

Screening candidate systems engineers: exploratory results

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INTRODUCTION

Systems engineering is one of the tools for the CSIR to make an impact. While there are several definitions of systems engineering (SE), for the purpose of this paper, SE is (Halligan, 2003) "...an interdisciplinary, collaborative approach to the engineering of systems which aim to capture stakeholder needs and objectives and to transform these into a description of a holistic, lifecycle balanced system solution which both satisfies the minimum requirements and maximises overall project and system effectiveness according to the values of these stakeholders. Systems engineering incorporates both technical and management processes".

However, locally and internationally, there appears to be a shortage of SE skills. The defence, peace, safety and security (DPSS) unit of the CSIR provides defence science and technology support to the South African National Defence Force (SANDF) and various international customers. This unit has experienced growth of 30% in some business areas for a number of years, leading to significant demand for SE skills. The business value of screening lies in the cost currently incurred because of the shortage of SE skills and the time it takes to develop SE skills. The current costs resulting from this shortage includes:

- SE recruitment costs include advertising, interviewing and recruitment agency fees
- Training and coaching costs resulting from candidates who do not develop successfully
- Opportunity costs that come as a result of not being able to access new projects
- Project risk; a consequence of not having the adequate skills on current projects.

The next section reviews the literature regarding this problem, as well as some gaps and limitations that we propose to address. We identify a framework for assessing competence in potential SE candidates based on this literature. Section 3 formally defines the problem (research question). The conclusions of the study follow.

THE LITERATURE: ASSESSMENT OF SE SKILLS AND THE SE PROFILE

Figure 1 is a model of constructs assembled from pertinent literature in the assessment of competence (Brannick and Levine, 2002). Competence is defined as the necessary ability, which consists of talent and skill to do something successfully. It depends on knowledge, skill and various psychological attributes. For the purposes of this study, assessment is defined as the measurement of psychological attributes, knowledge or skills. Therefore, in order to determine SE competence, one should assess all of these constructs. Evaluating candidate SE however, is more complicated than for evaluating fully qualified SE. This is because candidate SE would not yet have fully developed knowledge and skills. Thus we focus on candidate potential in terms of the psychological attributes only.

It can be seen from **Figure 1** that motivation consists of values, interests and attitudes. However, we are most interested in values because these are most stable over time.

"work attitudes, as knowledge structures, should exhibit a certain degree of stability, but not as much stability as values because one of the functions of attitudes is to help the individual adjust to changing conditions over time and stay attuned to the social context" (George and Jones, 1997).

Thus, in terms of motivation, we focus on values for the remainder of this paper.

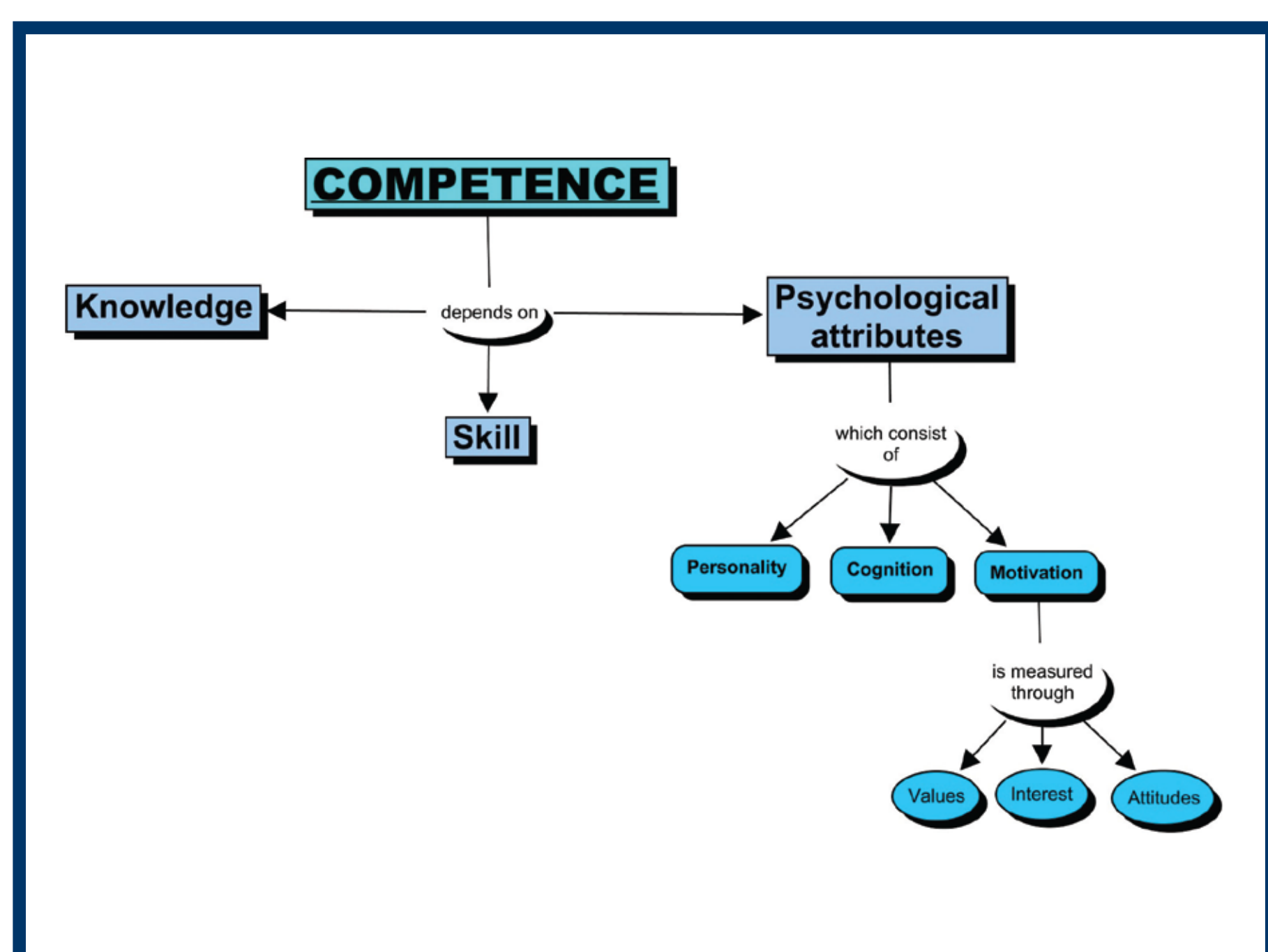


Figure 1: Assessing competence

Apart from these contributions identified in the literature, certain limitations and gaps have also been identified. In terms of the assessment model, there does not appear to be literature on SE-psychological attributes holistically – the focus is mostly on personality or cognition. Literature on values or other motivational constructs in the context of SE is limited. Furthermore, the list of characteristics and abilities identified in the literature are not linked to individual SE competencies, and a quantitative interrelation between attributes and SE competencies has not been shown.

DEFINING THE PROBLEM

The previous sections shows a need for a method to address the shortage of SE over a long-term period and to select candidates with adequate SE potential for development (in different cultural, ethnic and population groups). The basic research question is:

Can the successful development of SE competencies be predicted from personality preferences, cognitive preferences and values (the SE profile)?

Thus to address this research question, we need to design a screening methodology in phase 1. The screening design needs to be followed by validation of the screening methodology in phase 2 to confirm that engineers with the SE profile develop successfully into systems engineers. In other words, to answer our research question, two different hypotheses would need to be tested, which constitute two different phases of the study. In the screening design phase, we test the hypothesis:

H1: The level of SE competencies can be predicted from personality preferences, cognitive preferences and values (the SE profile).

While the level of SE competencies also depends on knowledge and skills, this is not directly relevant because our focus is on the development of potential systems engineers. The purpose of the screening validation phase is to test the second hypothesis:

H2: Successful development of SE competencies is predicted from engineers with the SE profile.

This paper focuses only on H1. The methodology used to collect the data is discussed in detail in the companion paper.

CONCLUSIONS

We need to look beyond individual psychological measures to combinations of measures and levels. Cognitive constructs are very useful for reducing risk during appointment, given a sample of engineers as a baseline (e.g. high preference for logical thinking, but low preference for impulsive thinking). These measures are also different for management versus technical competencies. Thus, we cannot refer to psychological attributes for SE as whole as has been done in some previous literature (Marais, 2004; Toshima, 1993). Treating SE as a whole or singular competency can confound the experiment because different psychological attributes may be required for different SE competencies.

Values have not been considered in the literature for SE screening. Values, as assessed by the value orientations assessment, are useful for predicting high competence on at least 11 SE competencies.

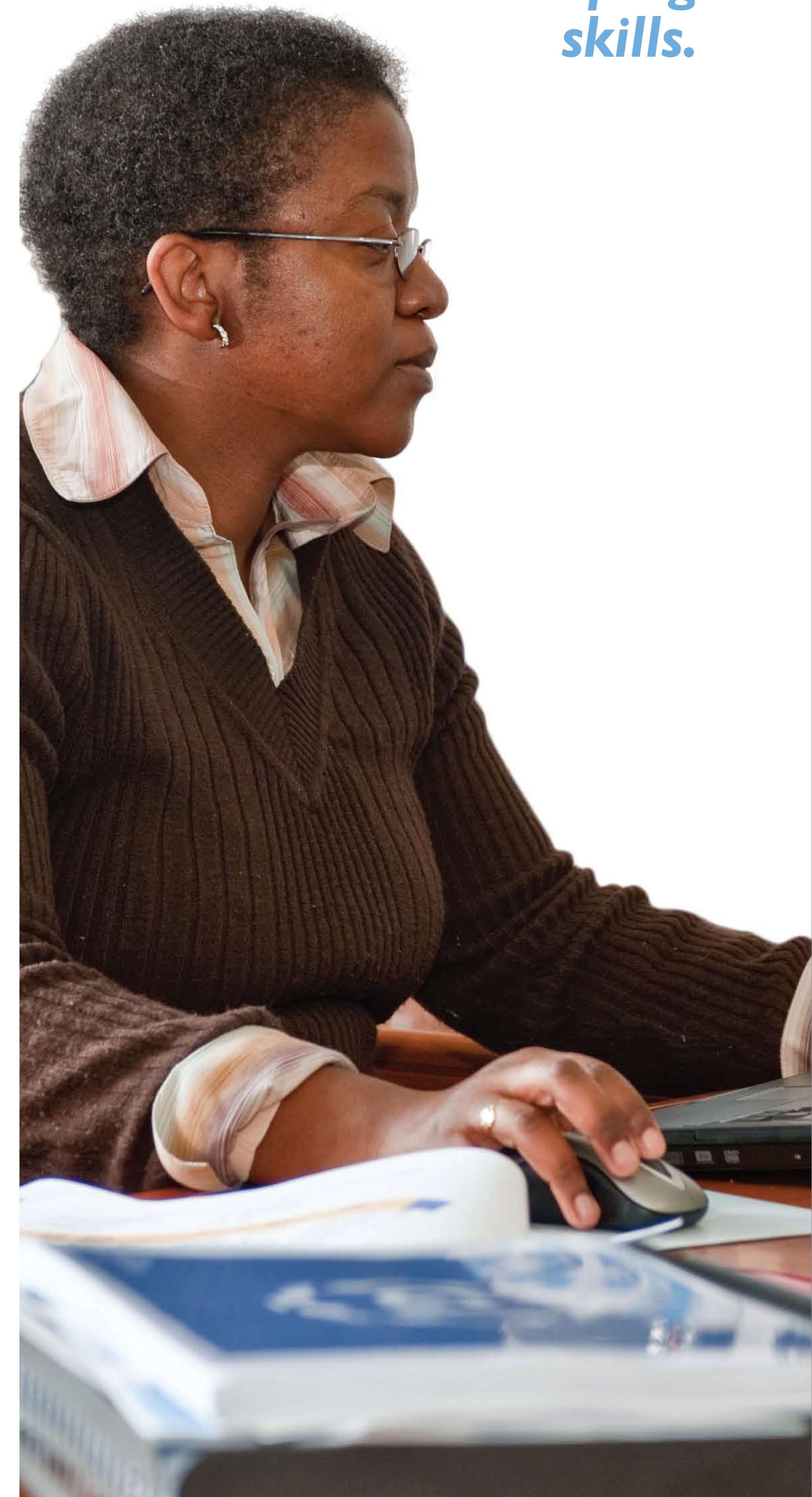
Also profiles are not static and may shift as the organisation develops, not so much in terms of the measures, but increasing preferences for certain cognitive styles or personality characteristics. There is also a risk of replicating or perpetuating organisational characteristics (such as culture or personality) which may be less than effective. For example, recruiting more engineers that have exactly the same profile as DPSS engineers with high competence in determining and managing stakeholder requirements may have some risk. Screening can be used as a tool for SE development and more broadly, organisational development by detecting anomalies and managing change to a new state.

Correlation between years of SE experience and level of SE competence could only be shown for six of the SE competencies in DPSS. The highest correlation (55%) was for determining and managing stakeholder requirements. We should not cling blindly to the notion that the number of years of systems engineering experience leads to high competence. We found SE with many years of systems engineering experience who had not reached practitioner level on various SE competencies.

Methods for identifying engineers with potential have been published as a separate paper (Gonçalves, 2010). Going forward, gathering additional data and validating whether the SE profile leads to the successful development of systems engineers are important issues.

The shortage of SE skills in South Africa requires strategic action, including screening potential candidates and developing skills.

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