Improving Software Engineering Through Holistic Project Coaching

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Abstract. The process to successfully engineer quality software suffers from challenges identified over 40 years ago. Upon deeper review, a majority of the factors related to software development failure are human factors. Including a Project Coach (PC) who is focused on humanistic issues in the software engineering process will have a positive impact in addressing software engineering challenges. A PC focuses on Knowledge Management (KM), cyclical assessment, informal learning, and dynamics coaching to ensure team harmony and growth, sound project management practices, and most importantly— quality, on time software.

The 1968 NATO International Software Engineering Conference [1] in Munich, Germany, raised a series of complaints about computer software including its unreliable nature, late delivery, cost-prohibitive nature of modification, challenges in maintenance, inadequate performance, and budget cost excesses. This conference resulted in the coining of the phrase "software engineering." Over 40 years later, the software engineering field has failed to significantly diminish or eliminate many of these serious complaints.

An IEEE Spectrum article entitled "Why Software Fails" [2] cites 12 common failure factors:

1. Unrealistic or unarticulated project goals
2. Inaccurate estimates of needed resources
3. Badly defined system requirements
4. Poor reporting of the project's status
5. Unmanaged risks
6. Poor communication among customers, developers, and users
7. Use of immature technology
8. Inability to handle the project's complexity
9. Sloppy development practices
10. Poor project management
11. Stakeholder politics
12. Commercial pressures

While the article categorized deficiencies into technical, project management, and business decision deficiencies, it can also be noted that nine of the 12 factors are human factors. A recent focus has been placed on management and people issues in the software development process.

This focus on the importance of people in the software engineering process has appeared in early works ranging from McGregor's [3] Theory X - Theory Y to Deming's [4] Total Quality Management approach. To further quantify the impact of people in the software development process, both the Constructive Cost Model [5] and Software Evaluation and Estimation of Resources (SEER) [6] software estimation models forecast the relative impact of the development environment parameters. The most important parameter group (Staff Capability) shows a relative cost impact of 0.5 on the positive side and greater than 2.2 on the negative side (see Figure 1).

Figure 1: Relative cost impact of the Constructive Cost Model and SEER environment parameters
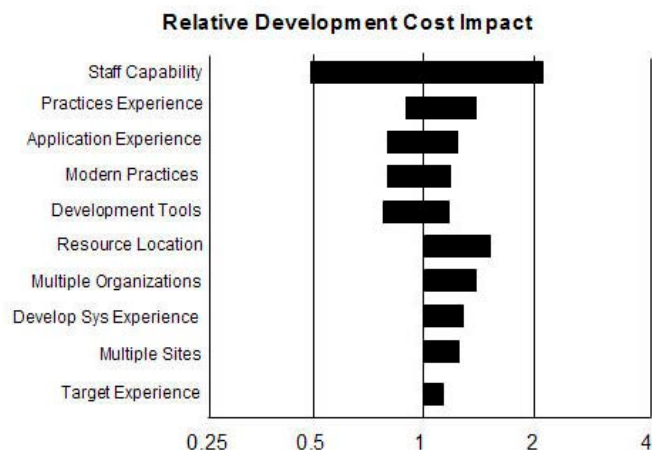
A second aspect relative to the importance of people in the product–process–people triad is the generational diversity that is now representative of a majority of the workforce population. Today's workforce is divided among Baby Boomers; generally described as those born between 1944 and 1966, Generation X; born between 1967 and 1979, through Generation Y; born between 1980 through 1995. Each workforce generation is shaped by key events in their development and results in differing needs, desires and expectations as it relates to work environments. For example, Generation Y has never known a time in which there was no Internet. They have grown up in a "connected" world. This has helped to shape their expectations in terms of teaming, communication, learning and information sharing. There are growing cases of Generation Y Project Managers (PMs) who are now managing Baby Boomers [7]. These dynamics presents new challenges to projects such as software development and, at a minimum, require an awareness of differences in expectations and outlooks.

Unless people are considered as an equally important leg supporting the product–process–people triad of software engineering, the results will remain inconsistent and unstable at best.

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14. ABSTRACT

The process to successfully engineer quality software suffers from challenges identified over 40 years ago. Upon deeper review, a majority of the factors related to software development failure are human factors. Including a Project Coach (PC) who is focused on humanistic issues in the software engineering process will have a positive impact in addressing software engineering challenges. A PC focuses on Knowledge Management (KM), cyclical assessment, informal learning, and dynamics coaching to ensure team harmony and growth, sound project management practices, and most importantly?quality, on time software.

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1. Holistic Project Coaching

Given this background, one approach which has proven to have a positive impact on the software development process is Holistic Project Coaching (HPC). HPC is an experiential, performance-oriented development process that builds a project team's capability to achieve short- and long-term project success. It is conducted via individual and team-based interactions, incorporates multiple perspectives, and focuses on building positive actions based on mutual trust and respect.

HPC utilizes an existing member of the project team to act as the PC. The PC is not an additional resource; rather they are an internal team member who works in conjunction with the PM to ensure project success by bridging technical and non-technical issues as was the case in our case studies. The PM and PC are co-supportive of each other. The PC supports the PM with Project Management Body of Knowledge (PMBOK) practices and techniques, but primarily focuses on such activities as conflict management, purposeful on-the-job education, cyclical assessment and Human Performance Technology (HPT); all of which are outside the PMBOK scope. This allows the PM to continue his or her focus on development, schedule, and quality.

HPC is applied to both individuals and the team as a whole. The HPC process has four primary underpinnings that serve as the foundation for HPC activities. These include KM, cyclical assessment, informal learning, and dynamics coaching. The PC is responsible for the facilitation and application of the following four prongs of HPC:

1.1 HPC and KM

The objective of KM is to improve the quality of decision making by ensuring that the right information is available to the right person, at the right time, to enable an individual or team to make an informed decision. The quality of services delivered is directly impacted by how the team responds to circumstances. Their response will be governed by what they perceive their options to be as well as the consequences and benefits of those options.

Their overall knowledge of the situation will ultimately influence how they execute processes and what the output quality will be.

KM can aid the team's ability to adapt and overcome challenges through collaboration and shared knowledge. An effective KM strategy will positively influence project costs by increasing staff capabilities through knowledge discovery, sharing, and collaboration thus contributing to workforce development.

As shown in Figure 2, KM is often expressed as a knowledge hierarchy [8]. Data is the foundation from which we obtain information, build knowledge, and apply wisdom. Data itself is just a point in space and time without reference to either space or time. It has no context and thus has little or no meaning. Information (the what, who, when, where) is built from the understanding of the relations between the data. Information generally does not provide a foundation for why the data exists, what it is, nor how the data is likely to change over time. Thus information is simply the relationship between data and has great dependence on context for its meaning with little implication for the future.

Figure 2: Data − Information − Knowledge − Wisdom Hierarchy
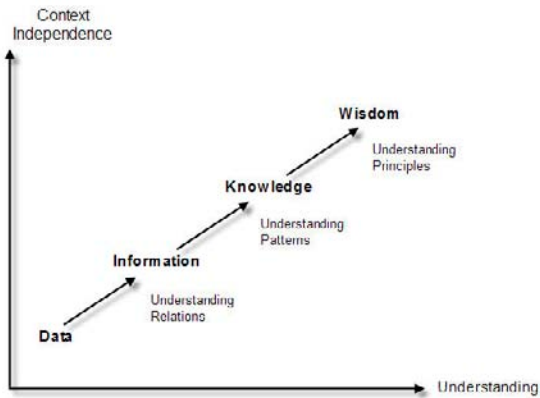
Knowledge (the how) is based on patterns that exist amidst the data and information. These patterns have a tendency to create their own context rather than being context dependent like information. They also provide a high level of reliability or predictability as to how the pattern will evolve over time. They have completeness to them that information simply does not contain. Wisdom (the why) is generated when understanding of the foundational principles responsible for the patterns representing knowledge is achieved. Likewise, wisdom, even more so than knowledge, tends to create its own context.

Why is this important for the PC? The goal of KM is to try to maximize the value of knowledge holdings within an organization. This includes knowledge that is both explicit (e.g., codified) and tacit (i.e., "know how"). KM facilitates access to knowledge including pointers to tacit knowledge and thereby encourages collaboration, innovation, and promotion of existing knowledge as a foundation for new ideas.

For the PC, KM hinges on creation of a sound KM plan. A good KM program facilitates capture during the entire project lifecycle. At a minimum, a KM plan should include:

	Information	Instrumentation	Motivation
Environment Supports	**Data** Relevant and frequent feedback about the adequacy of performance. Description of what is expected of performance. Clear and relevant guides to adequate performance.	**Resources** Tools and materials of work designed scientifically to match human factors (e.g. databases, digital systems, knowledge management tools).	**Incentives** Adequate financial incentives made contingent on performance. Non-monetary incentives. Career development opportunities.
Person's Repertory of Behavior	**Knowledge** Scientifically designed training that matches the requirements of exemplary performance. Informal learning opportunities.	**Capacity** Flexible schedule of performance to match peak capacity. Selection. Supportive devices (e.g. prosthesis, text readers)	**Motives** Assessment of people's motives to work. Recruitment of people to match the realities of the situation.

- **Mission:** What are your goals? What knowledge is useful to that mission?
- **Competition:** How are you gaining and maintaining competitive advantage? How are you going to improve comprehension and knowledge building within your stakeholder community?
- **Performance:** How are you going to deliver results? How do you get the right information to the right person at the right time to improve decision making?
- **Change:** How will you cope with change? How do you make outside external knowledge available to help your organization adapt and overcome?

A critical task for the PC is facilitating knowledge transfer. Knowledge transfer is defined as the process through which one unit of an organization is affected by the experience of another. The knowledge transfer process consists of identifying the knowledge holders within the organization, motivating them to share, designing a sharing mechanism to facilitate the transfer, executing the transfer plan, measuring to ensure the transfer, and applying the knowledge transferred. The effectiveness of knowledge transfer can be measured by how the receiving organizational behavior changes; that is, how they apply it.

Some common impediments to knowledge transfer that HPC can help resolve are: areas of expertise identification, internal conflicts (territorial), generational differences, union-management relations, incentives, geography or distance, culture, knowledge visualization, faulty information, motivational issues, and lack of trust.

Tools at the PC's disposal for KM and transfer range from content and document management systems for explicit knowledge to newer web tools such as social networking sites for tacit knowledge. A robust KM strategy will most likely consist of a mix of several components that may or may not be technology based. The PC can help to determine the best mix of tools and which will best support the project team.

1.2 HPC and Cyclical Assessment

A primary role of the PC is to continuously measure the pulse of the individuals and the project team as a whole (including the PM). As previously noted, the PC is concerned with the human factor; that is, the support required to ensure success in terms of human performance. In contrast and as the name implies, a PM is primarily concerned with managing such aspects of the project as schedule, budget, and quality.

PCs and PMs are both constantly monitoring; however the PM primarily monitors the project and the PC primarily monitors the people. Additionally, the PC often includes the PM's needs in the measurement of the health of the project since the PM has a profound impact on the success of the project.

Teams are dynamic and are in the midst of a dynamic activity called a project. Because of this dynamic nature, the PC must conduct ongoing assessments of the team and individual's health and needs. But what do they measure?

The field of HPT provides several models that can help to guide the HPC in this matter. Thomas Gilbert's Behavioral Engineering Model (BEM) [9] proposes that it is possible to engineer worthy performance. To do so, the PC must provide environmental support and individual support.

Within the environment, the PC must measure what deficits exist in terms of data, resources, or incentives. Once a deficit is identified, the PC's role is to modify the environment to provide the necessary support. This can be a challenging undertaking and years of measurement using the BEM have revealed that challenges to exemplary performance in the workplace are most frequently tied to deficits in environmental support. In the words of HPT pioneers Rummler and Brache, "If you pit a good performer against a bad system, the system will win almost every time" [10].

Within the individuals, the PC must measure possible deficits in knowledge, capacity, or motivation. A deficit in knowledge is most often tied to a need for formal or informal learning. A deficit in capacity is most often tied to improving the selection process to bring on the right people for the work at hand. A deficit in motivation is probably the most challenging as this relates to intrinsic motivation within the individual. Addressing this deficit is often accomplished by merely assessing what motivates individuals and feeding that information into incentives within the environment.

A primary strength of HPC is the dynamic nature of the assessment–implementation cycle the coach uses to identify and measure the ongoing needs of the project team and to implement solutions. From each assessment, the PC can then create micro-implementation plans to meet immediate human and resource needs. Measurement tools are used from a broad array of disciplines ranging from psychology (e.g., personality tools) to organization behavior (e.g., 360-degree feedback). Once a plan is implemented, a cyclical series of assessments followed by modified implementation and reassessment continues throughout the life of the project. A key to success for the PC (and for the team) is this constant measurement and implementation cycle.

1.3 HPC and Informal Learning

One of the strengths of a project team is the ability to share knowledge and wisdom informally and to create new knowledge. This process is known as informal learning and is a primary tenet of HPC.

Of the three generations in the workforce, Generation Y has strongly embraced informal learning using techniques and tools such as blogs, Tweets, and social networks. Generation Y has never known a world without computers [11]. Similarly, a majority of Generation X has grown up in a work environment in which computer use has grown exponentially [12]. This technologically savvy workforce has different communication expectations than its Baby Boomer predecessors. Informal learning allows use of newer technology-based tools to assist in augmenting the communication and learning environment.

Traditional training tends to be monolithic in nature where pre-planned courses that consist of defined lessons and topics are prescribed for any person with a knowledge deficit in that particular area. From an organizational point of view, traditional training is efficient in terms of measurement and tracking. Learners sign up for specific courses, receive scores upon completion, and are assigned further courses based on the

outcomes. But from the individual perspective, traditional training approaches cannot easily account for individual differences, individual learning styles and preferences, and nuances in learning needs.

In contrast, informal learning is micro in nature. It is a ground-up approach. Individuals share their thoughts and experiences on specific topics. Persons interested in learning about the specific topic take in the information provided, critically assess the value and validity of the information, and assimilate the new information into their internal mental schema. This is a fundamentally different approach to learning. It is driven and directed by the learner seeking data, information, knowledge, and wisdom. Additionally, the learner must then assess the value of the new information and determine if and where this information should now exist to expand their worldview.

As such, there are several benefits to informal learning:

- **Just-in-time:** Learners seek out information from immediate colleagues, recognized experts, and easily accessible information at their point of need. It is not pre-scheduled.
- **Just What I Need:** Informal learning is efficient because learners only seek out what they need to know to meet their immediate need.
- **Gestalt:** Informal learning tends to happen in synergistic relationships and therefore often results in the creation of new knowledge. The learner's mental model now has new connections and becomes deeper and richer.
- **Critical Thinking:** The process of learning informally requires the application of critical thinking skills. Because there is no official vetting process, learners must conduct an evaluation of incoming information to determine its validity and how to assimilate it into their existing mental models.

Three primary challenges related to informal learning include:

- **Tracking and Measuring Learning:** from an organizational perspective, measurement of learning is key to determining if knowledge and skill gaps are being filled. Measuring the impact of informal learning is often more subtle; did the learner progress through the process because they found the information they needed? How long did they have to search to find the information they needed?
- **Required Communication and Collaboration Tools:** the ability to participate in informal learning is dependent upon being able to access data, information, knowledge, and wisdom. It is also closely tied to open communication channels and tools that support collaboration. Social networking and web 2.0 tools [13] are coming into accepted use at an amazing rate within organizations. These tools are ideal to both capture micro-learning content and to share it in unobtrusive manners. Common tools in this genre include blogs, wikis, tweets, crowd sourcing, and status updates.
- **Quality of Content:** A major challenge in the world of informal learning is the responsibility of the learner to make a critical determination about the quality of the content they are learning. New tools are emerging (e.g., rating systems, expert profiles systems) and new research is being conducted that will help learners make these determinations, but the responsibility still rests on the learner's ability to make a proper assessment.

As the value of informal learning becomes recognized and as new tools come to use, these challenges can be overcome.

1.4 HPC and Dynamics Coaching

As noted previously, a PC is created to focus on the humanistic needs of the team in relation to the project and provide the care and feeding needed as projects and teams progress through the project lifecycle as well as the many facets of team dynamics. For discussion purposes we make an underlying assumption that teams are composed of members selected primarily because of technical capabilities. The PC looks further to discover typically untapped, intangible resources residing within each employee. Some examples include abilities such as leadership, communication, problem solving, organization, relationship building, and consensus building to name but a few.

Many personality and strength identification tools exist to assist a PC in discovering these hidden gems. While specific tools cannot be recommended in this article due to legal restrictions, it is recommended that a combination of personality and strength indicator tools be used to provide a well-rounded data set. The personality tool reveals information about who the person is and how they prefer to work and interact. The strength tool identifies skills and talents that even the individual may not know they possess.

Once the team has identified personality and strength factors, a team-blending meeting is held where team members simply share their results and make each other aware of what each person has to offer. The PC facilitates this meeting and begins to strategize with the team concerning optimal usage of each member's strengths. More seasoned coaches can build Integration Charts where team members are combined for specific tasks based upon combined strengths or to compliment an identified limitation. An example might be to assign a team member with an innate ability to communicate with people and get them to feel comfortable in speaking and exploring issues and link them with another team member who possesses organizational and strategic thinking to meet with customer groups in building a requirements document or a risk management plan. The entire purpose of understanding the individual composition of the team is to place people in a position of strength and aptitude to lend to overall team and project success.

Redistributing tasks based on individual strengths is a Dynamics Coaching element that results in increased team productivity. This is because teams begin to grow in confidence due to the fact members are now working in areas where they are naturally talented. They also begin to blend and work more harmoniously because teams now better understand each other's strengths and recognize differences among themselves as alternate strengths rather than discordant traits which can break teams down. Individuals also show a significant increase in productivity. This may seem obvious, but Gallup polls report [14] only 32% of U.S. workers utilize their primary strengths in the work they perform daily. This statistic reveals the heightened need for an increased focus on individual and team strengths if an organization is to harness the most productivity from a team. Gallup also reports: "People who use their strengths every day are *six* times more likely to be engaged on the job and three times more likely to be happier with their lives in general. Not

only do engaged workers stay on the job longer–saving millions in training and turnover costs–but they also get more done while they are there. So when workers are able to apply their talents and strengths at work, productivity also rises" [15].

Another beneficial result of the Dynamics Coaching element is an increase in team trust. Trust is the high-octane fuel that really makes team engines roar. Steven H.R. Covey reports [16] trust increases the speed of business and reduces costs. A study published in the European Journal of Work and Organizational Psychology concluded: "Cooperative behaviors were the second strongest component of trust" [17]. Conversely, breakdowns in team civility will reduce productivity and increase costs. A 2009 national study [18] consisting of a large diverse sample of managers and employees reports that of those among co-workers who have been offended:

- **48% intentionally decreased work effort**
- **47% intentionally decrease time at work**
- **38% decreased time at work**
- **80% lost time worrying about the incident**
- **63% lost time avoiding the offender**
- **66% said their performance declined**
- **78% said their commitment to the organization declined**

The studies [17, 18] augment the need to create harmonious and cooperative teams. Such harmony is accomplished by focusing on the secondary Dynamics Coaching role of the PC; harnessing and resolving conflict. Conflict is generally thought of as bad and in most cases this is true, but in some cases, a specific type of conflict is very beneficial and can boost productivity, creativity, and harmony.

Relational Conflict is a term defined by Steven P. Robbins [19] that describes a mean-spirited and personal type of conflict involving differences between people and their personalities. These conflicts revolve around team members and behaviors and do not lend themselves to productivity or team harmony in any way. In fact Relational Conflict is the seedbed for mistrust.

The beneficial element of conflict was termed Functional Conflict [19] by Robbins and is described as two parties disagreeing about the functionality of an occurring problem or its functional solution. Some examples include two team members disagreeing about how to diagnose a problem, what methodology to use in developing a solution, disagreeing about the outcome of a procedure, or the amount of resources needed to accomplish a task. Personality is removed in each example and a focused discussion is held where both parties are focused on how to solve a problem rather than the people who are trying to solve a problem and therein is the difference. This thought process stems from a portion of our brains called the neocortex where rational and logical thoughts occur. It is where we perform reasoning, problem solving, decision making, impulse control, and limit the emotional portion of our brains. Try to be angry or sad while solving a complex math problem and you will find out it is next to impossible because the neocortex and the amygdala (the part of the brain that performs emotional reactions and stores emotional events) are separate in location and function; making it difficult for each to work in conjunction with one another. This mutually exclusive trait of the brain provides insight on how to bring relationally conflicted groups together using functional conflict. Functionally conflictive groups

are proven to get closer to true resolution in a shorter amount of time than groups who do not practice conflict resolution type activities [20, 21, and 22]. Armed with the understanding of the dissonance of Relational and Functional Conflict, a PC can now be on constant lookout for burgeoning disputes and must be prepared to act upon them immediately by turning team focus from relationally conflictive topics to functionally conflictive ones.

Some conflicts are purely relational in nature and can be solved by more mature HPC techniques not discussed in this article, but many conflicts are functional in nature, but have been convoluted and complicated by relational conflict. The following steps are suggested to move a team from a relational to a functional state of conflict when functional issues are present:

1. **Gather the parties in dispute**
2. **Hold a discussion about the nature of the problem**
3. **Identify the functional elements of the problem**
4. **Lead and focus discussions on how to solve the functional aspects**
5. **Minimize and redirect relational comments**
6. **Hold follow-up sessions to discuss functional progress until progress is made**

Dr. Gerald Weinberg stated, "No matter how it looks at first, it's always a people problem [23]." Project teams have untapped resources and can solve innumerous problems when working together in harmony and building off each other's strengths. HPC's Dynamics Coaching element is designed to tap into those previously untapped resources to (1) shape and unite teams, (2) move projects and people toward success, (3) identify individual and team strengths, and (4) build trust and rapport without bringing in outside assistance that may slow or disrupt the sometimes fragile balance of project team dynamics. Dynamics Coaching should become a natural part of managing any project.

2. HPC and Workforce Development

HPC is also valuable in shaping a workforce for long-term success. The benefits to an organization include:

Strong Skills: Getting the right resources to the right people at the right time strengthens employees' technical and non-technical skills and improves the overall competence of the workforce.

Highly Competitive: HPC addresses humanistic factors that cause project failure, optimizes the skills and talents of individuals and teams, and mitigates the risks commonly associated with software engineering projects, which enables an organization to be much more effective and economical. This greatly increases competitiveness in the marketplace.

Agility: Because the strengths of employees and teams and the HPC principles are easily transportable to other projects, the workforce becomes much more adaptive and better able to respond to new, complex situations.

Productivity: HPC enhances the effectiveness of both individuals and teams through collaboration and synergy. This significantly increases productivity.

Employee Satisfaction: One of the greatest benefits of HPC is employee satisfaction. Empowerment, trust, and ownership are powerful motivators, and HPC builds trust between team members and management, values the individual, inspires the team, and motivates and rewards the workforce. This enables an

organization to attract and keep the best employees.

HPC plants seeds of excellence that can blossom anywhere, creating a highly competent workforce that thrives on change and challenges, and that is highly motivated and productive. This in turn makes the organization more competitive and able to accomplish diverse and profitable projects. HPC has a profound impact on the project, the workforce, and the bottom line. ✧

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