Emotional Intelligence in COCOMO II for Software Cost Estimation

Soogambal Chinien
Department of Computer Science and Engineering
University of Mauritius
Reduit, Mauritius
soogambal.chinien@umail.uom.ac.mu

Mohammad Yasser Chuttur
Department of Computer Science and Engineering
University of Mauritius
Reduit, Mauritius
y.chuttur @uom.ac.mu

Abstract—**Cost Constructive Model (COCOMO II) is a well-established estimation tool employed by project managers when estimating software development duration. Following project size, COCOMOII estimation is highly dependent on the accuracy with which the skills of staff involved in a proposed software development project are estimated. In this paper, we propose to revisit the criteria used to estimate Analyst Capability (ACAP) and Programmer Capability (PCAP) in COCOMOII by the inclusion of measures to evaluate the emotional intelligence of analysts and programmers. Preliminary results indicate that when considering emotional intelligence of software professionals in COCOMOII a better estimate of projected cost can be obtained.**

Keywords—COCOMOII; software development; cost estimation; project management;

I. INTRODUCTION

Lack of skills on the part of software professionals is one of the most important causes of software cost overrun [1]. In commercial environment, software development is rarely the output of a single person. Instead a team is required. In general, a team consists of individuals with varying hard skills and soft skills [2]. Hard skills refer to technical (theoretical and practical) knowledge required by an individual to successfully carry out a given task wheareas soft skills comprise interaction abilities, communication skills, and other personal habits that characterize an individual's personality. Hard skills must be complemented with soft skills in order to have successful interaction in teams and good teamwork performance. The need to consider the impact of individual soft skills differences on teamwork performance is therefore warranted.

The Cost Constructive Model (COCOMO II) is a well-known software estimate tool used in software development industries worldwide. COCOMO II is a follow up of an earlier COCOMO software cost estimation technique [3] and has since then been the interest of several studies. COCOMOII provides various output estimates (e.g., cost, schedule, person month), of which the person month estimate is of our main concern as both cost and schedule are directly affected by person month (PM) estimate.

In COCOMO II, input factors affecting PM fall into four categories: product factors, platform factors, project factors and personnel factors. Personnel factors, further, take into account Analyst Capability (ACAP), Programmer Capability (PCAP), Personnel Continuity (PCON), Application Experience (APEX), Platform Experience (PLEX) and Language experience (LTEX).

Of the six personnel factors, ACAP and PCAP give a project manager the ability to indicate the level of hard and soft skills of individual professionals who would be part of a software development team for a given project. For ACAP or PCAP, factors to be considered when rating are analyst's or programmer's "*ability, efficiency and thoroughness, and the ability to communicate and cooperate*" [4]. Rating to be used for ACAP and PCAP is based on five values (nominal/percentile) shown in Figure 1.

Very Low	Low	Nominal	High	Very High
15th percentile	35th percentile	55th percentile	75th percentile	90th percentile

Fig. 1. ACAP/PCAP rating used in COCOMO II

Estimating hard skills for ACAP and PCAP should be a straightforward process as rating can be based on measurable academic performance or previous work experience. Evaluating soft skills, on the other hand, is a more complex process, which relies on the perception of project managers and their acquaintance with the individuals being rated. In software cost estimation, a poor estimation of soft skills could seriously affect the estimated cost, which can result in cost overrun and other associated problems.

In this paper, we propose that soft skills of software professionals can be measured in the form of emotional intelligence. When estimating ACAP and PCAP, emotional intelligence could provide a better indication of risks factors that could contribute either to the success or to the failure of a software development project in meeting estimated costs.

II. EMOTIONAL INTELLIGENCE

Emotional Intelligence (EI) can be understood as "the ability to perceive emotions, to access and generate emotions so as to assist thought, to understand emotions and emotional

knowledge, and to reflectively regulate emotions so as to promote emotional and intellectual growth" [5].

Previous studies have shown that competencies based on emotional intelligence (EI) are reliable predictors of performance at the workplace. [6,7]. Most studies support the argument that despite having similar skills level, individuals have varying emotional adjustment due to their EI and related competencies and will have different performance depending on varying situation [8].

Of the many studies that have been carried out in the area of emotional intelligence, the framework proposed by Goleman's (1998) [9] as shown in Figure 2. has attracted our attention for this study. Goleman's framework provides a simple, yet powerful means to measure the EI of individuals.

Self-Awareness	Social Awareness
- Emotional self-awareness	- Empathy
- Accurate self-assessment	- Organizational awareness
- Self-confidence	- Service
Self-Management	**Relationship Management**
- Emotional self-control	- Inspirational leadership
- Transparency	- Influence
- Adaptability	- Developing others
- Achievement	- Change catalyst
- Initiative	- Conflict management
- Optimism	- Building bonds
	- Teamwork and collaboration

Fig. 2. Goleman 2X2 matrix emotional intelligence framework

The proposed framework includes a set of nineteen competencies categorized into four domains: self-awareness, self-management, social awareness and relationship management which consider the emotional intelligence of an individual both when left to himself/herself and when placed in the context of a team. Brief explanation of each quadrant shown in Figure 2 follows.

The core of Emotional Intelligence is self-awareness. Self-awareness consists of three competencies; emotional self-awareness, where one can read and understand emotions and identify their impact on work performance and relationships; accurate self-assessment, where one can give a realistic evaluation of his/her strengths and limitations; and self-confidence, where one can have a positive and strong sense of self-worth.

Self-management consists of five competencies; Self-control, which keeps disruptive emotions and impulses under control; transparency, maintaining honesty standards, managing oneself and responsibilities; and adaptability, which is the flexibility in adapting to varying contexts and tackling obstacles; achievement, which is driving force to excellence; and initiative, which is the to seize opportunities and peform.

Social Awareness consists of three competencies; empathy, which is the understanding of others and taking an active interest in their concerns; organisational awareness, which is one's ability to read organisational culture, create decision patterns and respect politics; and service, which is attending to customers needs.

Relationship Management consists of seven competencies; inspirational leadership, which is motivating and leading groups and individuals; developing others, which is the ability to build upon and support the abilities of others by providing feedback and directions; influence, which is the ability to persuade; change catalyst, which is the ability to generate new ideas and support people in new directions; conflict management, which is managing and handling disagreements and collaboratively coming up with resolutions; building bonds, which is the ability to build and maintain good working relationships with others; and teamwork and collaboration, which is the ability to promote cooperation and teamwork.

As shown in Figure 3, individuals with knowledge of self-awareness (path 1a) are able to identify and control their own emotions [10]. They are less likely to be affected by fear, troubled by negative feelings, and stunned by anxiety, all of which have negative effects on both individual and team performance [11].
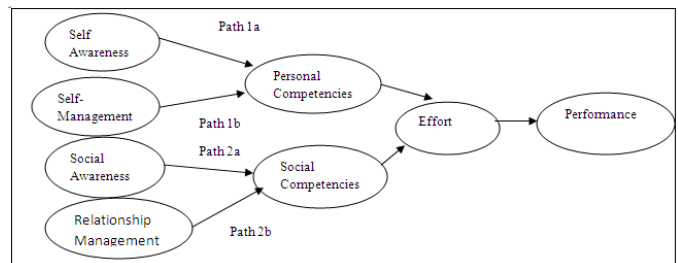

Fig. 3. Effect of emotional intelligence on performance

Individuals with knowledge of social awareness (path 2a) are able to treat people according to their emotional reactions and maintain sustainable business relationships and gain the buy-in and collaboration of other team members for increased productivity.

Given that emotions can interfere with role and affect task performance [12], it is expected that individuals with both self and social awareness will be better equipped to exert positive emotions and use them to achieve maximum productivity. This calls for investingating the effect of incorporating EI measures in estimating cost in COCOMO II.

III. INTEGRATING EI INTO COCOMO II

Despite its popularity and controversies, a fully validated and reliable instrument that was solely based on Goleman's framework was surprisingly not available. Instead we relied on the Global Emotional Intelligence Test - GEIT, which uses 40 questions in the form of simple statements that an individual needs to choose in order to obtain an indication of the individual soft skills in each of the four quadrant of Goleman's emotional intelligence model. GEIT is available at https://www.globalleadershipfoundation.com/geit/eitest.html and once the test is complete, a table gives out the score over a scale of 10 for each of the four soft skills competence, i.e., self-awareness, self-management, social awareness, and

relationship management. A sample output is shown in Figure 4.

Self-Awareness	Self-Management	Social-Awareness	Relationship Management
9	5	2	5

Fig. 4.   Effect of emotional intelligence on performance

The mean value computed from the output results can be easily transformed in the form of percentile measures as used in COCOMO II to evaluate ACAP/PCAP. By using a combined measure of both the hard and soft skills of an individual in COCOMO II, it is expected, at leat in theory, that a better estimate of an individual's skills would be obtained, which in turn should give a better cost estimate.

IV.   TESTING, RESULTS AND DISCUSSIONS

Test data was obtained for two projects from a Mauritius based international software company offering consulting and technological services to its clients worldwide. For convenience and confidentiality, the projects will be referred to as project A and B and the company as company X. Data collected allowed us to use COCOMO II to obtain an estimate of the projected PM that would have normally been required for each project. We repeated the calculation with EI measures to obtain another PM estimate when emotional intelligence is considered. Staff involved in the two projects were asked to self-report their EI by taking the GEIT test and results obtained were combined with their ACAP and PCAP percentiles in COCOMO II calculations. Table I shows the results obtained.

TABLE I.   COCOMO II ESTIMATE WITH ACTUAL COST

Project	Person Month (PM)		
	Without EI	*With EI*	*Actual*
A	5	8	10
B	15	28	25

Poor capability assessment has significant impact on project estimation. An analyst with a self-esteem problem along with poor responsiveness and social skill has a cascading effect on project effort. This is because the analyst guides the programmer with the functional aspects of the project under development. This observation supports studies that claimed that clients are rather dissatisfied with the personal rather than the technical services (Capretz et al., 2010; eWorkshop, 2002; Lindvall et al., 2002) and these studies highlight the need of skill diversity for software professionals to stay in business.

Project A had a cost overrun and reason gathered from interviews with project managers revealed that poor team work was the major reason behind for this cost overrun. Efficient teamwork rests on the contribution and effort from each project member but if the ability of working in team is not measured correctly, there is little that can be done to predict teamwork failures. COCOMO II as is relies on the sole perception of the project manager to evaluate the soft skills (teamwork ability) of an individual. This perception can be flawed and is subject to errors. In contrast, with EI measures, a project manager obtains a near objective measure of the ability of an individual to work in team. In the present case for project A, when EI was considered, a closer estimate was obtained for the PM calculations.

In regards to project B, as per the project report, problems associated with time delays were attributed to the difficulties faced by team members were in adapting to Extreme Programming as a development methodology. Extreme programming demands frequent interactions and communications with other team members and users. Despite being technically qualified, team members had a hard time managing their new workplace relationships with ill-defined achievement needs, poor communication and random workload sharing. GEIT test results could easily indicate that team members had good self-control when working alone but would not be fitting well in the same group.

V.   CONCLUSIONS

As mentioned by Goleman (1998) [13], in order to cope with the rapidly evolving technological advances, increasing environmental pressures and demanding customers, software professionals not only require technical skills, but they also need other skills known as emotional skills. These emotional skills help individuals regulate and guide their behavior in their daily operations when dealing with others. Every individual is right in his/her perspective but when confronted with someone with opposite views, an individual with poor emotional intelligence will tend to feel agitated and very often convey their views without due respect to other's feelings and perspectives. On the other hand, an individual with good emotional intelligence, will work for a win–win conflict resolution in a wise manner with minimum harm caused to other's feelings which contribute to better performance in the workplace. COCOMO II could use results from emotional intelligence test to obtain a better cost estimate that can prevent, if not, predict cost overrun. Although preliminary testing has shown conclusive results, the model presented in this study must still be validated with other test data and as any other model should be calibrated before a reliable measure can be obtained.

REFERENCES

[1]   R. Pressman. Software Engineering: A Practitioner's Approach, McGraw-Hill, 2005.

[2]   L. F. Capretz, F. A. *"Making Sense of Software Development and Personality Types," IT Professional*, vol. 12, no. 1, pp. 6-13, Jan./Feb. 2010.

[3]   B.W. Boehm. "*Software Engineering Economics*", Prentice-Hall, Englewood Cliffs, NJ, USA.1981.

[4]   Boehm, B., Abts, C. & Chulani, S. (2000) Software Development Cost Estimation Approaches - A Survey, Annals of Software Engineering, 10(1-4),

[5]   Mayer, J. D., and P. Salovey. 1997. What is emotional intelligence? In *Emotional development and emotional intelligence*. Edited by P. Salovey and D. J. Sluyter, 3–31. New York: Basic Books.

[6]   Cherniss, C., 2000. "*Social and emotional competence in the workplace, in Bar On, R. and Parker, J.D.A. (Eds)"*, The Handbook of Emotional Intelligence, Jossey-Bass, San Francisco, CA, 433-58.

[7] Feist, G.J. and Barron, F, 1996. *"Emotional intelligence and academic intelligence in career and life success."* Paper presented at the Annual Convention of the American Psychological Society, San Francisco, CA.

[8] Emmerling R.J. and Goleman D, 2005. Leading with Emotion'. *Leadership Excellence. 22 (7)*, 9-10.

[9] D. Goleman (1998). Working with Emotional Intelligence. Bantam. New York.

[10] Lam, L.T., & Kirby, S.L. (2002). Is emotional intelligence an advantage? An exploration of the impact of emo- tional and general intelligence on individual perfor- mance. *Journal of Social Psychology,* 142(1), 133–143.

[11] Seipp, B. (1991). Anxiety and academic performance: A meta-analysis. Anxiety Research, 4, 46–53.

[12] Ashforth, B.E. and Humphrey, R.H. (1995), "Emotion in the work place: a reappraisal", Human

[13] D. Goleman (1998). Working with Emotional Intelligence. Bantam. New York.

Dr. M. Y. Chuttur obtained his PhD from Indiana University, USA and works as Senior Lecturer in the Computer Science and Engineering Department at the University of Mauritius. Dr. Chuttur research interest includes the study of human factors in technology acceptance and adoption.

Soogambal Chinien received her bachelor degree in Computer Science with Multimedia in 2006 and her master degree in Software Engineering and Project Management in 2014 from the University of Mauritius. She works as senior software analyst at Astek Mauritius Ltd. After completing seven years in software development, she is now more inclined towards the non-technical aspect of software development process which is the human aspect. Her curiosity about human development and performance has acted as an impetus for her to dive in the ocean of hard and soft skill assessment. Her main areas of research interest are software psychology, soft skill assessment, personality traits, sustainable human development and emotional intelligence.