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A STUDY OF CAPTURING THE SKILL COMPETENCIES OF THE WORKFORCE WITHIN A SMALL MANUFACTURING ENGINEERING COMPANY

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ABSTRACT
Within companies across many engineering industries, there is a growing realisation that human capital provides the greatest force for economic competitiveness. Indeed, this realisation is true of companies in a wide variety of industries, as well as national governments. Furthermore, harnessing this human capital, referred to as employees' skills and abilities, will contribute towards improved organisational performance. That is, the effective utilisation of a company's personnel, through the most appropriate application of their skills and competencies, can improve performance thus aiding the achievement of sustained competitiveness. A pre-cursor to enabling the effective utilisation of the workforce is for a company to gain knowledge regarding the skills and competencies of its individual members. Only by being in possession of such knowledge, can companies make advances in terms of realising the full potential of its workforce.
This paper highlights the need for organisations to gain measures of the skills and competencies held by the members of their workforces. In the early stages of this research, a small manufacturing engineering company has contributed not only in the development of a formalised skill competency assessment process, but also realised its implementation in conducting an assessment exercise on its workforce. Consequently, the company has been able to identify skill gaps, along with competency deficiencies, within its workforce. As such, it is now proceeding to develop a strategy for training and development needs, and recruitment needs. Furthermore, additional potential benefits of the skill competency assessment process and its application are discussed.

Keywords: Skills, competencies, individual and company development

1 INTRODUCTION
There is a growing realisation within companies across many engineering industries, that human capital provides the greatest force for economic competitiveness. In order to channel this force and achieve sustained competitiveness, engineering companies need to facilitate the effective utilisation of their personnel leading to efficient performance. A pre-cursor to enabling the effective utilisation of the workforce is for a company to gain an awareness of the skills and competencies of its individual members. Only by a company being in possession of such knowledge, can advances be made in terms of realising the full potential of its workforce. Furthermore, such knowledge may also provide the foundation for individual continuous development plans to strengthen the workforce with the intention of simultaneously increasing productivity and stimulating an efficient workforce.
In the current knowledge-based economy, employee skills and abilities, also referred to as human capital, are fast becoming an organisation's most valuable asset [1-2], a key driving force in economic development [3-5], and a source of competitive advantage [6-8]. For example, it has been stated "in particular, emphasis has been placed on the importance of a company's human capital – the value-creating skills, competencies, talents, and abilities of its workforce – as an essential component of gaining competitive advantage" [9]. Indeed, human capital is high on the policy agenda of national governments and international organisations [3]. The United Kingdom's government has been widely reported as recognising the growing importance of intangible assets, which include skills or human capital [4-5, 7]. As such, it has been indicated that British businesses must compete by exploiting capabilities, such as skills and knowledge, which its competitors cannot easily match or imitate [7].

Further, it is stated "the United Kingdom's government would like to see better guidance for companies of all sizes on assessing the strengths and weaknesses of their intangible assets, including the skills of their people". Indeed, recognition has been given to the fact that there is now a greater need then ever to monitor and assess the stock of human capital [3]. Similarly, wide recognition has been reported regarding the need for companies to develop mechanisms that enable them to determine the value of their employee base [9].

Traditionally within manufacturing engineering companies, decisions regarding the selection of the most appropriate individuals to undertake particular tasks can involve managers and supervisors using their subjective, but informed, judgement and experience. This decision-making is made more difficult since people can be multi-skilled with varying levels of competency in these skills, and different tasks require specific skills. As such, difficulties lie in knowing what specific skills and level of competency in these skills the manufacturing engineers possess. Further, failure to select the right individuals to undertake the work can result in extra budget being consumed, missed deadlines, and accompanying compensation payments to clients. Based on the difficulties highlighted, there is a requirement to provide managers and supervisors with an assessment process enabling them to measure and represent the skill competencies of their manufacturing engineers. Consequently, managers and supervisors can establish important information related to skill gaps or competency deficiencies in their workforce. In turn, this will inform the company's training and development needs, in addition to formulating skill and competency profiles of manufacturing engineers it needs to recruit.

The remainder of this paper is organised as follows. Section 2 presents a summary of related work. Section 3 presents an overview of the assessment process used to capture measures of the level of competency in core skills for manufacturing engineers. In Section 4, the skill competency assessment process is applied in an industrial setting involving part of the workforce of a small manufacturing company. This application is then discussed in Section 5. Finally, Section 6 presents conclusions and possible direction of future work.

2 BACKGROUND

It is expected that regular measuring of skills will become commonplace, which could contribute to improving organisational performance [7]. At an individual level within a company, a means of assessing and measuring engineers' skills and competencies is required to aid managers in the decision-making process regarding which people should work on which tasks. In turn, this will facilitate the effective allocation and utilisation of engineers with regard to the varying tasks, given that each task requires particular skills and levels of competency in these skills. It has been recognised that by not effectively matching together employees' skill ability and work, productivity can be greatly reduced [1]. Similarly, it has been reported that employees' competency in performing skills and a company's ability to deploy them is a significant factor in determining the company's success [2].

With regard to the skills of an individual, research literature distinguishes between soft and hard skills [3-4, 10-14]. Hard skills are viewed as those primarily related to a technical domain [13]. Further, with a particular focus on engineers, hard skills are referred to as defining skills, which are said to be unique to the engineer and encompass a sound knowledge of the engineering fundamentals within their discipline. In contrast, soft skills are seen as interpersonal skills that enable effective performance in a commercial working environment. Collectively, soft skills have been defined as including communication skills, teamwork skills, problem-solving skills, and conflict resolution skills [4, 9, 12-13]. In the research reported, it has been widely recognised that companies desire individuals with both hard and soft skills. However, it has been reported that most research and studies have focused on aspects of hard skills, i.e. highly specific skills pertaining to particular tasks, since these are relatively well-defined and accessible to measurement under controlled conditions [3]. In contrast, soft skills are viewed as more difficult to measure [3-4, 9]. Primarily with respect to hard skills, a variety of methods commonly used to assess skill levels are cited as objective measures through assessment and testing, subjective measures through supervisor rating, and self-assessment [3].

Establishing a way to quantify a person's skills is recognised as a fundamental problem and a significant challenge [15-16]. While not offering a means of measuring skills, a number of numerical scales have been proposed such as rating scores of employees' skill performance from *1* to *5*, where *1* represents no ability and *5* represents an expert understanding [2]. Similarly, level of experience has been ranked from *0* to *9*, where *0* represents no experience and *9* represents expert/specialist [15]. However, it has been reported that there is no natural scale on which to measure skills, which is seen as placing a burden on researchers to provide a scale that is uniformly understood [3]. Also, it has been noted that existing research suggests there is no universal formula to measure the value of employee skills and competencies [9]. Regardless of the scale used to represent an individual's skills, it has been recommended that it should be based on a combination of professional training, practical experience, and academic qualifications [2, 15].

In order to remain competitive, organisations need to maintain a strategic approach to their business involving the continual assessment of their strengths and weaknesses [17]. By identifying skill strengths and weaknesses within an organisation, workload can be better matched with skill strengths, and training strategies can be developed to address skill weaknesses or skill gaps with respect to its future business needs [2, 18]. Companies have been noted as adopting several strategies in response to perceived skill deficiencies including up-skilling by increasing training, in-skilling through intensified recruitment efforts, and out-skilling through the use of third parties to undertake skilled work [13]. Indeed, it is recognised that by not appropriately managing peoples' skills, an organisation could be wasting money on ineffective training programmes and strategies [1]. As such, skills management is reported as growing in popularity. Indeed, the capability to assess competencies and determine skill gaps enables organisations to implement more cost-effective and meaningful training and development practices such that they can meet their specific business goals.

3 AN ASSESSMENT PROCESS TO CAPTURE SKILL COMPETENCIES

The assessment process, which has been developed in collaboration with a small manufacturing engineering company, is aimed at ascertaining knowledge of the competencies of individual members of its workforce in relation to a set of core manufacturing skills. The process involves a synthesis of supervisor-assessment and self-appraisal in order to establish the competency levels in a range of skills for each manufacturing engineer. Figure 1 presents an overview of the skill competency assessment process, and serves as a prescriptive guide to conducting the assessment of the manufacturing engineers within the company.

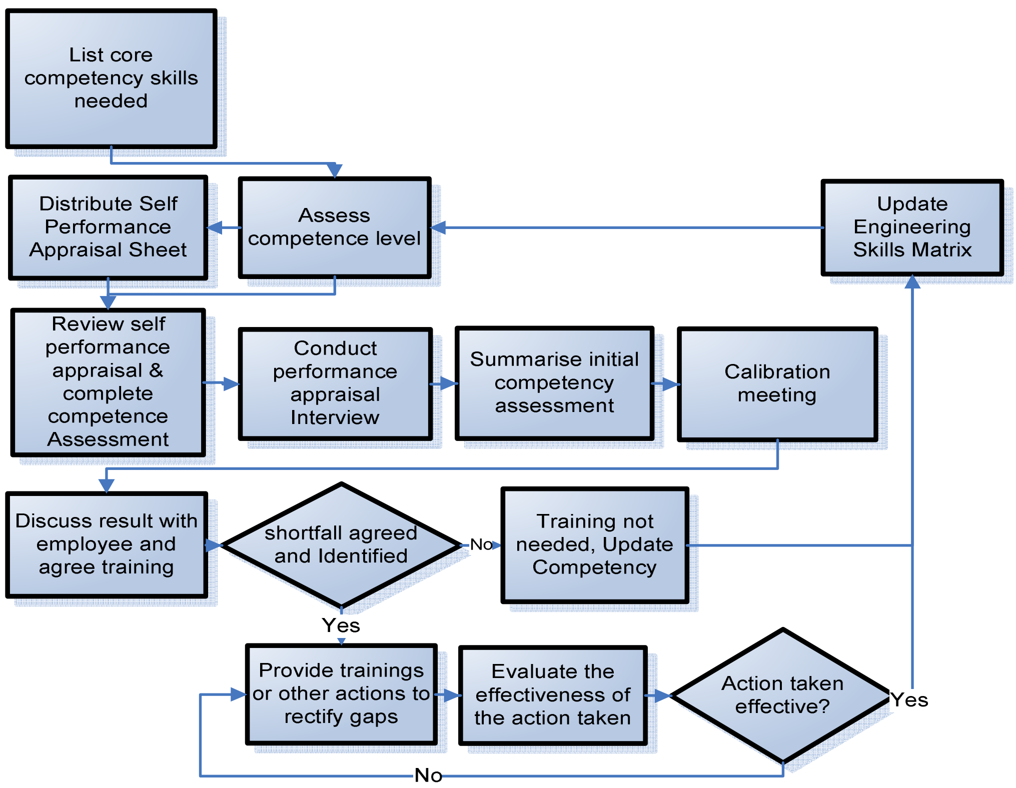

Figure 1 Skill competency assessment process

An overview of the skill competency assessment process is now presented. For the purpose of brevity, only the key stages of the process are described.
The assessment process begins with the development of a list of core manufacturing skills needed in relation to the existing tasks, or jobs, undertaken by the company's workforce. This list is reviewed on an on-going basis such that it can be extended in response to the identification of new core manufacturing skills required in the event of new product development plans of the company. The nature and frequency of such events is directly related to the needs and demands of the company's customer base, which as such plays a significant role in determining the skill requirements of the company.
Initially, for each manufacturing engineer, a supervisor conducts an assessment of the level of competency in relation to each of the company's core manufacturing skills. These core skills include pressing, welding, drilling and tapping, grinding, laser operation, punching, milling, and turning. Competency in each core manufacturing skill is represented over a range of eight levels, each of which defines a unique degree of capability. The representation of competency in each core skill is heavily based on the visual *ILUO method* [19], which is reported to have originated in Japanese industry. Further, this visual representation is intended to publicly display the current levels of skill competencies of each individual, which can be used to identify their specific training and development needs that will enable them to operate more effectively, thus improving organisational performance. While there are variations in the ratings associated with *I*, *L*, *U* and *O*, the definitions developed within the small manufacturing company are presented in Figure 2.

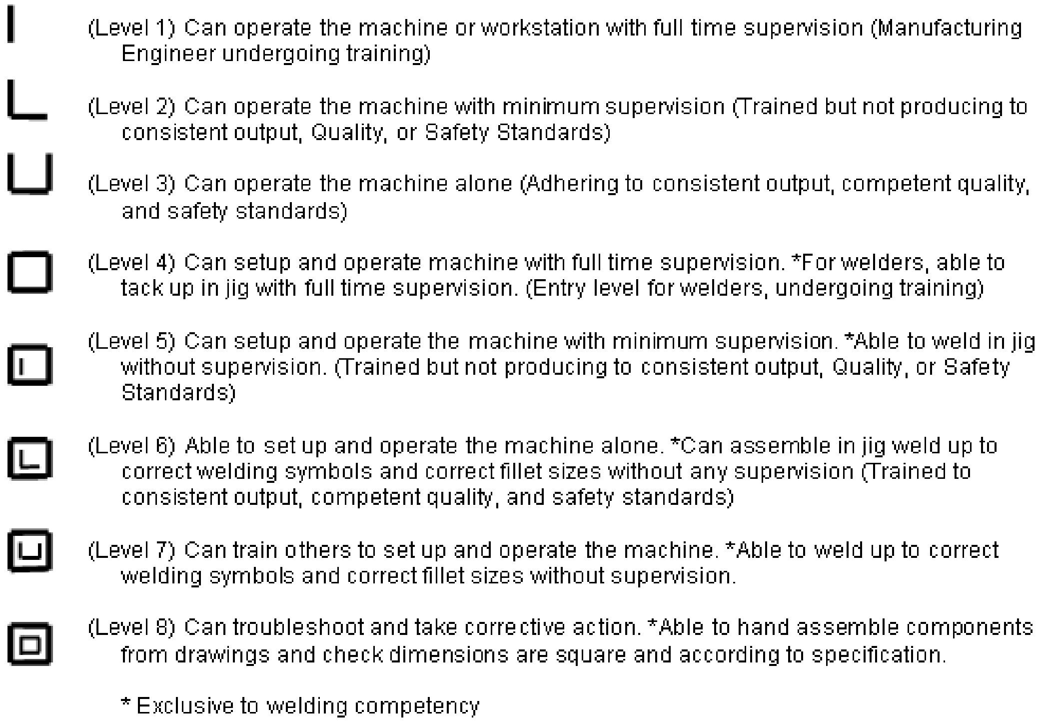

Figure 2 Definitions of level of skill competency

From Figure 2, it can be seen that the least level of competency, which is referred to as *Level 1* and is represented by the letter *I*, relates to an individual who requires full time supervision to perform a particular machine or workstation operation associated with a core manufacturing skill. In contrast, the greatest level of competency, referred to as *Level 8* or represented by the letter *O* within the letter *O*, corresponds to a manufacturing engineer who is able to perform a particular operation alone, and also is able to diagnose problems and take remedial action.
Clearly, the assessment carried out by a supervisor is not only subjective but it also is dependent on the particular supervisor involved. Ideally, ensuring that the same supervisor conducted the assessment of all manufacturing engineers' skill competencies would remove this potential inconsistency.

However, in larger organisations this would not be practical. As the company involved with this initial stage of the research is small, with less than twenty manufacturing engineers, then it was possible for the same supervisor to carry out all assessments. Further, in order to provide more rigour to the assessment process, a decision guide was devised for the supervisor to use. This decision guide is presented in Figure 3. Although it has been indicated that the same supervisor would conduct all assessments within the small manufacturing company, it is considered that the decision guide would prove useful in reducing the likelihood of inconsistency alluded to earlier if different supervisors were involved.

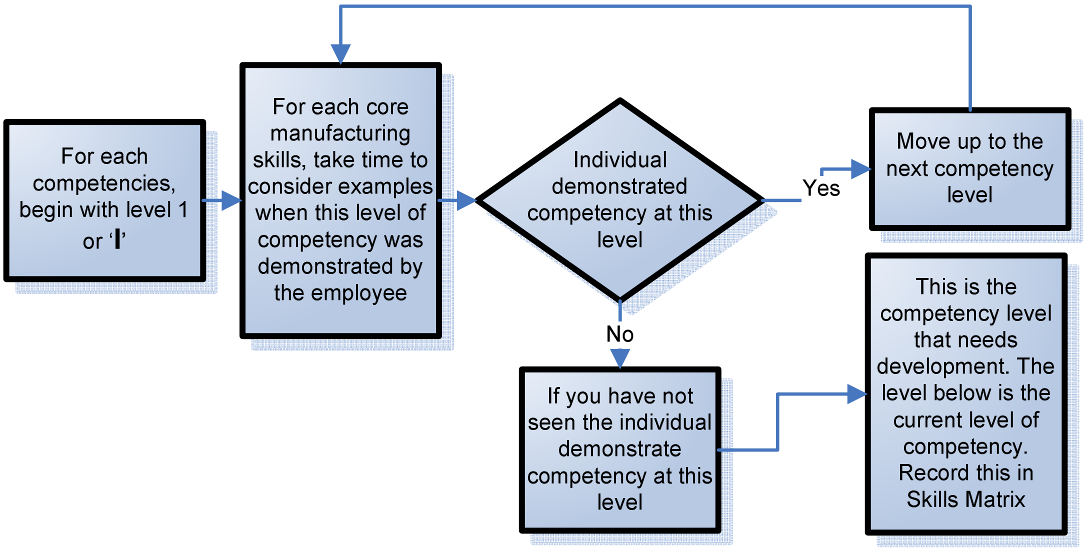

Figure 3 Skill competency assessment decision guide

The decision guide provides a uniform means of considering the level of competency in each core skill for each manufacturing engineer. In essence, with regard to an individual and a core manufacturing skill, the supervisor begins by considering the definition of competency for *Level 1* along with examples of work undertaken by the manufacturing engineer demonstrating the necessary degree of capability. If the supervisor deems that the manufacturing engineer has not demonstrated this level of skill competency, then this is recorded as the level at which training is required for this individual. However, if the individual has demonstrated this level of skill competency, then the supervisor moves to the next level. This process continues until a level is reached that the supervisor adjudges, based on the definitions given in Figure 2, the manufacturing engineer has not demonstrated the required skill competency. As such, this is the level at which it is deemed the manufacturing engineer requires training. In addition, the individual's actual skill competency level is recorded as that previously considered. This process is followed for each manufacturing engineer against each core skill.

Once the supervisor has completed the assessment of all manufacturing engineers' competency level in relation to each core skill, each individual is provided with a self performance appraisal form. The contents of this form enable a manufacturing engineer to evaluate themselves in relation to the work they have undertaken and the core skills. Subsequently, a performance appraisal interview is conducted with the purpose of bringing together the supervisor and manufacturing engineer in order to discuss their respective assessment and appraisal. Once mutual agreement has been made in terms of the skill competency levels of the manufacturing engineer, training and development needs are identified. The nature of these needs is related to enabling the individual to improve to the next level of skill competency. However, prior to these training and development needs being sanctioned, a calibration meeting between supervisors and the manager takes place in which the needs of the organisation are considered in tandem with individual manufacturing engineer needs. Once sanctioned, the training and development plan can commence. On completion of each individual's plan, which will occur over varying time periods depending on a number of factors, the manufacturing engineers will be at a stage where their relevant skill competencies can be assessed. Factors influencing the time taken for a plan to be completed include the current skill competency level of the individual and the means by which their training and development is implemented.

4 INDUSTRIAL STUDY: SKILL COMPETENCY ASSESSMENT EXERCISE

Thompson Manufacturing and Engineering Limited is a small company involved in the manufacture of fabricated engineering components and machine parts for heavy equipment within the excavator industry. Established for over fifteen years, the company has focussed on cutting-edge technology and has seen the implementation of some of the most advanced sheet metal cutting and processing centres available.

Over a three week period toward the end of 2006, Thompson Manufacturing and Engineering Limited conducted a skill competency assessment exercise of its manufacturing engineers. This assessment was undertaken in adherence with the process and decision guide outlined earlier in Figures 1 and 3 respectively. Furthermore, in determining individuals' competency levels in each core manufacturing skill, the definitions presented earlier in Figure 2 were used. As a result of supervisor assessment and self-appraisal, levels of competency were estimated for each manufacturing engineer in relation to the company's core manufacturing skills, which include stock management, hand tool utilisation, press break operation, guillotine and band saw operation, drilling and tapping, turning, dressing, laser operation, welding, milling, punching, and threading. Collectively, these core manufacturing skills are those required in order for the production of the wide and complex variety of parts and components that the company produces.

The outcome of the skill competency assessment exercise conducted by the company is presented in the form of a skills matrix, which is shown in Table 1. As this paper only presents a summary of the assessment results, knowledge pertaining to the skill competencies of only ten of the company's eighteen manufacturing engineers is presented. However, all of the core manufacturing skills are included within Table 1.

Table 1. Skills Matrix for Manufacturing Engineers

NAME	Warehouse	Hand Tools	Press Breake		Guillotine	Band Saw		Drill & Tap	Lathe Machine		Dressing	Laser	Welding		Milling Machine		Punch Press	Threading
			MAN	CNC	MAN	MAN	CNC		CTR	CNC			MIG	TIG	HOR	VMC	MAN	
M.E. 01	L	U	O(U)	U	O(U)	O(L)	O(L)	O(U)	O(U)	U	O(U)	I	I	I	U	U	U	U
M.E. 02	O(U)	U	U	U	O(U)	O(L)	O(L)	O(O)	U	U	O(U)	I	O(I)	I	U	U	U	L
M.E. 03	L	U	I	I	O(U)	O(L)	O(L)	U	I	I	O(U)	O(U)	I	I	I	I	I	I
M.E. 04	I	U	U	I	O(L)	O(L)	I	I	I	I	O(L)	I	O(U)	U	I	I	U	I
M.E. 05	I	U	U	I	O(L)	O(L)	I	I	I	I	O(L)	I	O(U)	I	I	I	U	I
M.E. 06	I	U	I	I	I	I	I	I	I	I	O(L)	I	I	I	I	I	I	I
M.E. 07	L	U	U	U	U	U	U	U	U	U	O(I)	I	I	I	I	U	U	U
M.E. 08	I	U	U	U	U	O(L)	U	U	U	I	U	I	O(U)	U	I	I	U	I
M.E. 09	I	U	U	U	U	I	I	U	I	I	U	I	I	I	I	I	U	I
M.E.10	U	U	I	I	I	I	I	I	I	I	U	I	I	I	I	I	I	I

With regard to Table 1, competency in each core manufacturing skill is represented over a range of eight levels from level 1 (represented by the letter *I*) to level 8 (represented by the letter *O* within the letter *O*) in accordance with the definitions given in Figure 2.

By visually representing the results of the assessment in the skills matrix, the company could immediately identify manufacturing engineers requiring urgent training. From Table 1, it can be observed that manufacturing engineering *ME09* and *ME10* possess low competency levels in many of the core skills. In fact, a skill competency level of 3 is the highest demonstrated by both of these manufacturing engineers. The remaining eight individuals, which are represented in Table 1, all possess a competency level of 5 in relation to at least one core skill. A reason for manufacturing engineers *ME09* and *ME10* possessing relatively low skill competency is primarily due to the fact that these individuals are recent recruits.

The company was also able to recognise those core skills in which the workforce must acquire a greater level of competency: Computer Numerical Control (CNC) press breaking, CNC lathe machining, and vertical milling. A contributory factor toward the lower competency levels in these core skills can be attributed to the relatively short period of time the equipment and manufacturing techniques, associated with these skills, have been in the company. As shown in Table 1, eight of the eighteen core skills have at least one manufacturing engineer with a competency level of 7. As indicated in Figure 2, these manufacturing engineers with the level of competency are able train others to setup and operate machines. As such, the remaining ten core skills, in which no manufacturing engineer possesses the competency level required to train others, were observed as requiring consideration. In particular, it was necessary to seek external training for a number of key individuals in these core skills. In addition, relatively high levels of competency in these core skills were seen as desirable in terms of potential new recruits to the company.

5 DISCUSSION

A key outcome of the assessment is that the company is now in possession of measures of its manufacturing engineers' competencies in relation to its core skills. Consequently, the company is able to establish which manufacturing engineers most urgently require precision training and development in specific core skills and what level of competency is required in these skills. The term *precision* is used to emphasise that the training and development is tailored to the individual with a focus on improving their skill competencies, and improving the company's performance in terms of productivity and responsiveness. For a small company, such as Thompson Manufacturing and Engineering Limited, productivity and responsiveness are of key importance to its survival. As such, this endeavour to gain an awareness of its workforce's levels of competency in its core manufacturing skills is essential in a strategic sense.

A significant point to note is that, although not part of the industrial study presented, the results from the skill competency assessment exercise have enabled the company to establish its needs in terms of recruiting manufacturing engineers with desirable competency levels in specific core skills. That is, the company is now in a position to be able to develop a *wish list* with regard to the skill competencies required of any future employees joining the manufacturing capability. As such, the assessment exercise has not only served to identify where development is required for the existing manufacturing engineers within the company's workforce, it has informed future recruitment needs.

As a result of the industrial study, a further consideration relating to the assessment process is the need to assess members of the workforce holding a supervisory role. This focus of assessing supervisors could be oriented towards establishing if they are identifying the appropriate manufacturing engineers to be developed in the relevant core manufacturing skills given the nature of the company's current and forecasted workload.

It is acknowledged that the skill competency assessment process is in its very early stage of development and application. As such, a further means of evaluating the process is required, which will be achieved through its application in other companies within the manufacturing engineering sector. Also, further assessment exercises will result in the development of the process. Indeed, it is envisioned that such further development and applications will ultimately lead to a *general process*, which is uniformly understood with wide applicability in the manufacturing engineering sector.

6 CONCLUDING REMARKS

Small engineering companies face fierce competition if they are to sustain their competitiveness and continuously satisfy their customers. Consequently, these companies are continually searching for approaches to improve their performance. One approach recognised as of key significance to such companies is assessing the skill competencies of its labour force, which can then be used to its competitive advantage. Indeed, in the current knowledge-based economy, the importance attached to employee skills and competencies, which have been referred to as human capital, is increasingly being recognised. Further, harnessing this human capital has been widely viewed as an organisation's most valuable asset, a key driving force in economic development, an enabler for improving organisational performance, and a source of competitive advantage. It is acknowledged that different companies have different skill and competency requirements. As such, companies need to establish appropriate skill competency assessment methods for their particular purpose and environment.

This paper has presented an overview of a formalised skill competency assessment process developed and formalised in collaboration with Thompson Manufacturing and Engineering Limited. This company is seeking to develop its existing methods with the aim of improving performance in terms of productivity and responsiveness. The formalisation of the skill competency assessment process has aimed to bring a level of consistency required in such an undertaking. Furthermore, an industrial study has been undertaken in the form of a skill competency assessment exercise involving the company's manufacturing engineers. Presently, from the company's perspective, the assessment process provides a mechanism to determine gaps and/or deficiencies in skill competency within the workforce of its manufacturing engineers, which inform its training and recruitment needs. In addition, the assessment process offers the company a means of identifying its key needs in terms of the skill competencies of future employees joining the workforce of manufacturing engineers.

In terms of a potential future development of the work, it would be useful to investigate the integration of the competency assessment process within an analytical approach to scheduling. This would allow the outstanding work to be assigned to the manufacturing engineers taking into account that individuals have their own level of competency in the identified core skills. This development could make use of quantitative measures of skill competency levels, which could be directly related to the current form of qualitative descriptors being used to establish a visual representation. However, the relationship would need to be investigated between the qualitative descriptors and a numerical scale of measuring skill competencies.

In terms of the competency assessment process, a possible development to its operation could focus on the introduction of mechanisms to facilitate self-monitoring by manufacturing engineers and timely communication to a supervisory level. Potentially, this would serve to keep an organisation up-to-date in terms of its individuals' skills and competencies rather than being up-dated at regular, but perhaps infrequent intervals.

Finally, the development of a process to capture the competencies of its workforce provides the company with visibility in terms of its organisational capability and also how it potentially could collaborate with other organisations. Academic interest is growing in the area of representing an organisation's capability so that they can be viewed externally as offering a range of services rather than developing specific products [20]. Such views of an organisation, referred to as *competence profile*s *or portfolios*, are reported as facilitating the creation of virtual enterprises, which involve several companies forming temporary alliances to address some need [20-21].

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