

Implementation of Agile Manufacturing Principles in Small and Medium Enterprises (SMES)

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Abstract

Modern manufacturing is under ever increasing pressure to develop solutions for highly complex tasks. In order to maintain the business survival in a highly competitive environment, it is vital to obtain customer satisfaction, which requires developing products with shorter lifecycles and higher quality meanwhile to reduce the production costs. In order to achieve such objectives a paradigm has been developed called “agile manufacturing”. However according to the literature, this tool has been widely used within the large companies, there is still an ongoing research to prove their applicability in Small and Medium Enterprises (SMEs). This paper aims to assess the feasibility of applying agile manufacturing principles within SMEs using 10 case studies in the UK and Malaysia. It contributes to theory by being able to identify the main barriers in the implementation of agile manufacturing by dividing them into three categories namely “lack of management skills”, “technological limitations” and “lack of workforce experience”. It also provides recommendations for each aforementioned issue so it could be used as guidelines for the industries to employ these methodologies.

Keywords

Agile Manufacturing, Small and Medium Enterprises

1. Introduction

The manufacturing sector has been playing a critical role in developing and advancing the world. It is considered to be a cornerstone in the global economy through its influence on areas such as mining and construction in upstream and warehousing and transportation in downstream. This has resulted in various challenges to develop new approaches to maximize the production efficiency [1] in terms of cost, quality of the products, required resources, environmental impacts and many others described by [2]. The emphasis for perfection in manufacturing operations has been evolving throughout history.

As the time passes, with the aid of advanced technologies, the agile manufacturing techniques have gained considerable popularity among the industries to boost productivity, effectiveness, responsiveness and the quality of the product. It is concluded from the available literature that the agile techniques are theoretically applicable in majority of the industries and has proven their success in practice specifically in large organizations [3]. Despite having a rich literature about the applicability of the agile tools in large companies and the importance of this production philosophy in SMEs, it is evident that there is still a gap existing in the current knowledge to provide a classification of tools that enables the SMEs to adopt this approach.

Due to the dearth in the available literature and the lack of emphasis within the industries, agile manufacturing concept has not been widely introduced to the SMEs, hence the advantages of such production philosophies are not fully appreciated. Consequently it can be seen that the number of manufacturing SMEs are gradually decreasing in the UK's manufacturing environment regardless of their substantial influence in the overall economy of the country and being shifted to the countries that offer lower production costs.

2. The importance of the SMEs

At present the private sector (SMEs) is playing a substantial role in the UK's economies and is significantly influencing the large-scale manufacturing firms due to their significant contribution in the supply chains. According to the statistic, it was anticipated that there were 4.8 million organisations in the UK private sector businesses. This would account for 14.1 million employments provided by these businesses, which resulted in approximately £1,500 billion annual turnover [4]. It can be seen in Figure 1 that in 2012 the SMEs are considered to stand for more than half of the employment as well as approximately half of the total turnover in the UK private sector [4]. This fact emphasises the importance of focusing on optimization of the manufacturing systems and their efficiency in the SMEs since it can greatly affect the UK economy in the current turbulent business climate. As a result, the necessity for the enhancement in the production effectiveness has obligated the SMEs to adopt the lean manufacturing techniques, which is currently considered to be the most acknowledged production practice for this purpose. On the other hand the requirement for the responsiveness and the flexibility of the production, which can have conflicting goals than developing an efficient system has imposed a tremendous pressure on the companies to provide wider choice of products in the market and deal with well-educated customers. This has led an establishment of a new methodology named agile manufacturing. The applicability of these two widespread techniques is discussed in this paper by investigating each of the tools separately as well as the combination of them.

The figure below illustrates the share of businesses in the UK private sector and their associated employment and annual turnover, by size of business. The figures illustrate the importance of preventing the gradual decrease in the number of SMEs in the UK. This decline is regardless of their substantial influence in the overall economy of the country and being shifted to the countries that offer lower production costs such as China or India.

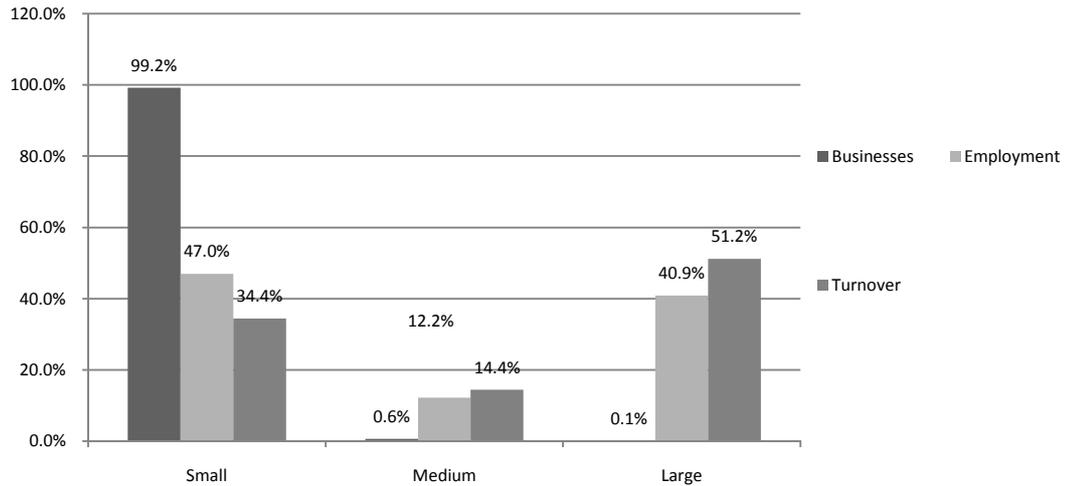


Figure1. Share of businesses in the UK private sector and their associated employment and turnover, by size of business, start of 2012 [4]

3. Agile manufacturing (AM)

Today's businesses are experiencing dramatic changes with an accelerating rate in the global market environment which ultimately leads the manufacturing industries to undergo tremendous difficulties to achieve a conflicting target of improving the efficiency and coping with ever changing customer demands and providing wider choice of products and services for the end users [5]. Therefore the turbulent times and the significant uncertainties in the business environment have created the challenge for the industries to formulate a new paradigm to maintain the competitive advantage in the market. Hence there has been an ongoing fragmentation of the mass market into niche market as the customers becoming well-educated and expecting products with shorter lead times and high quality [6]. This concept has been widely applied to the majority of the enterprises since changes are constantly occurring in all facets of the businesses such as in the market, in the technologies and in business relationships [7]. According to [8], this has also drawn the attention from the most traditional companies to develop strategies to satisfy the sophisticated customer expectations and remain competitive in the market.

As a result, about two decades ago, a group of more than 150 companies contributed to a research, which studied the possible direction of evolution of the US industrial competitiveness during the next 15 years, which can be found in the two-volume report entitled "21st Century Manufacturing Enterprise Strategy". Consequently, a forum under the name of "Agile Manufacturing Enterprise Forum (AMEF)" was formed in Iacocca Institute at the Lehigh University that ultimately led to the introduction of the Agile Manufacturing (AM) concept [9]. This concept enables the organizations to react and pro-act to the unpredictable and diversified market changes while minimizing the modifications to the company's main structure by establishing an intimate commercial relationship with the suppliers and the customers [10-12]. Due to the vast amount of resources required in implementation of this methodology, which is considered to be inaccessible by a single company, collaboration among the companies is obligatory in terms of sharing the resources and technologies. Therefore it is vital for the enterprises to build strong relationships [9]. However it should be noted that according to [13], the selection of the manufacturing strategies entirely depends on the

objectives of the organizations to maintain the competitive advantage. Thus agile manufacturing concept is considered to be a dynamic-driven and depends on specific contexts.

A wide range of research has been carried out to deliver a literature on agile manufacturing techniques. In order to obtain an overall view about different aspects of the AM methodology, [14] reviewed the classification AM tools in the available literature and highlighted the key factors in implementation of agile techniques. This is introduced in four main groups, the Strategies, Technologies, Systems and People, having sub-classifications each. The first one being strategies comprising the “virtual enterprises”, “supply chain” and “concurrent engineering”. Then the next one is the Technologies with the sub-classifications of “Hardware- tools and equipment” and “Information technologies”. The systems come next with an abundant literature available in “Design systems”, “Production planning and control systems” and “System integration and database management”. Last but not least the “Knowledge workers”, “Top management support and employee empowerment” and “Training and education” falls under the “People” category [14].

There are number of arguments available in the literature on the key enabler of the agile principles. One of the most widely cited works agile enablers is found to be [15]. They claim that the main enablers of agile manufacturing can be classified into seven elements as follow: virtual enterprise formation tools, physically distributed manufacturing architecture and teams, rapid partnerships formation tools/metrics, concurrent engineering, integrated product/production/business information systems, rapid prototyping; and electronic commerce [15]. Conversely, [16] have developed a conceptual model for agile manufacturing comprising four elements. These elements are as follow: knowledge-driven enterprise, virtual enterprise, core competence management and the capability for reconfiguration as the core concepts of AM [16].

A review of agile manufacturing was also conducted and a classification scheme for agile manufacturing research was provided by [9]. In this research, nine major categories were identified and the importance of each one was determined by allocating number of citations by other researchers in this field. The research available are in the following topics. The largest number of citation appeared to be in the “Information systems” followed by the “Supply chain”. “Product and Manufacturing systems design” and “Business practice and process” appeared to be the next ones respectively. After that “Facilities design and location” comes next. The last three categories which were attributed the least were “Process planning”, “Production planning, scheduling and control” and “Human factors” respectively. Further information about this can be found in the following paper [9].

Agile methods have proven successful in increasing customer satisfaction and cost reduction in the large companies leaving opportunity for the researchers to investigate a possible solution to overcome the problems caused by a drastic competitive environment faced by SMEs. One of the recent work was achieved by [17] where a model was presented to prioritise available management systems for SMEs. Another study has attempted to achieve an agile system by maintaining the identity of a production system through the effective participation of workers [18]. By looking at the available literature, it can be seen that various reseaches have been focusing on new paradigms such as Mass Customization (MC), Agile Manufacturing, and Flexibility which share a wide range of characteristics. One of these studies is conducted by [5] where mass customization strategy is studied from product configuration and component similarity perspectives.

Various studies have also been conducted focusing on the specific agile enablers in SMEs. One of these studies was carried out by [19] in which the applicability and the effectiveness of IT solutions are assessed and consequently a guideline is developed to facilitate the implementation of IT system within SMEs. The major observation in this investigation appears to be the requirement for enhancement of workforce skills and expertise in regards to IT solutions [19]. Meanwhile another study was carried out to investigate the gap between the application of lean and agile manufacturing techniques in SMEs as well as large companies [16]. In this study it was found that, unlike in large companies, many aspects of lean principles can be avoided within SMEs. This was further continued by [20] research in which it is claimed that SMEs can totally avoid lean principles and solely concentrate on agility aspects of the production.

4. Methodology

For the purpose of this investigation, qualitative data collection method was nominated since this technique offers a range of benefits in this instance [21]. These types of research enable to gather in depth information about the human behavior and their justifications. It also determines the reason behind any decision-making (why and how) as well as the time and location of each decision. Therefore one of the advantages of qualitative research is that it allows discovering the reason for any failure or success in implementation of lean and agile programs. Another advantage of this technique is its flexibility according to the types of the industries being studied [22].

In order to undertake the interviews, an open-ended questionnaire was used in ten different companies within the UK and Malaysia. This approach has been recommended by various authors such as [17, 23] who have carried out similar studies to this investigation. Planning an exploratory interview questions can only be achieved after obtaining a good understanding of the recent literature about the agile techniques and the relevant tools that supports their objectives. It is also essential to discover their functionalities within different industries (electronic, food, etc.), meanwhile to gather adequate knowledge about the Small and Medium Enterprises in the UK as well as Malaysia. For the purpose of this investigation the interview questions contains only basic terms. It was found that the SMEs tend to have limited knowledge about the technical terms used in the agile manufacturing principles. Therefore to minimize the misinterpretations the generalized questions were asked to cover wider areas and the results were then extracted from the recorded or written documents during the interviews. The data gathering addresses the questions about the agile techniques and how the companies approach the design changes and respond to the demand fluctuation. It also questions to what extent the companies manufacture customized product and the possible barriers in implementation of agile manufacturing.

In order to attain more reliable results from this paper, the investigation was extended to more than one country. As a result, SMEs in the UK and Malaysia were targeted to select the case studies and obtain a conclusion, which can be considered in a global context rather than being specifically focused on the British companies. This provides a good viewpoint to the perception of agile philosophy by different organizations in different countries. However author's previous knowledge about the SME in Iran and Germany were also taken into account in the discussion part. It should be noted that the definition of SMEs in the UK and Malaysia are different and this is discussed in the "Literature review" section of this paper.

5. Findings

For the purpose of this study, the case studies were selected in a way that it allows the author to investigate the companies who operate in an unpredicted, fast changing environment having relatively high product diversity. For further validation of the results, it was important to ensure that the selected case studies work in a fluctuating environment caused by competitive market. Thus, half of the interviewees appear to operate within an international market and collaborate with other countries in terms of outsourcing their components and importing/exporting goods. This is essential due to the importance of the organization objectives that is considered to be the indication for the manufacturing strategy required in the company (Esturilho, Estorilio 2010). Therefore the targeted companies provide this opportunity to investigate the feasibility of the agile concept in SMEs in the UK and Malaysia.

The result obtained in this investigation indicates that the majority of the corresponding companies unconsciously employ agile manufacturing techniques within their systems. This was observed as the companies were questioned for the level of their awareness about the agile manufacturing concept. As a result, approximately two thirds of the companies showed unawareness and unfamiliarity with the concept of agile manufacturing, although agile technologies and knowledge management were employed in their organization to some extent. Thus, due to the nature of the businesses in SMEs such as being handcraft orientated specifically in majority of the small organizations, the agile manufacturing techniques are already being practiced. This can be seen in terms of the SMEs main characteristic such as high flexibility of the multifunctional workforce.

After collecting data and conducting a broad literature review, the barriers for the implementation of agile principles can be categorized into three different groups. These categories appear to be in parallel with the factors recommended by [24], which are believed to be the key enablers of agile manufacturing. These factors are the management, technology and the workforce in the organization [24]. However, studies show that having a small or medium size company can be approached as an opportunity towards achieving agility. One of the major advantages of SMEs in terms of responsiveness over the large companies is having a flat hierarchal structure, which facilitates the decision-making processes. Hence this allows establishing a close relationship between the employees to enable better knowledge transfer. In addition to this, high flexibility of the SMEs can be considered to be another advantage to cope with the market fluctuations and operate in a turbulent environment. There are two reasons behind this flexibility. The first reason is due to adoption of traditional approaches for the production and minimum investment on automatic machinery and the second reason is because of employing high skilled workers and relying on multifunctional employees. Although in order to achieve shorter product life cycles and be able to face the ever-changing environment, it is essential to be able to eliminate the barriers for company's agility.

However a series of studies have been carried out to identify the barriers towards agility such as [25] who claims that "it is generally acknowledged that isolation, rather than size, is the key obstacle, preventing SMEs boosting their competitiveness". As a result of this study the following factors are considered to be the main obstacles for agile manufacturing within the SMEs, which are lack of management skills, technological limitations and lack of workforce experience respectively.

5.1 Lack of management skills

One of the critical factors for the implementation of agile manufacturing in an organization is known to be the management capabilities. The management resources are responsible for establishing a collaborative relationship between customers as well as the suppliers. In addition to this, suitable management skills are also required for better utilization of technologies such as computer-based technologies [26]. This study shows that the managers in SMEs tend to not pay enough attention on improving the core competencies within the organizations. Consequently this results in reducing the opportunities to access different markets as well as developing value perceived by the customers.

As a manager's role, it is important to create a close relationship between the people within the supply chain. This can be in terms of people inside the company, customers and the suppliers. According to the data collected, the SMEs appear to have a close relationship with their employees and the customer.

“In our company we try to ensure a friendly environment to form a strong relationship with the shop floor workers” (Production Manager)

“Due to the size of our company we have been able to establish relatively close relationship with our technicians and top management but as the size increase this task is getting more challenging for us” (Line Manager)

This is whilst due to the low bargaining power and the size of the companies, specifically in the small size enterprises, the relationship with the suppliers tend to be not as strong. Therefore the lack of communication with the suppliers results in company's isolation (Ismail, Reid, Mooney, Poolton, Arokiam 2007).

“We do not currently have a strong position within the supply chain, this limits us from ordering the parts with our own specifications from our main suppliers” (Production Manager)

5.2 Technological limitations

Technology is considered to be another fundamental element to enrich the agile aspects of an organization [19]. This category comprises different aspects of technology. For instance, the technology can be provided in terms of production automation using advanced machines, IT supports such as ERP software and manufacturing cells. The result collected shows that the majority of the SMEs tend to not consider investing on advanced IT solutions due to their business size and the scarcity of the financial resources, whereas according to the existing literature, researchers such as [27] strongly believe that agile manufacturing in SMEs strongly depends on IT devices. Because of this barrier, SMEs have difficulties for accessing the latest information about the customer demands, production level and resource analysis [27]. The following quote was recorded from small company.

“The only method for us to find out about customer demand is by looking at the estimation gained from customers visiting our local shop or contacting via telephone to place an order, I think

this limits us from operating with full capacity and be aware of the real customer demand” (Production Manager)

As a result, the advanced planning technologies such as SAP and ERP have not been widely introduced and applied among the visited SMEs with the exception of one company (NiftyLift) that has employed mid-size ERP's to support and integrate basic internal business processes such as product planning, development, manufacturing processes, sales and marketing within their organisation. The remaining case studies indicated several constraints for adopting advanced IT systems. The main reason was found to be the significant cost of the hardware and software required as well as on going support cost and maintenance costs (Uden 2007). They believed that implementation of IT systems requires technical skills and training as well as a good understanding of the associated legislations.

5.3 Lack of workforce experience

The requirement for educated workforce is considered to be the next constraints for the implementation of agile in SMEs. However, according to the data collected and the available literature, the company managers believe that the employees are the key success factor for the majority of the SMEs due to being highly experienced and flexible [24]. Nonetheless this can be also considered to be a negative point for the SMEs for being highly dependent on their employees. This was observed when three managers mentioned about their frequent delays on the production and delivery due to the absence of their key organization members or shortage of human resources.

“It is our main target to train every employee within the production line and make sure that they are familiar with all the processes. We have now learnt a lesson from having many problems from staff shortage” (Manufacturing Engineer)

Such barrier can be resulted from the lack of sufficient training provided by the management support for all the personnel. This barrier was found to be the most significant obstacle for the agility of the production specifically in two case studies, which were the Moulton Bicycles and Caterers Equipment World. This was observed during the data collection from the factories, when one of their key employees was sick so some part of their production had to be postponed until beginning of the coming week.

Another barrier for pursuing the agility in conjunction with leanness in SMEs is the lack of employee participation in important decision-making. In other words, the employees are not empowered by the management to contribute to the process improvement, which ultimately enhances the responsiveness of the company. Hence it was perceived that the concept of the concurrent engineering is not being practiced within the SMEs in which people from different departments are involved in various stage of product development.

“Unfortunately most of the design decisions are made in our design department without considering the manufacturing department. So after any new design we surely face new problems” (Production manager)

6. Guideline for the implementing agile principles

These recommendations are based on the observations gained from interviewing ten companies in the UK as well as Malaysia and the existing body of knowledge (e.g. [17,18, 5]). For the purpose of this investigation, a series of parameters are recommended that is targetting to improve the agility in any industries. Therefore the case studies chosen are only for the purpose of gathering background knowledge about the SMEs.

Any agile manufacturing programs can start by establishing a clear understanding of the agile values and its objectives. Meanwhile the companies need to attain a clear picture of the market they operate in and assess the degree of its turbulence. This is then followed by the identification of the company's critical capabilities and its core competencies to sustain competitive advantages in the market. Once the core competencies are fully acknowledged, the remaining barriers should be eliminated. The following section only highlights the main factors to be considered in terms of the lack of management skills, technological limitations and the lack of workforce experience.

6.1 Management perspectives

One of the agility initiatives to be considered in SMEs is to ensure that the managers are familiarized with the concept of agile manufacturing and are fully educated about its benefits, which can ultimately be transferred to other members of the organization. Once the organization is introduced with this concept, the managers can take the first step and make changes towards the agility. One of the main responsibilities of a company manager is to identify the core competencies of the organization and establish a comprehensive strategic vision on how to adopt agile methods. This should be followed by the alignment of the strategic approach with their business objectives. In order to do so, the company's business processes with regard to agile principles should be analyzed. Once the strategic approach has been developed, the managers should transfer the ideas to the other members of the organization via an appropriate communication method. One approach is to arrange regular meetings comprising highly skilled team of employees in which the knowledge and ideas are shared and discussed to increase the efficiency and productivity. Meanwhile the employees should be encouraged to discuss their new ideas with each other to develop best practices. Hence by encouraging the employees' participation as well as involvement of the clients in early phases of the project, solutions for process improvement can be attained.

Due to the size of the SMEs and low bargaining power, it is important to establish a trusted relationship with the customers and the suppliers. In one hand, creating a close relationship with the customer enables the companies to obtain a good understanding of the market requirement and anticipate the potential changes in the future. Consequently this enables the managers to manage their production processes according to the more precise information received from the end customers. One way to achieve this is to form an informal partnership with the customers by taking advantage of casual meetings whereas, on the other hand, an appropriate relationship with the suppliers allows formation of a long-term relationship with the suppliers to ensure a high quality supply.

In addition to the manager's duties regarding the establishment of a reliable partnership with the customers and the supplier, they are also responsible for prompting the workforce's capabilities for agility [28]. Believe that it is the management requirement to encourage the employees to focus on the main business objectives and what is known to be the core aspects of the business. The

employees should also be encouraged to increase their tolerance with regards to the frequent changes and the market condition ambiguities. Another important support to enhance workforce agility is the rewards contribution to agility-promoting behaviors [28]. This can be in terms of offering job promotions and incentives in order to improve teamwork and innovation. Last but not least, in order to ensure an ongoing improvement, it is important that the managers are well informed with the new concepts and possible methodologies for agile manufacturing by studying the latest articles for further improvements in the processes.

6.2 technological perspectives

The evidence from this study indicates a direct relation between the technology level employed in the company and the size of the organisations. In other words, as the size of the company increase, the requirement for an advanced planning technologies such as ERPs or a customized IT system also increases. The data gathered from ten interviews confirm the fact that the majority of the small companies tend to have a traditional approach in production and their core business are based on handcrafts products.

However due to the financial constraint the investment on IT systems was mainly avoided but in order to improve the overall performance, the companies can be promoted to employ software such as CAD and databases in the case of product design and emails in order to improve their communications with the employees. In addition, from manufacturing technology point of view, the flexibility of the handcraft based productions has allowed the small compsnies to be independent from automated systems. Therefore it is generally recommended that small companies to minimise any investment on advanced automated machinery.

According to the literature available, IT systems have been strongly recommended in medium size companies [27]. [17] believe that the information and communication technologies should be used in medium size companies to improve cooperative teamwork to provide supportive network systems that all the employees can get access at the same time. Hence the team members can contribute and share corporate information. As a result, it is believed that there is greater need for the IT solutions in medium size companies. Hence it is recommended that these companies employ mid-size IT solutions according to their requirement. For instance, according to the nature of the businesses, stock keeping systems, Customer Relationship Management (CRM) and ERPs can be recommended to enhance the company's responsiveness to the customer demands. In addition these systems allow the managers to access the latest information about customer demands, production level and resource analysis [27]. Moreover, it enables the top managers to develop overall outline in order to align the resources, planning and production. It should be noted that to ensure a good utilization of this technology the employees should be familiarized with the IT solution. Last but not least, regarding the manufacturing technologies, the cellular manufacturing is recommended which allows a modular production line design in which variety of products can be manufactured without any modifications in the layout. This is achieved through standardization of the processes which enables to completely manufacture an item from start to finish using the equipment and workbenches that are organized in a single cell.

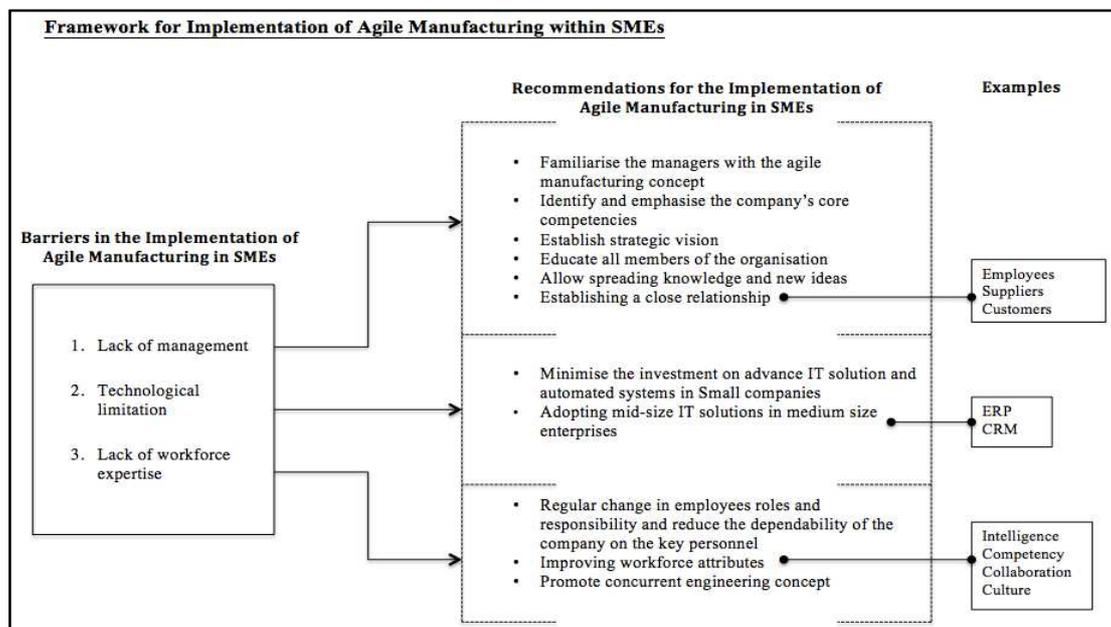
6.3 Workforce barriers

The last barrier identified in this study for the implementation of agile methodology in SMEs, was the company’s dependability on the key employees. This can be considered as a bottleneck in different stage of the production when an employee is absence due to illness or vacation purposes. One way to overcome such a barrier is to continuously change the employee’s role and responsibilities to give them the chance for learning all the processes required in the production and be familiarized with the agile techniques. The rotation of employees results in a significant increase in their abilities for tackling production related issues. However SMEs are known to have a capability of being flexible, it is still required to have continuous training sessions and fully educate the workforce about the agile principles and its objectives using formal and informal training methodology. This training should aim to improve the workforce following attributes [28].

1. Intelligence: This is the ability of the employees to act fast according to the external changes such as customer demands
2. Competency: This refers to a continuous attainment of the skills related to IT solutions, management and business processes and their alignment according to changes in market condition.
3. Collaboration: This is the ability of the workforce to undertake the projects as a team and work effectively with other team members.
4. Culture: This is the extent to which the employees are encouraged to participate in decision-making.

In addition the managers can promote the concept of the concurrent engineering in which the tasks can be completed simultaneously and the product time to market can be significantly reduced. As a result, the implementation of this strategy allows better communication between different groups undertaking a variety of responsibilities, shorter product development time, and significant improvement in quality of the product and finally considerable reduction in overall costs.

Figure2. Framework for Agile Manufacturing in SME



7. Conclusion

This investigation was undertaken to assess the applicability of the agile manufacturing techniques within SMEs and identify the potential barriers for implementation of these tools. The findings suggest that in general, the agile manufacturing tools are not fully developed within SMEs. Hence there were number of obstacles identified towards the agility of the organisations. These barriers appeared to be lack of management skills, technological limitations and lack of workforce expertise. These findings propose several courses of action. In order to overcome the barriers regarding the management skills, it is essential to ensure that the managers are well educated about the agile manufacturing and its objectives. Once the managers are informed, it is their responsibility to identify the company's core competencies and align the strategic approach with their business objectives. It is also crucial to establish a close relationship with the employees, customers and suppliers. The findings in terms of technological limitations suggests that the small companies should generally minimise any substantial investment on advanced IT solutions and automated machinery due to the size and nature of their businesses and stick with low investment software such as CAD and emails. Whereas the medium size enterprises are suggested to employ mid size IT solutions such as ERP and CRM to improve cooperative teamwork to provide supportive network systems that all the employees can get access at the same time. Last but not least, the lack of workforce expertise and companies dependability on key employees can be addressed by rotation of employees and allocation of different responsibilities. As a result workforce's attributes in terms of intelligence, competency, collaboration and culture should be enhanced.

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