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Models of motivation in software engineering

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Models of motivation in software engineering

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Abstract

Motivation in software engineering is recognized as a key success factor for software projects, but although there are many papers written about motivation in software engineering, the field lacks a comprehensive overview of the area. In particular, several models of motivation have been proposed, but they either rely heavily on one particular model (the job characteristics model), or are quite disparate and difficult to combine. Using the results from our previous systematic literature review (SLR), we constructed a new model of motivation in software engineering. We then compared this new model with existing models and refined it based on this comparison. This paper summarises the SLR results, presents the important existing models found in the literature and explains the development of our new model of motivation in software engineering.

Keywords: motivation, project management, human factors, systematic literature review

1. Introduction

In this paper we use the results of our systematic literature review (Beecham et al, in press) (SLR) to construct a model of motivation in software engineering. Motivation is increasingly cited as a particularly pernicious people problem in software engineering. In DeMarco and Lister's survey, motivation was found to be one of the most frequently cited causes of software development project failure (DeMarco and Lister 1999). The Standish report (1995) emphasises this finding by reporting that having access to competent, hard working and focused staff is one of 10 success criteria for software projects. More recent studies also link project success with motivation (Procaccino et al, 2005; Hall et al, 2008).

Motivation refers to the initiation, direction, intensity and persistence of behavior. It is acknowledged to have a major impact on software quality and productivity (Boehm, 1981), yet as it is a soft factor, and difficult to quantify, it often takes a backseat (McConnell, 1998). Concentration on rewards and recognition (e.g ProjectLink (2006)) for software engineers may be misguided as some studies show that Software Engineers have a distinctive personality profile (Capretz, 2003) and are motivated by the nature of the job, e.g. challenging technical problems (Tanner, 2003; Ramachandran and Rao, 2006) and peer interaction (Klenke and Kievit, 1992; Linberg, 1999).

Over the last 30 years there have been several research efforts to understand and model motivation in software engineering. However, much of this work has been isolated from other efforts, specifically classical motivation theory (Hall et al., in press), and there is a need to pull together existing knowledge and rationalise the findings in order to produce a clear map of the state of current knowledge. To this end, we undertook a SLR of the area, drawing on over 2000 papers, and analyzing 92 of these in detail. From the information collected we constructed a new model of motivation which incorporates existing literature. In this paper we focus on the construction and evolution of the new model of motivation.

Models are used in all fields of software engineering, from requirements engineering (Rashid et al 2002) to software evolution (Lehman et al 1997) and from human interactions (Checkland 1981) to the visualization of algorithms. Throughout the spectrum of software engineering, models have been used in the classic way that operational managers and management scientists describe: that is either to explore possible consequences of an action before taking that action or as embedded parts of a system to aid in routine decision making (Pidd 1999).

Pidd (1999) defines a model as:

> "An external and explicit representation of part of reality as seen by the people who wish to use the model to understand, change, manage and control that reality in some way"

Pidd also stresses that no model will be a complete representation of reality, since such a model will be too complicated, expensive and hard to manipulate. Instead, models tend to make partial representation of the real world and such partial representations should be fit for some purposes, but not necessarily all purposes. In fact, there are different ways in which a model may be partial. A partial model may present a detailed view of one aspect of the phenomenon, or a partial model may present a more abstract view of a wider set of aspects, or a range of coverage and level of detail in between.

Acknowledging the partial nature of models, our aim was to identify models of motivation in the literature and then combine them to create a new model. While this new model would still be partial, it would provide an overview of motivation in software engineering which has so far been lacking. However this proved to be less straightforward than had been anticipated as models in the literature were either focused on one common base (and hence were already 'integrated') or were disjointed and difficult to reconcile. So the model was constructed in two stages. The first stage used findings about motivation in software engineering from the literature survey to construct a new model. The second stage then refined this new model by comparing it with existing models identified through the survey .

Section 2 briefly describes the SLR and summarises the results of the literature review that were used to construct the new model (for a more detailed description see Beecham et al, in press). Section 3 introduces the new model of motivation in software engineering built using the information from the SLR. Section 4 presents the existing models identified from the SLR. Finally, the new model is compared with the models from the literature review and refined according to the similarities and differences identified. Finally, future research in this area is suggested.

2 Published findings on motivation in software engineering

The SLR of motivation in software engineering followed the guidelines suggested by Kitchenham (2004). This approach to literature review has been adapted from the medical field and represents a rigorous approach to investigating specific research questions. Based on initial investigations, the following set of research questions were formulated:

RQ1: What are the characteristics of software engineers?

RQ2: What motivates software engineers to be more productive or demotivates them to be less productive?

RQ3: What are the external signs or outcomes of motivated or demotivated software engineers?

RQ4: What aspects of software engineering motivate software engineers and what aspects demotivate them?

RQ5: What models of motivation exist in software engineering?

The results of the first four questions were used in the first stage of model construction; the results of the fifth were used in the second stage.

We drew up keyword searches for each of these questions and systematically searched eight research databases, including IEEE Explore and Ei Compendex. The searches elicited over 2,000 references published between 1980 and 2006. Evaluating the title and abstract enabled rejection of approximately 1,500 of these. Five hundred and nineteen papers were read in full and stringent acceptance and rejection criteria were used to establish a final list of 92 papers. These criteria included the fact that the paper must be published in a journal, conference proceedings, or empirical experience report and be based on theoretical or previous rigorous research. Opinion pieces or viewpoints that do not reference any other study or are not based on empirical work were excluded. We also excluded work on cognitive behaviour, general group/team motivation and dynamics, manager motivation, user/end user motivation and acceptance of technology, gender differences and education (e.g. motivating IT students to learn). Each of these 92 papers was then assessed using a clearly-specified quality assessment, focusing on aspects such as the size of the sample studied, clear objectives and sound methodology. The steps undertaken, and the

details of acceptance criteria and quality assessment are detailed in the protocol (Beecham et al 2006) and summarized in the full SLR report (Beecham et al, in press).

The procedure was piloted with four researchers and refined three times. The final protocol was then reviewed by an independent expert in systematic review development in Software Engineering. The main SLR was conducted by one researcher, but a random sample of papers was extracted and results were checked by an independent researcher in two validation stages (see Table 1).

Table 1: Papers reviewed and validated

Selection Process	Papers used in validation	# Papers
Papers Extracted from Databases	n/a	> 2000
Sift based on Title and Abstract	n/a	519
Papers – full versions available [519-19]	(58 papers randomly selected from this set for validation 1)	500
Papers accepted (by primary researchers)		94
Papers rejected by independent researcher (validation 1)	[1 paper rejected from the 58 paper sample that formed part of the 94 accepted papers]	93
Papers added by independent researcher (validation 1)	[2 papers accepted out of the 58 randomly selected papers that were previously rejected by primary researchers]	95
Papers rejected in Validation 2 (92 papers remain in our review)	All 95 papers assessed and qualitative forms completed by two independent researchers – 3 rejected	92

As motivation and demotivation are different constructs and the aim of this research is to propose a model of motivation, we focus here on the findings related to motivation factors and not demotivational aspects, although the SLR identified both. The results of the first four questions of the SLR that focused on motivational factors are summarized below; for more information about these results and a general discussion about all five research questions, please see Beecham et al (in press). In Section 3 we analyse these findings further and show how they informed the new model of motivation.

2.1 What are the characteristics of Software Engineers?

Table 2 presents results from the research question "what are the characteristics of software engineers?" This question was included in the survey as initial investigations suggested that software engineers have a distinct personality profile that affects their motivation. Note that in Table 2 (and all tables below), we report the number of studies identifying this characteristic, but a high number here does not necessarily equate with any perceived level of importance for that characteristic.

The SLR reports software engineers to have a wide variety of characteristics. The most frequently-cited being *growth oriented,* i.e. they like challenges and like to learn new skills, *introverted* with a low need for social interaction and *autonomous*. The characteristic *need to be sociable* appears to contradict the studies identifying the *introverted* characteristic, while others such as *growth oriented*, *need for challenge* and *need for variety* are complementary.

Table 2: Software Engineer Characteristics

Software Engineer Characteristics	Paper references (in Appendix)	# of studies reporting
Growth orientated (e.g. challenge, learn new skills)	[4, 7, 9, 12-17]	9
Introverted (low need for social interaction)	[12-14, 19-22]	7
Autonomous (need for independence)	[3-5, 11, 13, 17, 22]	7

Need for stability (organisational stability)	[1-5];	5
Need to be sociable/identify with group/organisation	[4, 8, 9, 17, 25]	5
Technically competent	[1, 3, 6-8]	5
Achievement oriented (e.g. seeks promotion)	[2, 9-11]	4
Need for variety	[3, 5, 17, 23]	4
Need for challenge	[5, 11, 17, 20]	4
Need for competent supervisors	[2, 3, 8, 18]	4
Need to make a contribution (job is worthwhile)	[3, 4, 8]	3
Need for feedback (needs recognition)	[14, 15]	2
Marketable	[5, 17]	2
Creative	[17, 24]	2
Need for involvement in personal goal setting	[14]	1
Need for Geographic stability	[3]	1

2.2 What motivates software engineers to be more productive?

Table 3 presents results from the research question "what motivates software engineers to be more productive?" The most widely reported motivator of software engineers is the ability to identify with the task. This means that the task should have clear goals, be interesting to the individual, be clearly defined and be linked into the wider set of activities. A comparison with Table 2 indicates how these aspects relate to software engineer characteristics, e.g. need to make a contribution.

A variety of other motivators are also cited by many studies, e.g. *employee participation*, *good management*, *career paths*, *variety of work*, *sense of belonging* and *rewards and incentives*.

Table 3: What motivates software engineers?

Motivators of Software Engineers	References	# of studies reporting
Identify with the task (clear goals, personal interest, know purpose of task, how it fits in with whole, job satisfaction; producing identifiable piece of quality work)	[7-9, 11, 18, 20, 22, 23, 33, 47-51, 53, 54, 56, 67, 68, 72]	20
Employee participation/involvement/working with others	[23, 33, 43, 44, 49, 52, 54, 58, 60, 66, 67] [10, 25, 49, 63, 68]	16
Good management (senior management support, team-building, good communication)	[7, 10, 18, 22, 25, 37, 44, 46, 48, 49, 51, 53, 54, 56, 59, 60]	16
Career Path (opportunity for advancement, promotion prospect, career planning)	[3, 9, 11, 25, 29, 37, 43, 44, 47, 48, 50-52, 55, 57]	15
Variety of Work (e.g. making good use of skills, being stretched)	[9-11, 25, 29, 37, 43, 44, 48, 50-52, 55, 57]	14
Sense of belonging/supportive relationships	[8, 10, 21, 22, 25, 43-45, 49, 56, 61-64]	14

Rewards and incentives (e.g. scope for increased pay and benefits linked to performance)	[7, 23, 36, 43-53]	14
Recognition (for a high quality, good job done based on objective criteria).	[7, 8, 10, 22, 23, 25, 46, 48, 49, 51, 54, 68]	12
Development needs addressed (e.g. training opportunities to widen skills; opportunity to specialise)	[3, 7, 22, 25, 43, 44, 48, 49, 54-56]	11
Technically challenging work	[11, 22, 42, 46, 48, 54, 59, 64, 65, 67, 68]	11
Job security/stable environment	[23, 25, 43, 46-48, 50, 56, 59, 71]	10
Feedback	[9, 10, 20, 23, 33, 37, 45, 56, 67, 69]	10
Autonomy	[7, 9-11, 33, 56, 67-69]	9
Work/life balance (flexibility in work times, caring manager/employer, work location)	[4, 25, 43-45, 64, 65]	7
Making a contribution/task significance (degree to which the job has a substantial impact on the lives or work of other people)	[8, 9, 11, 33, 48, 61]	6
Empowerment/responsibility	[7, 11, 44, 54, 57, 58]	6
Appropriate working conditions/environment/good equipment/tools/physical space/quiet	[4, 7, 47, 64, 67, 73]	6
Trust/respect	[8, 33, 58, 70]	4
Equity	[52, 67, 70]	3
Working in company that is successful (e.g. financially stable)	[4, 44]	2
Sufficient resources	[25, 48]	2

2.3 What are the external signs or outcomes of motivated software engineers?

Table 4 shows that the most widely reported outcome of motivated software engineers is *retention*. Other external outcomes are improvements in *productivity* and *project delivery time*, adherence to *budgets*, low *absenteeism* and improved *project success*. These factors are primarily important from an organisational perspective rather than from an individual's perspective.

Table 4: External signs of motivated software engineers

External signs of motivated software engineers	References	# of studies reporting
Retention	[21, 25, 32, 38, 43, 45, 50, 52, 57, 62, 66, 81]	12
Productivity	[6, 21, 58, 68, 73]	5
Project delivery time	[16, 82]	2
Budgets	[81]	1
Absenteeism	[50]	1

Project Success	[68]	1

2.4 What aspects of software engineering motivate software engineers?

This research question was included to identify the inherent characteristics of software engineering that make the discipline motivating to its practitioners. Table 5 shows that *change* and *challenge* were the most cited motivators in the SLR, but they were closely followed by a variety of motivators including, *problem solving*, *team working*, the *science* and *experimentation* involved in software development, and even the *software lifecycle* aspect of the discipline.

Table 5: Motivational aspects of software engineering

Motivational aspects of software engineering field	References	# of studies reporting
Change	[2, 11, 42, 85]	4
Challenge (Software Engineering is a challenging profession and that in itself is motivating)	[22, 42, 61, 65]	4
Problem Solving (the process of understanding and solving a problem in programming terms)	[10, 22, 83]	3
Benefit (creating something that is of benefit to someone or enhances well-being)	[10, 61, 83]	3
Team Working	[61, 84]	2
Science (making observations, identifying, describing, engineering, investigating and theorising, explaining a phenomenon)	[77, 83]	2
Experiment (trying something new, experimentation in order to gain experience)	[55, 83]	2
Development practices (Object Oriented, XP and prototyping practices)	[85, 86]	2
Software process/lifecycle – Software development, project initiation and feasibility studies, and maintenance	[77]	1

3. A new model of motivation in software engineering: stage one

The research questions for the SLR arose from initial reading in the area, and this preliminary work suggested that the questions were related as shown in Figure 1.
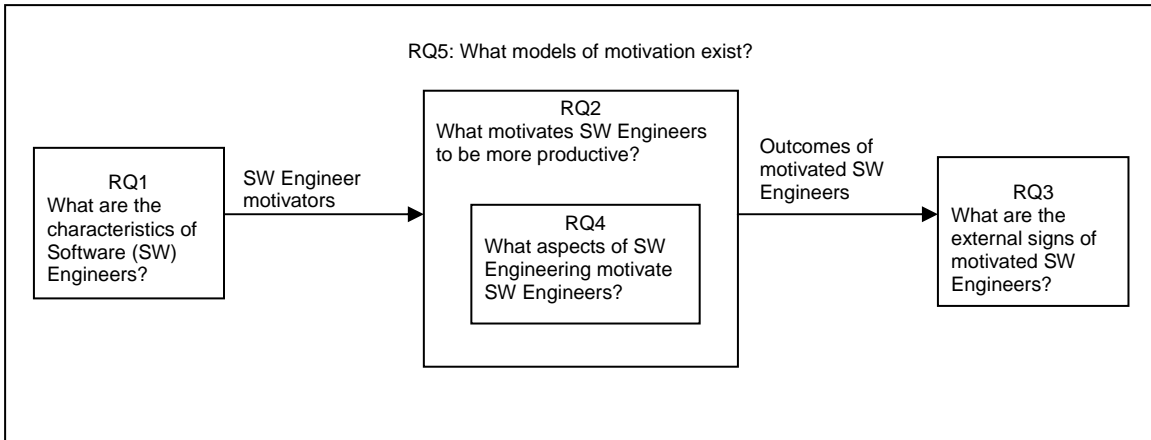
Figure 1: Framework of research strategy for SLR [Beecham et al 2007].

We used the framework in Figure 1 to start structuring the new model and evolved it according to the detail of the SLR findings for each research question. As they were asked in a modular fashion, much of this evolution involves populating the framework in Figure 1, however there were also results from the SLR that confirmed the credibility of the basic structure as well as indicating where changes were needed. We return to the models of motivation found in the literature in Section 4.

The software engineer characteristics listed in Table 2 fall into two different categories: characteristics of the individual, and expressed needs. So for example, the literature says that a software engineer is introverted by nature, but also has a need for variety in his/her work. Re-presenting this set of results by clustering characteristics on one side and needs on the other, gives a picture as shown in Figure 2.

Figure 2: Software engineer characteristics fall into two categories

This provides some detail to understand what the literature says are the characteristics of software engineers, however the literature appeared to be conflicting, e.g. one study would report that software engineers have a distinctive set of characteristics, while another would say that they do not. After a closer analysis of the relevant papers, it became clear that the research indicated a more sophisticated answer to RQ1 than we had anticipated. The research showed that these characteristics are influenced by contextual factors, most specifically the individual's personality and the environment in which they are practicing. The structure of our answer to RQ1 therefore changed to take account of these extra factors. We modelled this

as two components, with the characteristics (as detailed in Fig 2) being mediated by individual personality traits and environmental factors (see Fig 3).
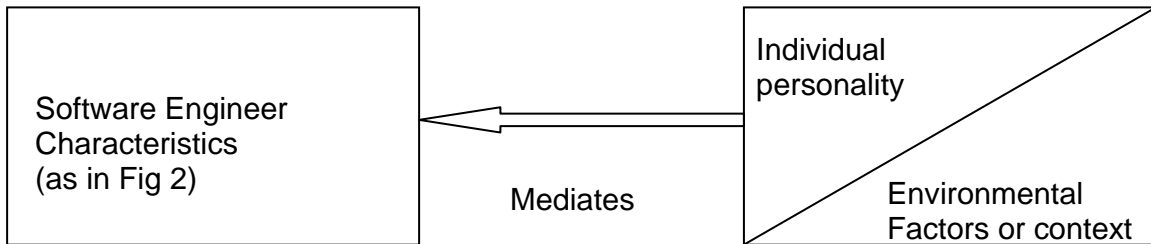

Figure 3: The context mediates Software Engineers' Characteristics

Factors of individual personality that the SLR findings show to have an affect on engineers' characteristics are: managerial or technical leanings (e.g. Iqbaria et al, 1995), innate abilities (e.g. Darcy and Ma, 2005), and MBTI score (e.g. Capretz, 2003; Myers et al, 1998). Factors associated with the environment or context that mediate an engineer's characteristics are: the state of the profession (e.g. Myers, 1991), career stage (e.g. Enns et al 2006), national culture (e.g. Khalil et al, 1997), job role or type (e.g. Couger and Mcintyre, 1987), and the organization (e.g. Garza et al, 2003).

RQ2 asked in general terms 'what motivates software engineers', and the SLR identified 21 motivators in answer to RQ2. A common distinction between motivators is those that are intrinsic, i.e. come from the pleasure of doing the work itself, and those that are extrinsic, i.e. are related to factors external to the job such as working conditions (Herzberg, 1959). So rather than simply populate the RQ2 box in Figure 1 with the SLR findings, we have divided these 21 motivators into intrinsic and extrinsic factors.

Both RQ2 and RQ4 sought to identify motivators for software engineers, but RQ4 asked specifically 'what aspects of software engineering are motivating?'. This is reflected in the way RQ4 is embedded within RQ2 in Figure 1. The motivators inherent in software engineering are all intrinsic factors as they relate solely to software engineering. Refining the original relationship in Figure 1 according to these observations gives the structure shown in Figure 4.
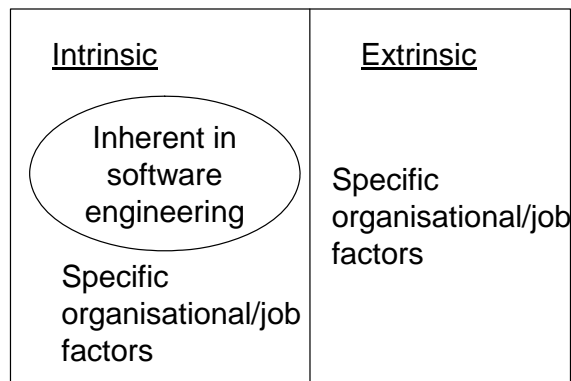

Figure 4: Factors that motivate software engineers can be classified as intrinsic or extrinsic

Taking the list of factors from Table 3 and dividing them into intrinsic and extrinsic factors, and incorporating them into this structure together with the motivational factors found in software engineering from Table 5, gives the representation in Figure 5. We have used a shortened label for these factors in Figure 5 in order to reduce clutter; for a more detailed description of the factors, please see Tables 3 and 5.
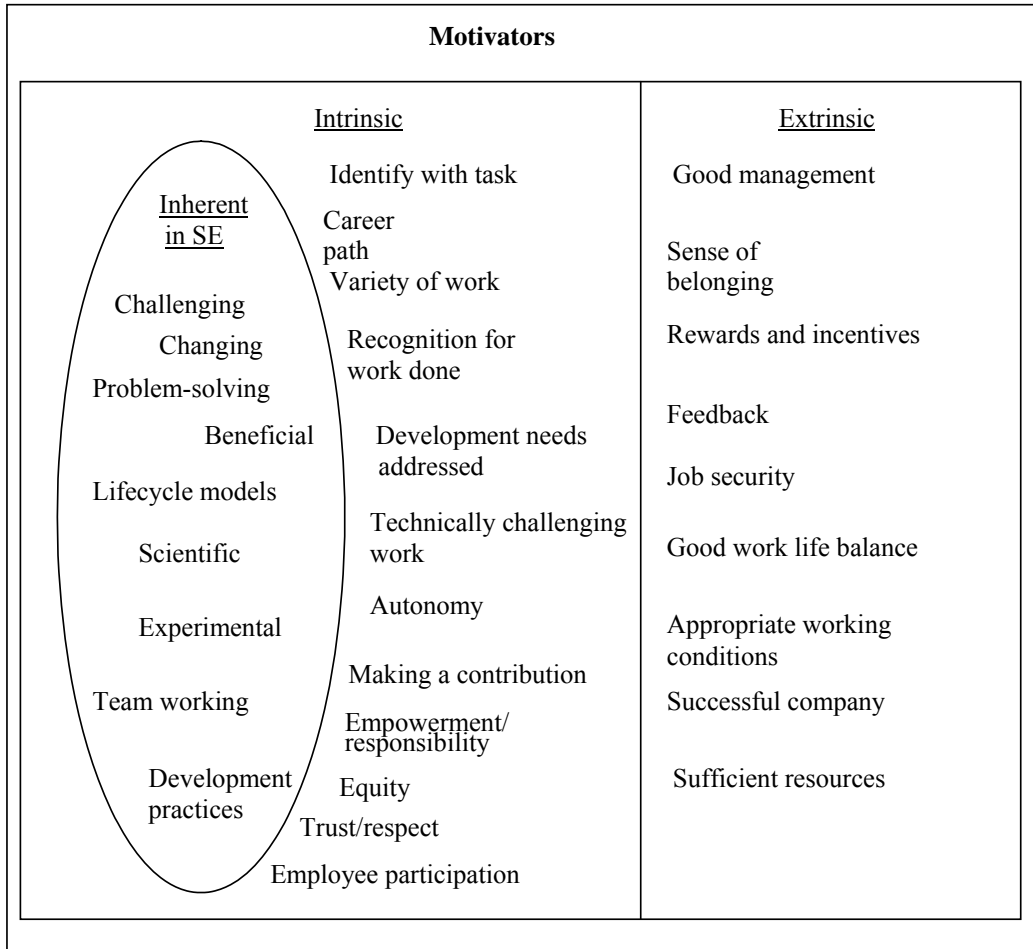
Motivators

Intrinsic

Extrinsic

Inherent
in SE

Identify with task

Good management

Career
path

Variety of work

Sense of
belonging

Challenging

Changing

Recognition for
work done

Rewards and incentives

Problem-solving

Beneficial

Development needs
addressed

Feedback

Lifecycle models

Job security

Scientific

Technically challenging
work

Good work life balance

Experimental

Autonomy

Appropriate working
conditions

Team working

Making a contribution

Successful company

Empowerment/
responsibility

Development
practices

Equity

Sufficient resources

Trust/respect

Employee participation

Figure 5. Details of motivating factors in software engineering. For a more detailed explanation of each factor, please see the short descriptions provided in Tables 3 and 5.

The relationship between a software engineer's characteristics and the motivation factors they will respond to is not explicitly addressed by much of the literature found in the SLR. However some of the papers (e.g. Enns et al, 2006) show that individual characteristics orientate the individual towards certain motivation factors, while other papers imply a similar relationship. Figure 6 reflects this finding.
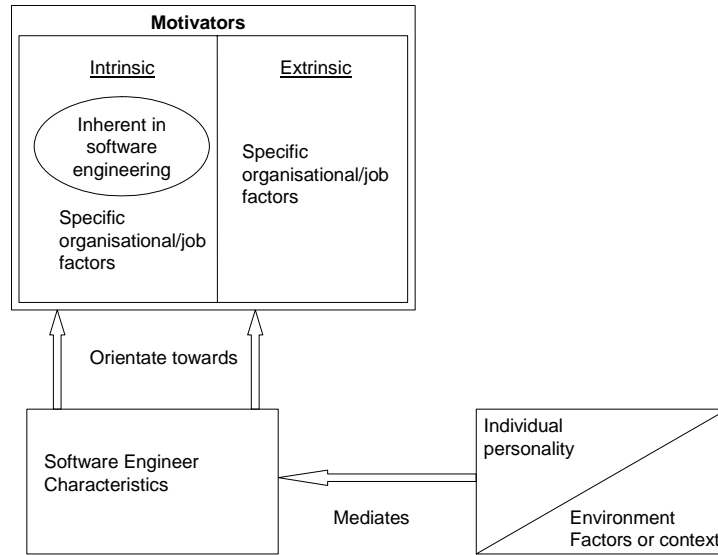
Figure 6: Software Engineers' Characteristics orientate the individual towards certain motivators

Finally, RQ 3 explored the external outcomes of motivated individuals, i.e. what are the consequences of motivation? In terms of the first-stage model, the relationship with these findings and the rest of the SLR stays as in Figure 1. This provides the last component of the model − see Figure 7. As the key components of the model are Motivators, Outcomes, Characteristics and Context, we refer to it as the MOCC model.
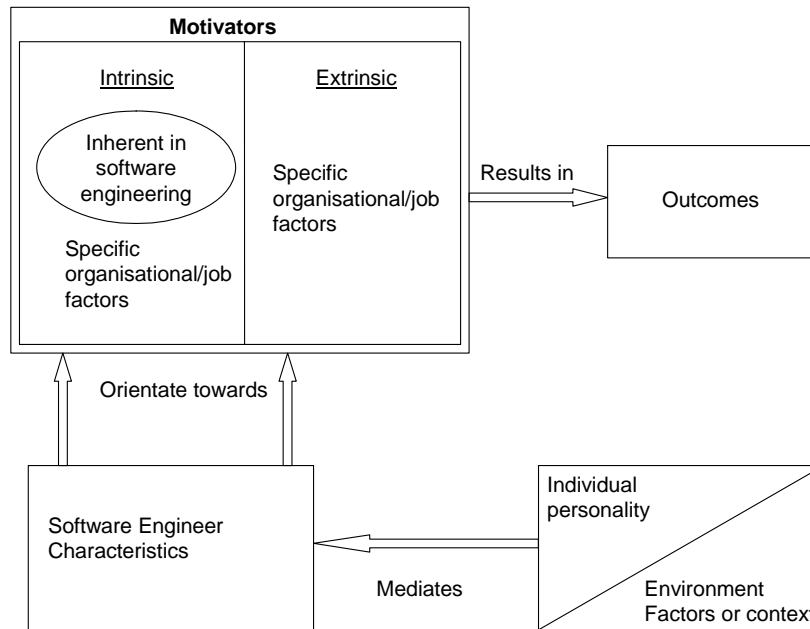

Figure 7: A new model of motivation in software engineering – the MOCC model. Details of the factors inside each box are given in Figures 2 and 5

4. Published models of motivation in software engineering

In this section we return to the SLR results and examine the existing models of motivation developed specifically for the Software Engineering industry, and compare them to the new model derived in Section 3 and summarised in Figure 7. In doing so, we specifically focus on how the models in the literature relate to the components of the new derived model. For example, does an existing model provide more detail about a particular component, or does it explore the relationship between elements of different components, or does it offer a perspective across all components (or indeed identify other components). We want to highlight what is missing from the new model so that it can be enhanced.

Table 6 summarises the findings from RQ5 in the SLR. These findings show that there is a variety of models, some of which are simple, some complex, some that apply specific motivation theories, and some that apply theories from other domains. Before discussing the models and how they relate to the new model in detail, we give an overview of them, clustered according to the primary focus of each model. These clusters are listed in Table 6; note that some models fall into more than one cluster.

Table 6: Models for motivating software engineers

Models of motivation	Frequency (# of studies)	References
1: Job Characteristics Model (JCM) of Software Engineer (SE) Motivation (development, enhancement or validation)	11 (including 5 studies from Couger et al)	(Goldstein and Rockart 1984; Couger and McIntyre 1987-1988; Couger and Adelsberger 1988; Couger et al. 1990; Couger 1992; Couger and Ishikawa 1995; Khalil et al. 1997; Smits et al. 1997; Gambill et al. 2000; Ferratt et al. 2003; Ferratt et al. 2004)
2: Models focusing on Software Engineer Job Satisfaction	6	(Goldstein 1988; Santana and Robey 1995; Ridings and Eder 1999; Mak and Sockel 2001; Lee 2002; Thatcher et al. 2002)
3: Models of Open Source Developer SE Motivation	3	(Hertel et al. 2003; Roberts et al. 2004; Li et al. 2006)
4: Models of leadership influence on SE motivation	3	(Goldstein and Rockart 1984; Frangos 1997; Li et al. 2006)
5: Model drawing on expectancy theory, goal-setting theory, and organisational behaviour specific to the software development process	1	(Rasch and Tosi 1992)
6: Model of Task Design influence on SE motivation	1	(Gambill et al. 2000)
7: Model of Career Progression influence on SE motivation	1	(Smits et al. 1997)
8: Social support influence on Software Engineer turnover	1	(Lee 2002)

Table 6 shows that a lot of the literature presenting models of motivation focuses on the JCM (Hackman and Oldham 1976). We highlight the number from Couger et al because this is the group of researchers who first adapted the JCM for software engineering and they have written extensively about it. We therefore want to make clear the possible bias in these numbers. In fact, we found that all of the research

questions resulted in a large number of papers based on the JCM (Hall et al., in press). The essence of this model is that an individual's need for growth (growth need strength (GNS)) must be matched by the degree of richness of the job assigned to that individual (measured using the motivating potential score (MPS) calculated based on the core job dimensions), to ensure motivation and productivity. An imbalance between GNS and MPS can result in de-motivation. The same applies to Social Need Strength (SNS) and the amount of socialisation offered and demanded by the job. A more detailed view of the model is given in Section 4.1.

The 11 papers focusing on JCM compared JCM findings with countries outside the USA, such as Japan, Austria, Israel, and Singapore e.g. (Couger et al. 1990; Couger and Ishikawa 1995), or extended the JCM to include role ambiguity/conflict and leadership styles (Goldstein and Rockart 1984) or enhanced it by looking at employment fit (Ferratt et al. 2003; Ferratt et al. 2004)

Job satisfaction is the specific focus of six papers. The relationship between motivation and satisfaction has been researched for many years and has generated significant debate (e.g. House and Wigdor, 1967). The distinction between these two concepts was not a focus of the SLR, and so we only recognise a distinction between these two concepts if the original paper does so. Many, however, do not, which implies that the originators of these papers may not be aware of the distinction or of the debate around it. On the other hand, job satisfaction is one element of the JCM and so a focus on satisfaction in the context of motivation may be explained by this link. It is tempting to see these papers as further reinforcement of the JCM model, but we keep them separate in our clustering to reflect the focus of the papers themselves. Each paper in this group looks at a different aspect of job satisfaction. For example, Goldstein (1988) focuses on practitioner performance, Thatcher et al (2002) looks at intrinsic motivation.

One of the three papers focusing on leadership (Goldstein and Rockart, 1984) adds two sets of variables to the JCM to represent the effect of conflict and ambiguity in a worker's job, and to measure the quality of leadership provided by the workers' supervisors and peers. Frangos (1997) reflects how the work environment and management procedures can de-motivate or motivate the software engineer. For example, a lack of office space and engineer concentration, unpaid overtime, non-productive meeting cultures, performance appraisals and absence of team work all contribute to de-motivation. Li et al (2006) focuses specifically on leadership in OSS, and posits that a leader's behaviour will affect subordinates' motivation.

Three papers from the SLR explicitly investigated the motivation of open source developers. The study of open source developers provides an opportunity to take a different perspective on motivation, as OSS developers often take part in projects voluntarily, and the reward structure is more socially-oriented than those found in organisations. These papers have used existing theory to characterise how developers in the Open Source movement are motivated. Li et al (2006) suggests that in OSS the leadership style is different, and has consequential impact on intrinsic and extrinsic motivation. Hertel et al (2003) draw on two models from social science which look at voluntary action and small teams, while Roberts et al (2004) draw on a general model of motivation and performance in organisational and social psychology.

The last four 'clusters' each contain just one paper. This illustrates how much the approach to modeling motivation varies once researchers move away from the popular JCM and job satisfaction models. Rasch and Tosi (1992) draws on two behavioural theories (expectancy theory and goal-setting theory) to produce a model of performance, Gambill et al (2000) brings together four widely-used task design theories to investigate IS employees, Smits et al (1997) focuses on 'met' or 'unmet' needs, and the effect of career progression on motivation, and Lee's (2002) model looks at workplace social support and its effect on turnover.

In the rest of this section, we consider how the models found in the literature relate to the new model derived in section 3. We divide the rest of this section into four: the JCM model, models that provide a more detailed treatment of a single component of the new model, models which explore the relationship between two of the components in the new model, and models which explore the relationship between several of the components in the new model.

4.1 The Job Characteristics Model

We devote a whole sub-section to this model and its relationship with the new model because of its dominance in the literature.

The original JCM publication falls outside the SLR as it was first published prior to 1980 (Hackman and Oldham, 1976). However, one of the first and most significant enhancements to the JCM was proposed in 1980, and focuses on software engineering (Couger and Zawacki, 1980). Based on this enhancement, Couger and Zawacki developed the Job Diagnostics Survey for Data Personnel (JDS/DP). Most of the studies of software engineers that have attempted to examine motivation from a job characteristics perspective have started with this JDS/DP. A strength of replicating this approach is that comparisons can be made across groups to either agree or refute previous findings, while taking a different approach would prevent such comparisons. However, the work reported in these papers does not seek to validate the JDS/DP but to compare findings in different countries. Figure 8 shows the enhanced version of the JCM with the new job dimensions to reflect the focus on 'data personnel'. It also shows Social Need Strength as a mitigating factor in practitioners' motivation. The new additions are underlined.
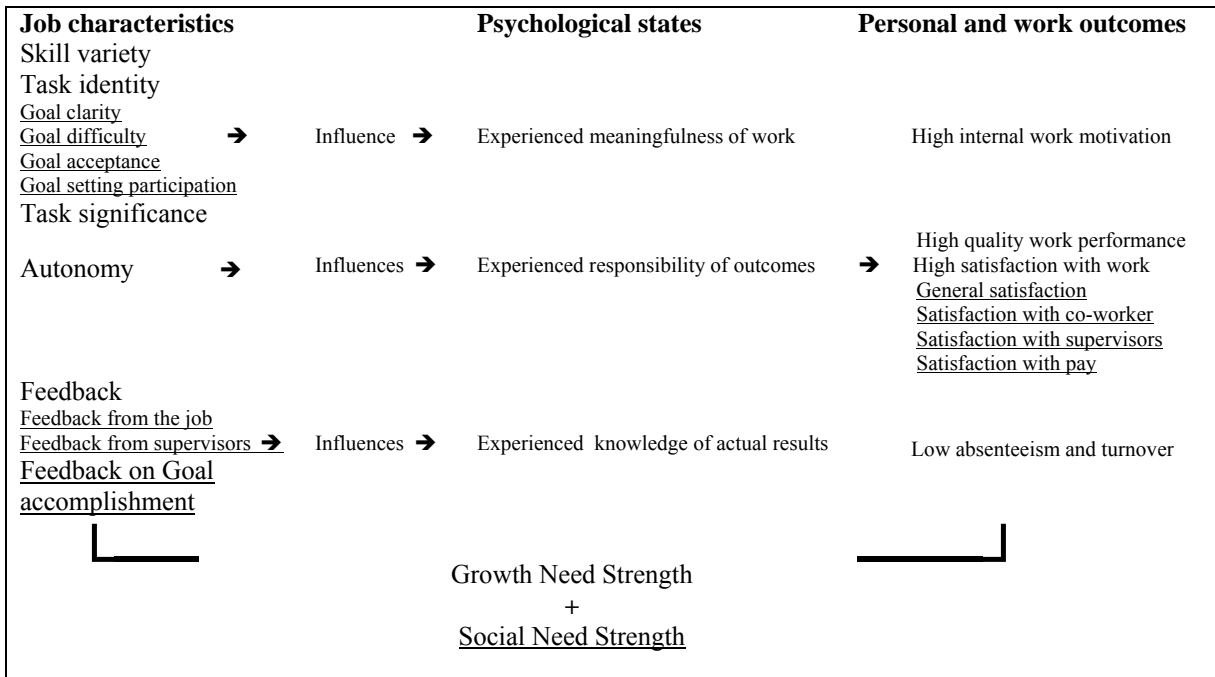

Job characteristics		Psychological states	Personal and work outcomes
Skill variety			
Task identity			
Goal clarity			
Goal difficulty ➔	Influence ➔	Experienced meaningfulness of work	High internal work motivation
Goal acceptance			
Goal setting participation			
Task significance			High quality work performance
Autonomy ➔	Influences ➔	Experienced responsibility of outcomes ➔	High satisfaction with work
			General satisfaction
			Satisfaction with co-worker
			Satisfaction with supervisors
			Satisfaction with pay
Feedback			
Feedback from the job			
Feedback from supervisors ➔	Influences ➔	Experienced knowledge of actual results	Low absenteeism and turnover
Feedback on Goal accomplishment			

Growth Need Strength
+
Social Need Strength

Figure 8: Job Characteristics model of motivation as interpreted by [Couger and Zawacki, 1980] (additions to the original Hackman and Oldham model are underlined)

The new model does not focus on job characteristics, yet it has similarities with the JCM. For example, the intrinsic motivators identified in the SLR and presented in the model map to the core job characteristics of the JCM (see Figure 9). This mapping considers problem solving and technically challenging work as facets of skill variety.

JCM job core dimensions		SLR intrinsic motivators
Skill variety	➔	Variety of Work (e.g. making good use of skills, being stretched) Development needs addressed (e.g. training opportunities to widen skills)
		Technically challenging work
Task identity	➔	Identify with the task (clear goals, personal interest, know purpose of task, how it fits in with whole, job satisfaction; identifiable piece of quality work)
Task significance	➔	Employee participation/involvement/working with others Career Path (opportunity for advancement, promotion prospect, career planning) Making a contribution/task significance (degree to which the job has a substantial impact on the lives or work of other people)
Autonomy	➔	Autonomy
Feedback	➔	Recognition (for a high quality, good job done. This is different to 'rewards and incentives' which is about making sure that there are rewards available). Feedback
No match	**X**	Trust/respect Equity

Figure 9: Mapping intrinsic motivators from SLR to core job dimensions of JCT

The additional job dimensions proposed by Couger and Zawacki don't map quite so clearly, but 'goal setting participation' relates to 'employee participation', and 'feedback from supervisors' is related to 'good management'. However the new model doesn't encompass satisfaction as an outcome at all, yet the enhanced JCM included four new refinements of 'satisfaction'.

It is noticeable that there are significantly more motivators in the new model than are captured as job characteristics in the JCM. For example, a sense of belonging is not a job characteristic but is concerned more with the organisational context; similarly trust/respect and equity are not reflected in the JCM at all.

The JCM focuses mainly on job characteristics, but it also recognises the importance of growth need and social need strength. The new model does not refer to these explicitly, but growth need strength and social need strength are software engineer characteristics, and so these are missing from the characteristics component. In other ways the new model extends the original JCT, and the enhanced JCM by considering a more detailed list of software engineer's characteristics, and explicitly acknowledging that motivation is dependent on individual personality and contextual factors including the organisation but also personal context such as career stage.

4.2 Models giving more detail of a single component

The models by Santana and Robey (1995), and Ridings and Eder (1999) and the three papers focusing on leadership (Li et al in OSS (2006), Goldstein and Rockhart (1984), Frangos (1997)) all provide insight into a sub-set of the motivators labeled as organisational motivators in the new model and their relationship with job satisfaction. Although the notion of 'good management' is listed in the new model as an organisational motivator, we do not include as much detail as these models do, so we view these as detailed enhancements to the new model.

Santana and Robey's (1995) model suggests that managerial, team member or self-control of tasks influences the level of job satisfaction felt by an employee. Two of these motivators are represented in the new model by 'good management', and 'empowerment/responsibility' but the notion of other team members controlling tasks is not explicitly mentioned.

Ridings and Eder (1999) focus on the effect of career path by studying the attitudes of IS technical employees compared with their peers on the managerial career path. Hence, their work provides a small refinement of the 'career path' intrinsic motivator in the model.

Li et al's (2006) research is based on Path-goal theory that posits that the leaders' behaviour will affect subordinates' motivation and in turn influence the outcome of a task. This model (see Figure 10) indicates that transformational leadership is positively related to developers' intrinsic motivation and active management by exception, a form of transactional leadership, is positively related to developers' extrinsic motivation. It also indicates that there is a direct relationship between the context, i.e. the culture,

organisation and fellow team members, and the motivators themselves – how effective they are. This link is missing from the model.
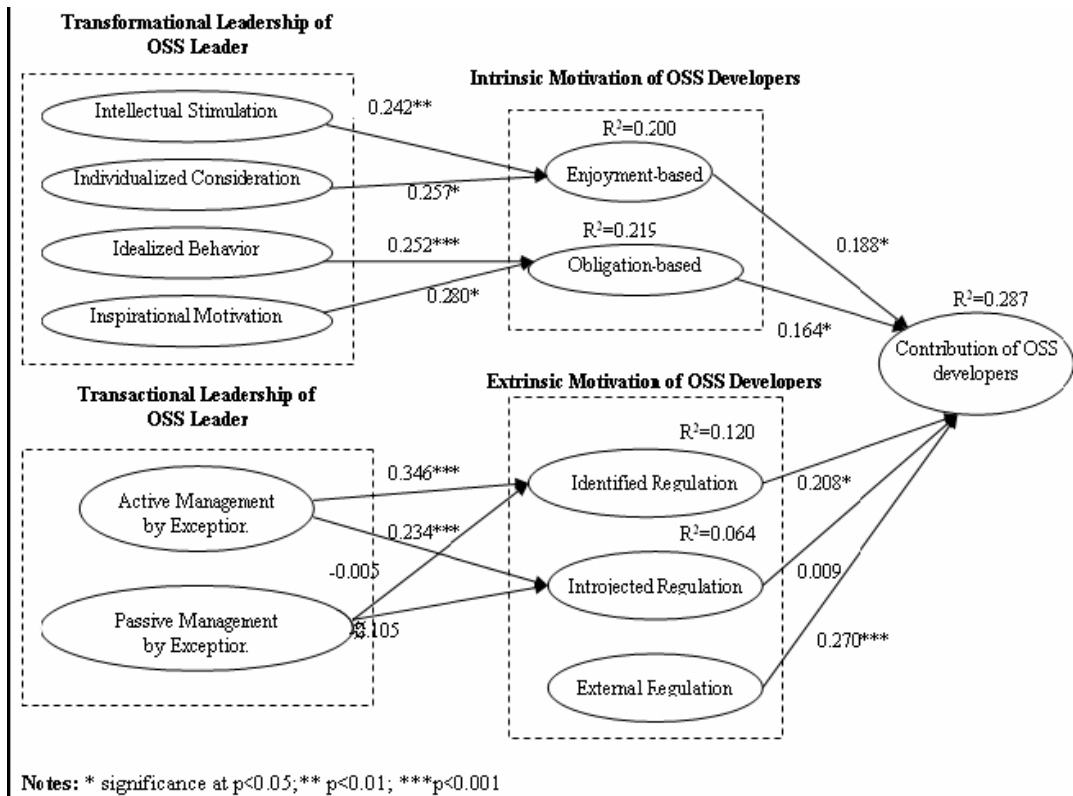

Figure 10: Path-goal theory, leadership styles and OSS developer motivation (Li et al. 2006).

Goldstein and Rockart's (1984) model extends the JCM with two new sets of variables to reflect the needs of software engineers working in teams. One set of variables measures the amount of conflict and ambiguity in a worker's job; the second set of variables measures the quality of leadership provided by the worker's supervisors and peers. Both variables are expected to influence levels of job satisfaction, and hence are viewed as motivators in the new model. The notion of job clarity (lack of ambiguity and conflict) is not explicit in the new model, although good teamwork could be seen to include lack of unproductive conflict. The quality of leadership is one aspect of good management which is listed as an extrinsic motivator.

Frangos' (1997) model reflects how the work environment and management procedures can de-motivate or motivate the software engineer.
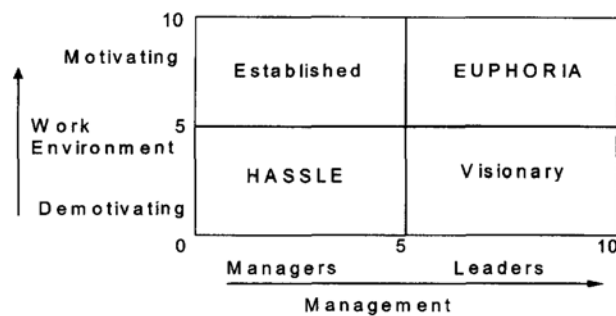
The 'euphoria quadrant' (see Figure 11) aims to provide a simple means for software-producing units to gauge management (or leader) style and overall working environment. This model provides more detail on the 'appropriate working conditions' motivator, and shows more specifically how these conditions can be achieved.

Goldstein (1988) uses a five factor model of practitioner performance to explore job satisfaction, and hence focuses on the Outcomes component of the new model. The performance factors that appear to influence job satisfaction are: 'overall performance; communication skills; job attitude and technical skills'. But note that some of these relate to components such as the 'technically competent' software engineer characteristic. Communication skills are not listed in the new model, but job attitude is mediated by the other characteristics listed.

It is noticeable that apart from Goldstein (1988), these models focus on exploring the detailed workings of the 'motivators' component.

4.3 Models exploring the relationship between two different components

Mak and Sockel (2001), Lee (2002) and Thatcher et al (2002) explore the relationship between a sub-set of motivators, and outcomes - specifically turnover and retention.

Mak and Sockel's (2001) model reflects that job satisfaction, perception of management on career development, loyalty, burnout, and turnover intent are indicator variables for motivation and retention. The notions of loyalty and burnout do not feature in the new model, although they could be viewed as characteristics of some software engineers, dependent on individual and contextual factors.

Lee (2002) has developed a model using workplace social support and social affiliation needs to explain turnover intentions. As Figure 12 shows, the model has five constructs: turnover intentions, job satisfaction, social support from supervisor, social support from colleagues and social affiliation needs. Findings from this work indicate that job satisfaction mediates the relationship between social support and turnover intention and that workplace support is negatively related to turnover intentions for computer professionals with high social affiliation needs. The new model does not consider social support or social affiliation needs, although some elements of the motivator component such as team working and trust may relate to social support.
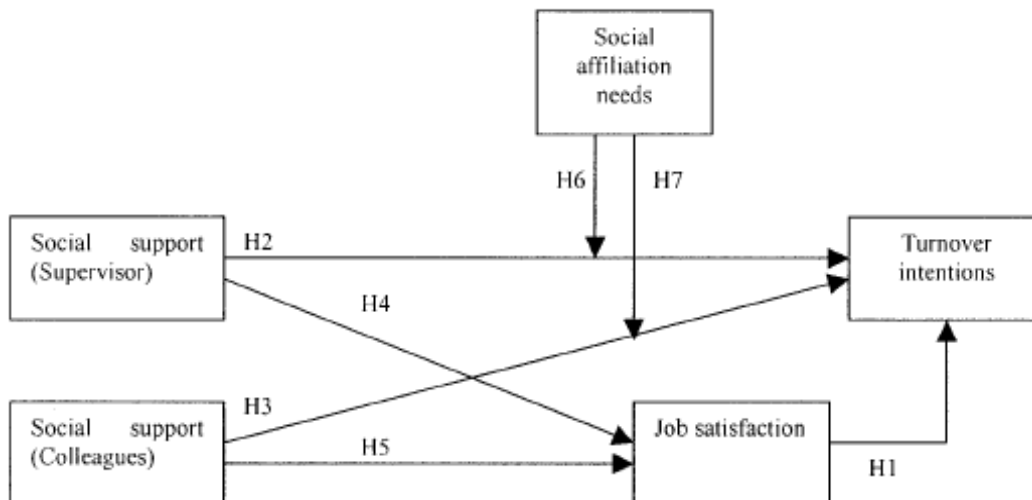

Figure 12: Lee's turnover intentions model (Lee 2002)

Thatcher et al (2002) shows how five intrinsic motivators (autonomy, task variety, task significance, task identity and feedback) mediate the effect of two hygiene factors (supervisor satisfaction and pay satisfaction) on job satisfaction and organisational commitment. They posit that all these factors might influence an individual's intrinsic motivation, and they model intrinsic motivation as a direct antecedent to attitudes such as commitment and job satisfaction, and an indirect antecedent to turnover intention. In relation to the new model, they add some detail about relationships between motivators and outcomes, but also how 'organisational commitment' is mediated by other organisational factors.

Hertel et al (2003) investigate developers' participation in OSS from a perspective of voluntary action and an individual's desire to be part of a virtual team. Part of the former perspective includes how people feel and define themselves as members of a specific group related to the social movement and how people behave according to the norms and standards of this group, and hence this relates to the characteristic 'identify with group' in the new model. The virtual team perspective includes trust (identified as an intrinsic motivator in the new model). As this model focuses on the motivations for volunteering rather than those for developing software, the issues here are tangential to our focus.

4.4 Models exploring the relationship across several components

Four of the models from the literature consider issues related to several of the new model's components. As might be expected, these models focus on different elements and provide a cross-section through the model in different directions.

Rasch and Tosi's (1992) model combines two theoretical behavioral approaches, expectancy theory (Vroom, 1964) and goal-setting theory (Locke 1968). Their empirical results indicated the relationships shown in Figure 13. The number on the connector indicates the influence of one on the other, and could be between -1 and 1. For example, individual ability, with a direct effect on reported performance of 0.54 was the strongest connection. This model is unusual in that it represents the effect of various elements quantitatively. It was not possible to glean a quantitative assessment from the literature for the new model, so this is clearly one area where this model differs from ours. However in terms of elements, this model identifies three aspects which the derived model does not cover: effort, locus of control and self-esteem.
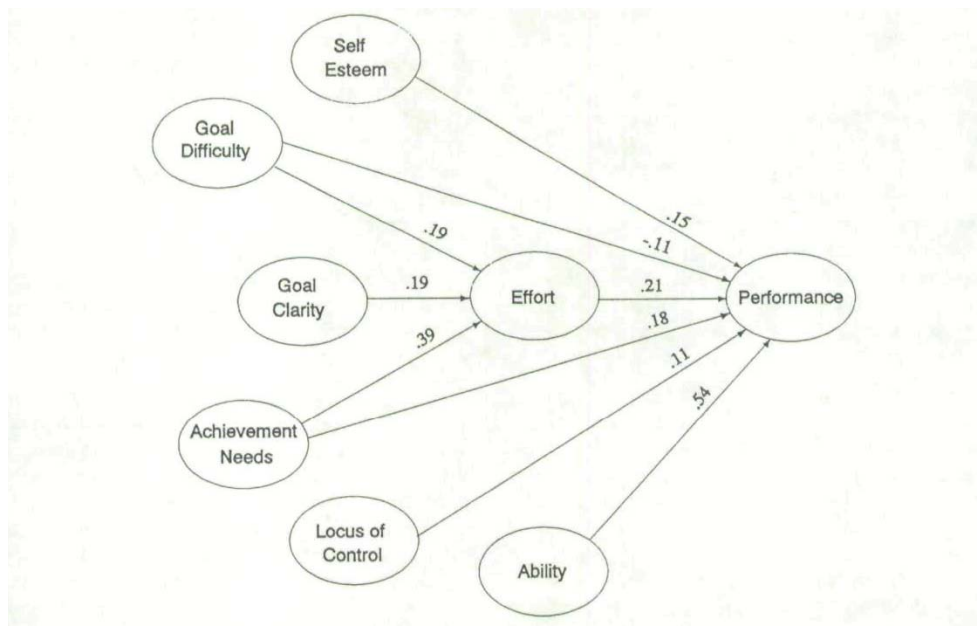

Figure 13: Integrated model of performance

Gambill et al [2000] presents a holistic task design model with eight task design factors that affect employee motivation: task identity, employee voice, feedback, goal difficulty, autonomy, justice, physical dressings (workplace environment) and individual differences. These factors relate to different elements of

the new model: most of these correspond to motivators, while the need for feedback is a characteristic, and individual differences relates to individual personality and personal context. There is nothing specific is this model which is missing from ours, except for the detail of relationships.

Smits et al's (1997) model (Figure 14) is a synthesis of Mowday et al's (1982) theory, in which 'met' versus 'unmet' job expectations start an employee on a path leading to organisational commitment or, conversely, to a renewed job search. Their model depicts the dynamic nature of careers in software engineering, and addresses the requirement for jobs capable of meeting interpersonal needs through teamwork, contact with users, and the opportunity to develop professional friendships. The new model includes teamwork as a motivator and retention as an outcome, but does not explicitly talk about expectations.
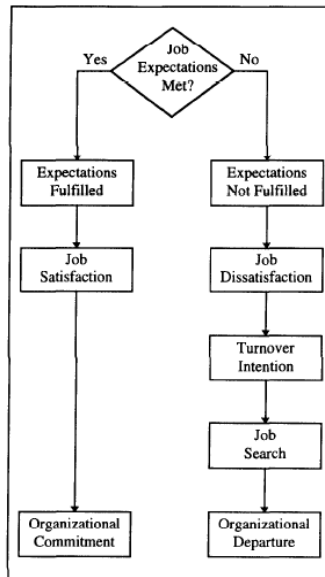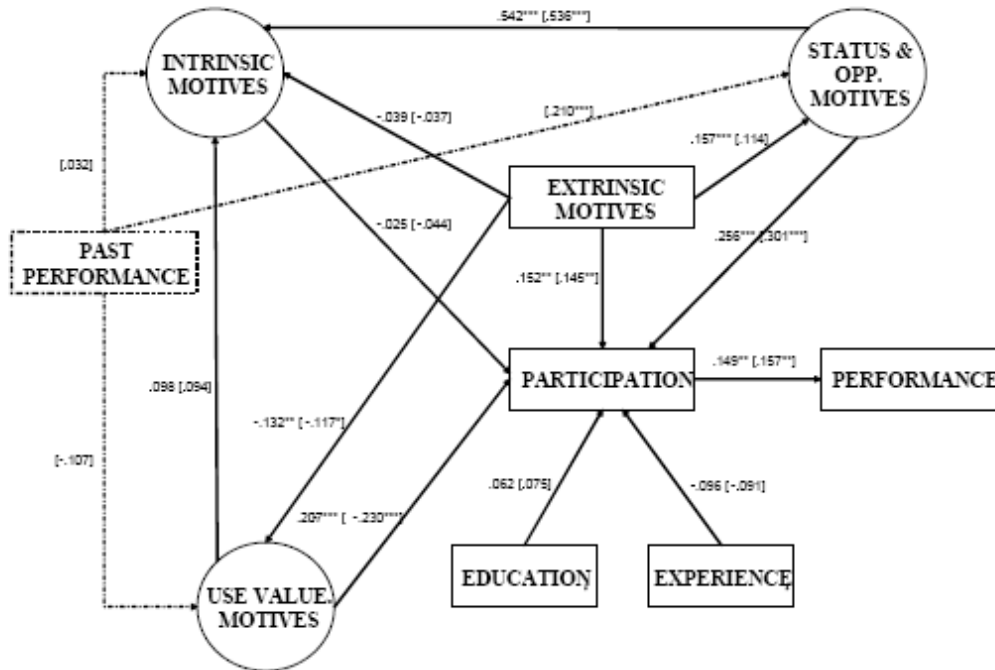

Figure 14: Organisational Commitment & Job Satisfaction model (Smits et al. 1997)

Roberts et al (2004) focus on open source development and the effect of 'internalised extrinsic motivators' (use value motives and status and opportunity motives). They show how motivators vary across individuals and combine with individuals' knowledge, skills and abilities to produce task relevant behaviours which contribute to individual performance. Over time, contributors' participation is evaluated by the OSS community, and this evaluation may lead to an increase in a contributor's rank within the community, thus providing feedback which influences contributors' future motivation. Figure 15 illustrates Roberts et al's proposed relationships between motivations, participation and performance in OSS development.

This model is one of the few that explicitly tries to understand the impact of a software engineer's personal experience and abilities on their motivation. In terms of the new model, Roberts et al focus on the characteristics and personality of an individual software engineer, and the relationship of these factors to different motivators. The new model does not account for the internalized extrinsic motivators listed here.

INTRINSIC MOTIVES

STATUS & OPP. MOTIVES

.542*** [.536***]

-.039 [-.037]

[.210***]

.157*** [.114]

[.032]

EXTRINSIC MOTIVES

PAST PERFORMANCE

-.025 [-.044]

.256*** [.301***]

.152** [.145**]

PARTICIPATION

.149** [.157**]

PERFORMANCE

.098 [.094]

-.132** [-.117*]

.062 [.075]

-.096 [-.091]

[-.107]

.207*** [-.230***]

USE VALUE MOTIVES

EDUCATION

EXPERIENCE

Notes: Coefficients are shown for both Primary and Enhanced models. Coefficients for Enhanced Model appear in [ ].
*** p <.01, ** p=.05, * p=.10

Figure 15 Motivations, participation and performance in OSS development (Roberts et al. 2004)

5. Discussion

The models discussed above show that some very interesting work has been done to model software engineers' motivation. However, as we found with other SLR results, the models mostly focus on a management perspective. Models of Open Source development report on what motivates practitioners to participate in the activities of software engineering, and so they appear to be more pertinent to individuals' desire to work as software engineers, but they do not take into consideration the particular characteristics of a software engineer nor the contextual factors that affect them. Similarly, models that look at leadership influence on motivation ignore many of the core job characteristics of software engineering. Does leadership alone influence good practice, even when the job itself might be unsatisfactory? In this respect, the JCM and its derivatives are more useful models because they focus on motivation as a factor of the nature of the job itself. However, none of these takes into account the software engineers' characteristics or personal context.

In addition, none of the models previously published takes a birds-eye view of motivation. Each model represents a partial (although sometimes detailed) view of motivation issues in software engineering, but often without attempting to accommodate other work in the area. So although previously-published models provide valuable insights into software engineers' motivation, together they present a disjointed view of motivation. As we discussed in the introduction, Pidd observes that a complete model of reality would be too difficult to manipulate, and we would agree with this. We suggest, however, that the new MOCC model introduced in section 3 is an abstract, holistic model that enables researchers and practitioners to chart the landscape of motivation and provides a coherent framework for integrating other findings.

This discussion section focuses first on enhancing the MOCC model as presented in Figure 7 with the existing models presented in Section 4, then describes the limitations of the approach, and finally suggests some future research directions.

5.1 Enhancing the new model of motivation in software engineering: stage two

There are two kinds of discrepancy between the published models and the new MOCC model: missing factors which can be slotted into one of the components, and missing relationships between components.

Several of the factors raised by existing models have already been included in the MOCC model, e.g. autonomy, control, equity, career paths, retention, productivity, and so on. Some factors have not been explicitly included in motivation models in the literature but do feature in the MOCC model, e.g. software engineer characteristics and their relationship to context and personality.

However there are also factors that the MOCC model does not include, and we can see that it needs to be refined in these areas. Elements that aren't reflected explicitly in MOCC are: growth need strength, social need strength, job satisfaction, job and goal clarity, team member control of tasks, burnout, effort, locus of control, self-esteem, communication skills, internalized extrinsic motivators and expectations. Other aspects are that the kind of leadership affects motivation, and organisational commitment is mediated by job satisfaction.

Some of these elements can be added into the MOCC model's components, e.g. locus of control, team member control of tasks and job and goal clarity are intrinsic motivators, and hence would be added to the lists in Figure 5. Similarly, self-esteem and communication skills are characteristics of an individual and would be added to the list in Figure 2. Others relate closely to elements already in the model but are named differently, e.g. growth need strength relates to the need for challenge, while social need strength relates to the need to identify with a group. Internalised extrinsic motivators however are not represented in the MOCC model, and it's difficult to slot these in anywhere as they will be dependent on individual personality and contextual factors but are also influenced by motivators connected with the specific job (intrinsic and extrinsic).

In terms of relationships between the components it is clear from previous models that they are more complex than the MOCC model as presented in Figure 7 suggests. For example, we can see that the contextual factors have a direct effect on motivators and how effective they are. It is also clear that the balance between intrinsic and extrinsic motivators related to the job, and the motivators inherent in software engineering have an effect on software engineers' characteristics, and their reactions to different motivators.

Taking these relationship issues into account results in a modified MOCC model as shown below. Note that we do not present updated Figures 2 and 5, but that these would be expanded to include the factors, as discussed above.
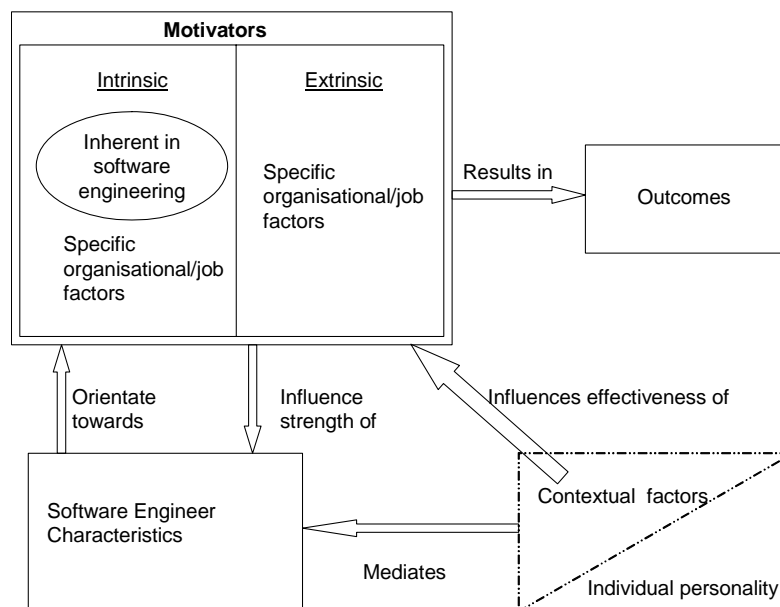
Figure 16 The enhanced MOCC model of motivation in software engineering

One of the key findings from analyzing the literature for questions 1 – 4 is that motivation is heavily dependent on context. This is represented in the MOCC model by the split component 'Individual Personality' and 'Environment'. We've commented above that the impact of context is more complex than we initially suggested, but it is also clear that the notion of 'context' itself has several layers each with its own impact on motivation. The literature on models does not shed much light on how this influence works, but it implies a set of layers as shown in Figure 17, which may be viewed as a spiral as they also change over time.
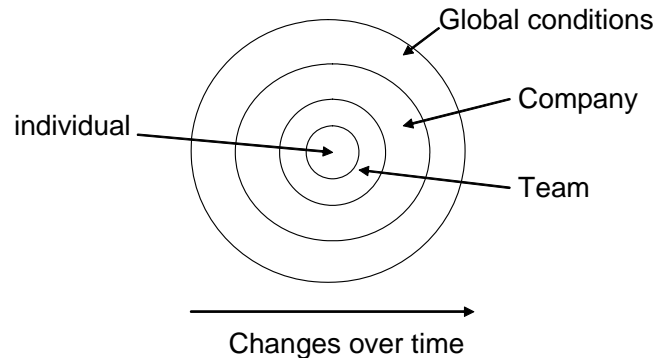

Figure 17 The spiral of contextual layers

5.2 Limitations

There are four areas of limitation on the work presented here: circularity of the model's evolution, reliance on literature, the emphasis on an organisational perspective to motivation, and the implications of extracting results from their specific context.

The model is constructed from the literature on motivation, and compared with other models in the literature in order to enhance it. We have found areas of agreement and disagreement, but there is an inevitable circularity in this approach, e.g. many of the studies in the SLR rely on JCM and hence there are bound to be several similarities between the new model and the JCM. As a result, it is important to conduct an empirical investigation of the refined model to establish its applicability.

The majority of studies identified in the SLR looked at motivation from an organisational management perspective, e.g. to reduce turnover and increase productivity and performance. In the course of this approach, some of the technical and personal aspects of motivation have been overlooked. We therefore suggest that in order to revise and augment the model presented in this paper, further understanding of the software engineering-specific issues that underpin motivation is needed.

Finally, the model presented here is a result of collating answers to research questions that were extracted from the original studies. Although we have attempted to carry through the significant findings from each piece of work, this approach may result in a loss of coherence that was present in the original studies.

5.3 Future research directions

The MOCC model presented here is based on existing literature which spans over 20 years, a long time in software engineering. It provides an integrating framework for existing studies except for two aspects: internalised extrinsic motivators, and the impact of context. Future work is required to investigate further and to accommodate these issues. The MOCC model also lacks concrete realisation, and needs to be investigated through empirical work with the current software engineering profession, and it forms a sound basis for any such work. One of the themes that emerged through the SLR is the emphasis in current literature on the organisational view of motivation rather than the individual view; we maintain that individuals are just as keen to make sure that their jobs match their own motivation profile, as organisations are to retain staff.

Empirical work will pursue this emphasis on the individual and will utilise simulation approaches to investigate the detail of and inter-relationships between the MOCC components and their constituent factors. We aim to develop personal motivation maps for specific software engineers to improve our understanding of an individual's motivation. This will help to bring the model to life, confirm the elements in each model component, and refine the relationships between the model components. That is, in terms of Pidd's (1999) definition of a model, we will verify the model by exploring the extent to which the model is useful in understanding, changing, managing and controlling the reality of motivation in software engineering.

6. Conclusion

Motivation in software engineering is a complex topic and one that is poorly understood. The findings from the SLR which covered the key software engineering journal and conference publications show that although there is valuable work in the area, the models that have been proposed are fairly disparate and disjointed. Although JCM has proved to be very popular, there has been little work to validate this model, and particularly as time has moved on, the relevance of the model in a changing world needs to be confirmed.

We have constructed a new model of motivation that pulls together previous research findings on motivation, and have refined it according to other models in the literature. Most of the existing models relate to the detail of one part of this model, but some of them also address the relationship between components. A significant amount of work aimed at modeling motivation in software engineering has been based upon the JCM, and hence much of the literature seems to be mutually-supportive. In addition, a predominant perspective in the motivation work is that of the organisation, focusing on issues such as turnover, performance and absenteeism. In recent years, alternative models that take a different approach to motivation have emerged. In particular, work that focuses on open source software developers, where the traditional emphasis on organisational concerns such as turnover and productivity is less important, has taken a different perspective.

The new model we have presented here represents the sum of existing literature on models of motivation in software engineering. It was built initially from published findings that explore motivation in software engineering and then enhanced to take account of existing published models of motivation in software engineering. Hence, we believe that this refined model is a credible picture of the current literature on motivation in software engineering. This means that it will be a valuable starting point for practitioners wanting to understand their own motivation and managers wanting to get an insight into their team's behaviour. The new model also provides a platform on which we and other researchers can base their empirical studies.

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