Making Quality Happen: The Managers' Role

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When managers insist that their professional employees rigorously apply the recognized disciplines of their fields, they will do better work [1]. In this paper, we provide data from two AIS projects, Project A and Project B, that demonstrate how managers profoundly affect the way their engineers behave and how managers can motivate the engineers to apply the disciplined methods they have learned. Project B data is used here as control data. We conclude with lessons learned.

Advanced Information Services Private Ltd. is the Indian subsidiary of Advanced Information Services Inc. of Peoria, Ill. This case study is based on data from two projects executed by the subsidiary company in Chennai, India. Engineers in both projects have been trained in the PSP[SM]. They used PSP methods to plan the critical design/implementation/test phases of the projects.

Project Domain, Technical Environment, and Engineers' Qualifications

The projects' mission is to build Personal Productivity System (PPS), a commercial tool to automatically log time, track defects, maintain data, do calculations, and simplify routine tasks. Personal Planning Assistant (PPA 1.0), and Personal Quality Assistant (PQA 3.0) are two subsystems described in this article.

The target environment is a two-tier client server architecture with a Visual Basic client application for Windows 95, 98, NT, and SQL Server (under Windows NT) for the server.

The engineers' experience level ranged from one to two years. Project managers had three to five years' experience. All have a master's degree in computer science or computer applications. All are trained in PSP, software inspections, managing the software process, and requirements engineering—the required software engineering training for AIS engineers.

Development Strategy

Following the requirements and high-level design phases, PPA 1.0 had 13 components to be developed and PQA 3.0 had four components.

PPA 1.0 was divided into three incremental development phases. A project manager and three engineers participated in Increment 1 development. Two more engineers were added for Increment 2. A project manager and three engineers participated again in Increment 3 development. PQA 3.0 team consisted of a project manager and three engineers.

All engineers were responsible for creating PSP plans for their components. Project managers also participated in development.

The sizes of all 13 modules of PPA 1.0 are given in Table 1.

PPA1.0 Increments 1 and 2 – Delivery Commitment *What must happen* and *What will happen*

The Chennai team had committed to deliver PPA 1.0 (Increments 1 and 2) to the AIS Development Group in the U.S. by Aug. 1, 1999—four weeks prior to the SEI Symposium. The AIS Development Group had planned to demonstrate the PPS product (PPA1.0 Increments 1 and 2 and PQA3.0) at the Symposium.

PPA 1.0 Increment 1 was completed four weeks behind schedule against a planned schedule of 16 weeks. Analysis of the Increment 1 Defects by Process chart (See Figure 1.) showed that engineers found and fixed more defects through team inspections and test than through personal reviews.

Planned test defects/KLOC were high for PSP trained engineers; actual test defects/KLOC were even higher (see Table 2).

About half of the slippage in schedule was directly the result of engineers spending more time than planned in test and rework. Their plans simply did not include enough time for early defect removal through personal design reviews, code reviews, and team inspections.

The engineers' PSP Plan Summary indicated that they had spent time on post-mortem when their modules were completed. Asked what they did in the post-mortem phase, the engineers said that they only had time to gather the PSP data for inclusion in the organization database, and that they did not have time to analyze the data and adjust the plans for Increment 2.

As the acting Development Manager, I reviewed the plans for Increment 2. I realized that the plans were based on the team's perception of what must happen (i.e. we *must* ship by August 1). It was obvious that if the team planned Increment 2 similarly as in Increment 1, what would happen is that the schedule would slip again and we would likely miss our dates.

Engineers Not Using Known Effective Methods

Clearly, the engineers were not using the disciplined methods

Table 1. *Module Size*

Module Name	Module Size (Lines of Code)
Estimate Size	2107
PROBE	2043
Plan Summary 1	1738
Plan Summary 2	1154
Track Time	1914
Track Size	4250
Size Range	965
Object Data	1123
Standards & PQA Update	1286
Interruptions & Tool Bar	403
Defect Analysis	850
Plan Analysis	532
Quality Analysis	714

Table 2. *Defects/KLOC*

Test Phase	Plan	Actual
Unit/Integration/System	4.8	6.2
Acceptance	0.7	1.4

they learned in the PSP training. They knew that the PSP Plan Summary gave them useful data on their performance and they should spend time in post-mortem to improve the process and set personal goals.

They knew that they should strive for at least 80 percent yield, and Appraisal/Failure Ratio (A/FR) should be greater than 1.5 and close to 2.0. [2]. Yet, their planned A/FRs were less than 1.0. (See Table 3 for definition of PSP quality measures.)

The engineers were also aware of AIS Chennai's business goals of defect-free delivery of the PPS product on time.

Changing the Engineers' Behavior

I realized that I must direct the change in the engineers' behavior. I must insist that they rigorously apply known PSP principles in their work. If I did not, nobody else would. In a team meeting I reviewed the PSP data for size, appraisal hours, failure hours, and test defects for each of the four modules in Increment 1. I used charts showing relationship of yield and Lines of Code (LOC)/hour (Figure 2) and A/FR and test defects. (Figure 3). It was not possible to draw statistically valid conclusions with only four data points. It was not necessary. The engineers got my message. Schedules were important. But a quality process is how we measure our success.

Goal Setting

I involved the project manager and engineers to set process quality goals for Increment 2:

Goal 1: Reduce test defects/KLOC
Plan for A/FR between 1.5 and 2.0

Goal 2: Increase effectiveness of design and code reviews
Plan for reviews of 100–150 LOC/Hour

Goal 3: Increase process yield
Plan for yields greater than 80 percent

PPA1.0 Increments 2 and 3 – *Quality is free*

The engineers revised their plans. They planned for more appraisal time and less failure time. They increased their post-mortem time for analysis and process improvement. They increased total development staff hours by less than 10 percent.

Table 3. *Definition of PSP Quality Measures*

Measure	Formula
Failure Hours	Total time spent in test (compile time not applicable in Visual Basic)
Appraisal Hours	Total time spent in design and code, personal reviews and design, and code team inspections
Failure Cost of Quality	100 × (Failure hours)/Total development hours
Appraisal Cost of Quality	100 × (Appraisal hours)/Total development hours
Total Cost of Quality	Appraisal COQ + Failure COQ
A/FR Ratio	Appraisal COQ/Failure COQ
Overall Process Yield	100 × (defects removed before test)/(defects injected before test)
Personal Review Yield	100 × (defects removed in personal reviews)/(defects removed in personal reviews + escaping from personal reviews)

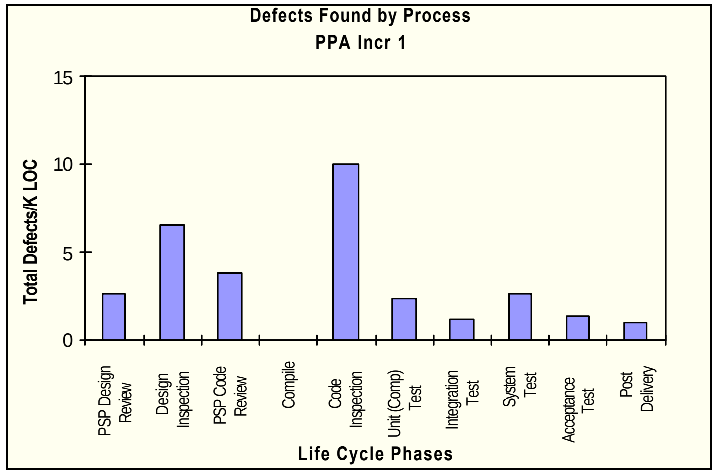

Figure 1

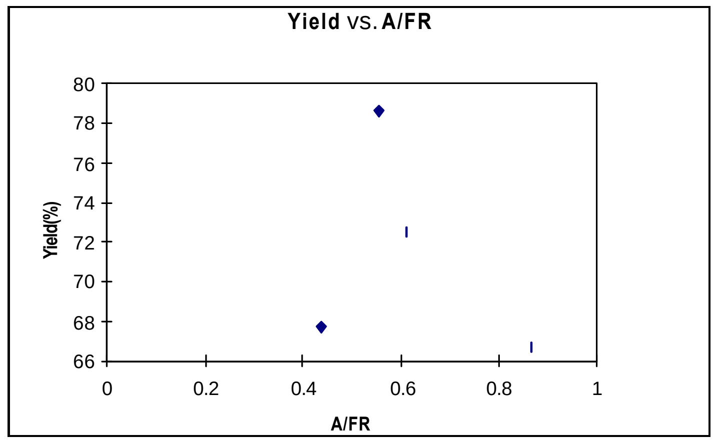

Figure 2

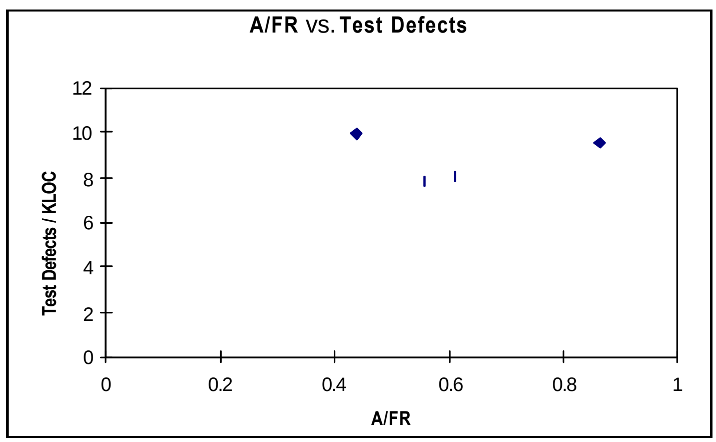

Figure 3

Increment 2 was completed on schedule. The team analyzed the data at the conclusion of Increment 2. Process data showed improvement in measures such as yield, A/FR, and test defects/KLOC. Cost of quality remained nearly the same.

The team set more aggressive goals for Increment 3. They planned for A/FRs greater than 2.0, process yield greater than 90 %, and test defects/KLOC less than 1.0. Process data showed further improvements in quality measures. Cost of quality declined.

We present the results in charts that accompany the Web version of this paper. The data in the charts are averages of four modules in Increment 1, six in Increment 2, and three in Increment 3 of PPA 1.0 and four modules in PQA 3.0.

PQA 3.0 is used as control group since it did not have the same executive leadership to direct and change engineers' behavior by defining criteria for success and setting aggressive individual and team goals.

Lessons Learned

1. When engineers use PSP on a real project following classroom training, their plans continue to rely on what they are most comfortable with. More time for test and rework and less time for reviews and inspections for early defect removal.
2. Management support is most critical during the transition from classroom to actual industrial use of the PSP.
3. Management support should include active participation in data analysis, goal setting, and process improvement.
4. Schedules dictate what must happen. Engineers' personal data show what will happen.
5. Managers and engineers should jointly make commitments based on what will happen and learn to manage by data.
6. For incremental development to be effective, managers and engineers should spend post-mortem time to adjust and improve the process.
7. PSP Cost of Quality measure provides compelling evidence that quality is free.
8. PSP enables alignment of engineers' personal goals with business goals for defect-free software delivery on time.
9. For quality to happen, managers and engineers must have mutual trust.
10. Engineers tend to improve their performance over time when they use a disciplined process and management is supportive.
11. We still have a long way to go to realize the full human potential in software development.

Acknowledgments

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References

1. Humphrey, Watts S. *Managing Technical People,* Addison-Wesley, Reading, MA, 1997.
2. Humphrey, Watts S. A *Discipline for Software Engineering,* Addison-Wesley, Reading, MA, 1995.

Please refer to the Web version of this paper [available at www.stsc.hill.af.mil] to see the complete set of module charts.

☞The Software Quality Institute in Chennai, India was recently named after Watts S. Humphrey.

About the Author

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PSP/TSP Web Sites

http://stsc.hill.af.mil/ptech/pt_art.asp
This site by the Software Technology Support Group features its Process Team's favorite CROSSTALK articles. It links readers to such articles as *Process Assistance Visit: A Tool for Process Improvement; Software Process Automation: A Technology Whose Time has Come; Air Force Policies on Attaining SEI CMM Levels;* and *Continuous Process Improvement for Software: Data Definition.*

www.sei.cmu.edu/publicaitons/documents/97.reports/97tr001/97tr001abstract.html
Personal Software Process: An Empirical Study of the Impact of PSP on Individual Engineers. This report documents the results of a study that examined the impact of the PSP on the performance of 298 software engineers. The report describes the effect of PSP on key performance dimensions of these engineers, and discusses how improvements in personal capability also improve organizational performance in several areas.

www.cs.usak.ca/grads/vsk719/academic/856/project/project.html
T*he Personal Software Process in Meta-CASE CMPT 856 Project* by Vive S. Kumar has links to PSP-related topics such as an Overview of PSP Principles of Meta-CASE Systems, How to Incorporate PSP in Meta-CASE, and Metrics for PSP.

http://archives.distance.cmu.edu/psp/pre_May
The Personal Software Process^{SM}: A Practitioner's Starter Kit is a course intended for practicing software engineers and their managers. It introduces the highest-leverage metrics of PSP. Students watch nine lectures, do seven programming problems, four reports, and read selected chapters from Watts Humphrey's book, *A Discipline for Software Engineering.*

http://psp.distance.cum.edu/oct/resource/online.html
This site offers a list of online readings related to PSP.

www.sei.cmu.edu/psp/Results.htm
This is a Software Engineering Institute site with links to sites such as Defects vs. Experience (programs 1 and 10), Yield vs. Program Number, and Lines of Code per Hour Improvement.

http://emhain.wit.ie/!doconnor/lectures/se3/project/team14/slides/psp1.htm
This gives an introduction and the seven progressive steps of PSP, such as Baseline Personal Process, and Personal Quality Management.

www.computer.org/computer/co1997/r5924abs.htm
This is an article by Pat Ferguson, Watts Humphrey, Soheil Khajenoori, Susan Macke and Annette Matvya that appeared in the May 1997 issue of *Computer* magazine. The article is "Results of Applying the Personal Software Process."

www.acm.org/pubs/citations/proceedings/cse/273133/p322-hou/
This takes visitors to the proceedings of the 1998 SIGCSE technical symposium on computer science education, and to the paper, "Applying the PSP in CSI: An Experiment."