case studies or the case cluster method[11]. This study maintained diversity of research participants and then looked for convergence of characteristics to provide for transferability.

3) Dependability and 4) confirmability were established through maintaining proper records that are auditable. First, close adherence to established qualitative methods and process was maintained and considered essential for dependable data and results. Second, the products (data, findings, interpretations, and recommendations) were analyzed and coded to confirm that the data were internally coherent and resulted in the conclusions that were obtained.

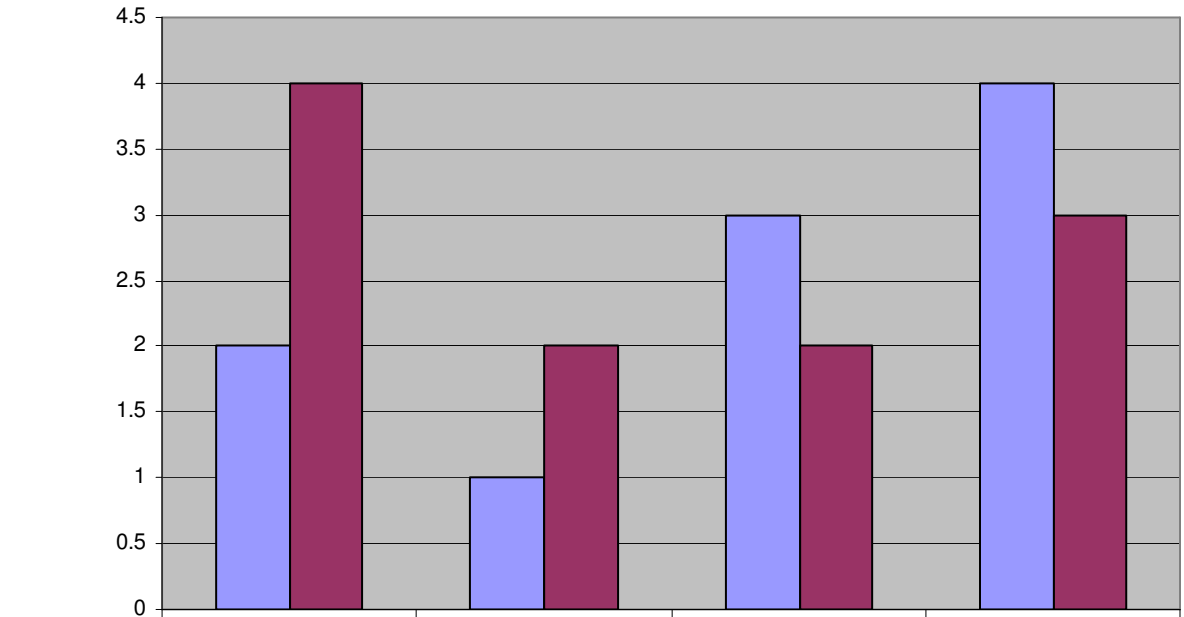
Results

Analysis of the data revealed that: the pattern of learning interventions along the educational continuum is different for those that made a successful transition versus those that did not, the key educational content for those who successfully made the transition is multidisciplinary, and this multidisciplinary education takes place early in a career.

Pattern of Learning Interventions. During the data gathering interviews, each participant was questioned about the skills and experiences that were learned, developed and applied throughout their career. The interview probing began at the beginning of each person's career and examined skill development up to the date of the interview. Covering the entire career made sure that data were discovered pre-, during, and post-transition. This questioning direction was looking for key events that impacted individual's development toward management. Towards the end of the interview, the participants were given the taxonomy of the learning interventions as it relates to the educational continuum. Participants were asked to indicate where on the continuum their particular career was impacted. Their responses were scored with a "4" indicating place for highest learning and a "1" the area of lowest learning. The median numerical rankings for both

the general management and technical participants were calculated and are graphically displayed in Figure 1.

Figure 1. Learning intervention rankings



	Formal	Non-Formal	Informal	Experiential
Management	2	1	3	4
Technical	4	2	2	3

As participants were interviewed the emphasis on experiential learning was consistent and strong. Of the 13 general management subjects, all ranked experiential as the intervention of greatest impact on their career, whereas only one of the technical subjects ranked this intervention highest. A sample of the general management responses is shown below:

> (1) "Experience has always been the best teacher."
> (2) "A large part of what I do now (as a general manager) was learned through experience."
> (3) "It became clear that my early experience was worth about half an MBA."
> (4) "As situations come up, you think about how this person or that person might deal with it and you make a choice. Clearly, in the school of hard knocks, learning from experience."
> (5) "My boss would worry about the fact that I didn't have a box checked in my experience card yet. He wanted to find an assignment for me that would enable me to do that so he could say, 'yes, he has the experience as well.'"

Eleven out of thirteen general management participants indicated that they had some form of mentoring during their career. Ten out of those eleven ranked informal interventions second in importance. On-the-job training experiences and mentoring were given credit for strong impact to career development. The eleven general management participants and three of the four

technical participants were mentored through an informal relationship. This pattern is consistent with the findings of Chao, Walz and Gardner[12] that the results of mentoring, when measured by higher levels of career progression, were greater for informal relationships that develop through natural relationships than for formal mentoring where mentors are assigned by company programs.

Formal education ended up rated third for the general management participants. But the participants did not report that formal education in technical areas provided the impetus to their career development. Instead they consistently saw formal education as a foundation or "ticket."

> (1) "Writing skills, reading skills, speaking skills, philosophical analysis, logic... those things that I picked up through my formal education... stood me in very good stead and....usually made me stand out. My engineering program put me in philosophy classes, logic programs, heavy writing and speaking. In a lot of other engineering curriculums that my co-workers went through, none of that existed."
> (2) "Formal education gave the discipline of learning how to learn.
> (3) "Formal education is a foundation. The formal side of engineering was learning where to go to get information when you need it. Very few things that you encounter five to ten years into your career, or later, is like your formal education. But you have to have that foundation to know where to draw on specific skills for dealing with problems."
> (4) "The formal education was the ticket that allowed me to be considered for other thing."
> (5) "A master's degree as expected of someone in my job and a Ph.D. was a lot better. Formal training in a scientific or engineering profession was essential to getting me into the organization. The importance of that diminishes over time, clearly, as one becomes a manager and is more and more removed from scientific work."
> (6) "It was a ticket. Without that ticket to open the door, I wouldn't have been exposed to anything."
> (7) "It's a threshold situation. I have academic credentials that open doors. I believe that, in reality, is just about all they're good for. Beyond that all that I've achieved and positions that I've secured have been based on education other than formal education."

This attitude of the general management participants held true even for those that had master's level management studies and degrees.

Non-formal training not only rated last for 12 out of 13 general management participants but it was given little or no credit for any career impact at all.

> (1) "I have stopped taking seminars. I don't gain much from them. ... Some seminars reinforce things that you already know. .... Some seminars have been entertainment. The presenter was an actor... I left. The value to employees is a reward in recognition ...that you are giving them a great complement by spending money on them."

(2) "I've always been so busy that I couldn't fit them into my schedule. I never felt there was the right subject matter that I wanted to go learn about. I was always busy doing something else. Learning through experience."
(3) "I didn't go to those (seminars) until I had been a manager a while. I didn't have a lot of seminars and special short course stuff and things like that in my early management. Most of that stuff came late (in my career)."
(4) "I don't have time for anything like that. I don't even have time to read a book except when I am on an airplane."

The general position of the participants was that seminars and non-formal education played no role in a successful career transition. This finding supports the position of Gordon[13] that the effectiveness of management seminars and "soft-skill" courses is questionable. Whether or not seminars could or should have an impact on sustained general management capability was not evaluated and should be further evaluated in future research.

The technical participants had a different attitude toward non-formal education that was well summarized by this comment:

(1) "Seminars always influenced us. Technical seminars came into play time and again preparing you to do jobs. ...You can force the (seminar) selection by knowing somebody in the country is an expert and asking them to conduct a seminar to meet your specific needs. ..Technical seminars permitted you to do your job better. ...Those were the easiest seminars to evaluate because there was an immediate impact to a job situation if they could be focused on exactly what you would be working on."

All of the technical participants stated some level of importance in maintaining technical skills and knowledge as they kept up with the rapid movement of technology. Value was stated for those that remained in a technical career for seminars that expanded levels of technical capability. The immediacy of impact, incorporation into current activities and specific technical needs supports the research conclusions of Gordon[14]; Wallace[15]; and Smock[16] (1993). The attitude of technical people who attended management seminars though was about as poor as the general management participants.

(1) "In some areas of management where you attend management seminars, you don't know the next day what exactly you got from that seminar. You may not know for six months. It's tough to evaluate those seminars as to their value."

Key Educational Content. The second independent variable that was analyzed indicated what was being learned and applied in a career for a successful transition from technologist to general manager. The results, shown in Table 2, reveal that there is a strong multidisciplinary learning component that separates general management from technical. The learning categories consistently noted from the research were: people skills, project management, finance, marketing/sales, operations, contract/procurement/legal, quality, and international. The career timing column indicates when any early career experiences were introduced into a participant's career and differences became apparent during the first eight years of employment after entering

a professional career. Initial learning of these multidisciplinary components took place both before and during the actual career transition.

Participant	People Skills	Project Management	Finance	Marketing/ Sales	Operations	Contracts	Other	Career Timing
GM #1	X	X	X	X	X	X	I	6
GM #2	X	X	X	X	X	X	I	8
GM #3	X	X	X	X	X	X		5
GM #4	X	X	X	X	X	X		6
GM #5	X	X	X	X	X	X	Q	5
GM #6	X	X	X	X	X	X		5
GM #7	X	X	Y	X	X	X		6(10)
GM #8	X	X	X	X	X	X	Q	7
GM #9	X	X	X	X	X	X		4
GM #10	X	X	X	X	X	X	Q	8
GM #11	X	X	X	X	X	X	I	6
GM #12	X	X	X	X	X	X		3
GM #13	X	X	X	X	X	X		6
Tech #1	X	X						
Tech #2	X	X						
Tech #3	X	X	Y	X	Y		I	(12)
Tech #4	X	X	Y					(12)
Tech #5	X	X	Y		Y			(15)

Legend: X = Early career experience; Y = Later career experience; Q = quality; I = International; ( ) = time to later career experience.

Table 2. Management and Functional Experience Matrix

As the research data was analyzed, the coding did not key on changes in title or functional responsibility over the career path, although those could definitely be predictor variables. Skills and experiences were discovered from which a participant recognized that he or she learned something new that brought success in the current task or position and was important in continued growth and development. These experiences involved contact and involvement with others and a learning experience or activity that went beyond the participant's immediate technical job assignments. These various characteristics were observed and identified in the multiple research participants and grouped under skill category headings. A participant had to have learned some, but not all, of the characteristics noted under a particular category in order for the category to be coded. It was verified that a significant portion of the characteristics were learned and continued development in a career.

A technical expertise category was also apparent from the data. But this was not considered a growth area since this was a requirement of the dependent variable. However, a shift in the pattern of responses was recognized relating to technical skills for the two groups of participants. Those who were successful in making the general management transition had some technical

growth and development within the first few years of their career, but as they made the transition to general management the importance of technical skills diminished to varying degrees. Predictably, the participants who remained in technical positions showed a pattern of maintaining or strengthening their technical skills.

To recognize the differences that were found, it is important to look at each category shown in Table 2.

People skills. Every research participant recognized the importance of other people in the successful completion of job requirements. One participant summarized it well: "It's a skill that everyone has to learn. How to get things done through others." As participants commented on this part of their development, they listed skills and experience of: supervision, working with others to coordinate tasks, motivating others, encouraging others, working to solve colleague's personal problems, personnel development. Each participant identified human relation skills and human interaction skills being expanded during the transition from a formal education world to their professional career. There was no difference between technical and general management participants in their responses concerning people skills.

Project Management. Within this category, the various skills of scheduling, directing, planning, budgeting, organizing, critical path networking, and other PERT (project management evaluation and review techniques) type management tools was grouped. Again, this developmental area was identified by all participants as being important to their career progression and did not separate the general management participants from the technical participants.

The two categories of people skills and project management were identified by Lewey and Davis[17] and Medcof[18] as classes of management skills that technologists have to develop as they move to management, regardless of whether it is general management or technical management. The research data supports those positions. Additional learning is necessary to separate those that move into general management. Wheelwright and Clark[19] would identify the categories that follow as representing cross-functional or multidisciplinary skills. These skills were demonstrated in a manner that showed a distinct difference between technologist and those that move into general management.

Finance. The data analysis revealed experience and learning beyond simply managing a project budget. Financial exposure and development went across functional boundaries for a broader understanding of business operations. The data showed an ability to read, understand and respond to a balance sheet, cash flow management, pricing decisions, investment analysis, asset utilization, return on assets analysis, and pursuit of outside funding.

This area shows a definite difference between general management and technical participants. All of the general management participants gained experience in finance within the first ten years of their professional career. Two of these were identified as later career experience only because there was a gap between other experiences and when this particular ability was acquired. But this skill for all successful general management participants was definitely earlier than any of the technical participants. All of the general management participants continued to develop and expand skills and responsibilities that involved financial operations as their career progressed.

The technical participants had a different pattern. Only three of the participants displayed financial learning that was multidisciplinary and these learning experiences did not take place until 12 to 15 years into their career. The involvement also appeared to be more restricted in later years as each technical participant learned to use the financial information to enhance only technical operations and did not show an impetus to move to organization wide financial deliberations and responsibility.

Marketing/Sales. Analysis of the data revealed some participants with direct job assignments in roles of technical sales engineer, applications engineers, marketing or sales. This made for easy evaluation of this category for their career. However, others had experience that required identification of marketing/sales tasks rather than a job title:

> (1) "We would travel to visit customers. We would respond to a request for a new product idea. At the development lab, we put together plans and a rough design of what could be done. Cost estimates were created. The package was sent to the customer in the form of a development proposal.... Problems were resolved and the deal closed."

The process allowed for recognition of the tasks involved in the marketing/sales process and properly categorization of the data. There were many instances that were extracted from the data that demonstrated interface and activity with the customer for the express purpose of new product development and market development.

This analysis again showed a difference between general management and technical participants. Only one of the technical participants had any early experience in marketing/sales and that participant had some strong reservations on having that as a job requirement:

> (1) "I was introduced to marketing. I got to go out and talk to the customers... .I like the people interface. ...But I was always a part of the engineering team." "(Later), I was asked to transfer to marketing. They needed somebody that knew technology. I didn't move. I didn't have a good impression of them (marketing)."
>
> "(Later), I agreed to do it (move to marketing) for a couple of years to help set up a new position. There was no intent of staying. ... It was not attractive. I moved reluctantly. By and large I would say I was not successful."

This participant was involved in marketing at least three different times over a seventeen-year period of a career. Each time there was an expressed hesitancy except for enjoying talking with other people and trading technical ideas. Each time the participant chose to stay in engineering or chose to return to engineering after a short tenure.

Operations. This category identified learning experiences that demonstrated new capabilities in an operational area. Since participants came from both service and manufacturing industries, it was necessary to include activities for delivering both products and services within the operations category. The individuals moved beyond technical developments to responsibility for

meeting contractual deliveries, understanding the interaction of both product and process, and responsibility for company order delivery measurands.

Early career learning in operations was distinctively an element for all general management participants, but not for the technical participants. There was evidence of operational responsibility in two of the technical participant's careers during the 12 to 15 year experience points. But in each case the individuals continued their technical focus and moved back into engineering tasks.

Contracts/Procurement/Legal. This category evaluated learning in situations where the outcome was legally binding documents that impacted business. This learning was demonstrated through activities on either a subcontracting/procurement side or the customer/contracts side. Credit for development in this area required going beyond technical requirements definition or specifications. Technical participants stated that they sat in negotiations to come up with technical terms and conditions, but they had no part in the legal terms and conditions. General management participants went beyond this level to participating in operational and legal negotiations, determining payment issues and legal risks or directly leading negotiating efforts. Movement beyond the technical scope was missing from all technical participants resulting in an identifiable difference in the learning content from the general management research participants.

Other. Within this area of Table 2, the additional disciplinary capabilities of international business knowledge and quality management were noted. These categories were a distinct part of the careers of the individuals with these skills.

Early Career Multidisciplinary Development. As the final independent variable of timing was analyzed, the career time when the participants experienced their initial educational interventions for learning new skills was recorded. Since multidisciplinary skill emerged in this study as a key to general management transition, the timing variable recorded indicates when the majority of the functional experiences were learned. The final column in Table 2 displays the intervention time within each career. The time into a career was found to be a stronger indicator than time relative to a job title transition point. Therefore, the number of career years, when the initial skills in the "content" area were learned, was measured. As one looks at the times, the following results were noted: (1) 5.6 year average, (2) 6 years for both mode and median, and (3) the longest time to early multidisciplinary career experience was 8 years.

Result Summary

The research focus was to understand the ranking of various types of educational interventions, the content of what was learned and applied toward career development, and the timing of key learning interventions. This was a study of multiple cases. Analysis revealed: (1) a distinct pattern of ranking types of learning interventions that differentiated general management from technical people, (2) a differential multidisciplinary learning content for general management individuals, and that (3) early multidisciplinary learning impacts the transition.

Learning Intervention Patterns. The interview rankings were recorded, compared to data and results shown in Figure 1. For general management participants, the dominant ranking pattern (most important to least important interventions) was: experiential, informal, formal, then non-formal. For the technical participants, the median ranking pattern was: formal, experiential, informal, non-formal. This graphical presentation shows a distinct difference between the two groups of research participants.
The responses of general management participants indicate that the time spent in the various types of interventions was consistent with the ranking pattern. The importance rankings reflect the relative amount of time spent in the different types of learning interventions as indicated within the interviews and documentation.

Learning Content. As seen in Table 2, a distinct difference in learning content between the general management and the technical participants has been identified for various multidisciplinary learning experiences. This led to the conclusion that multidisciplinary learning experiences are essential to successful transition from technologist to general manager.

Comments made during some interviews indicate that the participants recognized the need for development of a breadth to their capability:

> (1) "One of the attractive features of my career has been the breadth of responsibility... punched the tickets of engineering, marketing/sales, some kind of manufacturing operation. ... My peers did not have as broad a background in operating responsibility or education for that matter. .... It was kind of demonstrated capability in a variety of situations that people recognized."
> (2) "Learning what is expected or demanded... a manager who has grown up from either a task manager or project manager getting into bigger and more complex management issues. You are really growing in the direction of becoming a general manager. .... Someone who is strictly a technical problem solver, those people are just not going to be able to handle the totality of the responsibilities."
> (3) "I had success in building and being part of a team that was inter-disciplinary. One guy (a peer) made more money in his department. But he didn't branch out. He was narrowly focused. ... I was promoted over him because I thought broader. It was the natural way of thinking for me."
> (4) "The man who ran the work did not want to interface with manufacturing. He did not want to interface with quality. He wasn't particularly interested in developing good relationships with the customer. ... things he lacked were things that I enjoyed doing. .. I learned from him negatively (what not to do)."

One technical participant who commented expressed this same thought on the possibility of moving to general management sometime in his later career. "I need that kind (breadth) of experience to be a manager at the next level."

This study indicates that breadth of multidisciplinary learning across is important to making a successful transition from technologist to general manager. However, one should not presume to state that breadth of education alone would bring success. For the research participants studied there was recognition by peers and superiors that broad skills were being developed and

appropriately preparing the individuals for continued career growth. Along with broad skills development there also had to be an opportunity to move to a general management position. This opportunity may have existed within a current company or may have required a change in employment to find that opportunity. The general management participants demonstrated personal initiative to both broaden their skills and pursue career development opportunities in general management. Multidisciplinary learning continued both during and after the transition as breadth was strengthened with increased depth and complexity in the skill areas.

Timing of Interventions. It was also instructive to understand when certain learning interventions took place with respect to the successful transition to general management. There was a definite pattern of early career educational interventions that came out of the data. However, it was also noted that six of the thirteen general management participants had some form of MBA degree or studies. This data required further evaluations.

For the general management participants interviewed, MBA studies played a relatively low priority in the transition process. This observation appears to be driven by the timing of these formal MBA learning interventions with respect to the career transition. Of the six management participants who had participated in MBA courses, five individuals participated in those courses after they had had the same experience in industrial settings and were either well into or had completed the transition to general management. These courses may have helped in reinforcing knowledge that already existed and sustaining general management capability, but since the study was searching for antecedents to successful transition, not sustained capability, it could not link these courses to success.

Emergent Theory

From this qualitative study into the research question: What role does education, in its various forms, play in the successful transition of an individual from technologist to general manager?, the following theory emerges:

> For the successful transition from technologist to general manager the optimal educational intervention is to build on one's foundational formal education through a series of experiential and informal interventions that facilitate development of both basic management skills and multidisciplinary skills. Breadth of learning should be the focus early in one's career with depth and complexity continuing throughout this career.

Application and Further Research

This study provides multiple areas of application for university engineering educators:

- Continue the classroom paradigm shift that would create additional experiential learning opportunities. Proven teaching models include “flip” classroom model, service learning, co-curricular projects, increased laboratory and/or design activities, and other hands-on learning opportunities.

- With the experiential learning activities, engineering educators can help the students to develop life-long learning skills of project evaluation, problem definition, organization, independent data research, and understand of diverse needs of a project.

- For those interested in this career path, multidisciplinary learning experiences should be developed with other university departments. As an example, service learning opportunities could be jointly administered with the business school. The engineering student would design for a particular problem. The business student could help to set up a microenterprise using the design. By working as a joint team, they both begin to get exposure to multidisciplinary activities.

- Internships have been established where students rotate through many different departments of a company so that the students are exposed to all elements of a company. For those students considering a general management direction, this type of exposure should be encouraged.

This study also provides additional research areas for consideration:

- For this study, international development came up on a limited basis. There are multiple papers that indicate this will be an important element of future engineering activity.[20] [21] [22] Engineers will have to deal with the even greater complexity of both cultural diversity and multidisciplinary. Additional research is needed to understand how engineers learn intercultural competencies and how this may change teaching paradigms.

- This study looked at the transition to a general management career. Additional studies should be performed to look at learning paradigms for sustaining management careers, both technical and general.

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