Special Issue: SAICSIT '99
The South African Computer Journal

An official publication of the Computer Society of South Africa and the South African Institute of Computer Scientists

Die Suid-Afrikaanse Rekenaartydskrif

'n Amptelike publikasie van die Rekenaarvereniging van Suid-Afrika en die Suid-Afrikaanse Instituut vir Rekenaarwetenskaplikes

World-Wide Web: http://www.cs.up.ac.za/sacj/

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Think different.
Running SAICSIT '99, the annual research conference of the South African Institute for Computer Scientists and Information Technologists, has been quite an experience.

SAICSIT represents Computer Science and Information Systems academics and professionals, mainly those with an interest in research. When I took over as SAICSIT president at the end of 1998, the conference had not previously been run as an international event. I decided that South African academics had enough international contacts to put together an international programme committee, and a South African conference would be of interest to the rest of the world.

I felt that we could make this transition at relatively low cost, given that we could advertise via mailing lists, and encourage electronic submission of papers (to reduce costs of redistributing papers for review).

The first prediction turned out to be correct, and we were able to put together a strong programme committee.

As a result, we had an unprecedented flood of papers: 100 submitted from 21 countries. As papers started to come in, it became apparent that we needed more reviewers. It was then that the value of the combination of old-fashioned networking (people who know people) and new-fashioned networking (the Internet) became apparent. While the Internet made it possible to convert SAICSIT into an international event at relatively low cost, the unexpected number of papers made it essential to find many additional reviewers on short notice. Without the speed of e-mail to track people down and to distribute papers for review, the review process would have taken weeks longer, and it would have been much more difficult to track down as many new reviewers in so little time.

Even so, the number of referees who were willing to help on short notice was a pleasant surprise.

The accepted papers cover an interesting range of subjects, from management-interest Information Systems, to theoretical Computer Science, with subjects including database, Java, temporal logic and implications of e-commerce for tax.

In addition, we were very fortunate in being able to invite the president of the ACM, Barbara Simons as a keynote speaker. Consequently, the programme for SAICSIT '99 should be very interesting to a wide range of participants.

We were only able to find place in the proceedings for 36 papers out of the 100 submitted, of which only 24 are full research papers. While this number of papers is in line with our expectation of how many papers would be accepted in each category, we did not have a hard cut-off on the number of papers, but accepted all papers which were good enough, based on the reviews. Final selection was made by myself as Programme Chair, and Derrick Kourie, as editor of the South African Computer Journal. Additional papers are published via the conference web site.

We believe that we have put together a quality programme, and hope you will agree.

Acknowledgments

I would like to thank the South African Computer Journal production team, Andries Engelbrecht and Herna Viktor, respectively from the Department of Computer Science and Informatics, University of Pretoria, for their work on producing the proceedings.

The reviewers listed overleaf did an excellent job: many wrote very detailed reports, sometimes after being called in on very short notice. Inevitably, there were some glitches resulting from the unexpected workload, but the buck stops with the programme chair: I promise to do better next time.

I would also like to thank my own department for putting up with the extra work and expense that running a conference entails. I tried not to burden them with too much extra work, but our secretaries, Zalm Gowar and Leanne Reddy, inevitably had to take on some extra work. John Ostrowick provided valuable assistance with design of our web pages and call for papers poster. Carol Kernick, who handles our finances and membership records, did a fine job of keeping up with the demands of the conference.

Finally, I would like to thank our sponsors, whose contribution made this conference been possible:

- PricewaterhouseCoopers – sponsored generous prizes and the conference banquet
- National Research Foundation (NRF) – provided financial support
- University of the Witwatersrand – provided financial support
- Programme for Highly Dependable Systems, University of the Witwatersrand – provided financial support
- Standard Bank – provided financial support
Editorial

- Apple Computer – provided equipment for the conference
- Qualica – provided technical support including helping with the conference web site

Web Site

For more information about SAICSIT, including a pointer to the conference site, see <http://www.saicsit.org.za>.

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An application of a framework for evaluation of the factors affecting software development productivity in the context of a particular organisational environment

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Abstract

The goal of this paper is to present the practical implementation of a novel framework for evaluation of the factors affecting software development productivity, combining elements from several systems approaches and Multi Criteria Decision Making (MCDM). The framework can be seen as a complementary approach to the existing methods, helping to analyse the relationships between factors affecting software development productivity. The framework is portable to different software development environments.

Keywords: IS Development, Software productivity, Soft Systems Thinking, AHP

Computing Review Categories: D.2.9, H.1.1

1 Introduction

The reasons why research on factors affecting software development productivity is of paramount importance can be summarised as follows:

• software costs continue to be significant, and industry's understanding of how to reduce them has improved very slowly [7];

• existing software cost estimation models do not seem to capture productivity factors very well [18];

• managers are keen not only to measure software development productivity but also to understand how to improve it [4];

• despite the prevalence of inaccurate estimates, little is known about their causes [8].

The results of previous research [14] demonstrated the need for a systemic pluralist methodology for addressing the issue of evaluation of the factors affecting software development productivity. The goal of this paper is to present the experimental implementation of such a methodology. We first provide a brief overview of the nature of the problem of evaluation of factors affecting software development productivity. This is followed by a brief presentation of a framework for this purpose, and an analysis of its experimental implementation in an industrial environment.

2 The process of pluralist systemic evaluation of factors

Conclusions from previous research highlighting the complexity of factors affecting software development productivity can be summarised as follows:

• The algorithmic models of relationships between such factors have so far not contributed significantly to the improvement of the precision of estimates for software development effort or costs [8].

• There is a need to provide a link between research on software measurement with research on the management of the software development process [1].

• A holistic framework for evaluation of the factors affecting software development productivity is needed [14]. Such a framework should be comprehensive, easy to use, adaptable to any software development environment and well justified regarding its origins within the body of knowledge of information systems and systems thinking.

The issue of evaluation of these factors within a particular environment is a complex and "messy" organisational problem. A single approach or methodology may not sufficiently reveal its many facets without losing important information. Hence the need to seek a pluralist way for achieving the required deeper understanding of these factors.

An analysis of pluralistic thought in the fields of systems thinking and information systems (see [13]) indicated some issues that are not resolved methodologically in the literature. Several goals can be identified for a framework
for evaluation of factors affecting software development productivity:

- To protect the interests of software developers for the purpose of releasing their creative potential.
- To account for the role of the users in the process of software development.
- To recognise the issue of paradigm incommensurability and to offer guidelines for its resolution.

The first goal above implies that the framework can be based on, or enhanced by Critical Systems Thinking (see [10]). The second goal implies a framework that is able to take into account the strengths of individual techniques and which promotes user involvement. It is suggested here that the third goal can be satisfied assuming the possible dialogue between approaches from different paradigms on the basis of Wittgenstein's theory of language games (see [5]).

The process of evaluation of factors affecting software development productivity (a cycle of critique, judgement and action) may be expressed as is shown in Figure 1. Its philosophical foundations are based on the work of Midgley [9] and Jackson [6]. The choice of techniques in this framework is, however, quite different from the one suggested by Midgley [9]. The multiple perspectives needed for a multimethodology approach are better suited, according to the authors, by referring to the work of Linstone (see Mitroff and Linstone [12] and Mingers [10]).

Multiple perspectives can be also enhanced through the application of Critical Systems Heuristics (CSH) in the application of which Boundary Judgement Questions play an important role (see Ulrich [19]). Thus the evaluation is influenced by the critical systems paradigm. As some of the parameters of the evaluation problem are already revealed through the included elements of soft systems methodology (SSM), it is suggested that only eight of the twelve critically heuristic categories are suitable for use in the framework: measure of improvement, resources, decision environment, expert, expertise, guarantor, witness, world view [19]. There can be possible cycles between the three stages in the framework. The individual techniques provide complementary insights into the relationships between the factors. This process of reflection reveals the power of the systemic approach. On the other hand, as a result of the incorporation of an MCDM technique, it is more focused than traditional systems approaches.

It is not possible to provide restrictions on the boundaries of the three stages during the application of the framework or to relate them only to one or more of the possible sessions associated with a given evaluation. The number of cycles through the framework depends on the needs of a particular problem situation. They are seen not just as physical cycles of repeating strictly a particular technique but as mental cycles through the framework. Further analysis of the justification of the framework based on Critical Systems Thinking and Software Measurement is presented in Petkova [13].

It seems that the idea of a descriptive framework for the evaluation of software development productivity factors fits very well into the concept of the need for every organisation to develop its own set of models for software development effort estimation, which draws on the works of Bailey and Basili [2] and Pfleeger et al. [15]. The reasons for justifying the above claim are in the nature of the evaluation problem under investigation. Software development organisations are not merely technical entities, but are more fully described as socio-technical systems. In social systems it is impossible to reproduce in a new setting all the parameters of the original environment in which a model was generated (see Rosenzweig [16]).

The framework described in this paper can be viewed as a learning process, leading to better understanding of the relationships between the factors affecting software development productivity. It is based on ideas related to a recent meta-theoretical approach to pluralism in Management Science, called Multimethodology (Mingers and Gill [11]). The framework is a synthesis of ideas from Critical Systems Thinking, Soft Systems Methodology and Multi-criteria Decision Making.

A question arises about the relationship of the proposed framework to existing methods for software development effort estimation. In many instances it may be too expensive to provide sufficient quantitative data to support such methods, and in that case expert judgement has to be used. Besides, many aspects of the software development process are qualitative in nature. The framework proposed in this research provides a complementary approach to the current techniques for software development effort estimation. It does not aim to substitute them as tools for revealing the importance of various factors affecting software development productivity. Further analysis of the justification of the framework is presented in Petkova [13]. An illustration of the application of the framework, by way of a case study, is presented in the following section.

3 A case study on the implementation of the framework

The framework for evaluation of factors affecting software development productivity was experimentally validated on a complex software project. The user company in question is a large metal processing plant. In 1997 it initiated a substantial expansion project. A major component of it was allocated for massive renovation of the hardware and software base of the Information Systems division of the company. The project required a lot of expertise that was not available in-house. It went through the route of outsourcing.

In this case two companies provided outsourcing solutions. One was engaged in the provision of software support for the integration of the automation of technological processes with the Shop Floor Execution System modules of an integrated Management Information System. The second outsourcer is engaged in the provision of support.
The implementation of the framework concentrated on two project teams only - one from the user company and the other from the outsourcing provider for the shop floor execution system. One team explored the software developer's perspective and the other how these factors demonstrate themselves within the user team. This two-dimensional implementation of the framework is also important from the point of view that outsourcing of information technology is a growing phenomenon in absolute and monetary terms (see Willcocks, Fitzgerald and Feeny [20]).

The first stage of the framework, as described in Figure 1, the Critique, involves the development of multiple perspective representations of the problem of evaluation of factors affecting software development productivity. This is explored through the application of stakeholder analysis, brainstorming and the use of rich pictures and CATWOE analysis from Soft Systems Methodology (SSM).

The first session with the two teams produced sufficient material for the Critique stage and the Judgement stage of the process shown in Figure 1. It was followed by a two month period for reflection on the results from the first session. Later there was a second session, in which possible actions were explored with respect to improvement of software development productivity. It involved a review of the results from the first session, and the formulation of answers to a questionnaire based largely upon Critical Systems Heuristics by Ulrich [19]. The purpose was to provide another iteration on the Judgement phase and possible material for the Action phase of the framework. However, this research concentrates predominantly on the evaluation process. The intervention takes place here through a dialogue on the basis of the increased knowledge and understanding about the factors affecting software development productivity as a result of the application of the framework.

The following paragraphs will present a brief summary of the findings from the application of the framework. The issue of evaluation of factors affecting software development productivity was new to both teams, and they needed some initial introduction to it in the form of a short explanation at the beginning of the first session. The complexity of the problem concerned within the framework was seen as a challenge by the teams. They showed quick understanding of the goals of the evaluation exercise and the techniques involved.

### 3.1 Implementation of the soft systems aspects of the framework

Rich pictures aim to represent the structure of a complex problem, the processes associated with it and the relationships between structure and processes (see Checkland and Scholes [3]). Ideally it should be possible to convey successfully more than one world view, guiding the organisational transformation, in a rich picture, though there are no direct guidelines for that in the literature (see Checkland and Scholes [3]). The rich picture in Figure 2 attempts to show the different world views of the various stakeholders associated with this large project. The rich picture tech-
nique helped the two evaluation teams to clarify better the stakeholders and the major issues related to the software project and the factors affecting software development productivity.

A further technique from Soft Systems Methodology (Checkland and Scholes [3]) was used with the two groups - the CATWOE analysis. Its purpose is to identify those affected by the project, the main actors in it, the essence of the transformation that is sought, the world view guiding this transformation, who owns or controls the project and what the environmental constraints are. The uniformity in the world views declared by the two working groups is an important precondition for the success of the project.

The participants in both teams were asked to raise ideas pertaining to the issue of factors affecting software development productivity and rate them. The rating of these ideas was according to their importance for the purpose of identification of key management issues. The participants were encouraged to generate ideas of three types in accordance with a mode II usage of SSM (Checkland and Scholes [3]):

- Ideas on the general (technical) side of the process of project development.
- Ideas related to the cultural analysis of the software project. These concern: various roles, norms, and values of the stakeholders in the project.
- Ideas related to the political analysis of the software development project, revealing power relations.

A total of twenty seven ideas were generated by the user team. The user group was then asked to rate those issues according to their importance on a scale from 10 to 1. The higher the rating the greater the severity of the issue with respect to the possible implications for the successful completion of the project. The top three important issues were related to the technical aspects of project management (lack of project management experience, lack of understanding for the complexity of the project, no grass root participation in the formulation of solutions proposals). This indicates serious problems with the state of project management at different levels within the company. The next two most important issues were of a political nature. The first of them, the need to match the business vision with technological vision, shows that there is insufficient alignment between the business goals and those of the IT function. The second one, insufficient involvement in Business Process Reengineering (BPR) of those affected by it, is a frequently observed problem that often causes a failure in business process reengineering efforts. Another disturbing concern of the members of this team was the observation that implementation strategy was technology geared under the disguise of BPR. Cultural issues were of lesser concern to the user company group.

Analysing the top priority issues for the outsourcing team it was found that there was no pronounced dominance of technical issues as in the previous case. Two important aspects related to inadequacies in the change management practices of the user company were ranked as third and fifth in the outsourcer's list. This can be seen as a reason for concern about the organisation of the change processes within the user company and points to the need for better training in change management practices. The results showed certain differences between the priorities of the user company project team and the outsourcing provider team. These will be further explored in the following section.

### 3.2 Multicriteria prioritisation of the factors

This step of the evaluation involved pairwise comparisons between the factors affecting software development productivity, which were seen as relevant for this project. The result is a prioritization of these factors. This can be used for the purpose of identification of those factors that can contribute most significantly to management improvement. The pairwise comparison process between the factors was conducted using a multicriteria decision-making (MCDM) technique, the Analytic Hierarchy Process (AHP) (Saaty [17]). It is a way of measuring the qualitative and quantitative knowledge that the members of the group have about the various factors.

Management of both teams is concerned most of all with the global priorities of all factors, showing their overall contribution to software development productivity. These can be synthesised using an MCDM software package. Prioritisation aims to help the management to concentrate on those issues that contribute most to the improvement in software development productivity.

The results show that project management plays a dominant role according to the user company team, with a priority of 0.336. The second most important factor, user management commitment, has a four times smaller global priority, followed closely by requirements volatility, software reliability and third party involvement. The outsourcing provider, on the other hand, considers motivation as most important (0.114), followed by software reliability (0.108), project management quality (0.100), team size (0.076) and the development schedule (0.70). There is no single dominant factor for this evaluation group, which differs from the findings for the user company project team.

Only two of the top five factors coincide for both groups: project management and software reliability.

There is a slight difference in the priorities of requirements volatility, and in general it is considered as important by both groups. The priorities of the rest of the top five factors closely reflect the operational features of the respective teams. Thus, user management commitment is seen as the second most important factor by the user company team. On the other hand, it features quite low as second least important factor for the outsourcing provider. This probably reflects that the top down line of communication within the teams and between the teams insulates the outsourcing provider team from the influence of the user management.

The preceding analysis shows that there are potential problems facing the software project under concern. This
Figure 2. A rich picture depicting the issues associated with the new IT system of the user company (the dotted line indicates the boundaries of the problem).
was confirmed by the developments within the company just two months after the first meeting. There was a sense of dissatisfaction with the overall progress on the project and the project was put on hold temporarily. Both outsourcing providers left the user site but continued work within their scope of activities. The user company then started a process of reassessment of the project goals, scope and schedule. This was accompanied by a change at the top of its team. Certain changes also occurred within the outsourcing providers.

3.3 Critically heuristic self-reflection and appraisal of the framework

The purpose of the second session was to provide critically heuristic self-reflection on the process of evaluation of productivity factors within the IT project under concern. Ulrich [19] extended his ideas on critical systems heuristics to the level of the ordinary citizen. By analogy to his findings, the authors claim that it is possible to define a set of boundary questions for a systematic boundary critique of the problem of improvement of software development productivity. These questions may be applied to any of the three stages of application of the framework defined in this research. These stages can be repeated in several iterations, depending on the complexity of the problem at hand. For example, new world views might be explored; new interpretations of the criteria in the AHP model might be developed to see their influence on the final rankings.

The framework suggested here assumes for pragmatic reasons that it might be better to avoid the use of boundary questions in the first meeting with the evaluation teams. The reason is that the techniques used in it were conceived as suitable for providing the necessary initial multiple perspectives insight into the project reality. The second session took the form of a structured in-depth individual interviews with the participants. The outcome of these interviews reflects further on the beliefs of each of the evaluation groups. An analysis of these outcomes seeks potential common grounds in those beliefs as a basis for actions on the way forward with the project.

The first eight items of the questionnaire used in the second evaluation session (its full text can be found in Petkova [13]), represent an operationalization of the relevant issues in the checklist of critically heuristic boundary questions defined by Ulrich [19]. They are sources of important aspects of the systemic enquiry: motivation, power, knowledge and legitimization. The last four questions deal with issues of experimental validation of the framework suggested in this research.

The results from the first and the second sessions on the evaluation of factors affecting software development productivity coincide significantly with the real problems that were recognised within this project by the company management. The second session (the details are omitted for space reasons) provided further insight with respect to the emancipatory elements of the framework, aiming at a better realization of the human potential of the developers.

4 Conclusion

This paper presented the results from the experimental implementation of the framework for evaluation of factors affecting software development productivity. It was conducted in the environment of a large software project in a metal processing production plant. The IT operation of this plant had been outsourced a few years ago. Thus the evaluation presented was made in two dimensions, one from the point of view of the user company project team; the second from the point of view of the outsourcing provider organisation.

The knowledge about these factors and their influence on productivity grew through the dialogue that accompanied the application of the framework. The MCDA approach was seen here as a tool for better prescriptive decision making. Experimenting with various changes of judgements and observing their influence on the final priorities of the factors is a revealing process about the dynamics of the relationships between the factors affecting software development productivity. The stakeholder analysis and Soft Systems Methodology, as well as CSH Boundary Judgement Questions helped with the diagnosis stage of the problem solving process.

The participating teams found the framework easy to use and relevant to the area of software project management. It consists of several techniques from different methodologies and paradigms and is justified on the basis of Multimethodology, a recent concept for pluralist research and intervention in the Management and Systems Sciences (Mingers and Gill [11]). It was found that the chosen combination of techniques assists in the learning process of gaining a better appreciation for the relationships between factors affecting software development productivity.

The framework can be easily adapted to any software environment. Some slight modifications in it, like the selection of the relevant technique for a particular case, including the selection of the MCDM approach, can be made in the context of a particular software project. The framework is portable to any software development environment and does not require prior data collection and software process modelling.

References


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