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Mentoring Among Scientists: Implications of Interpersonal Relationships Within a Formal Mentoring Program

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Implications of Interpersonal Relationships within a Formal Mentoring Program

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Abstract –*Mentoring is an established strategy for learning that has its root in antiquity. Most, if not all, successful scientists and engineers had an effective mentor at some point in their career. In the context of scientists and engineers, mentoring has been undefined. Reports addressing critical concerns regarding the future of science and engineering in the U.S. mention the practice of mentoring a priori, leaving organizations without guidance in its application. Preliminary results from this study imply that formal mentoring can be effective when properly defined and operationalized. Recognizing the uniqueness of the individual in a symbiotic mentor-protégé relationship significantly influences a protégé's learning experience which carries repercussions into their career intentions. The mentor-protégé relationship is a key factor in succession planning and preserving and disseminating critical information and tacit knowledge essential to the development of leadership in the science and technological industry.*

I. AN IMPENDING EDUCATIONAL CHALLENGE

In 2003, the National Science Board (NSB) declared, "Science and technology have been and will continue to be engines of US economic growth and national security." Later in their report, the NSB predicted that the "…[number of] science and engineering [S&E] graduates entering the workforce is likely to decline…" [1].

One year later, in 2004, former professor of engineering, now president of the University of Maryland, C. Dan Mote Jr., affirmed NSB's prediction about the decline in scientists and engineers. He warned, "The circumstances for our [United States'] decline are definitely in place…and we need to do something about the circumstances before this great decline does occur" [2].

Two years later, in 2006, the Committee on Prospering in the Global Economy (CPGE) released *Rising Above the Gathering Storm*, a report validating NSB's prediction. The CPGE expressed deep concern "that the scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength" [4]. The CPGE presents several "worrisome indicators," which include the following statistics:

- In South Korea, 38% of all undergraduates receive their degrees in natural science or engineering. In France, the figure is 47%, in China 50%, and in Singapore 67%. In the United States the corresponding figure is 15%.
- In the past three years alone, both China and India have doubled their production of 3-and 4-year degrees in engineering, computer sciences, and information technology, while the United States production of engineers is stagnant.
- About one-third of U.S. students intending to major in engineering switch majors before graduating [5].

In 2005, George Langford, Professor of Biological Science at Dartmouth College, stood before the Congressional House Science Committee and posed this important question regarding these trends in science and technology: "*What will it take to for the U.S. to maintain global leadership in discovery and innovation in a time of rising international competition in a global science and technology enterprise?*" [6]. Langford indicated that while the crisis is not immediate, "the long-term trends affecting the science and engineering workforce demand our attention" [7].

I.A. Recommendations to Improve Mentoring

The CPGE and NSB reports mention the educational approach of mentoring as a way to assuage the potential challenges facing the future of S&E. At the end of their report the CPGE recommends that each scientific organization "…*improve the mentoring, education, and training* of its own S&E students, including women and members of underrepresented minority groups" (emphasis added) [8]. Authors of the NSB's report recommend mentoring as a way to promote growth in science and engineering fields. They suggest that Federal [Government] and universities take more responsibility for the future of science and engineering by "increase[ing] time available for mentoring and other educational and

service activities that enrich the learning environment" [9].

In August 2005 the Energy Policy Act (EPAct) was signed into law with more references toward mentoring. This law directs the Secretary of Energy to "…attract new and talented students …to spend time at National Laboratories in the areas of nuclear science, engineering, and health physics *with a member of the National Laboratory staff acting as mentor*" (emphasis added) [10].

There is substantial research to affirm the effectiveness of mentoring, but without a contextual definition within S&E organizations, it becomes difficult to know which direction to pursue while attempting to follow these recommendations. Questions may emerge while attempting to implement or improve mentoring initiatives: What would it take to increase the quality and quantity of mentoring opportunities for S&E students? What are the implications of implementing and improving mentoring specifically for the scientists and engineers?

These recommendations from CPGE, NSB, and the EPAct are clear, but the concept of mentoring is yet undefined. The references to mentoring are mentioned unsupported by facts or experience, which raises other questions. What is meant by the term mentoring? Is it a process, procedure, an act, enculturation, succession planning, a way of doing some particular thing, or maybe all of the above? Indeed, while attempting to address these issues about mentoring one may wonder, can mentoring help alleviate the worrisome conditions of the U.S. math, science, and technology industry?

II. MENTORING TYPES AND TRAINING

One reason some science organizations have implemented mentoring programs has been based on necessity—necessity for succession planning, recruiting, retaining, and maintaining a viable work force. There are two types of mentoring that are typically implemented—formal and informal. Research on mentoring clarifies these two approaches and presents some outcomes from each.

Informal Mentoring	Formal Mentoring
An unmanaged spontaneous relationship that occurs without external involvement from the organization [11]	A structured mentoring relationship…with the primary purpose of systematically developing the skills and leadership abilities of less-experienced members of an organization [12].

Informal mentoring has been shown to be more effective than formal [13]. The benefits of informal mentoring have aroused a great deal of attention from many corporate, government, and private organizations.

In an attempt to replicate these benefits, many organizations have become relentless in their pursuit of effective formal mentoring programs [14]. Unfortunately, many of these attempts have not been as successful as anticipated [15] [16].

Eby, Butts, and Lockwood [17] found that negative experiences were more likely to occur in formal mentoring compared to informal relationships. They also found that in formal mentoring, mentors were not as skilled or did not have the expertise in relationship building compared to those who were in informal relationships. With this in mind one can appreciate why Armstrong concluded his study with a suggestion for future research to seek understanding about how "formal mentoring systems should be designed to overcome differences in interpersonal relationships [which are]… the root cause of so many problems" [18].

Research from Ragins et al. [19] suggests that if a mentor-protégé dyad is in a satisfying relationship, formal mentoring may be as effective as informal mentoring. It is clear that the relationship between the mentor and protégé is a significant part of the entire learning experience. If interpersonal relationships are so important, there must be a means to help mentors gain what is needed to develop, strengthen, and cultivate relationships intended to improve their effectiveness.

This affirms Scandura's [20] assertion that for formal mentoring it is important to have interpersonal relationship training for mentors to help deal with potential difficult situations. Ehrich, Hanford, and Tennent explain that "a lack of mentor training was viewed by mentors and [protégé] as detrimental to the well-being of the program" [21]. Therefore, in formal mentoring programs where relationships have greater potential to be ineffective, it would benefit science and engineering organizations to focus on training that would help build effective working relationships.

III. HISTORY OF MENTORING FOR S&E?

The history of mentoring has ancient origins but did not attract scholarly research on the subject until the mid 1970s [22]. Mentoring has been known under different terms such as guild, artisanship, and apprenticeship. The term mentor is said to have emerged from Homer's epic, *The Odyssey* [23]. In *The Odyssey*, the leading character, Odysseus, leaves his son, Telemachus, in the hands of a trusted friend while he goes off to war. Odysseus's friend, Athena, disguises herself as the character, Mentor. Mentor acts as a teacher, counselor, guide, and friend to Telemachus as he searches for his father who has become lost in battle.

From Homer's example emerged some common characteristics associated with mentoring such as teaching, guiding, counseling, encouraging, and coaching for the purpose of helping a younger or less experienced

person develop skills, knowledge, competence, and abilities in a chosen occupational or personal pursuit. Given this widely accepted interpretation of mentorship, it may be assumed that the CPGE, NSB, and EPAct refer to mentoring as a means to teach, guide, counsel, and coach less experienced scientists and engineers.

However, these mentoring expectations are vague and may leave the mentor unsure of how to proceed, especially in the scientific and engineering fields where specific mentoring applications are yet to be defined and applied. Without clarity, human resource organizations may flounder in the development of a mentoring program specific enough to meet their organizational objectives.

With its growth over the past 25 years, the term has become so saturated with individual interpretations that there appears to be almost as many definitions as there are persons or organizations defining the concept [24]. Maryann Jacobi performed extensive research on mentoring and her assessment was that "[t]he results of this definitional vagueness is a continued lack of clarity about the antecedents, outcomes, characteristics, and mediators of mentoring relationships despite a growing body of empirical research" [25]. Instead of clarifying what a mentor does, history moved it from a concentrated trickle to a deluge of meanings, which inevitably dilutes the term [26]. It is for this reason S&E organizations would benefit by defining what mentoring is for their formal mentoring programs.

IV. PURPOSE OF THE STUDY AND RESEARCH QUESTION

According to Wanberg, et. al., "there is a striking dearth of literature on formal mentoring" [27]. Because there is insufficient literature on formal mentoring, and specifically mentoring among scientists and engineers, I have chosen to pursue this research. The lack of literature on the subject may be due to difficulty in accessing scientists and engineers in government organizations because of security clearances and various organizational regulations imposed by the Institutional Review Board.

I was fortunate to be granted approval to work among scientists and engineers within a U.S. national research and development laboratory. During the summer of 2005, I was invited to study the effectiveness of the organization's formal mentoring program. The findings of the 2005 project warranted continued investigation, and so the project continued through the summer of 2006. This study was granted approval by the Institutional Review Board at the National Laboratory as well as my university's Human Assurances Committee.

Initially, my assignment was to investigate the various perceptions scientists and engineers had about mentoring and how it was generally practiced. Of interest also were the perceptions of the protégés—university and college students who were doing summer internships—on how their mentor influenced their educational experience.

During the process of learning the organization's culture and getting a general sense of the perceptions of mentoring during the summer of 2005, I discovered that several mentors had attended a specific training offered to all laboratory staff. The intent of the training was to build and strengthen interpersonal relationships among co-workers and improve individual work performance.

A noted author on the subject of mentoring, Louis Zachary, argues, "Creating a supportive learning climate ultimately rests on building and maintaining relationships. Without building and maintaining a learning relationship, effective mentoring is impossible" [28]. Therefore, while continuing this investigation on mentoring among scientists, I investigated the characteristics of a mentor after having attended training designed to build, strengthen, and maintain interpersonal relationships.

The purpose of the study was to understand the dynamics of the mentor-protégé relationship within the laboratory's formal mentoring program, to examine the extent interpersonal relationship training influenced how the mentor related to the protégé, and to explore how that relationship influenced the protégé's career intentions.

V. RESEARCH METHODOLOGY

Science lives in the hearts of unusual human beings, not in the institutions which organize, use, and exploit what the scientists have found out. The general reader can understand the life of another human being when well told. And he may learn more about the meaning, possibility, and limitations of science from the biography of a real scientist than in any other reading [29].

To develop a clearer definition of mentoring and better understand the perspectives of the scientists and engineers, I employed a qualitative research design. Qualitative research is best utilized when the experiences of people and the meanings they derive from them are explored [30]. While quantitative research objectively attempts to answer the *why* of a thing, qualitative research subjectively attempts to address the *how* and *what*. To investigate the how and what of a phenomenon, the researcher attempts to get "close enough to the people and situation being studied to personally understand in depth the details of what goes on" [31].

Within the qualitative paradigm I employed the case study tradition. Each didactic relationship of a mentor and his or her protégé was considered as a case. One method of data collection in qualitative research is purposeful sampling [33]. During the summer of 2006 I purposefully selected a homogeneous group of mentors who had attended the interpersonal relationship training and the protégés who worked with them. Some mentors had more

than one protégé, so the total number of protégé was ten. To avoid losing any relevant statements each interview was audio taped after which I transcribed each one.

During the course of the study I was given the opportunity to conduct exit interviews for protégés who were completing their internships. This added eight more participants to the study. These interns had mentors who had not received the particular interpersonal relationship training discussed in this study. Information shared during all interviews or subsequent discussions is held in the strictest confidence. Participants either selected or were assigned a pseudonym to protect their identity.

In qualitative research, the researcher becomes the primary instrument for collecting data. As the primary instrument, I have an ethical responsibility to make every attempt to see things from the perspective of the participants. This process is called bracketing. Merriam described the process of bracketing out one's biases and values as etic: the setting aside of prejudgments and performing the interview with an unbiased, receptive presence [34].

During the interviews I asked the protégés about their mentoring experiences. I was particularly interested in how the mentor's attitudes and way of relating with the protégés might have influenced their career intentions. With the mentors we discussed their experience with the training and then how the training influenced their effectiveness or ineffectiveness as mentors.

Each scientist/engineer-mentor was interviewed twice, once after they received the training, before the protégé arrived for the summer, and again after the protégé concluded the internship. I conducted interviews with each protégé within the final two weeks of their formal internship.

The criteria for participant selection included the following:

- A homogeneous group of scientists and engineers who were currently involved in the laboratory's formal mentoring program administered by the laboratory's educational programs department.
- Protégé were involved in the laboratory's summer intern program.
- Mentors were full-time employees of the laboratory.
- Mentors had attended training to improve interpersonal relationships.

Qualitative methodology may cause concern among scientists who are more familiar with controlled hypothesis-testing research. However, the qualitative research paradigm provides a heuristic platform from which can spring understandings of a phenomenon that may be measurable in ways other than numerically, as Albert Einstein once said: "Not everything that counts can be counted and not everything that can be counted counts."

VI. THEORETICAL BACKGROUND OF INTERPERSONAL RELATIONSHIP TRAINING

The interpersonal relationship training that was offered at this laboratory was not targeted solely toward mentors. However, a significant number of those who either had mentored or were planning to mentor had been through the training.

The training consisted of the theoretical principles of The Arbinger Institute, a management consulting firm that has developed programs focusing on the particular phenomenon of self-deception. Because the Arbinger training is a significant part of the study, I will briefly explain some of their theoretical underpinnings and its relation to mentoring theory.

Arbinger [35] defines self-deception as the problem one has of not being able to recognize he or she has a problem or as not knowing—and resisting the possibility—that one has a problem. When George Berkeley said, "We first raised the dust and then complain we cannot see" [36], he was, in his way, describing the mechanics of self-deception. They claim self-deception is the foundational element in all people problems.

Theories of self-deception have been debated by philosophers for millennia and more recently by some psychologists, most notably Sigmund Freud. Arbinger states that Dr. C. Terry Warner discovered a solution to self-deception—how individuals become self-deceived and then can become free from it. From their experiences consulting with several government organizations, corporations, human services organizations, and with individuals, Arbinger describes the benefits of their training:

> Our experience in teaching about self-deception and its solution is that people find this knowledge liberating. It sharpens vision, reduces feelings of conflict, enlivens the desire for teamwork, redoubles accountability, magnifies the capacity to achieve results, and deepens satisfaction and happiness [37].

As with many relationship training programs, Arbinger's theoretical assumptions coincide with mentoring theory. A distinguishing foundational principle advanced by Arbinger was articulated by mentoring theorist, Laurent Daloz who reported, "…love plays an important part in [mentoring]." He continued, "…a sense of concern and caring… matters if a mentor-student relationship is to work at its best. It is important…because it allows [the mentor] to *see* the student as a total human being rather than simply a mind to be trained" (emphasis added) [38].

This concept was also explained by philosopher Martin Buber [39], who taught that people are inseparably in relationship with others. Buber explained that relationships can exist in either of two ways: as I-Thou or I-It. The implication is that there are two ways to *see* the protégé: (1) an I toward an It, or a mind to be trained, which Arbinger terms *object*, or (2) an I toward a Thou, a total human being, or, as Arbinger would say, a *person*.

Arbinger claims that this way of *seeing* is our way of *being* in the world with others. In Arbinger's use of the terms, *way of seeing* may be used synonymously with *way of being.* The term *way of being* is more commonly used as a philosophical term from ontological theorists. It is the term more often used in the Arbinger literature.

A foundational principle advanced by Arbinger is that behaviors and *way of being* are inseparably connected. That is, our way of being in the world with others lies "…deeper and is more important than behaviors" [40]. Way of being can determine how one employs any skill or strategy. Way of being determines one's level of influence in the application of a skill or strategy. Way of being elicits or provokes different responses in others because, as Arbinger states, "whatever I 'do' on the surface, people respond to who I am *being* when I am doing it" [41].

Kosslyn and Sussman put it this way: "There is no such thing as immaculate perception. What we see depends on what we thought before we looked" [42]. The belief is that the way we think about, or see, another in our minds and hearts will be communicated through our behaviors, no matter how skilled and honed they may be—we are transparent beings despite our performances. One mentor from this study captured the principle and expressed his understanding in this way:

> If you view people as an instrument [object or minded to be trained] they are going to see right through it and they are going to feel used…. So, I wouldn't want to do something like that to anybody. In fact it's counterproductive because you can fool them for a day, but the next day they know what you're doing and you're not going to get back any investment you put into it—time, effort, or money.

Mentors who participated in this study attended the Arbinger training where discussions were facilitated about the basic principles of self-deception: how one becomes self-deceived and how one can escape this state of being described as "being in the box." The term "the box" was referred to often by the mentors in this study when they discussed the Arbinger training. It is a metaphor that explains the alienated, self-absorbed state self-deceivers find themselves trapped within. Participants also learned idiosyncratic characteristics of being in "the box" and the process of becoming free of this state of being.

So, how did these teachings influence the mentor-protégé relationship within a formal mentoring program? Did this training influence the career intentions of the protégé? If so, how?

VII. THE INFLUENCE OF INTERPERSONAL TRAINING ON RELATIONSHIPS

By learning you will teach,
By teaching you will learn.
(Latin Proverb)

In the preliminary findings, the protégé whose mentors received the interpersonal relationship training as outlined by Arbinger unanimously reported positive experiences. During exit interviews and surveys with the protégés whose mentors did not receive this particular training, I learned that the majority of protégé also had positive experiences. The reasons for good experiences varied based on the original intentions of the protégé, not necessarily because of particular mentoring functions.

One member of the laboratory's educational programs staff reported that, in of all her years of doing exit interviews, "the majority of the students have had positive experiences, but there are some very bad experiences also." The positive experiences, she noted, were because "the students had a good time at the lab, with other protégé…enjoyed the natural resources of the area, because they were paid more, and because they were able to apply what they learned from school." During one of my exit interviews, a protégé expressed a positive experience because he was exposed to "the cool things" around the laboratory.

The positive experiences reported by the protégés of mentors who both had the training and who had not seemed to negate the need for interpersonal relationship training for mentors. Mentors who received the relationship training either stated or implied that, given their current situations, they probably would have done the same caring things and had the same attitudes as without the training. With such successful mentoring experiences, it is reasonable to question why an organization would invest time and money into training that would help mentors build, strengthen, and maintain healthy working relationships.

Regarding their attitudes before and after the training, mentors expressed comments similar to Bens', a computer systems engineer: "I hoped I would have responded the same without the training, but the training definitely helped keep me focused on [my protégé]." Gander, a nuclear reactor scientist said, "I think I would have responded the same, but it was good to remember to stay out of the box." Maria, a manager over mechanical engineering in robotics and human systems said, "I think I would have done the same things even though I had the

training." However, she described the training as more influential on the success of her mentoring relationship,

> Even though I might have offered the same things, I was more keen to his [my protégé's] human nature than to his degree…. Arbinger impacted things one hundred percent for the better. I saw him as a human being—as a kid that was doing wonderful things, that wanted to improve his life, that wanted to contribute. Aside from the benefit it may have done for [my protégé] is the improvement it has done for me. I like me better because I am doing it for the right reason. It was sort of a permission statement that said, Maria, be human; it's okay to be human first and then be a project driver.

VII.A. Protégé, Lucky or Not

It is interesting to note how many protégé attributed their successful experience to luck. Hacker, an undergraduate engineering student, said, "I can't imagine how lucky I am to have [my mentor]. He was awesome, I mean, perfect. I'd go in there and say, I need to talk and he'd drop everything." All of the protégés I interviewed who had a positive experience shared this particular theme. Many of them compared their experience with other interns at the laboratory. They reported that their colleagues "hardly saw their mentors," or their mentors "were just too busy," "did not have time for them," or "gave [them] things to do and didn't have much to do with [them] after that." Comparing his experience, one protégé whose mentor had the training reported:

> My office was in a room with ten different interns, and I remember there were weeks when some of those interns had absolutely nothing to do. Their mentors would leave on vacation and leave them with nothing to do. I don't know, to me I am so grateful that I had good mentors who would give me projects…not just easy fun projects, but hard projects that would help me grow and learn and challenge me and things like that. I was always busy and I think, I don't know, I just compare my experience with what some of these other people went through and even talking with my dad he said, 'I don't know how you got put on with such amazing people.'

Another protégé, Erwin, whose mentor had the training, also compared his experience with his colleagues, "There are mentors right now that I would definitely not have rather have than [my mentor]." When asked why he stated, "they expect you to do intern things, like requirements gathering, you know, and they'll turn you loose when the money runs out. To them, you're 'the intern.' I've heard that term quite a bit around here." Erwin also attributed his experience to luck.

Erwin's report about his "lucky" mentoring experiences lends hope to those who may have never considered a career in science and engineering industry:

> He gave me tasks that were not menial and that gave me a little more worth by doing that, and that's what made me respect him more, too. It's been good under him. If they [mentors] could all be like [my mentor], and people could realize that—the people who are in college, or not yet in college, or they're debating to go—if they knew that possibility was out there I guarantee it would change a lot of people's minds.

Erwin was hired toward the end of his 2006 internship in a software development organization at the laboratory. His story may help those who lack confidence in their schooling, or who aren't sure what career to pursue. Erwin was originally reluctant to pursue a computer engineering degree:

> I, myself, was intimidated by the whole idea of going to school …because… I was non-traditional. I worked construction building cabins, bartended for a while, did these other blue-collar things and didn't really give it a second thought because I guess I didn't give myself enough credit to think I could accomplish the education.

Now Erwin is a full-time employee at one of the nation's premier research and development laboratories. He attributed his success to a very positive interpersonal relationship with his mentor:

> He [my mentor] stuck his neck out, you know, not to go out and try to find somebody that was already working in the field. He picked me…. For six years of making an intern's wage, or minimum wage, that was pretty important to me at that point. For him to give me the opportunity was confidence building. …It's confidence and a little more change in your pocket. …Walking down the hall, I walk a little bit taller, so to speak.

Erwin's mentor, Ben, a manager who directs a computer systems engineering department, said that he was pleased with the work of Erwin from the get-go. "He was steady and eager to learn." Ben believed that he would have interacted with Erwin no differently without the training, but he admitted, "The Arbinger training was by far the best training I've ever been to. It applies not only to work, but to all aspects of my life, which is more important." He said that it "really helped me to see [Erwin] as a person, not as an object like the training teaches." Experiences like Erwin's were a recurring theme among protégés whose mentors had been through the training.

VII.A.I. Elujio and Fred, Professional and Personal

Elujio is a manager of a systems engineering department. He is responsible for a variety of projects around the laboratory. He attended the Arbinger training and was so impressed by it he invited his entire department to attend. During the interview with Elujio he expressed his appreciation for the training.

I interviewed Elujio before his protégé, Fred, arrived. Elujio's attitude toward Fred was expressed by eager overtones, **"I'm just excited and wishing for Fred to show up and begin to work."** After the Arbinger training and prior to the arrival of his protégé, Elujio stated, "I need to see [my protégé] as an individual, as a person, not as an object that's going to be instrumental in this proposal to NASA." Regarding the benefits of the training he said, "Arbinger works behind scenes, or in the background, [a] kind of engine that continuously pings the forefront of my head, if you will, on every decision that I need to make in dealing with people."

Elujio is a systems engineer who has worked at the laboratory for over thirteen years in various engineering capacities. He made it clear that he had always tried to see the humanness of people and not to reduce them to objects. However, he made this statement about the training:

> Arbinger has actually helped me cement some of the principles I may have been working on for some years, or decades if I may put is that way, but I was able to verbalize it and put some color to it as opposed to being something abstract on the subconscious level. It was very important because not only can you realize what you're doing but you can express it. And when you do that, you hear yourself saying things like, 'Well, I saw [my protégé] as a person. I didn't see his student ID number. I didn't see the cubicle that was just outside my office here (pointing toward the door). I didn't see the cost of paying for [my protégé] being here.' I saw [my protégé] as a young professional who wants to succeed. Yet, in doing so, that didn't distract at all from my other obligations like all the bureaucracy, all the forms and all that. It was just all part of what needed to be done. But the essence of the activity, or the experience, if you will, was to make sure that he left the [National Laboratory] with something more than when he came in.

Fred, Elujio's protégé, was "amazed" at his experience. Fred said, "every step along the way, he's [Elujio] been there to help, to consult." Fred described his perception of their relationship:

> It's more than professional, which was better. My first day here I went to his house. We had dinner and enjoyed ourselves…played ping-pong. He's taken me on as, almost like, a summer son. It's been a great relationship. By establishing such a comfort level there was in no way [a feeling like], 'Oh, I've got to go talk to the boss,' I didn't have to be intimidated. Every time I had a problem or anything I could go to him.

Fred expressed his gratitude to have such a mentor as Elujio because, as he said,

> I heard [from] of a lot of other interns around here that their mentors saw them once a week, if that. And I feel bad for them because I see Elujio every day.We talk every day. If I had not had him I probably would have not have a high consideration of coming back in my mind. Elujio created an environment to where I was nurtured as a person as well as a professional. …I think key points to hit for any mentor is to get to know your protégé, get to know them as a person… 'Cause if you satisfy somebody outside the professional environment then they're going to be a lot happier when they're working.

Fred expressed how intimidated he felt as an undergraduate student. He said he was surprised that Elujio would take time to get to know him as a person before they engaged in the work. Fred expected to have more of a boss than someone who "established a professional but casual relationship as well." Fred was pleased with what he was able to accomplish, "with the project I've done, good results were obtained." Fred was instrumental in presenting a successful proposal to NASA for a lunar experiment. Elujio's attitude and his commitment to mentor resulted in a satisfied protégé who was able to accomplish his goals and who was affirmed in his desires toward a career in engineering.

VIII. CONCLUSION AND IMPLICATIONS

> *Have you ever really had a teacher? One who saw you as a raw but precious thing, a jewel that, with wisdom, could be polished to a proud shine? If you are lucky enough to find your way to such teachers, you will always find your way back* [43].

If the situation regarding the U.S. S&E community is as worrisome as the CPGE indicates, then for students to find a caring mentor who has a sense of their potential should not be left to chance. The element of luck will always exist; however, how much can the risk of not finding a good mentor be reduced with effective interpersonal relationship training? Future research is needed to investigate this question.

A vast number of training programs, seminars, and workshops offer interpersonal relationship training.

Arbinger distinguishes itself with a unique treatment of the self-deception phenomenon. Arbinger's theoretical assumptions were applied among the mentors in this study not only at work but within their personal lives. Ben stated, "The training works… as a way of doing things that you incorporate into your daily life, not just at work, and that's better."

Mentoring researchers affirm, "Mentors transfer a kind of tacit knowledge to their protégé which includes enculturation" [44]. Tacit knowledge—possibly one's *way of being*—undergirds information sent and received within the mentor-protégé relationship. This may be a significant influence on an S&E protégé's career intentions. The principle advanced by Arbinger, that one's *way of being* or *seeing* another affects behaviors and as a corollary influences personal relationships, is worthy of further consideration.

This "relationship first" focus is affirmed in the mentoring literature, which repeatedly suggests that more important than building skills and strategies to achieve positive outcomes is building the relationship [45]. Arbinger suggests that foundational to building relationships lies deeper than what we "do," or the skills we employ toward another person; it is how we regard them—how we *see* them before we look at or work with them on a daily basis.

Other findings may yet emerge from this study. The stories recounted in this report offer only a portion of perceptions regarding mentoring and the influence interpersonal relationships had on the mentors' and protégés' experiences. The research of Mullen and Van Ast confirm that "…the better we understand [mentor-protégé] relationships, the more likely we are to be able to maximize the positive outcomes" [46]. The experiences analyzed thus far have echoed positive outcomes—protégé who have been strengthened in their resolve to pursue S&E careers. However inconclusive, any substantive information offered thus far may aid administrators in their efforts to improve, or implement formal mentoring programs.

Thus far I have identified four implications from the findings of this study.

VIII.A. Interpersonal Relationship Training Makes a Difference.

1. The effectiveness or ineffectiveness of the mentor-protégé relationship within a formal mentoring program is influenced by interpersonal relationship training which carries repercussions into the protégé's career intentions.

"The quality and quantity of learning is a function of the quality of the relationship in which the learning takes place" [47]. From the interviews and observations around the laboratory, a distinctive characteristic found among the mentors was their concerted efforts to see the protégé with respect. This established a foundation of trust. A genuine interest to help their protégés progress was manifest in their attitudes and behaviors. It was evident that the protégé's potential to become a successful scientist or engineer did not go unnoticed.

These findings are not anything new. This may be another way to emphasize the golden rule—treat others the way one would like to be treated. This is certainly fundamental to healthy relationships. However, it is not uncommon to forget the golden rule and respond otherwise. As Daloz, Arbinger, and Buber declare we have two possibilities to be in relation toward others: (1) "minds to be trained," objects, or an I toward an It; or (2) "total human beings," people, or an I toward a Thou. Because it is common to move from one way of being in relationship to the other—i.e., from a person to an object—and behave accordingly, training may prove to be a vital component in improving mentor-protégé relationships.

VIII.B. Defining Mentoring to Achieve Specific Outcomes.

2. For the U.S. to maintain global leadership in discovery and innovation in a time of rising international competition in a global science and technology enterprise, S&E organizations need to specifically define and operationalize what is meant by "mentoring."

Through the course of my research I developed a working definition that seems to apply to the practice of mentoring in general however, it should prove useful to S&E organizations as well:

Mentoring is an active invitational learning relationship where more experienced professionals share their knowledge and character with the intent to help less experienced colleagues achieve meaningful results, maximize their learning, and draw out their potential for leadership.

While a clear definition is important, it is only part of the equation and should, in turn, create a foundation upon which program administrators can develop a mission statement that clarifies program expectations.

Through a careful study of the literature and discussions with scientists and engineers who serve as mentors, I submit that the overall objective of a mentoring program is equally important. The purpose of a mentoring program should be to achieve the following program result:

Optimization of the transfer of important technical and tacit knowledge that will build new leadership and improve the recruiting and retention of highly productive, creative, and cooperative scientists within an invitational learning environment.

VIII.C. Fact or Fallacy?

There is a common concern about the time needed to build an effective working relationship while facing demanding results, deliverables, deadlines, and budget constraints. The findings of this study coincide with prior findings reported in the literature:

3. Sincerely considering another's concerns, hopes, needs, and fears stimulates self-assessment and higher accountability. The implication is that results are multiplied within caring organizations as opposed to organizations that are perceived as non-caring. It is worth the time and money investment.

VIII.D. Professional, Personal or Both

4. The better a mentor understands how to establish and strengthen healthy working relationships beyond what is typically noted as professional, the more likely positive outcomes will follow. The term professional in this study denotes coolness in the relationship, a distancing from others that appears trite, to the point, and without human recognition beyond the task at hand. A particular warmth in the relationship is what seems to engender effective learning situations.

This study confirms these findings and suggests learning is more likely to be embraced within healthy relationships which create healthy environments. In such an environment, the protégé is emboldened to reach out and discover possibilities they may have not previously considered.

As Erwin said, "If they [mentors] could all be like [my mentor], and people could realize that—the people who are in college, or not yet in college, or they're debating to go—if they knew that possibility was out there I guarantee it would change a lot of people's minds."

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