Starting the journey towards manufacturing excellence:

MX Start

Innovation Report

Heather Shona McDougall

The University of Warwick

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Abstract

Manufacturing matters. It matters because of the economic contribution it provides in terms of wealth generation, employment and exports.

The manufacturing industry in the United Kingdom can be strengthened. The opportunity for improvement includes closing the productivity gap between other countries, encouraging innovation and developing the skills of the workforce, in order to be globally competitive, drive growth and to help reduce the trade deficit. Critical to exploiting these opportunities, and to the success of the industry, is the adoption of best practice.

Existing support for manufacturing improvement can be costly, difficult to access or dependent on input from external experts. This support therefore is not readily accessible to every manufacturing company. There are also a number of quality and performance awards available, however these are predominantly focused on recognising success rather than on how this success can be attained. This research fulfils the gap by providing widely accessible support for manufacturing companies that is focused on helping them to improve. The support provided helps companies to identify and adopt relevant best practices.

This research work adapted a product evaluation framework to develop MX Start, a process that supports manufacturing companies to start their improvement journey towards manufacturing excellence. MX Start was developed following a review of the definition of Manufacturing Excellence, a needs assessment of the opportunity, analysis of best practice dissemination strategies, comparative analysis of existing tools and a review of effective self assessment and feedback principles. MX Start provides an easy to use, free of charge, web based system that facilitates manufacturing companies to start their excellence journey. It enables manufacturers to benchmark themselves against best practice in order to gain a greater understanding of what excellence entails, and to enable improvement areas to be identified. This is then supported with a report that helps companies to prioritise the improvement opportunities and provides feedback to then help them make these improvements.

The combination of the free of charge, widely accessible, self-directed system that is solely concerned with supporting and encouraging companies to improve, is the basis of the innovation of this work.

MX Start has demonstrated impact to the manufacturing industry through a pilot and on-going work with the Manufacturing Advisory Service (MAS). As part of the pilot, over two hundred companies used the process to conduct diagnostic activities to define areas for improvement, and identify where and how they could implement best practices. As a result, MAS in the West Midlands have adopted the tool and supported further developments of this research. This has increased the opportunity for MX Start to help companies progress on their excellence journey and therefore, help support the manufacturing industry to improve.

An evaluation of MX Start by companies and manufacturing experts, found that the tool was easy to understand and use, and that it helped companies to identify, and be motivated, to make improvements.

The web based system lends itself to further development. In addition to the assessment and report elements of MX Start, the website contains a resource library. The resources contain more information and guidance. The opportunity for the future is to expand this library and build a comprehensive database of support. This would increase the ability of MX Start to support manufacturers to exploit the improvement opportunities to strengthen the competitiveness of the manufacturing industry.

Acknowledgements

This work has been my own personal improvement journey and one that I could not have progressed along without the support of those around me.

I would like to thank Dr John Garside for all his hard work and support. His enthusiasm and passion for supporting manufacturing has been a continued source of motivation throughout my EngD and will be an inspiration as I progress in my career.

This work would not have been possible without the support and patience Dr Kevin Neailey, whose wise words will always stay with me.

I also wish to thank Dr Jay Bal for challenging me to think differently and providing guidance throughout this work.

I am grateful to the Engineering and Physical Sciences Research Council and The Institution of Mechanical Engineers (IMechE) for sponsoring this research. I am proud of the opportunity to have been part of the Manufacturing Excellence Awards and appreciate all the support provided over the last five years by Paul Terry, Hazel Morgan and Rachel Pearson.

The extensive testing and feedback of MX Start by manufacturing companies would not have been possible without the support of the Manufacturing Advisory Service in the West Midlands. In particular I would like to thank Simon Griffiths, Iain Robertson and Peter Arnott who championed MX Start.

Thank you also to Mohammad, without his determination and hard work, MXStart.co.uk would not have been possible.

The moral support of my Mum, Dad, and sister Kirsty, has been so important to me during my EngD and I must also thank all my friends who have been there for me along the way.

Finally, a big thank you to Chris, whose unwavering support has enabled me to get this far.

Declaration

The work presented in this document is entirely my own. All published work and sources have been acknowledged. This work has not been submitted or presented in any previous application for a degree or award.

Signed: Heather McDougall

Statement of Contributions

MX Start is the output of this research. The self-directed approach of MX Start was designed and developed by the author. During this research, MX Start matured and evolved from a self-directed approach to also incorporating a knowledge network and facilitated transfer. To achieve this development, in addition to the author's main body of work, contributions were made by others.

The significant contributions made by the author to MX Start are described throughout this document and are summarised below:

- Designing the assessment and feedback model for MX Start
- Redefining the definition of Manufacturing Excellence (as set out by the Manufacturing Excellence Awards) for the purpose of formative assessment
- Writing the questions statements and multiple choice answers that make up the assessment element of MX Start
- Writing the feedback statements with John Garside, following the principles set out by the author
- Designing the MX Start website and generating all content (except for the Best Practice Guides as explained below)
- Training the Manufacturing Advisory Service advisors to use MX Start

The specific contributions made by others are outlined below:

John Garside and Judy Walton wrote the Best Practice Guides which form part of the Resource Library of MX Start. The Best Practice Guides supplement the core assessment and feedback modules of MX Start. These guides align with the each section of MX Start and build on the feedback statements. This external input provided credibility to this extended feedback due to the extensive industrial knowledge and experience of Garside and Walton.

The Manufacturing Advisory Service in the West Midlands contributed by supporting the pilot and adopting MX Start. This included the advisors using MX Start on company visits,

collecting feedback to validate the content and process, and identifying improvement opportunities. This feedback was then used by the author to drive improvements.

The website was developed by the author using a content management system, DotNetNuke and through purchasing modules to achieve the required functionality. The available modules could not fully produce the graphs needed to display the results of the assessments and enable companies to understand how they compared against best practice. Mohammad Nabavieh contributed coding and technical expertise to develop the assessment and feedback module to produce these graphs and also improve the user interface. The author set out the objectives and project managed the implementation of this technical work.

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Abbreviations

AEA	American Evaluation Association
BDO	Audit, accounting and business services firm
BIS	Department for Business, Innovation and Skills
CIPP (evaluation model)	Context-Input-Process-Product
Civitas	Institution for the Study of Civil Society
EFQM	Formally known as the European Foundation for Quality Management
G8	Group of eight industrialised nations (Canada, France, Germany, Italy, Japan, Russia, UK and US)
GVA	Gross Value Added
IfM	Institute for Manufacturing
IMechE	Institution of Mechanical Engineers
ISIC	International Standard for Industrial Classification
JCEE	Joint Committee of Education Evaluation
MAS	Manufacturing Advisory Service
MAS-WM	Manufacturing Advisory Service – West Midlands
MBNQA	Malcolm Baldrige National Quality Award
MX	Manufacturing Excellence
MX Awards	Manufacturing Excellence Awards
MX Start	MX Start is the output of this research work
OECD	Organisation for Economic Co-operation and Development
OED	Oxford English Dictionary
OEI	Operational Effectiveness Index
ONS	Office for National Statistics

SME	Small to Medium sized enterprise
WCM	World-class manufacturing

1 Introduction

The manufacturing industry matters to the economy because of the number of people it employs, the wealth it generates and its contribution to exports. This research identified an opportunity to support the manufacturing industry to improve.

In 2009, the UK manufacturing industry was seventh in the world in terms of manufacturing output, accounting for 2.3% of the global total of manufacturing output [1, 2]. The industry employs 2.5 million people directly and contributes £139 billion in gross value added to the economy [3, 4]. Despite this contribution, the UK currently purchases more goods in imports than it sells in exports, resulting in a gap of £9.88 billion in 2009 [5]. This gap is supplemented by the surplus in the trade of services, but this is not sufficient to account for it all. This remaining gap has been funded through the sale of assets and borrowing, but this is not sustainable. To retain the standard of living in the UK, the deficit needs to be addressed. Manufacturing can be part of reducing the deficit through generating goods for export, by replacing those that are imported, or by generating new demand. There are several issues the industry must overcome to maximise this opportunity. These include reducing the productivity gap between other countries in order to be globally competitive; innovating to drive growth, and ensuring there are sufficient skills.

In 2002, the Government released the first Manufacturing Strategy for over thirty years. This strategy underlined a renewed focus on manufacturing and set out the Government's plan for supporting the industry. It identified seven critical success factors. These are provided in Appendix 1. One of these factors, best practice, is a key to this research [6]. The idea is that if companies adopt best practice, the competiveness of the UK's goods and services can be increased.

Following the 2009 recession, there has been focus on rebalancing the economy and in particular strengthening the manufacturing industry. Strengthening the manufacturing industry by supporting manufactures to identify and adopt relevant best practice in order to improve, is the aim of this research.

1.1 Background

This research work is concerned with supporting the manufacturing industry to improve through the dissemination of best practice. The inspiration for this work arises from the research sponsors, the Institution of Mechanical Engineers (IMechE,) and in particular their work on the Manufacturing Excellence (MX) Awards.

The IMechE have been operating the Manufacturing Excellence (MX) Awards for over ten years. The awards have two aims:

1. To recognise and celebrate the UK's excellent manufacturing
2. To support the manufacturing industry through the dissemination of best practice

The first aim is achieved through an annual assessment process and ceremony. The process encompasses self assessment, assessment boards, site visits and a presentation, and culminates with an awards ceremony where the winners are announced.

The second aim is met through issuing all entrants to the awards with a Feedback Report. This report outlines the scores achieved and provides guidance regarding best practice for any poorly scored areas.

The majority of companies entering the MX Awards are contenders for an award. Therefore the best practice dissemination is concentrated towards companies who already are excellent or progressing strongly towards it. The number of companies entering the awards also makes up a small percentage of the total number of manufacturing companies in the United Kingdom. This means the support provided through the MX Awards reaches a very small number of companies who are also likely to already be excellent or be approaching excellence.

Therefore the inspiration for this work centres on the second aim of the awards- that of supporting the manufacturing industry. The opportunity is to provide support to a large number

of companies and for this support to be focused on those companies in the early stages of their excellence journeys.

1.2 Research objectives

The importance of manufacturing to the economy, coupled with the opportunity for the industry to improve forms the starting point for this research work. This opportunity entails providing support to companies at any point of their journey towards manufacturing excellence and in particular, for companies at the beginning stages of their journey. Both the Government and the IMechE recognise that adoption of best practice is key to the improvement of the manufacturing industry. Therefore the focus of the support provided to the manufacturing industry should include the dissemination of best practice. The research objectives are therefore summarised as follows:

Main Objective:

To develop a tool to support UK manufacturing companies to start and progress on their journey towards manufacturing excellence

Subsidiary Objectives:

- To disseminate best practice to manufacturing companies
- To enable any and all manufacturing companies to access support
- To support companies to identify where and how they could implement best practice to achieve improvements
- To encourage companies to start and progress on their excellence journey by being a motivator for improvement

The research output (the tool developed by this research work) will be known as MX Start. 'MX' is derived from the abbreviation of Manufacturing Excellence from the MX Awards. 'Start' refers to the objective of this work to help companies start their excellence journeys.

The name of the tool therefore reflects the main objective of this work to support companies to *start* their journey towards *manufacturing excellence*.

1.3 Structure of the portfolio

The structure of the portfolio is shown in Figure 1-1 on page 6. The portfolio is made up of four individual submissions which are aligned with chapters 4-7 of this report. The fifth submission is the research output.

The arrows in Figure 1-1 indicate the recommended order in which to read the submissions. This Innovation Report provides an overview of the research as a whole, drawing all the individual submissions together. The Personal Profile outlines the development of the author during the doctorate and can be read independently of the other submissions.

Submission 1 is concerned with manufacturing excellence. The submission is divided into two parts. The first part analyses why manufacturing excellence is important and therefore identifies the opportunities for this work. The second part defines what manufacturing excellence is. This definition forms the basis of the best practice content of the support that will be provided to manufacturers.

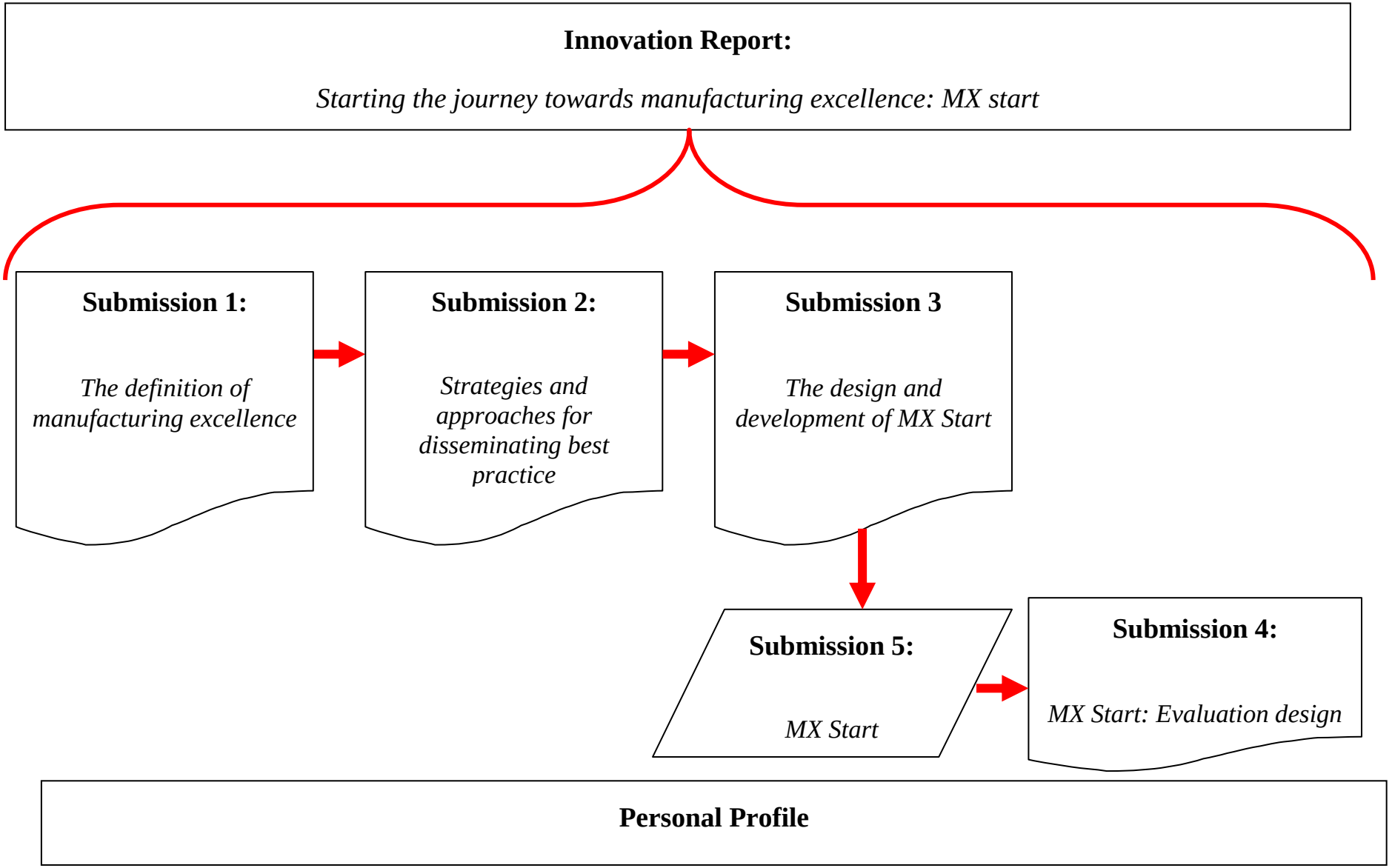
Submission 2 reviews the approaches to transfer best practice. The purpose of this submission is to select an appropriate approach to be used to provide support to the manufacturing industry. Therefore it identifies the mechanism to transfer the best practice using the content of manufacturing excellence identified in submission 1.

Submission 3 describes the design and development of the support to be provided to the manufacturing industry. The purpose of this submission is to review the principles key to the design of a support tool, and to combine this with the content and transfer approach selected from the previous two submissions.

Submission 4 outlines the evaluation approach for the support tool. The purpose of this submission is to design a method to understand whether the output of this research has met the research objective to provide support to manufacturers to help them start their journey towards excellence. This submission describes the evaluation design and presents the results.

Submission 5 is the output of this research. The output is named MX Start. MX Start is a three stage process involving self assessment, feedback reports and a resource library. It is a website. This submission provides instructions for accessing the website and provides examples of screen shots taken from it. The purpose of this submission is to demonstrate the content, process and operations of MX Start. Therefore it is intended that the website will be the predominant focus when reviewing this submission, with the document used to provide a brief overview of MX Start.

Figure 1-1 Structure of the portfolio



1.5 Structure of this report

The structure of this report is closely aligned with the structure of the portfolio.

Chapter 2 describes the research approach taken. The approach follows Stufflebeam's CIPP model, which is an abbreviation of Context-Input-Process-Product. This chapter will provide justification for selecting the approach and will give a guide to the main steps it encompasses.

Chapter 3 provides the background to this research work. This will include the inspiration and initial opportunities identified.

Chapter 4 is aligned with submission 1. It provides the background context to the research project, providing a needs assessment and a literature review of manufacturing excellence. The outcome of this aspect of the work is a definition of manufacturing excellence that forms the content of best practice.

Chapter 5 addresses the different strategies and approaches that were considered to achieve the aims and objectives of this research. This includes the differing types of benchmarking and best practice dissemination approaches. It is aligned with submission 2. The chapter concludes with the selection of an approach for supporting manufacturing companies, forming the basis of the structure of MX Start. The chapter relates to submission 2.

Chapter 6 describes the key areas of development for the research output. These areas are: the content, operations and process. It will outline the design stages of MX Start and provide an overview of the pilot.

Chapter 7 outlines the evaluation strategy for the MX Start and is based on the work of submission 4. It will also present the findings of the evaluation. The evaluation assesses whether MX Start has met the research aims and objectives.

Chapters 4 – 7 each start with an outline of the objectives and outputs of the submission. A process flow diagram is then used to provide a show to the key stages of the chapter. A word cloud will then be provided. A word cloud, which is also known as a tag cloud, is *"a visual depiction of the word content of a document and can provide a quick word-content summary of large documents"[7]*. The word cloud will therefore provide a visual representation of the keywords from the submission that the chapter is aligned with. Words that appear more frequently in the submission are shown with more predominance, such as a larger or bolder font. The word clouds have been included to provide a quick visual summary of the key themes of the submission.

The remaining chapters analyse the results further, and will reach a conclusion regarding whether MX Start has met its objectives and has provided an innovative contribution to supporting the manufacturing industry. The next steps for the development of MX Start and the emerging areas for future work will also be outlined.

1.6 Innovation

The innovation of this research is in supporting manufacturing companies to focus on how they can improve in order to progress on their journey to achieve manufacturing excellence.

There are several excellence awards and models that focus on recognising excellence. This recognition acknowledges companies who have already achieved excellence. Therefore the emphasis is on understanding what has been achieved to make a summative judgement on whether the company is excellent.

The emphasis of MX Start is to support companies to recognise where they are on their excellence journey and understand how they can progress from there in order to achieve excellence. MX Start is separated from any recognition of excellence to ensure the process is formative. Therefore it focuses not on what has been achieved, but how progress can be made towards excellence. It is this sole purpose on formative, rather summative, assessment and feedback that makes MX Start innovative.

2 Background

MX Start is the output of this research. It is a tool designed to help support UK manufacturing companies to start their journey towards manufacturing excellence. The tool enables companies to benchmark themselves against best practice as defined by the Manufacturing Excellence Awards. It then provides feedback to help companies identify the next steps for improvement.

2.1 The inspiration for this work

The sponsors of this work are the Institution of Mechanical Engineers (IMechE). The IMechE run the Manufacturing Excellence Awards (MX Awards). The awards stem from the Willis Faber Awards which were collaboration between the Institution of Electrical Engineers and the IMechE. The awards were re-launched in 2000 in order to update the awards in line with the challenges faced by the manufacturing industry today.

The MX Awards have two aims:

1. To recognise and celebrate the UK's excellent manufacturing companies
2. To support the manufacturing industry through disseminating best practice

The awards have been successful. Over fifty companies have been recognised and celebrated for their excellence at the annual awards ceremony.

Every company that participates in the awards receives a benchmark report. This report outlines the strengths and weaknesses of the company and provides feedback regarding areas where the company may benefit from the adoption of best practice.

Feedback regarding the MX Awards process is collected from the MX Award participants, the raw feedback can be found in Submission 2, Appendix 5. Table 2-1 summarises the key aspects that participants found useful. It can be seen that companies find the MX Awards

process useful for reflecting on their business and identifying improvements. In addition, the majority of companies found the benchmark report they received to be useful and a motivator for improvement in previously overlooked areas. Therefore the MX Awards process benefits those manufacturers who take part.

Table 2-1 Feedback from MX Awards participants [8]

Aspects considered to be useful
Content includes all business activities
Reflection/ thinking about the business
Promoted discussion
Helped identify improvements

The majority of companies entering the MX Awards are aiming to win an award. Therefore with respect to the two aims of the awards, there is a bias towards the recognition of excellence. As Table 2-1 shows, the process does support companies to identify improvements. However this support is only provided to those who enter the awards. Therefore the support is predominantly given to those companies who are already advanced on their excellence journey.

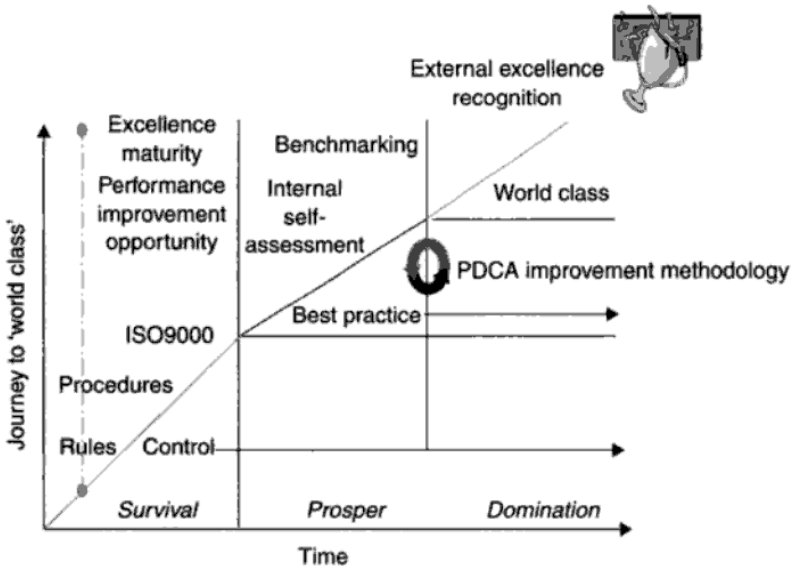
The number of companies entering the awards also makes up a small percentage of the total number of manufacturing companies. This means the support provided through the MX Awards reaches a small number of companies, who are also likely to be excellent or approaching excellence.

Whilst the awards have been successful, there is scope for the second aim, of providing support to manufacturers, to be extended to all manufacturers. The initial opportunity for this work was to extend the ability to support a greater number of manufacturing companies. In

particular, there was an opportunity to target those companies who may be discouraged from entering a competition and who are in the early phases of their journey towards excellence.

Porter and Tanner's excellence maturity model is shown in Figure 2-1 [9]. The model shows three phases on the journey to world class: survival, prosper and domination. The opportunity for this work is to target those companies in the first two phases (survival and prospering). As shown in Figure 2-1, those companies in the dominance phase can also benefit from support. Therefore those in the dominance phase will not be excluded; however they would not be the specific target user. The focus of this research therefore is to support companies to start and progress on their improvement journey.

Figure 2-1 The Excellence Maturity Model [9]



3 The research approach

The research approach taken follows Stufflebeam's CIPP model. CIPP is an acronym for Context-Input-Process-Product. CIPP "is a framework intended to guide formative and summative evaluations of projects, programs, personnel, products, institutions, and systems"[10]. Scriven describes the model as emphasising systematic processes that can incorporate the many aspects of program evaluation [11]. Cooksy et al also refer to the systematic approach to evaluation the CIPP model encourages users to take [12]. The broad applicability of the CIPP model, coupled with the flexibility and systematic approach, lends itself as an appropriate framework for this research [13].

An advantage of using the CIPP approach is that it encompasses both formative and summative evaluation, providing a comprehensive evaluation structure. Traditionally the formative aspects of evaluation in the model are used to evaluate a program already in existence [14],[15],[16]. For this research, the formative aspects are used to design a new program rather than improve an existing one. Whilst MX Start does have links to an existing program, the MX Awards, it is not an improved version of it. Instead, MX Start has been designed with a different goal, specification and target audience. The tool uses the experience and knowledge that the awards provide, to inspire and aid the MX Start decision making process. This then led to the development of a tool that complements the awards and can be used in conjunction with it, or prior to it, to provide a multifaceted approach to supporting the manufacturing industry.

Using the formative aspects of the CIPP model to design rather than improve a program, does not detract from the merits of model. Stufflebeam et al state that the model *"is based on the view the most important purpose of evaluation is not to prove, but to improve"* [13]. This holds true for MX Start. However the improvement is not for an existing program but instead the existing opportunity to improve the accessible support provided to manufacturing companies. The adaptability of the approach enables the systematic and questioning approach to be used in a way that can aid the decision making process for design, rather than its original intention of redesign.

3.1 The CIPP model for evaluation

The CIPP model for evaluation is represented by four components, Context-Input-Process-Product. The model is designed to meet the Joint Committee on Standards for Educational Evaluation by providing an organised approach to evaluation [17].

At the root of the CIPP model are the defined core values as shown in Figure 3-1. From the core values radiates out the four focal value areas of goals, plans, actions and outcome, which lead onto four evaluation types. Table 3-1 lists these evaluation types, outlining both their objectives and the methods this research used to achieve them.

The next section will outline what these core elements mean in relation to the design, development, implementation and evaluation of the output of this research.

Figure 3-1 The CIPP model for evaluation [15]

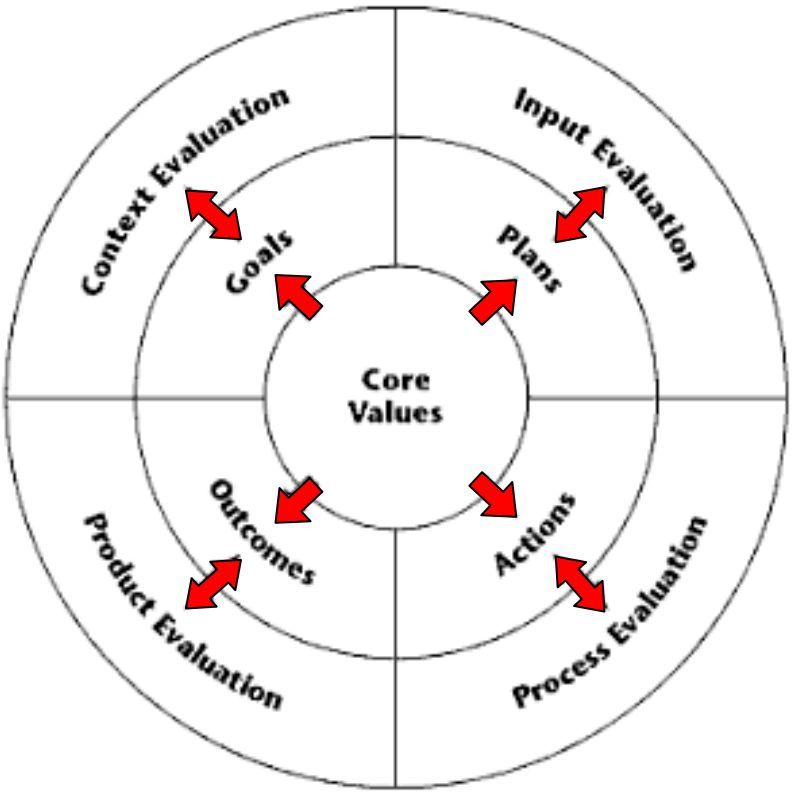


Table 3-1Types of evaluation with the CIPP model [15] and the methods used

	Objective	Methods used in this work
Context	To define the relevant context, identify the target population and assess its needs, diagnose problems, and judge whether program goals are sufficiently responsive to the assessed needs	Literature review of manufacturing excellence, comparative analysis of manufacturing excellence definitions , need assessment for the manufacturing industry
Input	To identify and assess system capabilities, alternative program strategies, procedural designs for implementing stages, budgets schedules	Literature review of best practice transfer approaches, comparative analysis of approaches, assessments of resources
Process	To identify or predict defects in the procedural design or its implementation, provide information for the decisions, and record and judge procedural events and activities	Define the design specification, test the concept, gather feedback, continuous improvement and development loop
Product	To collect descriptions and judgements of outcomes and relate them to objectives and to context, input and process information; and to interpret their merit, worth, significance and probity	Define criteria and stakeholders, data collection of judgements of outcomes from stakeholders, qualitative and quantitative analysis, assess the success of the work

3.2 Core Value

The CIPP model shown in Figure 3-1 on page 13 shows core values are at the centre of the framework. Lincoln and Guba define evaluation as:

"A type of disciplined inquiry undertaken to determine the value (merit and / or worth) of some entity – the evaluand – such as a treatment, program, facility, performance and the like – in order to improve or refine the evaluand (formative evaluation) or to assess its impact (summative evaluation)."

[18]

Therefore the concept of value is key to any evaluation. For MX Start, the core value is supporting the manufacturing industry. This value provides relatively little guidance at the beginning stages of this work beyond a generic research direction. However as the evaluation progressed and decisions were made following analysis of the information gathered, the original value was supported with more specific objectives and aims.

The methods used in the context, input, product and process evaluation will be outlined in the corresponding chapters 4 – 7. An outline of these methods is provided in sections 3.3, 3.4, 3.5 and 3.6 below.

3.3 Context

Context evaluation is concerned with examining the background and identifying the objectives of the program. This analysis can then be used to make planning decisions for the on-going work. The content evaluation can be found in chapter 4.

For MX Start, the context is manufacturing excellence. Therefore chapter 4 is concerned with what manufacturing excellence is and why it is needed. This evaluation was conducted through literature reviews.

The program planning decisions made during the context evaluation include selecting the definition of manufacturing excellence that was used in the subsequent evaluation phases and that formed the basis of the content of the research output. This definition was derived through analysing existing definitions, and identifying the key themes and concepts of the term.

The context evaluation also specified the direction and goals of the project beyond the original value of supporting manufacturing companies. This goal was to concentrate on supporting companies through dissemination of best practice. It therefore concentrates on the process of how companies can attain excellence, rather than what the content of it is.

3.3.1 Context Research Methodology

The aim of the Context chapter is to define the objectives for the on-going research. Therefore at this stage of the research, there were no definitive research objectives. In order to explore the research area of manufacturing excellence, a literature review was carried out. The aim of this literature review was to define and understand manufacturing excellence in order to identify the opportunities for the research.

To distinguish how manufacturing excellence differs from other aspects of excellence, the review spanned business, manufacturing and production excellence definitions. The definitions of excellence were taken from books, papers, awards and models in order to include both theoretical and practical definitions. The definitions were taken from 1950's – 2011. This enabled the differences to be identified to understand how excellence changed over time.

The literature review critiqued how the definitions were derived and systematically identified the key themes of each of the definitions of excellence. This enabled a comparison of the definitions to be made and the common elements to be recognised. From this analysis the most appropriate definition to be used in the research was chosen and the research direction defined.

3.4 Input

The input evaluation entails assessing the inputs and strategies for achieving the goals and then turning these into plans. Leading on from the context evaluation, the input evaluation for MX start assessed the available approaches for disseminating best practice and can be found in chapter 5. This included looking at benchmarking models and types of best practice

transfer. It was determined that a support tool would be the most appropriate method given the resource constraints and also the goal of the support to be able to be made available to any UK manufacturing company.

Existing support tools available to manufacturing companies were then benchmarked to understand their strengths and weaknesses, and identify key opportunities for developing a new tool. This led to the decision to structure the program into a two-step assessment and feedback process.

3.4.1 Input research methodology

The Context chapter identified that the opportunity for this work was focusing on how companies progress towards manufacturing excellence through the dissemination of best practice. The input research methodology began by undertaking a literature review to understand the principles of best practice transfer. The review analysed the scope of best practice dissemination, identified the spectrum of approaches available and evaluated the design considerations to be taken into account when designing a dissemination approach.

The literature review concerned the theory of best practice dissemination and identified there was a spectrum of approaches. The choice of approach is affected by the constraints of practical application. Therefore to balance the theoretical principles of best practice dissemination with practical application, a benchmark of existing dissemination approaches was carried out.

Five tools were included in the benchmarking. To understand the opportunity for MX Start, three manufacturing excellence dissemination tools were reviewed. These tools were the World Class Manufacturing Checklist, Manufacturing PROBE and the Manufacturing Excellence Awards. These three tools were chosen due to their focus on manufacturing excellence. Therefore the content was relevant to the research area and enabled the opportunities and gaps in the existing approaches to be identified. They were also chosen due

to information available in the public domain regarding the operations of the approaches, without this information the benchmark could not be carried out.

Two additional tools were included; Business Link and the EFQM Excellence model. These tools are business excellence dissemination approaches and therefore the content remains applicable, though not as specific, as the manufacturing approaches. They were chosen to be included in the review due to the scope and number of companies that each approach has involved. Business Link was nationally used and the EFQM model is used across Europe and beyond. Due to the research objective to support any manufacturing company in the UK, these tools were included to provide insight into disseminating best practice on a large scale.

A comparative analysis of the key design principles identified in the literature review included a comparison of the:

- Process for companies interacting with the tool
- Format of content
- Value for companies
- Resources required: from the participating company
- Resources required: from the entity operating the tool

There was a limitation regarding the depth of analysis that could be carried out in the benchmarking activity. The information the analysis was based upon was that which was available in the public domain. The information available was often aimed at promoting the tool and encouraging companies to use it. The exception to this was the Manufacturing Excellence Awards. The sponsor of this research, the IMechE, manages the Manufacturing Excellence Awards. Therefore the author has access to data regarding the internal operations and specific resources involved. The Manufacturing Excellence Awards could therefore be analysed in greater depth due to this access to the information.

3.5 Process

In the process evaluation for MX Start, the tool is designed and developed. A review of the principles of self assessment and feedback, coupled with expert opinion, are used to inform the design of the tool. The process evaluation can be found in chapter 6.

The process evaluation incorporates a pilot in conjunction with the Manufacturing Advisory Service in the West Midlands (MAS-WM). This allowed the tool to be developed through a Plan-Do-Check-Act cycle using feedback from key stakeholders. Stakeholder involvement is a key aspect of the CIPP model as it increases the likelihood of acceptance of the program [19].

3.5.1 Process research methodology

The outcome of the Input chapter identified self assessment and feedback as key elements required in the dissemination of manufacturing excellence. In order to understand the theoretical principles needed in the design of a self assessment and feedback approach, a literature review was carried out. More information can be found about this review in Chapter 6.4. A conclusion of this review was that MX Start required a formative assessment style with facilitative feedback in order to achieve the research objective to support manufacturing companies to progress on their excellence journey.

To achieve a formative assessment with accompanying facilitative feedback, the definition of manufacturing excellence needed to be altered. The elements that needed to be reconsidered were:

1. Refining the content into a simpler and less time consuming format
2. Realigning the content for companies in the beginning phases of their manufacturing excellence journey

The definition of manufacturing excellence as defined by the Manufacturing Excellence Awards (MX Awards) consisted of 185 open ended questions and best practice answers. The Content chapter identified that the definition of excellence is considered to be subjective and can depend on aspects such as the industry, maturity, operating conditions and company size.

Due to the dynamic nature of the definition, external experts were involved in the refinement of the content to ensure it remained relevant and up to date across the manufacturing industry.

A qualitative or quantitative approach could be used for the refinement.

3.5.1.1 Quantitative approach

A quantitative approach would entail asking a large sample of experts to select the content most relevant to those in the beginning stages of their journey towards excellence. The content could then be generalised from this sample of experts, based on a statistical analysis of the responses.

The benefits of a quantitative approach include reducing the opportunity for bias in the definition. This would be beneficial due to the high degree of subjectivity that is associated with defining manufacturing excellence.

The sponsors of this research are the Institution of Mechanical Engineers (IMechE). Through the IMechE, a number of experts that are members and also those involved in the Manufacturing Excellence Awards as assessors, sponsors and partners could be reached. Therefore gaining access to a large number of experts required for the statistical analysis would not be a barrier to this method.

A disadvantage of the quantitative technique is the risk that due to the subjectivity of the definition, a consensus for which content should be included in the simplification might not be reached. Therefore a narrowing of the definition might not be achieved.

The main disadvantage would be in the conclusive nature of a quantitative approach. The results from this approach would classify the content, but would not explore the reasons for the choices made. The next stage of the research required the refined content to be realigned to be formative and facilitative. A quantitative would provide no insight into why the content was chosen, and therefore would provide little guidance in how the content could be realigned. A qualitative approach was therefore preferred over a quantitative method due to

the formative and facilitative realignment of the content being key to achieving the research objective.

3.5.1.2 Qualitative approach

A qualitative approach was chosen due to the ability to explore the reasons behind the choice of content. This would enable a more informed approach for realigning this content to support companies to improve and progress towards manufacturing excellence.

The qualitative approach chosen was a focus group. This group was facilitated by the author.

A focus group was chosen over other approaches such as interviews, due to the interaction and debate among the group participants. This enabled the group to discuss and reach a consensus of the content. The exchange of opinions also meant the participants had to justify their choices. This justification helped to mitigate any subjective bias in the content selection.

The focus group was made up of five participants. Three experts were from the Manufacturing Advisory Service (MAS). MAS were a partner of the MX Awards and therefore were familiar with the content. MAS formed part of the Governments best practice support as part of the 2002 Manufacturing Strategy [6]. The remit of MAS was to provide advice for manufacturing small to medium sized enterprises (SMEs) to diagnose problems and identify opportunities [6]. The UK manufacturing industry is made up of 99.5% SME's [20]. Therefore the knowledge and expertise of the MAS advisors regarding a large proportion of the UK manufacturing industry meant they could provide valuable insight into the content that would be most applicable for MX Start. The advisors also work across all aspects of the manufacturing industry therefore reducing any bias for a particular sector.

The remaining two experts were lead assessors from the Manufacturing Excellence Awards. These experts could provide in-depth knowledge of the assessment process and content, as well as over five years' experience of assessing companies. This expertise provided guidance

to separate those questions that form the basic elements of best practice from those that were targeted at differentiating excellent companies.

The purpose of the panel was to discuss and debate the questions of the MX Awards and identify those which are important for companies at the early stages of their journey towards manufacturing excellence. The outcome of the process reduced the questions down to seventy eight.

3.5.2 Realigning the content

The next step in the research was to realign the simplified content into a formative assessment with facilitative feedback. The design principles for realigning the content were derived from the literature review of self assessment and feedback.

The author carried out this realignment using the knowledge gained from the literature reviews of submission 1 and 2, and the design principles derived from the review in submission 3. The author carried out this realignment in order to provide consistency to MX Start.

To realign the content, each of the seventy eight questions selected by the focus group was reviewed. The content of the question and accompanying best practice answer was broken down into the key component parts. Each component was then phrased as a statement, accompanied by between two and five multi choice answers. More information regarding this process can be found in section 6.5. This process realigned the seventy eight questions and best practice answers, into one hundred and sixty question statement, and five hundred and twenty five multiple choice answers. The pilot conducted with MAS then validated this content.

3.6 Product

For MX Start, the product evaluation will encompass determining the outcomes of the tool. In particularly this will include whether it met the intended goals and what the outcomes of the tool and its use are.

This evaluation helps the stakeholders of the research to make decisions regarding the continuation of the work, including the future opportunities for the website and building on the visions discussed in chapter 8.

For MX Start, the formative stages are conducted during the context and input evaluations. It is here that the guiding decisions were made to direct the approach and structure of the tool. The process and product evaluation are a combination of both summative and formative assessment to understand the effectiveness of MX Start, in order to determine its worth and also identify improvements and opportunities for further work.

3.6.1 Product research methodology

The Product chapter evaluates the program MX Start. English et al outline three design frameworks for carrying out program evaluation:

1. Experimental and quasi-experimental
2. Ex post facto
3. Survey and naturalistic

[21]

Experimental and quasi-experimental frameworks were not appropriate for the evaluation of MX Start. The users of MX Start are self-selecting manufacturing companies. Therefore there was not sufficient control over where, when, how and to whom the tool is administered to in order to use this approach.

An ex post facto approach is also unsuitable. Kowalski explains that a key feature of the ex post facto approach is its comparative nature, where the results of a program are compared with previous results [22]. This would be the most desirable approach to fully understand the impact MX Start has had on a company. However the improvements MX Start encourages may require a number of months or strategic changes to implement. There was not sufficient time available to feasibly carry out this approach of evaluation.

Thus survey and naturalistic approaches were the most appropriate for evaluating MX Start. Within this approach, a mixture of quantitative and qualitative methods was used. Quantitative methods were used to evaluate the extent to which MX Start has met its original goals and qualitative methods used to understand the company impacts and areas to further development and improvement.

3.6.2 Data collection methods

The four main methods of data collection are: questionnaires, interviews, observation, and unobtrusive methods.

Unobtrusive methods were disregarded as an appropriate approach for the evaluation. These methods gather data without the knowledge of the participants [23]. The evaluation of MX Start could not be completed without collecting data regarding the perceptions, outcomes and impacts from the stakeholders.

Observational research involves *"the systematic viewing of people's actions and the recording and interpretation of their behaviour"* [24]. This type of data collection was not appropriate for the evaluation of MX Start. Firstly, the evaluation of MX Start had to be carried out retrospectively. Secondly, observing the processes and behaviour of the stakeholders would not provide data regarding the extent to which MX Start has met its goals, outputs and impacts.

The evaluation of MX Start was carried out by questionnaires. The advantage of questionnaires over interviews was the ability for them to be anonymous. The research and development of MX Start led to the author spending a significant amount time of time with some of the key stakeholders who took part in the evaluation. Anonymity was therefore required to mitigate any bias and promote candidness in the evaluation responses.

The anonymity provided by the questionnaire also prevented participants from being linked back to their MX Start results. A key factor to MX Start achieving its objective is companies completing the assessment for formative, not summative, purposes. Without anonymity in evaluating MX Start, companies may have felt the purpose was summative and therefore that they were being judged on their results. This could have introduced bias and altered the perceptions of the participants.

The limitations of using self-administered questionnaires was the lack of opportunity to probe the perspectives of the participants beyond the original question asked and the inability to provide clarity for any ambiguity. Open questions were used in the questionnaire to allow participants to expand on their answers, but this limitation was the accepted trade-off for anonymity.

4 Context; *defining the need and goals*

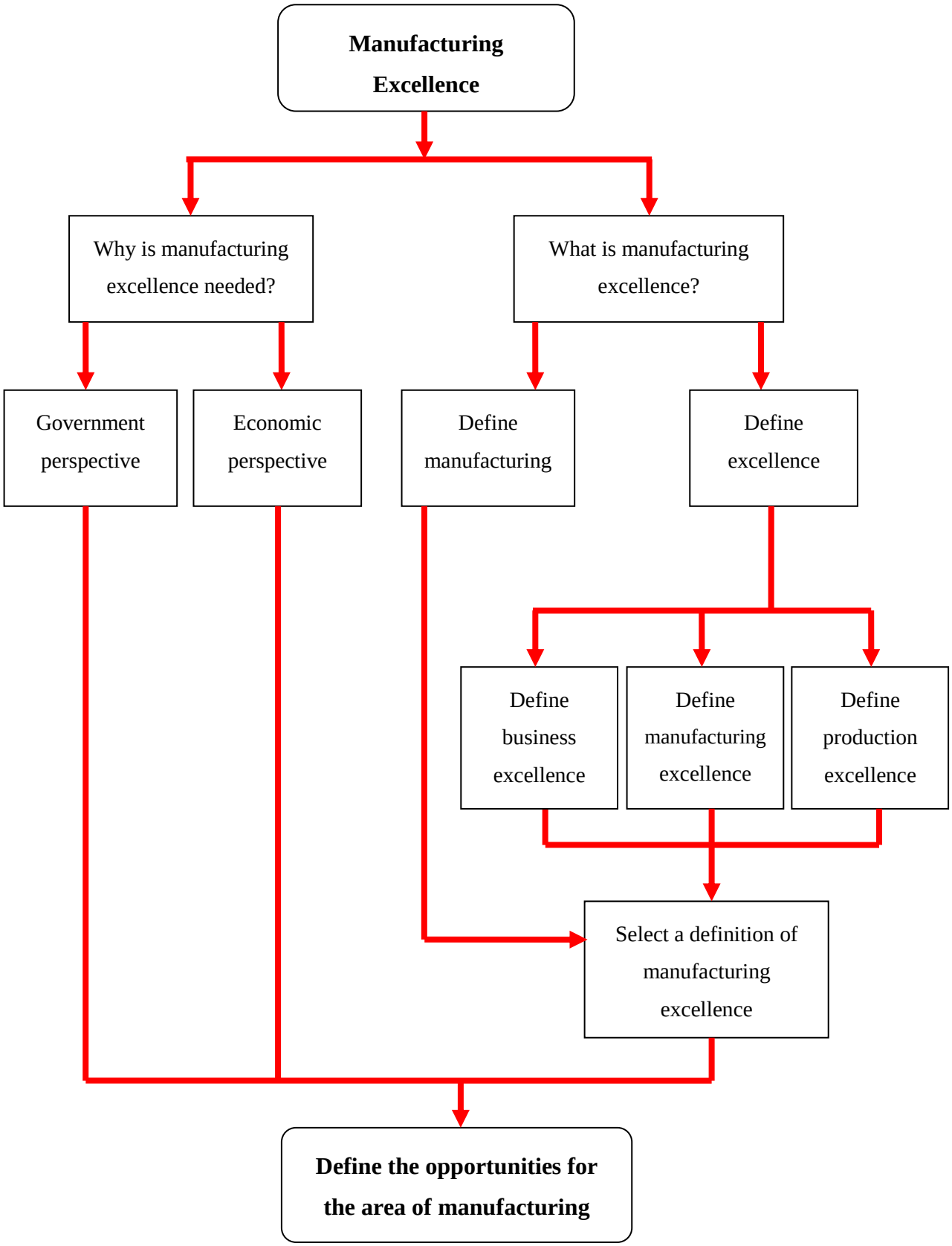
Objectives:

- To understand the need for manufacturing excellence
- To define manufacturing excellence
- To assess the needs and opportunities within the field of manufacturing excellence

Outputs:

- Literature review of the definitions of manufacturing excellence
- Selection of the definition of manufacturing excellence to be used throughout this research portfolio
- Recommendations for the scope and opportunity for this research

4.1 Flow chart of the approach taken in Submission 1: The definition of manufacturing excellence



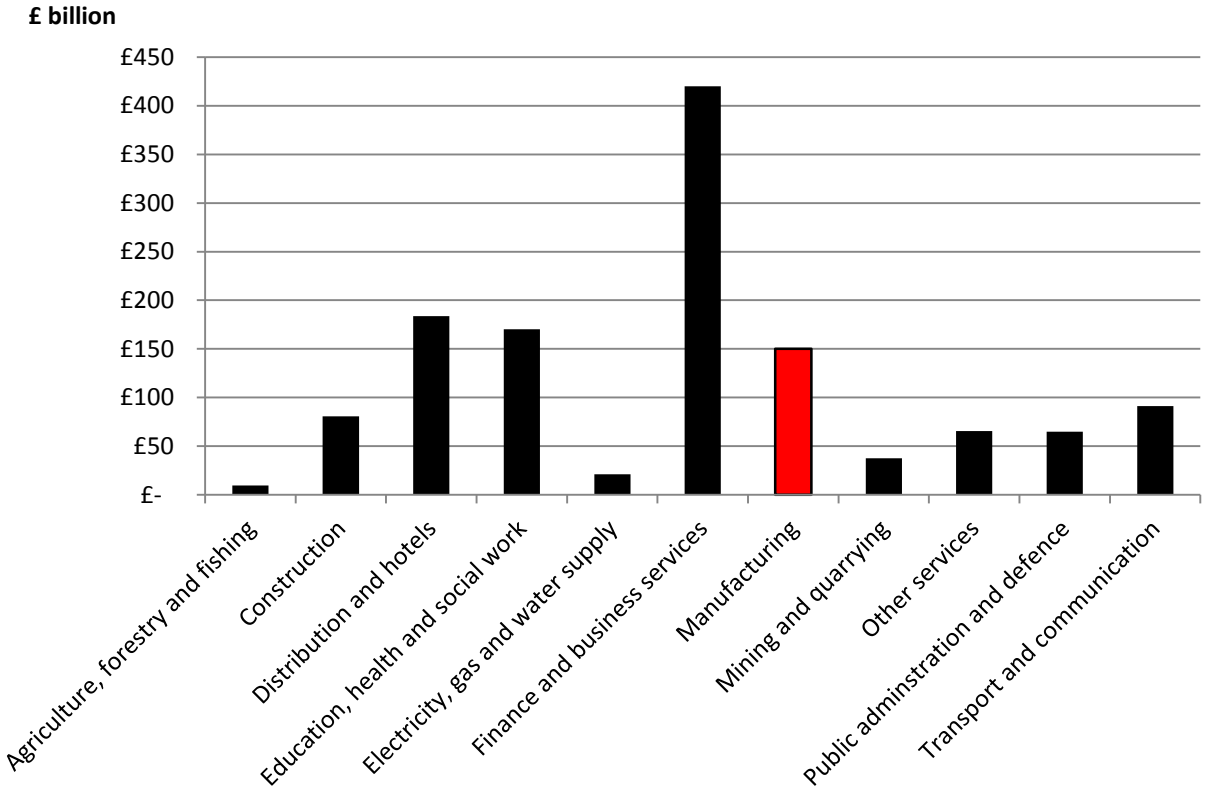
4.2 Word cloud of the key themes from Submission 1: The definition of manufacturing excellence

4.3 The UK's manufacturing industry

The section will analyse key performance metrics of the manufacturing industry, in order to determine its importance.

The manufacturing industry manufacturing industry contributes 12% of the total gross value added in the UK, as demonstrated by Figure 4-1 [5]. This contribution is worth £150 billion and therefore means that manufacturing is the fourth biggest contributor to the economy.

Figure 4-1 Gross value added at basic prices, 2008 [5]



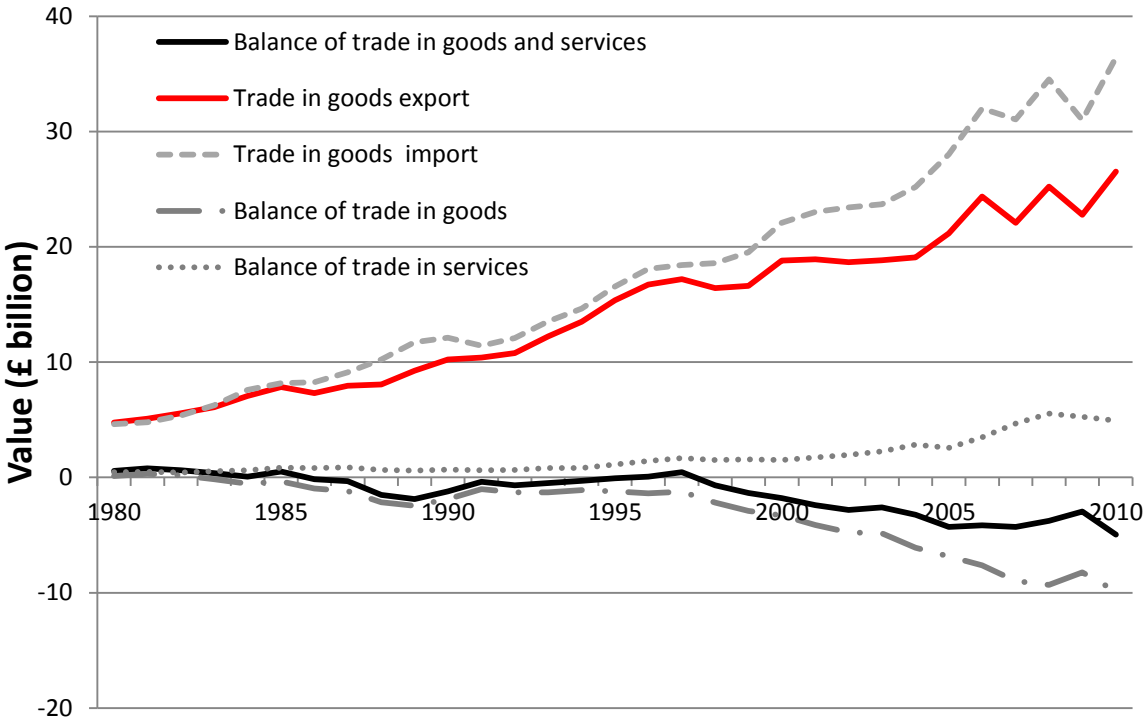
In addition to the monetary contribution, the manufacturing industry also directly employs 2.5 million people, 8% of the total employed in the UK [3]. It is not only the amount of employment manufacturing accounts for that is important, but also where this employment is based. The industry employs 2.8% of the total workforce in London, however it employs over 10% of the total workforce in the North East, Yorkshire and The Humber, East

Midlands, West Midlands and Wales [25], [26]. Therefore it has a significant impact on regional employment in the UK.

The manufacturing industry is also important because of its contribution to the trade balance. The trade balance is *"the balance between exports and imports of goods and services"* [27]. Figure 4-2 shows the UK trade in goods and services. It can be seen that since 1998 there has been an increasing trade deficit. There is a trade deficit in goods and a surplus in services. This surplus is not enough to cover the trade deficit of goods, which has resulted in the negative overall trade balance of goods and services.

In 2010, manufacturing contributed 46% of the UK's export [25]. Thus, manufacturing disproportionately contributes to exports, compared with the contribution the industry makes to national gross value added.

Figure 4-2 Values of UK trade in goods and services (1980 - 2010) [28]



The 2010 Deloitte report on the Global Manufacturing Competiveness Index reiterates the importance of manufacturing in terms of its contribution to the economy and states:

> *"There is no doubt that the competitiveness of a country's manufacturing sector is critical to its long-term economic prosperity and growth. A globally competitive manufacturing sector creates a sustainable economic ecosystem, encourages domestic and foreign investment, and improves a country's balance of payments. It creates good jobs—not just within the sector but spilling over into such areas financial services, infrastructure development and maintenance customer support logistics .information systems, healthcare, education and training and real estate."*
>
> *[29]*

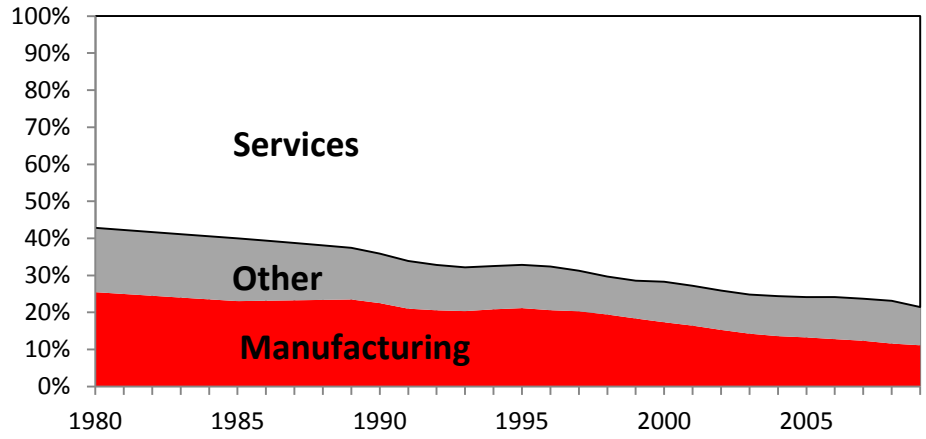
The Deloitte quote above does not single out the importance of manufacturing to a particular country, region or continent. Instead it is a quote designed to be applicable to any country, indicating that manufacturing is universally important to any economy. The report goes beyond the pure economic arguments set out earlier, suggesting that the manufacturing industry is not only vital for the 2.5 million directly employed by manufacturing in the UK but also for indirect jobs in other industries that are required, such as those that support and service manufacturing [29]. The Confederation of British Industry (CBI) is quoted as having estimated the indirect employment that is dependent on the manufacturing industry is a further 3 million [30].

4.3.1 Manufacturing trends

The data so far has focused on isolated key figures of how the manufacturing industry contributes to the UK economy. However by looking at the trends of the contribution manufacturing makes, the industry can be considered to be declining.

The percentage contribution manufacturing makes to the gross value added in the UK is declining as shown in Figure 4-3. Therefore when analysing the economy as a whole, the manufacturing industry has a reducing role, with services being the main and increasing contributor.

Figure 4-3 Percentage of UK Gross Value Added (1980 – 2009) [4]



Similarly, analysing the trend of manufacturing employment shows that the number of people employed in the industry is declining, Figure 4-4, and its contribution to overall employment has also been reducing, Figure 4-5.

Figure 4-4 UK Workforce jobs (1980 – 2010) [3]

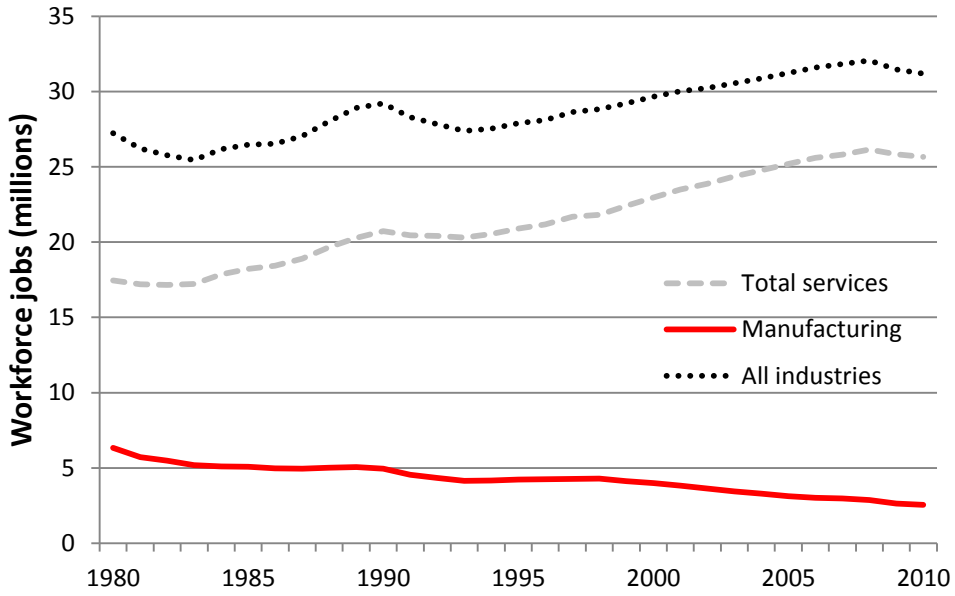
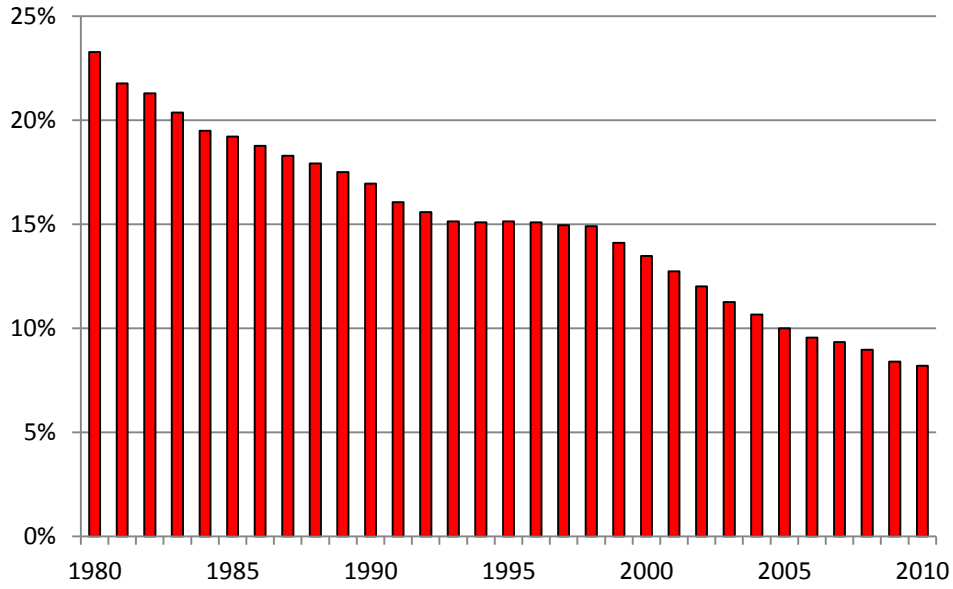
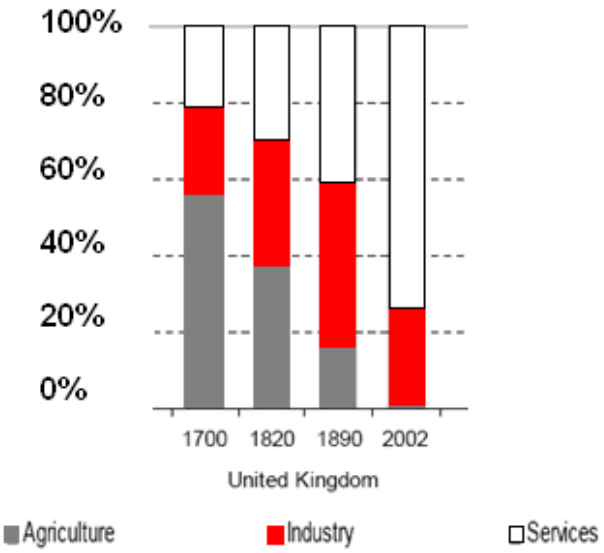


Figure 4-5 UK Manufacturing Employment as a percentage of Total Employment (1980-2010) [3]



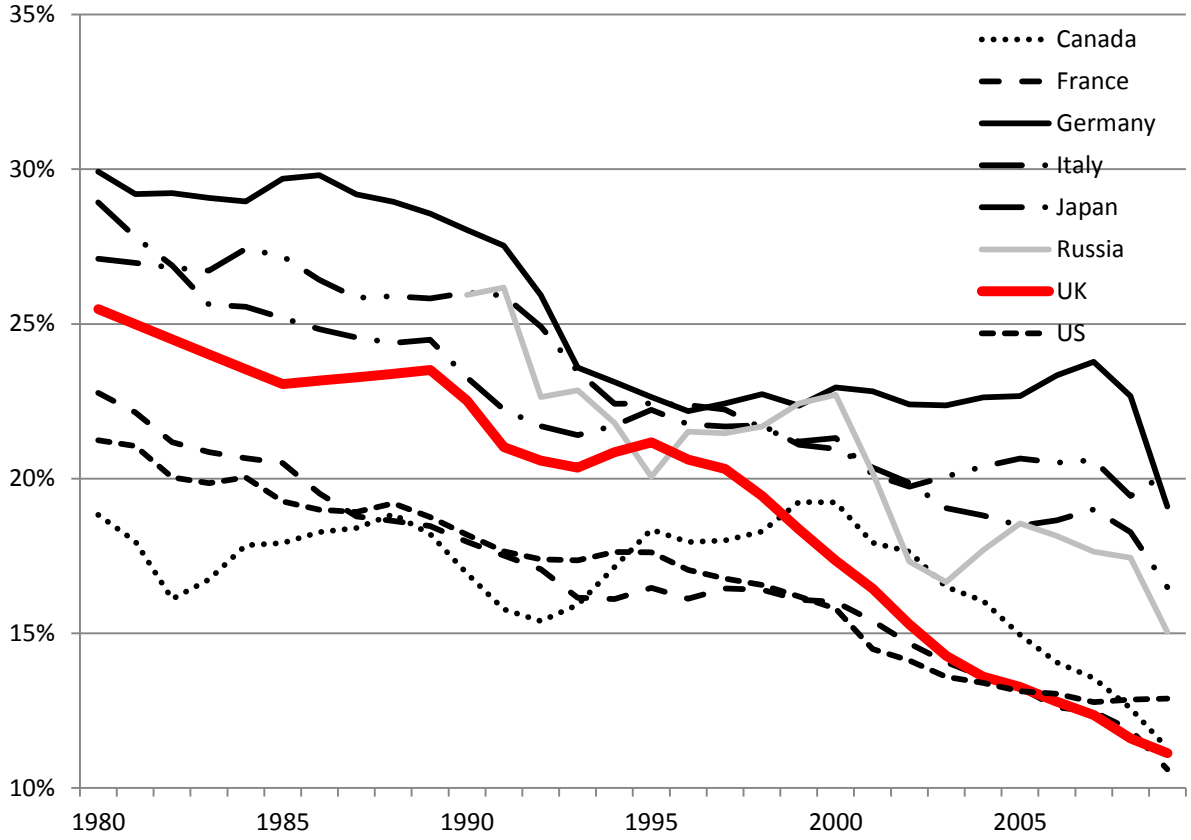
Pilat et al, in their paper "The Changing Nature of Manufacturing in OECD Economies" believe that declining manufacturing trends are a characteristic of an industrialised country's economic development [31]. Figure 4-6 shows the change in the percentage share of employment of the main economic activities making up the UK economy in four periods between the years 1700 - 2002. It can be seen that in the initial stages of economic development, agriculture accounted for the majority of employment. As the economy developed, the share of employment in services and industry increased and agriculture began to decline. In 1890, industry and services employ similar proportions. By the year 2002, agriculture accounts for a relatively small percentage, industry has declined and services employ the overall majority. From the Figure 4-4 it could be seen that the contribution of the manufacturing industry to the UK's total employment continues to decline.

Figure 4-6 Percentage share of main activities in employment in the UK economy (1700-2002) [31]



The decreasing percentage of employment provided by the manufacturing sector is not isolated to the UK economy. Pilat et al showed that all the Group of Eight (G8) industrialised nations have experienced a declining trend in the share of manufacturing employment of total employment [31]. The UK is also not alone in the declining contribution of manufacturing to the total gross value added. Figure 4-7 shows that the G8 industrialised nations have also experienced a decline. Therefore, these declining trends seen in UK manufacturing are not exceptional cases and may be a sign of a post industrial era where the economy is based upon services.

Figure 4-7 Percentage value added by manufacturing to G8 countries total GVA (1980 – 2009) [32]



4.3.2 Analysing manufacturing performance metrics

Analysing the performance indicators of manufacturing presents a conflicting picture. Examining the trends shows the industry to be contributing less in terms of employment and percentage of gross value added. However despite this decline, the manufacturing industry still makes a significant contribution to employment, gross value added and exports.

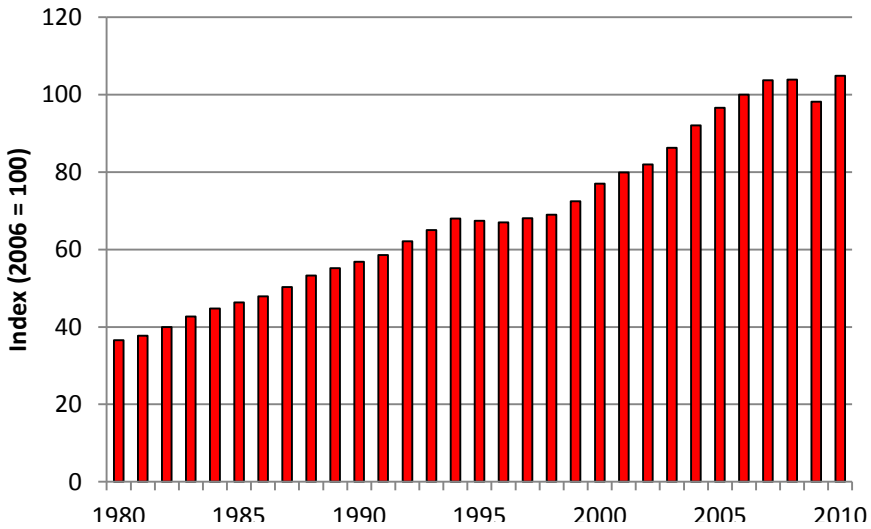
The decline of manufacturing's contribution to employment and gross value added could be taken as a decline of the industry's importance. However, the balance of payments is a compelling argument for the need for the manufacturing industry. Figure 4-2 on page 30 showed that the UK is spending more on imports than can be paid for through exports of trade and services. An ERA Foundation report found the UK was funding this deficit by taking on additional debt and the selling of assets [33]. This presents a problem. If the deficit continues, then extra cash and the continuation of asset sales will be needed to sustain it. However, *"the selling of long term assets to finance short term consumption cannot be a*

stable basis of the UK economy"[33]. The manufacturing industry's decline is a significant issue. Accounting for 46% of exports, a further decline could have a further detrimental impact on the trade balance. For the UK economy to become more sustainable an increase in exports is desirable and manufacturing could be a key contributor to this.

The declining trends of manufacturing are not an indication of a decline in the industry. Pilat offers the explanation that the manufacturing industry is subject to price effects and high growth in productivity, compared with the service sector [31]. Therefore, as the prices of manufacturing products tend to increase slowly compared with services which tend to increase more strongly, this contributes to the decline in manufacturing's GVA.

Manufacturing is also subject to productivity increases. Figure 4-8 shows the manufacturing productivity index (output per job) from the years 1980 to 2010. It can be seen there is an overall increasing trend. As productivity increases, there is more output per person. Therefore to produce the same amount, fewer people are required. This could be a contributory factor to the declining trend in employment.

Figure 4-8 UK Manufacturing: Output per job (1980 - 2009) [4]



4.4 The Government's position on manufacturing

In 2002, the Government released the first manufacturing strategy for over thirty years. Recognising the difficult trading conditions, the strategy set out the importance of manufacturing to the UK and the goals for the future of the industry.

The strategy confirms the importance of manufacturing to the economy as discussed previously. The strategy believes that *"the challenge for manufacturing in Britain is for more companies to match the performance of the best"* [6].

The strategy confirms the importance of manufacturing to the economy as discussed in 4.3, and outlines concerning factors such as the decline in output and the productivity gap, particularly in the US, France and Germany [6]. As Table 4-1 shows, in 2009, the UK ranked 34th in the global standings for manufacturing GVA per head [2]. The UK has the lowest ranking out of the G8 countries except Russia. The strategy outlines the productivity gap as a key opportunity for the UK's manufacturing industry. If the gap is reduced, this could increase the competitiveness of UK manufacturing.

Table 4-1 Comparisons of the rank of G8 countries for manufacturing gross value added by head [2]

Country	**Manufacturing gross value added per head (2009) Rank**
Canada	25
France	27
Germany	12
Italy	22
Japan	6
Russia	69
UK	34
US	18

In order to tackle the productivity gap, the strategy set out seven pillars necessary for success in manufacturing; the pillars are shown in Appendix 1. These pillars are centred on what the Government can do to help the UK manufacturing industry. However there are several pillars that companies can directly influence themselves including investment, science and innovation, best practices, and skills and education. The strategy states: *"the challenge for manufacturing in Britain is for more companies to match the performance of the best"* [34]. It is this challenge that MX Start aims to support through providing a mechanism for companies to understand best practices and identify improvement opportunities in areas including investing, innovation, skills and education.

4.4.1 Updates to the Manufacturing Strategy

In 2004, a review of the Government's Manufacturing Strategy took place. In the two years since the initial strategy was launched, manufacturing had seen a 10% decrease in the employment within the sector and a decline of 3.8% in contribution to total UK exports [35].

This review maintained that the 2002 strategy was still the correct way forward. The updated strategy introduced a forty-two point action plan in eight priority areas to complement the seven pillars previously defined. Whereas the seven pillars set out success factors, the priority areas set out the actions needed to be taken to strengthen the pillars.

In September 2008, a new manufacturing strategy was published by the Department for Business, Enterprise and Regulatory Reform. The strategy, called 'Manufacturing: New Opportunities, New Challenges' maintained manufacturing was vital to the economy. The strategy stated that manufacturing is a success story of the UK economy, and improvements since the initial strategy include closing the productivity gap between the UK's major competition [36]. The 2008 strategy maintained that the seven pillars remain the basis of Government support. The 2008 strategy stated that the global slowdown presented a challenge to manufacturing and as a result, the Government continued to be committed to helping manufacturing companies prevail.

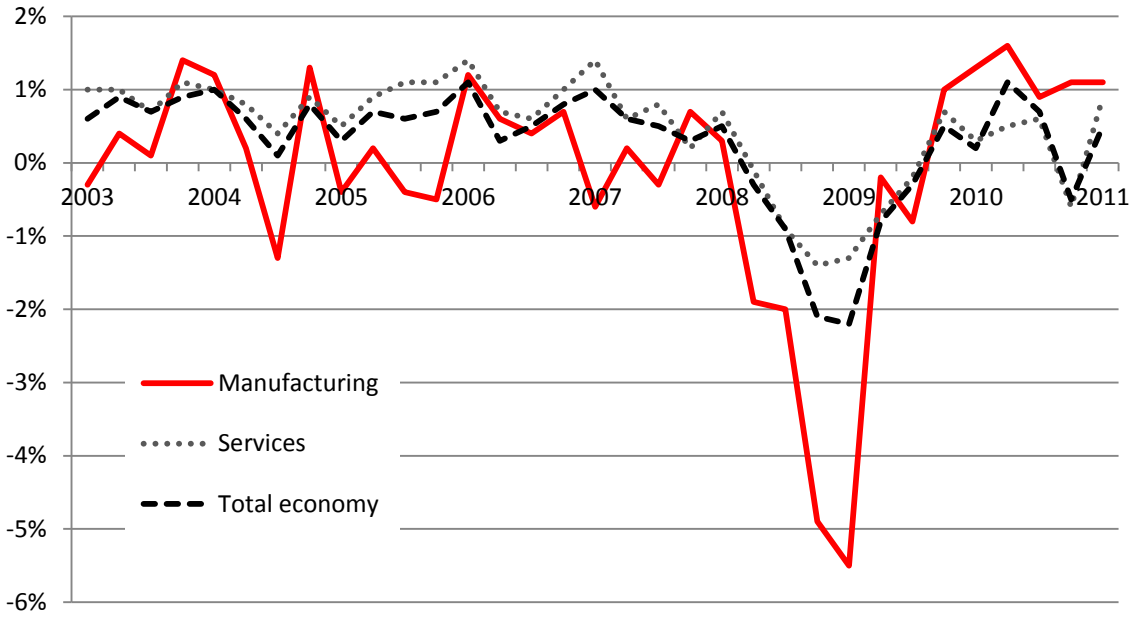
Throughout the manufacturing strategies, the Government's focus on the manufacturing industry is directed at what it calls 'Advanced manufacturing'. It is defined as *"businesses which use a high level of design or scientific skills to produce technologically complex products and processes"* [37]. Thus, it is the high value adding, highly skilled manufacturing, which the Government see as the UK's opportunity for competitive advantage against low-cost competition. In particular, the 2008 Manufacturing Strategy identifies high value components in high technology manufacturing and low carbon manufacturing solutions as key opportunity areas [38].

The publication of not one but three manufacturing strategies within a period of six years, highlights how important the Government considers the manufacturing industry to be to the UK. Since the last strategy was published, the economy has suffered a recession and as a result a renewed focus on manufacturing has occurred.

4.4.2 Rebalancing the economy

The world has changed since the first submission of this work was written. The UK has experienced and emerged from a recession, in which the economy shrunk for six consecutive periods [39]. The recession was particularly hard for the manufacturing industry as demonstrated by Figure 4-9, where the manufacturing industry can be seen to decline more dramatically than services and the total economy between 2008 and 2009.

Figure 4-9 UK growth rates from 2003-2011 (percentage change on previous year) [4]



Despite the severe decline, manufacturing can be seen to rebound more quickly than services and the economy as a whole in the recovery following the 2009 recession. Significant weight has been given to manufacturing leading the recovery and manufacturing exports being key to sustaining it [40-44]. There are barriers to an export led growth in manufacturing including availability of credit and growth in international overseas demand [42], however there is an opportunity and even a need for UK manufacturing to increase exports to create a more sustainable economy further confirming the need of manufacturing to the UK.

In May 2010, the UK elected a new government [45]. With this new government, there is a new focus on rebalancing the economy:

> *"This is my first major speech as Prime Minister – and I am going to address the first priority of this government: transforming our economy…….Our economy has become more and more unbalanced, with our fortunes hitched to a few industries in one corner of the country, while we let other sectors like manufacturing slide."*

[46]

Therefore a target of the new Government is to rebalance the economy in terms of the spread across industries. The banking crisis and the financial turmoil caused as a result are cited as

the cause of the 2009 recession [47-49]. In Figure 4-1 on page 29, it can be seen that Financial and Business Services contribute 32 % of the UK's GVA. This reliance on the financial service industry has prompted the re-evaluation of the balance of the economy after the recession and a renewed focus on manufacturing.

The renewed focus on manufacturing comes at a time of Government spending cuts in order to help reduce the deficit. On average, 19% will be cut from each budget, which could impact the manufacturing support available to manufacturers [50]. A planned Manufacturing Framework was due in 2010, but this was cancelled and replaced with a Growth Review. This review targets six areas for growth with advanced manufacturing being one of them. The goals outlined by the Advanced Manufacturing Review are:

1) Growth in UK manufacturing
2) Making the UK Europe's leading exporter of high value goods and related services
3) Increase the proportion of the workforce seeking and capable of, a career in manufacturing

[51]

The review continues to focus on manufacturing productivity as a key improvement area in order to meet the goals set out above.

4.5 The opportunity for MX Start

In 2002, the Government stated that *"the challenge for manufacturing in Britain is for more companies to match the performance of the best"* and a critical success factor to the industry is the adoption of manufacturing best practices in order to raise productivity [34]. In 2010, there is focus on growth with the underlying issue of productivity improvement still key to achieving growth through competitive advantage. Therefore best practice remains a critical success factor as suggested in 2002, as adoption of world leading practices can lead to competitive advantage. MX Start therefore can provide needed support to the manufacturing

industry through the dissemination of best practice and identifying key improvement areas for individual companies that could help improve their competitiveness.

4.5.1 Providing support to all

MX Start provides support to any manufacturing company. The focus of the government support is on Advanced Manufacturing. This is particularly noticeable given that the Manufacturing Framework due in 2010 was cancelled in favour of a Growth Review specifically for Advanced Manufacturing. The BDO report of the Changing Shape of UK Manufacturing, identified from a survey of manufacturers that this "*focus is too narrow and neglected traditional manufacturing"* [52]. A report by CIVITAS also believes there is an unbalanced focus, believing it ignores 86% of manufacturers and that Advanced Manufacturing Companies cannot operate in isolation and need the support of the other technology level manufacturers [53].

Figure 4-10 and Figure 4-11 show the GVA of manufacturing by level of technology using data from the Office for National Statistics, and definitions of technology level and manufacturing sub sector as defined by the Organisation for Economic Cooperation and Development (OECD) and the Department for Business, Innovation and Skills (BIS). The details of classifications can be found in Appendix 2. The figures show that in 2007, high technology manufacturing accounted for 14% of the GVA added by manufacturing. Therefore focusing on Advanced Manufacturing excludes a high proportion of manufacturers. MX Start does not discriminate which manufacturing companies can use it, providing a resource that is accessible to all.

Figure 4-10 Gross value added of manufacturing by level of technology in 2007 (Source of data Office for National Statistics and definitions of technology sub sectors OECD)

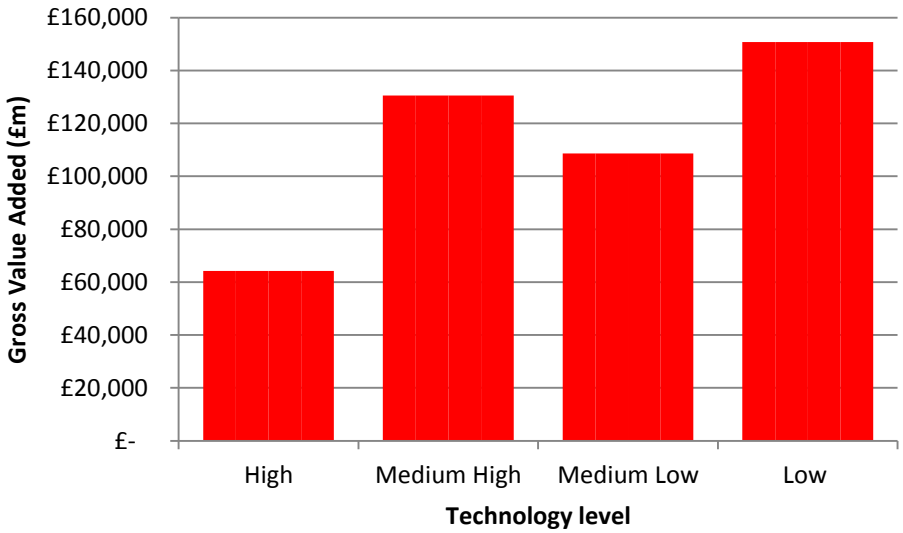
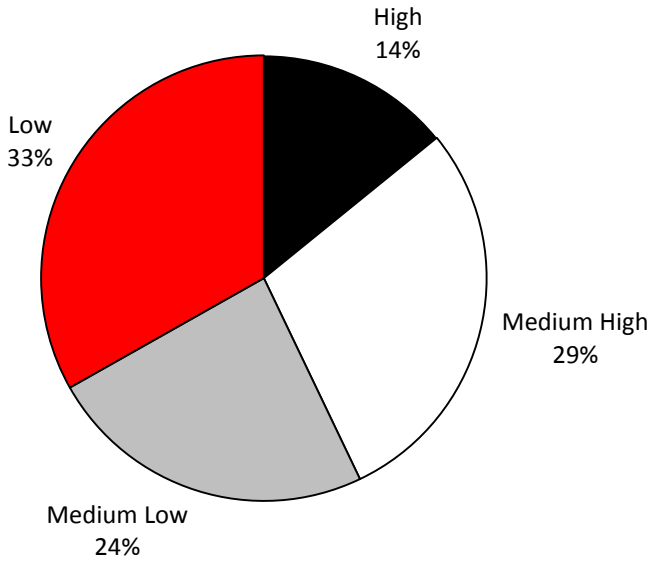


Figure 4-11 Proportion of Total Manufacturing GVA by technology level (Source of data Office for National Statistics and definitions of technology sub sectors OECD)



4.5.2 Providing accessible support

The previous section highlighted the breadth of Government support available to manufacturers. However, results from a survey by BDO (shown in Figure 4-12 and Figure

4-12) highlight frustration amongst manufacturing companies regarding the availability and access to the government support available [52]. 90% of those surveyed found access either hard or almost impossible, with reasons cited including a long / complex process or being excluded from support. There is opportunity for this research work to overcome these frustrations by providing support that is freely available to all, therefore excluding no company.

Figure 4-12 Ease of getting government manufacturing support [52]

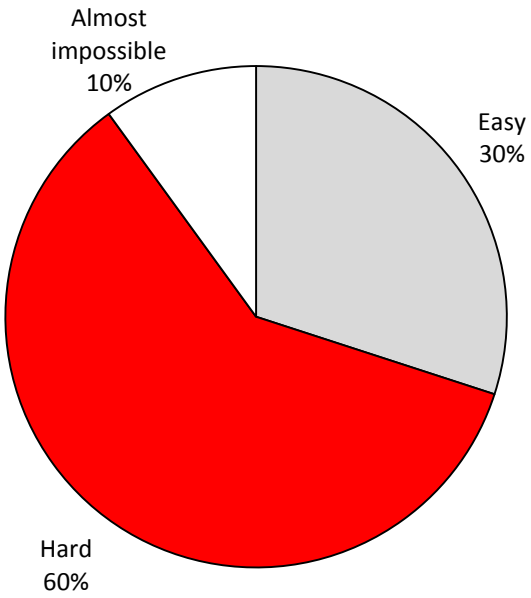
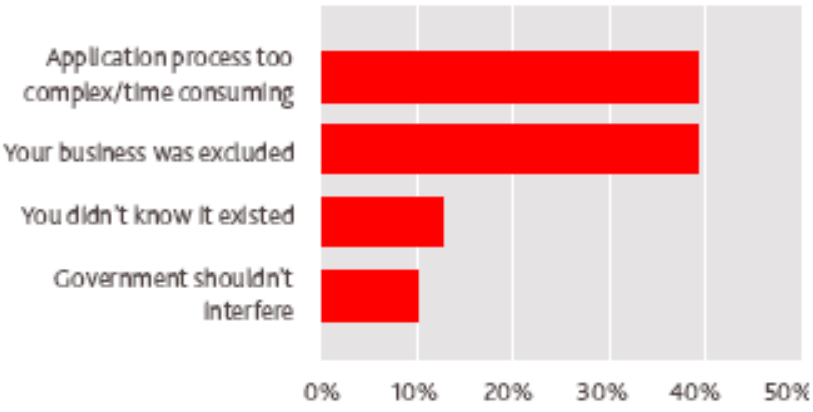


Figure 4-13 Reasons why government manufacturing support not received [52]



Further opportunities include ensuring the support is not time consuming and is simple. This would overcome the largest barrier to receiving support as shown in Figure 4-13.

4.6 The definition of Manufacturing Excellence

This report has so far discussed why manufacturing is important and why there is a need for UK manufacturing companies to improve to reach manufacturing excellence. However the term manufacturing excellence has not yet been defined. The next sections will analyse the term in its component parts in order to determine a definition.

4.6.1 The definition of manufacturing

The Oxford English Dictionary (OED) defines manufacturing as:

> *"The action or process of manufacturing something; production, fabrication. Now also: the sector of the economy engaged in industrial production."*
>
> *[54]*

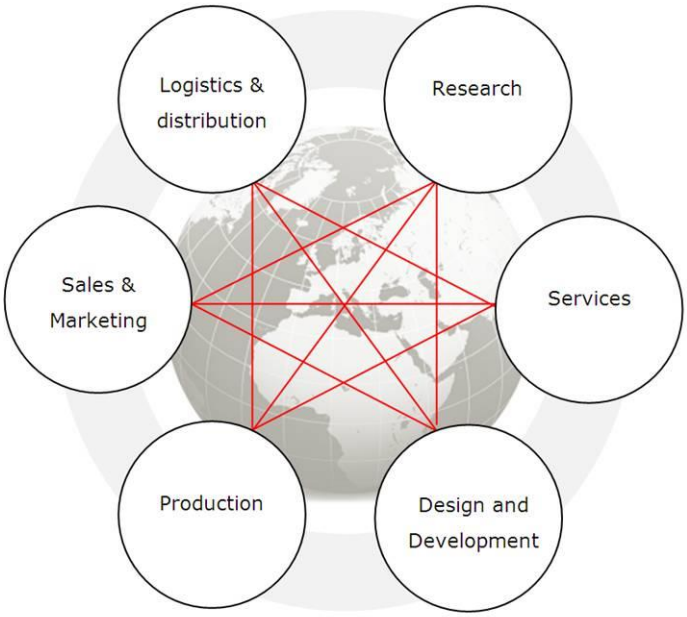
The International Standard Industry Classification (ISIC) offers the more developed definition of manufacturing that is given below:

> *"It is defined as the physical or chemical transformation of materials of components into new products, whether the work is performed by power- driven machines or by hand, whether it is done in a factory or in the worker's home, and whether the products are sold at wholesale or retail. Included are assembly of component parts of manufactured products and recycling of waste materials."*
>
> *[55]*

The dictionary definition and the ISIC both agree that manufacturing is an action that produces something. The OED definition indicates the term is used in a wider context to also refer to the overall industrial sector. Robert Hall, in his book '*Attaining Manufacturing Excellence'* believes that manufacturing and production are terms that are commonly used interchangeably and there is a need for clarification between them. Hall makes the distinction that *'manufacturing is all the activity of an operating company that engages in production, whereas production is the actual conversion of material to product'* [56]. This distinction separates the two elements of manufacturing as given in the OED definition. Manufacturing is attributed to the wider economic sector, whilst production is attributed to the specific process of making a product.

The Institute for Manufacturing (IfM) gives a definition for manufacturing that encompasses stages from the concept of ideas through to the supply of products and services [57]. The stages are summarised as six interlinked business processes as shown in Figure 4-14. The IfM definition considers manufacturing not as an isolated process, but as an integrated system of processes. This system of processes can be considered to represent the overall manufacturing sector. Within the overall sector, production is one of six contributing processes reinforcing the distinction between manufacturing and production. The IfM definition allows manufacturing not only to refer to a single company, but also to a number of different companies. Thus, a number of companies carrying out one or more or even part of a process could contribute collectively to an entire manufacturing system.

Figure 4-14 Extended definition of manufacturing [57]



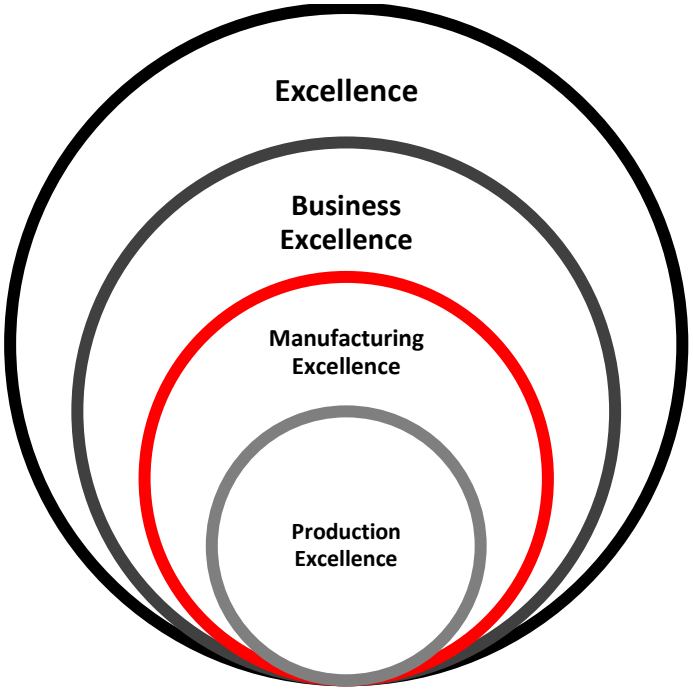
In addition to the individual processes involved in manufacturing as shown in Figure 4-14, there is increased complexity due to the variety of industry sectors a manufacturing company or companies can be engaged in. This complexity is demonstrated in the International Standard Industry Classification (ISIC). ISIC is used to "*classify business establishments and other statistical units by the type of economic activity in which they are engaged" [58]*. Under the ISIC system the section manufacturing is divided into 24 divisions, which is further divided into 95 groups, divided again into 230 classes and 51 subclasses *[55]*. A company is assigned an ISIC code according to its principal economic activity. The process for determining the principal economic activity for a company is based on the activity that contributes the most to the value added of the company. Therefore, for a company to be assigned under the manufacturing division, manufacturing activities must contribute the most value added.

In summary, there are two distinct definitions of manufacturing. The first refers to the production action of transforming material into products. The second encompasses all the activities of a system involved in the production of products. Therefore when defining manufacturing excellence it is important to understand which definition of manufacturing is being referred to.

4.6.2 The definition of excellence

This section will investigate the term excellence. The assumption is made that manufacturing excellence is a subset of business excellence, which is itself a subset of excellence as shown in Figure 4-15. In light of the discussion in section 4.6.1, production excellence would be a subset of manufacturing excellence.

Figure 4-15 Excellence definition assumption



The Oxford English Dictionary definition of excellence is:

> *"The state or fact of excelling; the possession chiefly of good qualities in an eminent or unusual degree; surpassing merit, skill, virtue, worth, etc.; dignity, eminence."*
>
> *[54]*

The OED definition indicates that excellence requires an element of superiority. This definition does not define what aspects to consider or how a company can be judged as being excellent. There is a need therefore, to look at the more focused term of excellence. The

following definitions found in the literature outline several perspectives on what excellence, and its subsets, constitutes.

Peters and Waterman Jr use the definition of excellence as *"continuously innovative big companies,"* where innovation is defined as the ability to continually respond to any change of the environment [59]. Peters and Waterman Jr used this definition to identify excellent companies to study, which led to the identification of eight attributes of these excellent companies [59]. The attributes are given in Appendix 3.

Samson and Challis use three characteristics to identify excellent companies: type of industry, annual revenue and reputation [60]. This introduces the concept that companies in different industries can be judged differently in terms of their excellence. The difficulty in this definition is there is no clarification of how to identify excellent reputations as this is dependent on subjective opinion.

Lascelles and Peacock draw of the EFQM model, which will be discussed in the next section, to define business excellence [61]. They believe that business excellence builds on the principle and philosophy of Total Quality Management (TQM), with companies considered to be excellent focusing on creating value above all else and making the right decisions to create value. Lascelles and Peacock's characteristics of world class performance can be found in Appendix 3.

Hayes and Wheelwright use the phase world-class manufacturing (WCM), but believe there is no single best way to achieve manufacturing excellence [62]. However they identify similarities within well run factories, these are listed in Appendix 3.

Schonberger compares the aim of becoming a world-class manufacturer to the slogan of the Olympics: 'faster, higher, stronger' [63]. Schonberger translates this into the world-class manufacturing equivalent of "continual and rapid improvement". The goals of world-class manufacturing under this definition include *"continual improvement in quality, cost, lead time, customer service, and flexibility"* [63].

Voss et al conducted a study regarding the understanding of how widespread and the impact of world class manufacturing defined WCM as *"the point at which a certain standard in both practice and performance has been achieved. This is where companies equal or surpass the very best of their international competitors in every area of their business"[64].* The six areas included in the WCM definition are provided in Appendix 3.

Elliot, in his article "Five Steps to Excellence" gives a prescriptive definition of excellence setting out that it is the achievement of performance that includes:

1. *Minimum 1.33 Cpk first-time quality*
2. *100 percent on-time customer service*
3. *Year-over-year process cost reduction*
4. *A zero-harm commitment to safety*

[65]

Kepner-Trogoe, consultants and training providers to organisations across the world, believe manufacturing excellence is the *"vision of "perfection" that guides an organisation's leadership in a relentless drive to improve the core value-creation process flow, from raw materials to finished product"* [66]. Kepner-Trogoe summarise the parameters of manufacturing excellence in a single measure; the operational effectiveness index (OEI). KT states that world-class performance is reached when the measures making up the operational effectiveness index are in the 85-96 percent range. The calculation is given below:

OEI = % Quality X % Uptime X % Standard Speed X % On-Time X % Complaint-Free Shipments

4.6.3 Models/Awards of excellence

In addition to the literature definitions, models of excellence exist. These models and frameworks are given in Appendix 4 and are summarised below.

Sharma and Kodali reviewed twenty three manufacturing and WCM frameworks [67]. This review discovered two hundred and fifty two unique and interrelated elements. Using comparative analysis, Sharma and Kodali grouped these into common elements to derive the Framework for Manufacturing Excellence. The framework is built on a foundation of leadership, change and human resource management. There are nine pillars which are the initiatives needed to achieve manufacturing excellence, with knowledge management required by all initiatives. At the top of each pillar, the competitive priority that differentiate a company is given.

Roth et al conducted a literature review of WCM and manufacturing excellence as part of their study of world-class operating strategies [68]. Roth et al used this definition and expert opinions to develop operating principles for WCM companies of the 1990's. This framework is shown in Appendix 3. From their study, Roth et al concluded that all WCM companies, whatever the industry or size, operate within the framework. As a 'framework for the 1990's it may now be considered out of date.

In addition to models there are several awards for excellence. Awards include the Deming Prize, Malcolm Baldrige National Quality Award (MBNQA), EFQM, MX Awards and Best Factory. Six awards are summarised in Table 4-2 and their models are given in Appendix 5.

Table 4-2 Summary table of awards

Award	Purpose	Start year	Awarding body	Original theme	Process	Award divisions
Deming Prize	Commemorate Dr W.E Deming and promote development of quality control	1951	Professional institution (Union of Japanese Scientists and Engineers)	Quality	1. Discuss eligibility to apply 2. Submit application form 3. Submit 'Description of Quality Control practices' 4. Document examination 5. On-site examination 6. Selection of Prize winners 7. Written and verbal feedback	Size and type of business
MBNQA	Promote awareness of performance excellence and share best practice	1987	Government Agency (National Institute of Standards and Technology)	Quality	1. Application form submitted 2. First Stage Review by examiners 3. Consensus meeting of assessors 4. Site visit 5.Secretary of Commerce makes prize decisions based on recommendations by the assessors 6. Feedback report	Economic activity
Shingo Prize	Promote operational excellence through awareness of lean principles	1988	In the US : University (Utah State University), in the UK Institution (Manufacturing Institute)	Lean	1. Submit intent to apply submitted 2. Submit achievement report 3. Achievement report reviewed 4. Site visit 5. Feedback report	Size and type of business
EFQM Award	To enhance the competitive position of European countries in the world market	1991	Organisation (EFQM)	Quality	1. Application form 2. Submission documents 3. Panel of Jurors 4. Site visit 5. Judge selection 6. Feedback report	Size / economic activity/specality areas
MX Awards	Supporting and recognising manufacturing success	2000	Professional institution and University (IMechE and WMG)	Process	1. Audit questionnaire 2. Assessment Board 3. Site Visit 4. Presentations 5. Feedback Report	Speciality areas /Size
Best Factory	Promote and reward manufacturing excellence to increase competitiveness	1992	University and Magazine (Cranfield University and Works Management)	Quality	1. Audit questionnaire 2. Assessment Board 3. Site visit 4. Judge selection 5. Benchmark Report	Economic activity / Size / Specialty area

4.6.4 Common themes of excellence

The previous sections have highlighted that there are many definitions of excellence, business excellence, and manufacturing excellence. Analysing the high level themes of these definition shows a degree of commonality as can be seen in Table 4-3 on page 54. The common themes have been taken from the high-level definitions of excellence and not from the detailed level. For example, questions on leadership are asked in the MX Awards self-assessment audit; however leadership is not a key concept in the framework or purpose of the award. Therefore it is likely that there is a higher degree of commonality if analysed at a more in depth level. However this is not necessary as it is clear that commonality does exist between definitions.

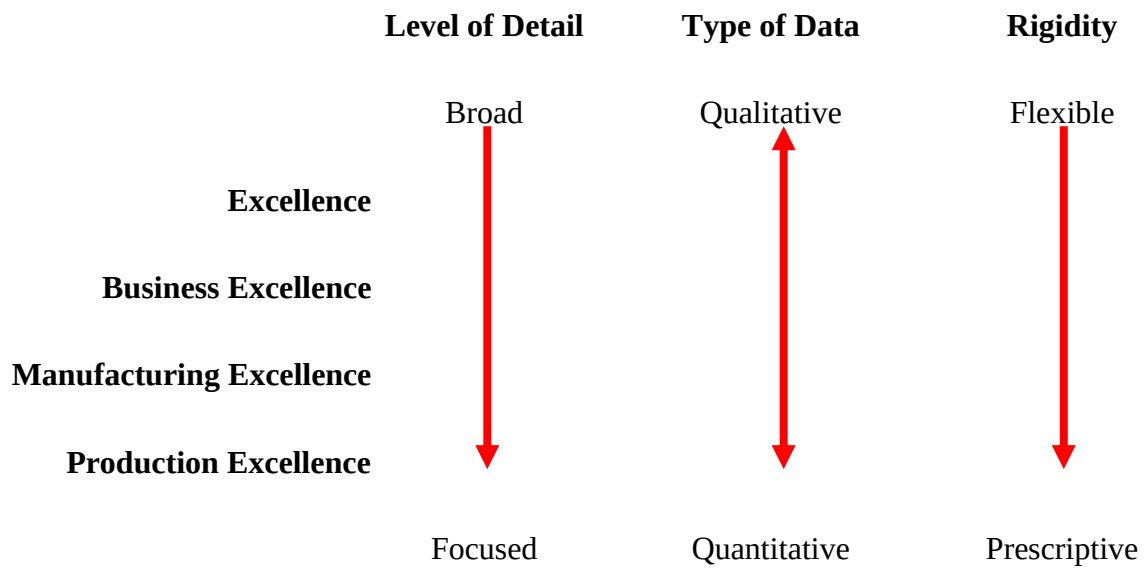
The common themes are not necessarily mutually exclusive. For example, best practice is found to be common in seven of the definitions. However best practice may be referring to other excellence aspects. For example, the MX Awards recognise best practice in the area of customer focus, innovation, processes and such. Similarly continuous improvement refers to the process of development but lacks a specific content area of application. Thus, excellence is made up of concepts (best practice, continuous improvement, innovation, processes), content areas (quality, lean, leadership, customers, people) and performance (turnover and value).

Table 4-3 Comparison of excellence themes

	Excellence				Business Excellence			World Class Manufacturing				Manufacturing Excellence				Production Excellence		
	The Deming Prize	MBNQA	The Shingo Prize	Peters and Waterman [59]	Lascelles and Peacock [61]	Samson and Challis [60]	EFQM Award	Hayes and Wheelwright [62]	Schonberger [63]	Voss et al [64]	Roth et al [68]	Government Manufacturing Strategy: Pillars [34]	Hall [56]	Manufacturing Excellence Awards	Sharma and Kodali [67]	Kepner-Trogoe [66]	Elliott [65]	Best Factory
Value				•	•					•		•						
Turnover (size)				•	•	•												
Innovative				•								•		•	•			
Continuous Improvement	•	•	•	•			•	•	•		•	•		•				•
JIT / Lean			•									•			•			
Quality / TQM	•	•					•	•	•	•	•		•		•	•	•	
Organisation/Culture/People		•	•				•		•		•			•				
Best Practice	•	•	•				•					•		•				•
Customer satisfaction	•	•	•	•	•		•		•		•			•		•	•	
Manufacturing capabilities			•					•			•				•		•	
Leadership		•			•		•								•			
Processes		•	•		•		•							•	•			

An initial assumption was made that manufacturing excellence was a subset of business excellence. Table 4-3 highlights that there is commonality between the different categories of excellence. However a distinction between the tiers of excellence (business, excellence, production) can be seen in the level of detail of the themes. Production excellence definitions focus on a prescribed level of performance that a company must achieve. In contrast to production excellence, business excellence takes a broader high-level view that allows more flexibility. Manufacturing excellence is the bridge between production and business excellence. Figure 4-16 highlights the differences between the characteristics of excellence. As the category of excellence becomes more specific, the level of detail increases as does the rigidity of the definition.

Figure 4-16 Characteristics of the definitions of excellence



4.6.5 Issues in defining excellence

The previous sections have shown that there are many definitions of excellence. This section will outline some of the issues faced when defining excellence and therefore outline the difficulties in selecting a definition for MX Start.

4.6.5.1 Subjectivity

It was evident from the literature review that there was a bias towards expert opinion rather than empirical data to define excellence. There are two distinct methods of using expert opinion to define excellence. Firstly, in the case of Peters and Waterman Jr [59] , Samson and Challis [60], Hayes and Wheelwright [62], and Lascelles and Peacocks [61], expert opinion was used to define excellent companies. From these identified companies, properties of excellence were then derived and these properties then became a definition of excellence themselves. This method is based on the assumption that the initial identification of companies was correct. The second method, as used by the award frameworks, bases the definition of excellence on a main theory. For example, the EFQM Award and Deming Prize are based on quality management. Expert opinions are then used to derive the fuller definitions. These two methods of deriving excellence lack validation and often result in circular reasoning, with a definition used to identify excellent companies. These companies are then held up as examples of excellence reinforcing the original definition as being correct.

Table 4-3 showed there is a significant amount of similarity between the definitions. Whilst some of the definitions of excellence have influenced subsequent definitions, for example the EFQM model influenced Lascelles and Peacocks, Deming influenced MBNQA which in turn inspired the EFQM model, there are also a number of definitions that have been independently derived. Due to the high degree of commonality between the elements of excellence it is assumed that these elements can be classified as the foundation of excellence. In the case of the frameworks such as the Deming Prize, MBNQA and Shingo, which have been in operation for decades and have reached the status of an accepted standard, it would be difficult to envisage their basis of excellence being dispelled as false due to the prolonged period of acceptance by industry.

The use of subjective opinion is particularly prevalent in the award frameworks. The first use of opinion is introduced when companies complete the self-assessment. Companies must first interpret the requirements of the audit and then convey how this applies to their company. Table 4-2 on page 52 showed that all the awards followed a similar assessment process, involving assessment by a number of experts and a site visit. These two steps

introduce further subjective opinions. It is also because of the subjective nature of the assessment that these two steps are needed. If the assessment process was rigid and robust enough to clearly identify excellence after the audit assessment, then there would be no need for further assessment steps. However, there is a need to visit companies to validate that the opinions given by the company are a true reflection of themselves, and also that the assessors have accurately evaluated the excellence from the audit.

4.6.5.2 Different definitions exist

Schonberger compared excellence to the Olympics [63]. Schonberger's comparison between WCM and the Olympics can be taken further. Excellence in the Olympics is recognised in individual events, combinations of events and overall teams. Therefore, manufacturing excellence could also have a variety of different definitions that realise different aspects of superiority. The award frameworks support this idea; however the categorisation differs between them. Divisions include:

Size	For example: large units, operational units, small-medium enterprises, individuals
Economic activity	For example: business excellence divisions include manufacturing / service / health care and manufacturing excellence divisions include electronic and electrical plant / process plant /energy
Specialty area	These are taken from the areas that make up the frameworks and include innovation, customer focus, leadership

Recognising excellence by size compares with the examples of the weight divisions in Olympic sports such as weight lifting and boxing. Divisions by size disagree with Peters and Waterman Jr [59] and Samson and Challis's [60] definition of excellence including the company must be large. The EFQM Award, MX Awards, Best Factory and MBNQA all recognise and celebrate excellence in small companies (based on turnover and number of employees) indicating that they do not consider that small companies cannot be excellent

companies. Distinguishing the size of companies however, indicates that excellence may be different for different sized companies, or that small companies cannot compete in terms of excellence with larger businesses. This may be a result of different levels of performance or even practices that can be expected from a company of a certain size and therefore resource.

Recognising excellence by economic activity gives the opportunity for companies to be assessed and recognised within the context of their own industry. Based on the assumption that companies of the same industry would face similar operating conditions, this enables fairer comparison of performance and practices to distinguish excellence. This correlates to the idea of the Olympics, and that companies recognised as excellent may only be so in the context of the operating conditions and competitors at the time. Therefore as time progresses and the external factors change, excellence may also change.

Partitioning the recognition of excellence by specialty area is similar to the conclusion drawn by Peters and Waterman Jr [59]. Peters and Waterman Jr concluded that attributes of excellence, or areas of specialty, need not be present in all excellent companies and also may be present in varying degrees. The EFQM Award and MX Awards also subscribe to this thinking and recognise companies for individual aspects of excellence. This raises the question whether it is possible to be excellent in every aspect. Companies operate within a finite boundary of resource and therefore it may not be possible to sustain excellence in every area. It is unclear therefore whether companies who are working towards becoming excellent, should target all areas of excellence or concentrate on becoming excellent in a few areas. Due to the finite resources of a company, targeting all areas of excellence could result in a company reaching a high level in all of the areas, but excellence in none. Alternatively, by only targeting some of the areas, the company could become excellent in these aspects, but could be held back by lower standards in others. For example, excellence in product innovation where new, innovative products are developed could be prevented from achieving the potential high sales if the company has an inferior business development, sales or marketing department.

With the need to take into account a company's size and economic activity and the varying levels of excellence present to assess whether they have reached excellence, the definition of excellence needs to be flexible.

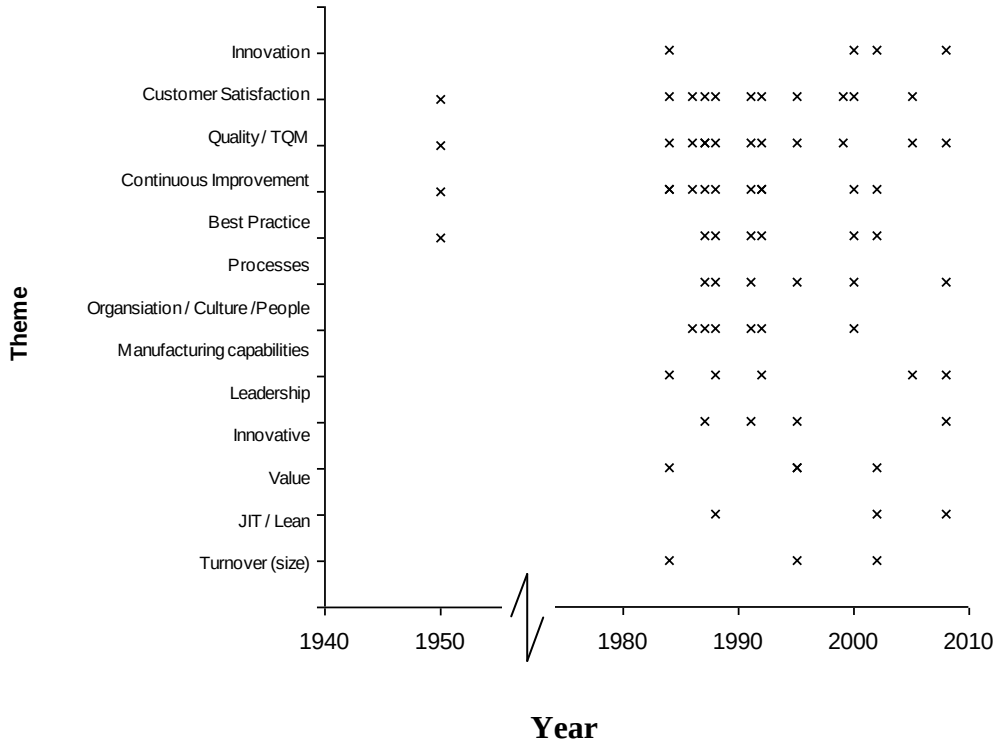
4.6.5.3 A true definition cannot exist

It was also shown in Table 4-3 that continuous improvement - the concept of constant evaluation and progress - was one of the most stated themes of excellence. Thus, if continuous improvement is part of excellence, there can be no end point as it is expected that excellence will continue to be built and improved upon.

Lascelles and Peacock stated in 1996 that "*whereas today excellence is so unusual it stands out, in ten years' time excellence will be taken for granted" [61]*. Therefore the excellence of today becomes the norm of the future, and so current excellence will eventually become standard. This highlights that due to the continually improving status of the term excellence, it is a dynamic definition as it refers to a state that evolves over time.

Figure 4-17 shows the timeline of the themes of excellence from the reviewed definitions frameworks. With excellence being considered a never ending journey it would be expected that the definitions of excellence over time would change to reflect the on-going improvements. Figure 4-17 however shows that the main concepts of excellence have not significantly changed over time. This graph only takes into account the common concepts of excellence, and does not show new concepts emerging after the year 2000, such as embracing information and communications technology, e-business and sustainability. The basis for excellence however has remained the same over a twenty-year period.

Figure 4-17 Timeline of the common concepts of excellence



This failure of the definition of excellence to move forward needs to be addressed. Currently, the foundations for excellence have been known for a significant amount of time, yet the manufacturing industry trends show the UK industry to be in need of improvement. An explanation for the slow progression of excellence can be due to the nature of the definitions provided. The key concepts shown in Table 4-3 highlight that the majority of definitions tend to focus on high level concepts / philosophies / approaches. Whilst these concepts have remained static over time, the practices used to achieve them along with the performance, change over time rather than the concepts themselves. Thus by not specifically outlining the precise detail of excellence and instead providing an overview of the key areas, the definitions can remain valid for a longer period of time, as only the practices and performance associated with achieving excellence evolve.

The main difference between the literature definitions and the award definitions of excellence, is that the awards are regularly updated. For example, at the detailed question level, the MX Awards are updated annually to ensure the definition remains relevant to the manufacturing industry.

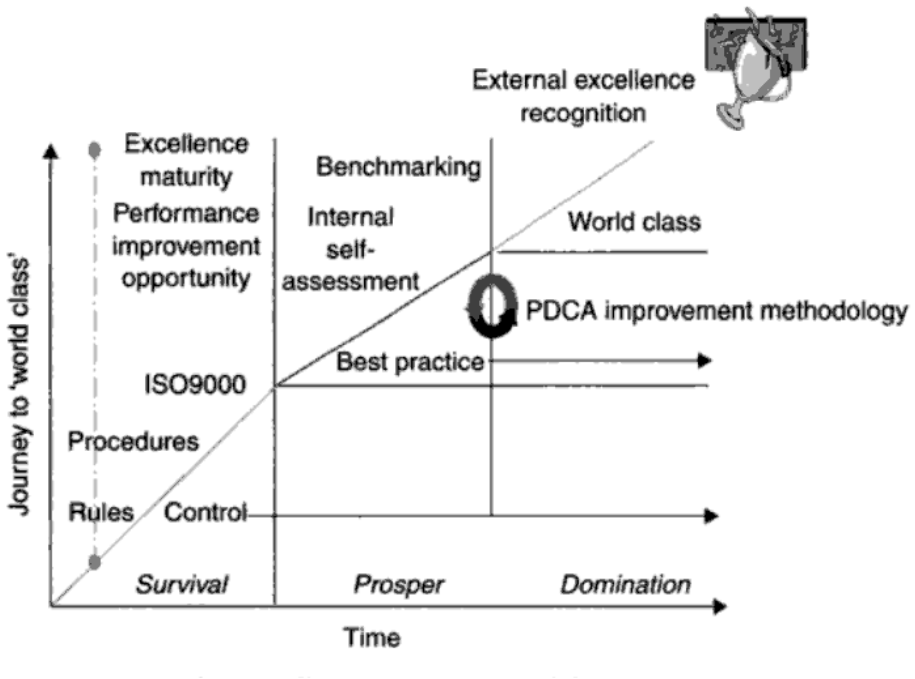
As excellence is an evolving definition and also given that it can exist in many forms as discussed in section 4.6.5.2, it can be concluded that there is no one definite and rigid definition of excellence. Existing definitions are high level to allow flexibility in the detail of attaining excellence or are regularly updated to ensure they remain relevant as the term continually evolves.

4.7 The vision for MX Start

Manufacturing is vital to the UK economy. There is a need to improve in order to close the productivity gap. The Government's Manufacturing Strategy states that best practice is one of the critical success factors for the manufacturing industry. Best practice and manufacturing excellence are linked, with best practice being one of the key themes of excellence as shown in Table 4-3. Companies who have implemented best practice and continually improve and develop what best practice is in key content areas (customer, quality, people) to achieve better performance (value, turnover), can be considered to have attained manufacturing excellence.

Excellence can be considered a journey. Porter and Tanner's 'Excellence Maturity Model' in Figure 4-18, divides the journey into three distinct sections: survival, prospering and dominance [9]. In survival, rules and procedures are required to be established. To prosper, companies need to reflect internally then benchmark and implement best practice. To achieve dominance and world-class status companies must maintain the control established in the survival stage and continually review and implement best practice. The basic concepts of excellence have been known for decades. Where the opportunity for MX Start lies, is in the process of supporting companies to understand where they are in terms of their excellence journey and where there are gaps between their existing practices and best practices. Companies need to understand what best practice is and where they would benefit from implementing these concepts into their business in order to be encouraged to make improvements.

Figure 4-18 Excellence Maturity Model [9]



The scope for MX Start involves helping supporting companies on their manufacturing excellence journey. It can be concluded that a rigid definition of excellence is unattainable. This is because there is a need for flexibility due to differing operating conditions, economic climate and industries. However there is a need for a definition if companies are going to be supported to reach such a status.

This work focuses on manufacturing and therefore should be based on a definition of manufacturing excellence rather than the broader term of business excellence or a more focused definition of production excellence. There needs to be flexibility in the definition to allow it to evolve as the term develops. This lends itself to the awards models and frameworks as these are regularly updating to remain relevant. Therefore the MX Awards definition is the only definition from those reviewed that fulfils both these conditions. Through the IMechE sponsoring of this work, the author has access to the review and updating procedure for the definition and therefore can integrate this process to ensure this research work remains relevant.

4.8 Context Summary

This chapter has reviewed definitions of excellence, and found a high degree of commonality. Excellence was found to be a dynamic term that is evolving, therefore the commonality tended to be at a high level allowing flexibility in the detail of excellence. Manufacturing Excellence, as defined by the MX Awards, was the definition chosen to be used as part of this research work, due to its ability to be easily updated to ensure the definition remains relevant.

The UK's manufacturing industry is a vital component to the economy, particularly in terms of its contribution to employment, wealth and exports. The recent recession has led to a renewed focus on manufacturing and its importance, with the Government believing the economy should be rebalanced in favour of such industries. The Government's support however, is focused on Advanced Manufacturing. There is an opportunity for support that is inclusive and available to all manufacturing companies and that is simple to use.

Critical to the success of the manufacturing industry is the adoption of best practice. Best practice was identified as a pillar, and therefore a key element in the Government's Manufacturing Strategy and it was identified as one of the most common themes of excellence. Therefore helping companies to understand what best practice entails and also where and how they could apply it to their business can support companies to start their excellence journeys.

The next steps involve evaluating the strategies and approaches for disseminating best practice and supporting manufacturing companies to start their manufacturing excellence journeys.

5 Input; *selecting the approach for MX Start*

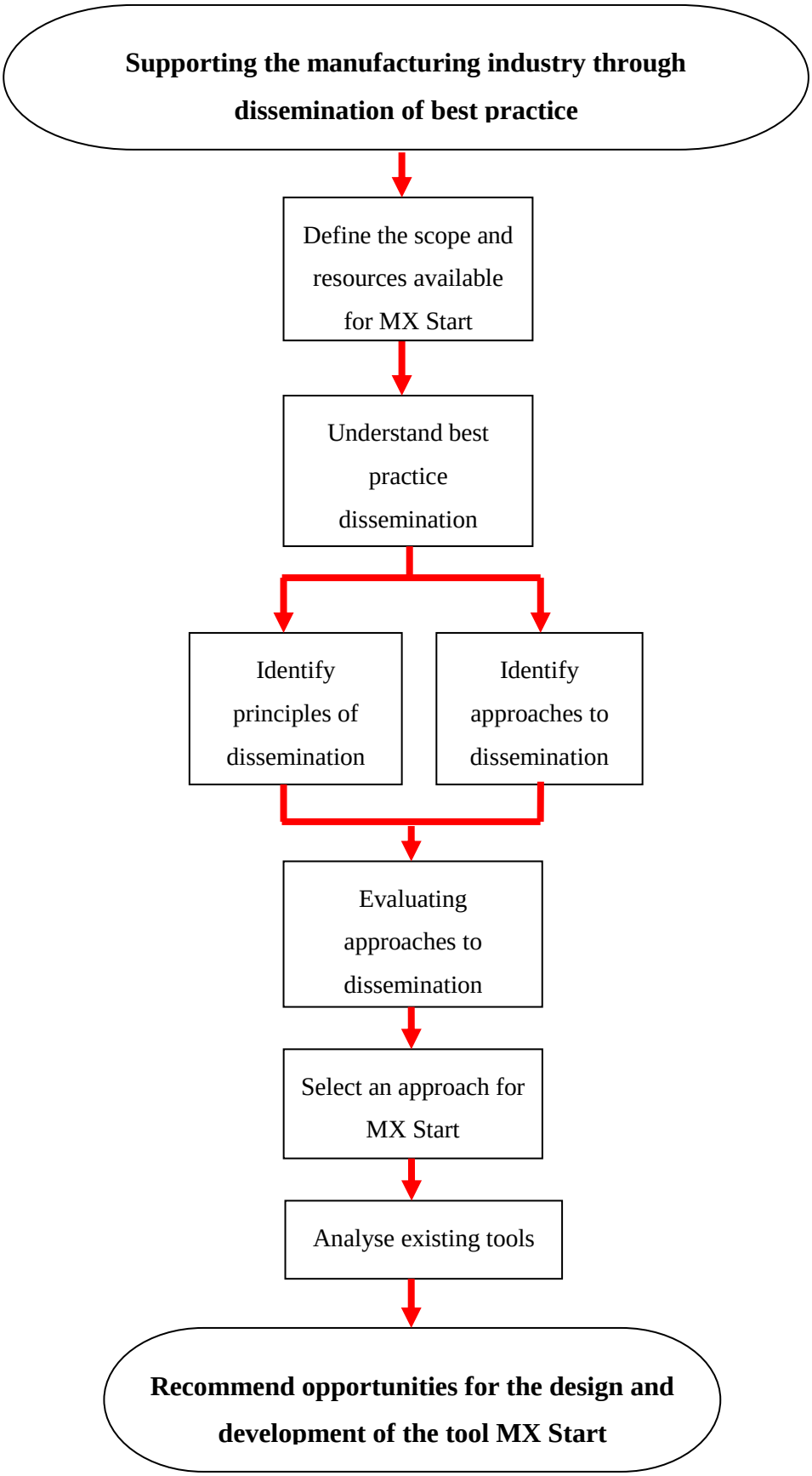
Objectives:

- To analyse the approaches to supporting the manufacturing industry
- To understand the principles of best practice transfer

Output:

- Selection of a dissemination approach to be used for MX Start

5.1 Flow chart of the approach taken in Submission 2: Strategies and approaches for disseminating best practice



5.2 Word cloud of the key themes from Submission 2: Strategies and approaches for disseminating best practice

5.3 Input introduction

In the Context chapter, it was identified that the dissemination of best practice is a critical success factor for a competitive manufacturing industry. By helping companies to understand what best practice entails and also where and how they could apply it to their business, can support companies to start their excellence journeys. This chapter therefore will analyse the strategies and approaches of best practice dissemination in order to identify an appropriate method to support the manufacturing industry.

5.4 Defining the scope

In was discussed in the Context chapter, that there is an opportunity to provide support that is widely accessible and targeted at the whole manufacturing industry. In 2009, there were 303,245 manufacturing enterprises [20]. Therefore there are a significant number of companies that this work is aiming to be able to potentially provide support to.

Defining such a large scope has its limitations however. The aim of this research is to provide support to all the different types of manufacturing companies. These differences include aspects such as size and industry type (sub-sectors). Therefore the support provided will be of a generic nature in order to be relevant to all companies.

5.4.1 Resources available

The scope of this research is wide in terms of who the support is targeted at. However, there are limited resources available, particularly on-going resources to support such a tool. Therefore an assumption has been made that there will be limited or no on-going funding past the completion of this research.

The support however must be able to be provided beyond the timeline of this research. It is unlikely that the time scale of this work would be able to cater for the potential number of companies, or for the support to gain enough credibility or awareness amongst the industry to

attract companies to use it. Therefore to make an impact on the manufacturing industry, a sustainable tool is required. Sustainability refers to the ability of the tool to operate on limited resources whilst continuing to provide support. Given that the definition of excellence was found to be dynamic, there must also be a low resource mechanism for updating the content of the support provided, in order to ensure it remains relevant.

There are options to enable the on-going resources to be increased. These include charging for the support or finding other resources **s**uch as grants. However, the ethos of the support is for it to be accessible to any company. Charging a fee for use is in opposition to this vision as any cost may be a barrier for some companies to use the tool. Grants are accompanied by their own limitations such as restricted time frame for expenditure. Therefore the support must be able to be provided without the need for significant on-going resources in order to ensure access can remain free of charge and to enable the support to be available for a long period of time.

In summary, the limited on-going resources mean that the support must be provided via a low resource mechanism and in order for it to be accessible; it must also be free of charge for companies to use.

5.4.2 Dissemination of best practice

At the core of the support this research aims to provide is the dissemination of best practice. Jarrar and Zairi compiled a framework of best practice transfer based on successful case studies from literature [69]. This framework encompasses six key stages which are summarised below:

1. **Searching:** Seeking out best practices
2. **Evaluating:** Valuing the ideas depending on the objectives
3. **Validating:** Analysing the best practice and the potential benefits and impacts
4. **Transfer:** Adopting and adapting the chosen practices

5. **Reviewing:** Ensuring the practices achieved the targeted benefits
6. **Routinising:** Embedding the best practice in the culture of the company

[69]

This research is primarily concerned with stage one of the framework, supporting companies to find and understand best practice. Stages two to six are focused on what a company should do internally once these best practices have been identified. This does not mean that stages two to six should be ignored. Once companies are aware of best practices, they will then need to continue to evaluate, validate and transfer these best practices into their own business context. Therefore whilst this work is primarily concerned with the first stage, there must be consideration of the subsequent stages required to make changes. Without such consideration there is limited scope for companies to adopt and adapt any of the best practices and therefore it would be unlikely any improvement would be made.

The consideration of the stages beyond the initial searching is particularly pertinent given the concern raised earlier regarding the generic nature of the support provided. There is an opportunity for the process to help with the evaluation and validation stages. This can be achieved through helping companies to understand where they might benefit from best practice and where the key areas for improvement might lie. Therefore there must be a balance between providing support that is applicable to all companies and helping companies to translate this data into meaningful information for their own business circumstances.

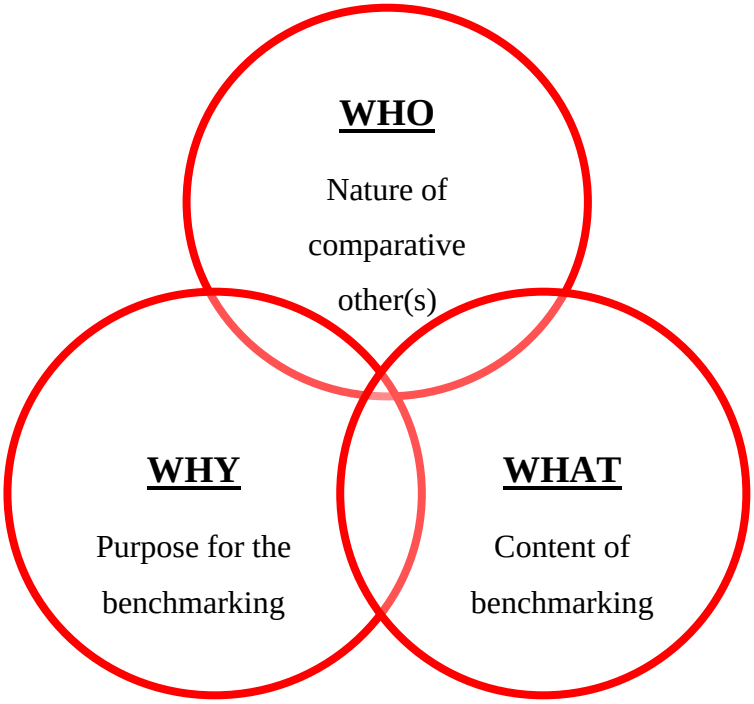
5.4.3 Benchmarking

The aim of this work is to provide an approach that manufacturing companies can use to understand what manufacturing excellence and best practice is. This can be considered as a type of benchmarking. The Oxford English Dictionary (OED) defines benchmarking as:

> *"A process in which a business evaluates its own operations (often specific procedures) by detailed comparison with those of another business in order to establish best practice and improve performance; the examination and emulation of other organisations' strengths"*

This definition cites that comparisons occur between two different businesses. However there are many definitions of benchmarking across the literature and these encompass comparisons made internally [70] and with external companies ([71], [72], [73], [74]). There are many classifications of benchmarking. Fong conducted a review and summarised the key classifications. As shown in Figure 5-1, there are three main groups of classifications. These are concerned with who the benchmark is with, what is being benchmarked and the purpose of the benchmarking. More details regarding the classification are given in Appendix 6.

Figure 5-1 Classifications of benchmarking, Fong et al [1]



From the detailed classifications in Appendix 6, this research work can be defined as benchmarking against generic best practices (as defined by the Manufacturing Excellence Awards). It entails aspects of both process and performance benchmarking as the definition of manufacturing encompasses both practices and production metrics. The purpose of this work encompasses aspects of each of the four whys in Appendix 6. The aim of this work is to increase awareness of manufacturing excellence. This will be achieved through a process that enables manufacturers to identify and define improvement areas through a process of comparison with manufacturing excellence (measuring gaps). It is then expected that as a

result of this process, companies will then go on to implement changes to make improvements.

5.5 Approaches to best practice transfer

Now that the scope and resource available have been discussed, there is a need to look at the process of transferring best practice.

Many approaches to transferring best practice exist. Table 5-1 shows a model derived from the experience of the NHS Executive Research and Development programme [75]. This model divides the transfer of best practice into approaches that share information (passive methods) and those that shape behaviour (interactive methods).

The type of approach can affect the amount of resources needed to transfer best practice. By definition, a highly interactive transfer through face to face activities would require significantly more resources than a passive transfer through general publications or a self-directed approach. Therefore the amount of resources available affects the selection of a transfer approach.

Table 5-1 A model of how best practice is spread (source: Olllerearnshaw et al [76], based on work by the NHS [75])

Sharing Information			**Shaping Behaviour**	
General Publications	***Personal Invitation***	***Interactive Activities***	***Public Events***	***Face to Face***
Flyers Newsletters Videos Websites Manuals Articles Guidelines CD ROM Posters Displays	Letters Reports Postcards	Telephone Email Visits Workshops Seminars Websites Toolkits Distance learning Team learning Learning sets Modelling	Meetings Visits Conferences Road shows Networks Fairs	One to one Mentoring Secondment Shadowing Focus groups

Whilst the goal of this work is to share best practice, if the process can also facilitate shaping behaviour then this would be of significant benefit. A process that shapes behaviour is more likely to lead to action and improvements from the company than a passive approach. This could help the bridge the gap between stage 1 and stage 2 of Jarrar and Zairi's framework as discussed in section 5.4.2 [69]. Therefore the ability to shape behaviour must be a consideration in the selection of a best practice transfer process.

O'Dell and Grayson also agree there are different levels of interaction possible when transferring best practice [70]. They define three main design approaches for dissemination as shown in Table 5-2 [70]. These approaches are not mutually exclusive, with each approach potentially building on the previous one. Therefore a transfer approach can be based initially on some form of self direction, with additional approaches added as this process matures and as resources become available.

Table 5-2 Design approaches to best practice transfer [70]

Design approach	Method
Self-directed	Databases are used to disseminate information, with guidance for users on how to access what they want
Knowledge services and networks	In addition to self-directed components, there are networks of people who share and learn both 'face to face' and electronically
Facilitated transfer	This complements the first two processes with a wide range of approaches, including designated individuals who stimulate and assist best practice transfer, are trained to assist in problem solving and improvement and may also act as consultants

5.5.1 Effective dissemination of best practice

The previous section began to identify key factors that may influence the selection of a best practice transfer approach, including the resources available and desired effect such as sharing information or shaping behaviour. This section will discuss further aspects that will need to be considered and that will affect the type of transfer process chosen. This section will also identify critical success factors in effective best practice transfer.

Karlof and Ostblom believe that when engaging in an organised activity the value created should outweigh the cost [77]. Lema and Price use this mantra to define the pre-requisite conditions needed for successful benchmarking within a company [72]. These factors are:

1. *The need for performance improvement*
2. *The recognition and acceptance that there are lessons to be drawn from others that can lead to improved performance*
3. *The willingness and capability to change for better performance*
4. *The accessibility to the best practices*

[72]

In response to these pre-requisites, this research work originates from the need to support the manufacturing industry to improve and work towards manufacturing excellence. Therefore assuming there is a need within the manufacturing industry to improve addressing point 1.

The second and third pre-requisites are more difficult, and can only be assumed to be the case. From Karlof and Ostblom's philosophy, it is assumed that if companies did not believe the support had value, then they would not devote resources to use it [77]. It can be inferred that by using the tool, a company recognises and accepts that lessons can be learnt from the manufacturing excellence best practices.

The emphasis of this work is on manufacturing improvement. This decouples the purpose of improvement from any other incentives. This is different to the excellence awards models, such as the MX Awards, where companies may enter to be recognised for their excellence in

addition to using the framework for improvement. This sole focus therefore should only attract companies who are willing to make some changes. This can also be seen as a limitation however. There is a reliance on companies to make improvements themselves. The users of the support are likely to be self-selecting, and therefore be those companies who realise the opportunity to improve. If they do not recognise a need to change, then they will not make use of the support and the impact is restricted to only those companies who are willing to improve.

5.5.1.1 Utilisation is key

In order for the support that this research aims to provide, to be of value to the manufacturing industry, it must first be used by companies. Westbrook and Boethel believe utilisation is the goal of dissemination. Utilisation is the concept that the information is used to make changes, improve and influence decisions [78]. From investigating effective strategies for dissemination from both research and field based experience, they identified five major areas for consideration: - user, source, content, context and medium. Appendix 7 highlights the key aspects of these five areas. Scullion similarly agrees that utilisation is becoming a prominent concern when disseminating information and defines the key areas that are closely aligned to Westbrook and Boethel's: source, message, method, and target groups [79].

The next sections will analyse how this research must consider the utilisation factors of user, source, content, context and medium when designing support for the manufacturing industry.

5.5.1.2 User

The intended user of the output of this research work is UK manufacturing companies, who are starting their journey towards manufacturing excellence.

The output of this research is aimed to be applicable across all companies within the UK manufacturing industry. Therefore due to this general approach, the dissemination media preferred by each individual company cannot be taken into account. However awareness that

there are different preferred media should be noted as a potential limitation of this work. The aim is to provide a tool that caters for most of the potential users (the UK manufacturing industry) however the effectiveness of the approach may vary across companies due to the variance in preferred media of transfer.

There is a further issue with this general approach from the user perspective - the perceived relevance to each company's own needs. Again due to the broad scope of this research work, the ability to tailor the tool to each individual company is limited. However this is a further aspect for consideration when structuring and choosing the best dissemination approach.

Consideration also needs to be given to the format and level of information provided. The current format of the definition of manufacturing excellence is aimed at companies who already perceive themselves to be excellent and worthy of an award. Therefore consideration of how this information should be presented to those at the start of their excellence journey is needed.

The key aspect that this research work has no control over is the readiness of the user to change. As discussed previously, due to the nature of the proposed research output, it can be inferred that any company using it already has a desire to change and improve.

5.5.1.3 Source

The source and motive of the dissemination is required to be trusted. The origin of this research work is the need for manufacturing companies to adopt best practice to become or remain competitive. As chapter 4 outlined, this objective is shared with the Government and several other award models. Whilst there are benefits for the collaborating parties of WMG and the IMechE in terms of gaining access to companies and marketing opportunities, the emphasis is on the objective to support the UK manufacturing industry. Therefore by clearly communicating that the sole goal of the support is to help companies improve is key to helping companies trust the source.

The Manufacturing Excellence Awards have been in operation for over ten years. In 2010, 42% of the entrants had entered the awards previously. This indicates the acceptance and credibility that users of the original source of this work have.

5.5.1.4 Content

The content must be perceived to the relevant to users. The intended users of this work are the manufacturing industry. Chapter 4 outlined the process of selecting the definition of manufacturing excellence that will form the basis of the content. The definition chosen was that defined by the MX Awards. Therefore the content can be assumed to be relevant to manufacturing companies as the content is specifically focused on manufacturing. There is a rigorous annual review procedure in place that involves members of the institution, participating companies, partners and sponsors to ensure that the definition of manufacturing excellence evolves and therefore still remains valid to the manufacturing industry. Therefore there is a process in place to ensure the content remains relevant. It is intended that this process will be also be used to update the content of the output of this research. This ensures that it remains applicable to the manufacturing industry and the definition of manufacturing excellence remains up to date.

The objective of this work is to help companies understand what best practice is. Therefore it is vital that companies can easily understand the content. As previously discussed in the User section, consideration must be given to the format of the content presented. Currently the format for the Manufacturing Excellence Awards is aimed at excellent companies. The questions used by the awards are therefore challenging to entrants, in order to distinguish and recognise those who truly represent excellence. The output of this research has a different goal. Instead of differentiating and recognising excellence, the objective is instead to help support companies to learn what manufacturing excellence is, in order for them to start their improvement journey towards excellence. Consequently the content must be easily understood. Consideration must be given to how the content is structured and presented to companies as this will affect how easy it is to understand.

Cost effectiveness has been previously highlighted as an area for consideration. This is of particular concern given the large number of potential companies who could use the tool. As the goal is to support the manufacturing industry and in particular those at the start of their excellence journey, the tool would ideally require a minimal amount of resource input from the participating company. It is therefore proposed the tool should be free of charge and therefore require time input from a company.

In addition to cost effectiveness from a user point of view, the cost effectiveness of running and managing the tool must also be considered. This research project does not have access to funds in the long term. Therefore for the tool to be sustainable for the future, it must also have minimal running costs.

5.5.1.5 Context

There are competing products available that provide support for companies to improve; these include the models and awards discussed in chapter 4. There is potential to compare these other products, in order to learn and improve on their practices and identify the opportunities for this research work. The comparison is carried out in submission 2 and the outcomes will be discussed in section 5.5.2.

5.5.1.6 Medium

The key considerations for the choice of medium are summarised as:

1. **Cost effectiveness:-** for both the user and to operate the tool.
2. **Access/capacity to reach users :-** the potential users include any company in the UK manufacturing industry, therefore the medium must enable both access for a large number of companies and have enough capacity to support this.

3. **Attractiveness :** -as noted by Karlof and Ostblom [77] the value created from engaging in an activity should exceed the cost. Whilst use of the tool is proposed to be free, the value in using the tool must exceed the time a company has to invest in using it.
4. **Ease of use :** -the medium must be easy to use. This is due to the limited resources that are available to support use of the tool and also the need to limit the resources a participating company must invest. Therefore training in use of the tool should be minimal and if possible the tool should have instantly / instinctive operability.

The flexibility element in the medium has been discussed before. The scope of users means that there is limited ability to be flexible, but it should be a consideration if possible.

5.5.1.7 Limitations and assumptions

Not all of the utilisation aspects are able to be controlled within the scope of this research work. Therefore there are a number of assumptions and limitations. The overriding assumption is that companies using the tool will want to improve and are ready to change. This is deemed a valid assumption as the goal of this work is to provide a tool to support companies on their excellence journey. This infers that the companies using the tool have recognised there is opportunity for improvement and have sought a tool to support this process.

The credibility of the content is another assumption. The content of the tool is based on the ten years of experience from the Manufacturing Excellence Awards. The awards are managed by the Institution of Mechanical Engineers, and partners in 2011 include WMG, Autodesk, and PricewaterhouseCoopers. The assumption of credibility of the content is supported by the level of repeat entries, the calibre and credibility of the partners involved, and positive feedback from entrants. There is a risk however that the content is deemed credible for the purpose of recognising excellence, but not for the purpose of supporting those at the start of their excellence journey to improve.

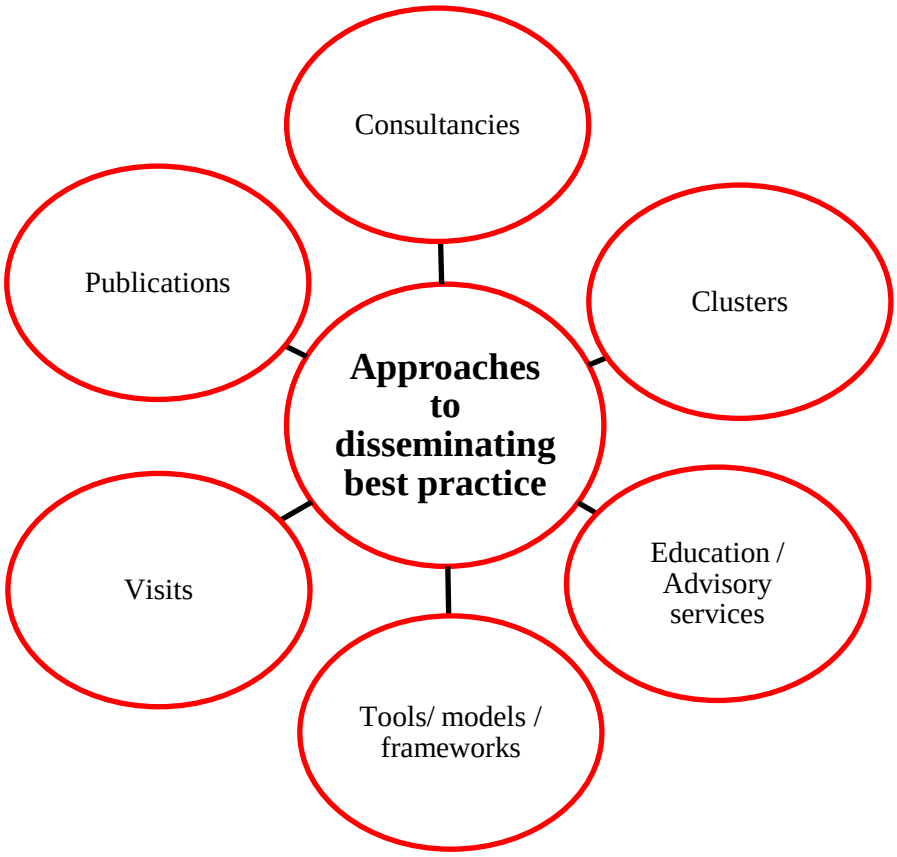
The broad scope of the project in order to appeal to all aspects of the manufacturing industry means that the ability to tailor the tool to individual needs and preferences of companies is limited. Therefore, the emphasis is on the company using the tool to tailor the information gained in order to plan and implement their own specific improvements. Therefore, whilst the ultimate goal of this project is to bring about improvement in manufacturing companies, the ability of this work to directly impact improvements is limited. Instead, this research output will be focused on the start of the excellence journey by facilitating companies to understand what excellence is, identify improvement opportunities and provide guidance on how to attain excellence.

Cost is another limiting factor. Ollererearnshaw's model on Table 5-2 highlighted that the greater the ability to influence and shape behaviour, the greater the need for interaction in the transfer process. Interaction requires resources such as expertise, time and cost. With limited funds available to support interaction, this restricts the transfer approaches available to this research project.

5.5.2 Approaches to disseminate manufacturing best practice

There are many approaches that can be used to disseminate best practice as shown in Figure 5-2. A tool was chosen as the preferred method. In terms of Olllerearnshaw's model in Table 5-2 [76], tools straddle both sharing information and shaping behaviour, thus are a balance between passive and interactive approaches. This means they are a compromise in terms of the amount of resource required and the effectiveness of the approach to bring about utilisation of the information transferred.

Figure 5-2 Approaches to disseminating manufacturing best practice (source: author)



There is a number of existing manufacturing support tools. Submission 2 reviewed three of these tools in order to understand what is already available and to identify key opportunities. The three tools reviewed were the World Class Manufacturing Checklist, Manufacturing PROBE and the Manufacturing Excellence Awards. Two additional tools were included; Business Link and the EFQM Excellence model. These tools are not specific to manufacturing, however offered further learning points that can help develop a new tool.

From the earlier analysis of aspects that are key to dissemination, the following points were identified as criteria for the comparative review:

- Process for companies interacting with the tool
- Format of content
- Value for companies
- Resources required: from the participating company
- Resources required: from the entity operating the tool

A summary of the comparison can be found in Appendix 8. The review raised a number of points:

i. All of the tools had a self assessment diagnostic element. Within this self assessment there were different variations:
    a. Structure of the tool (modular, one individual assessment, tiered assessments)
    b. Structure of the question (open or closed)
    c. Structure of the answer (multiple choice or free text)
    d. Length of assessment

ii. Process of how the tool works:
    a. Generation of the report (user compiled, automatically generated, compiled by an external expert)
    b. Method of comparison (company based, industry based, country based)
    c. Visual aids (use of graphs and tables to support understanding)
    d. Use of expert opinion (visits, compilation of reports, consultancy)

iii. Operation of the tool. There are differences in the way tools can be accessed and maintained, including the:
    a. Cost to access the tool and subsequent stages
    b. Timeliness of access (continually available, preset deadlines for use)
    c. Tool platform (web based, software based, paper based)

Therefore there are three key considerations for the design and development of the tool; the content, the process and how it will operate.

Some of the points have already been discussed for example, the need for the tool to be free of charge and to be continuously available to ensure manufacturing companies can freely access the support. The remaining aspects will be decided in chapter 6.

5.6 The use of self assessment

Self assessment was a key element to all the reviewed tools. Self assessment is a self-directed approach of transferring best practice as defined by O'Dell and Grayson (page 72) [70]. Due to the restricted ability to provide any external assistance, self assessment will form a key element of the support that this research will provide. Utilising self assessment enables wide use within the manufacturing industry because it requires only resources in terms of time from the participating company.

The benefit of using self assessment is that it does not require a lot of resources and companies can do it in their own time. The disadvantages include that the reliance is on the company to ensure the truthfulness and accuracy of the assessment as there is no external perspective to validate the

Due to the resources available, the ability to provide external opinions to support companies is limited. Ollerearnshaw's model on page 71 showed the different mechanisms for transferring best practice [76]. It is assumed that face to face and events methods, such as those which can be offered with external opinion through visits or consultancy, were the most desirable due to their ability to shape behaviour. However this comes at a cost, requiring more resources due to the high level of interactivity. The feedback gathered from the MX Awards and analysed in submission 2, showed that the self assessment was valued by participating companies. Self assessment was found to promote self reflection, discussion and the identification of improvement areas. Therefore despite low levels of interactivity and the reliance of companies to ensure honesty and accuracy of assessment, companies can still gain value from the process of self assessment that can help them start their journey towards manufacturing excellence.

Self assessment alone is limited in the ability to transfer best practice. All the tools reviewed made use of reports to support the assessment. Reports provide a tangible output of assessment that companies can use to identify and prioritise improvements. It also enables the data to be presented in easily digestible formats, including graphs and tables.

Use of self assessment coupled with reports, provides a more holistic approach to transferring best practice and supporting companies on their improvement journey. Companies can learn about best practice whilst benchmarking themselves against manufacturing excellence. The report is an output from this process and can provide supplementary information in different formats, thus enabling the value and benefit to companies to be increased.

Reports also provide increased learning opportunities. For example, the results of the assessment could be shown against others results such as results of an industry sector, or results for similar sized companies. The ability to benchmark against other companies within the industry enables the benchmarking to be increased from generic to include industry/competitor benchmarking (see the classifications of benchmarking in Appendix 6). Thus, the purposes of benchmarking can increase from measuring gaps and increasing awareness, to identifying the opportunities for competitive advantage. Comparative functionality requires a level of maturity in order for sufficient data to be collected to allow such comparisons to be made.

5.6.1 Opportunities for a new tool

Whilst the previous section outlined some of the initial decisions for the design of the tool, further consideration is needed of the additional points raised regarding the content, operation and process. These points formed the key areas for development of the tool and therefore will be discussed in the Process chapter. The key opportunities following the review of approaches and current tools are:

i. Tailoring of the tool to individual companies

All the tools reviewed have standardised content for all manufacturing companies. The Content chapter identified that one of the limitations when defining manufacturing excellence is the dynamic nature and the variability between industries and operating conditions. This

variation is not fully taken into account by any of the tools reviewed. This increases the work a company has to put in to obtain meaningful results as they must first understand and interpret how these differences effect their assessment and impact their results.

The opportunity is to develop a tool that embeds adaptability, thus allowing companies to tailor the tool to their particular circumstances and therefore increasing the relevancy of the information provided.

ii. Maximising value whilst minimising resource usage

The tool should be free of charge to ensure it is accessible for all companies and to limit the resources required to use the tool. Companies will need to invest resources, this will predominantly be their own time, in order to carry out the assessment and review the results.

To maximise adoption of the tool, companies must be able to gain value from the process. To encourage companies to use the tool, they must perceive the process to have value before they commit resources. The factors that positively affect this opportunity include the effectiveness of the best practice transfer, the comprehensiveness of the benchmarking and the ability of the tool to identify improvement areas.

The content of the tool is derived from the Manufacturing Excellence Awards. Feedback from the awards highlighted that companies found the content to cover all business activities and this was a benefit. When developing the tool, consideration should be given to how the content can be transformed into an improvement tool without losing the comprehensiveness of the content.

A factor that negatively affects the value proposition is the length of the assessment. A long assessment increases the time a company must invest. Therefore this increases the risk that the resources required will outweigh the benefit received or that companies will not complete the assessment before gaining the value of the report

The ability to enable companies to identify improvement areas is related to the feedback report format and structure. The tool needs to consider what results to feed back and how to communicate this so that companies can identify clear areas for improvement.

iii. Providing a comprehensive method of best practice transfer

The tools reviewed favoured either best practice transfer via the assessment or the report. The opportunity is to increase the value gained and reinforce the learning by providing mechanisms for best practice transfer at both stages. This opportunity ties in with the objective to maximise value because the more comprehensive the best practice transfer, the more value a company can gain from the process.

5.7 Input Summary

This chapter has analysed the process of best practice transfer. This has encompassed reviewing the approaches to transfer, understanding the key factors of dissemination and understanding the process of benchmarking.

The approach chosen was a tool. This was the most appropriate choice due to the ability to share information and shape behaviour, and reach a large number of companies due to its relative low cost. A review identified that self assessment and feedback are common elements of existing support tools. A tool made up of self assessment and reports, provides a low resource approach to best practice transfer whilst minimising costs. This allows the tool to be free of charge, widely accessible and sustainable in its approach in order to provide on-going support.

Key elements that the tool must include are:

1. Being free of charge
2. Having a process that includes self assessment and reports

3. Having a process focused specifically on improvement rather than recognition and reward
4. Being self sufficient, without the need for external perspective
5. Having the capability to include comparisons once sufficient data is collected

The subsequent Process chapter will outline how the remaining elements of the content (its level, format and structure of the content), process (how companies interact and use the tool), and operations (how the tool is accessed, maintained and disseminated), will be considered in the design and development.

6 Process, *developing MX Start*

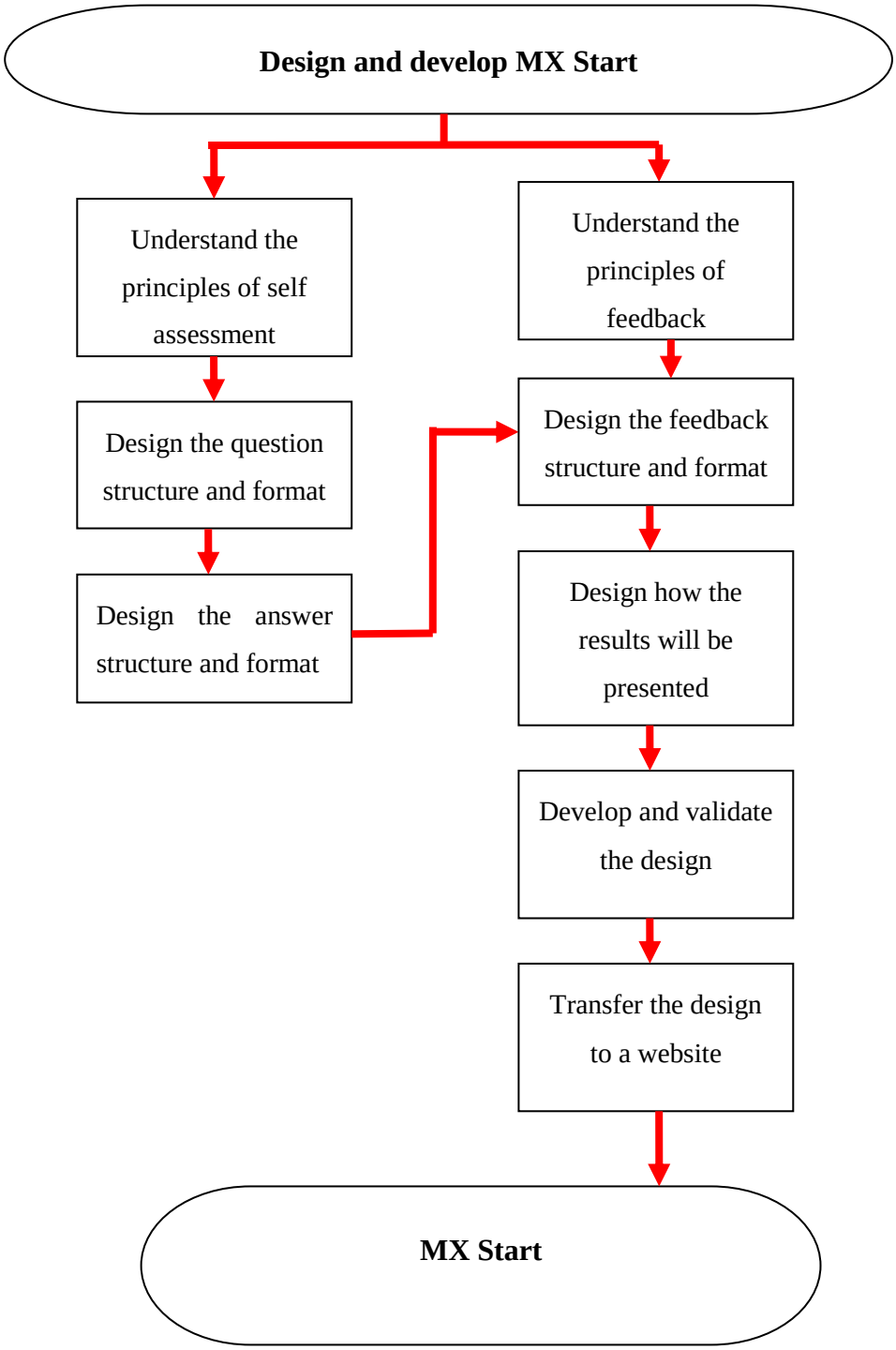
Objective:

- To design and develop MX Start

Output:

- MX Start

6.1 Flow chart of the approach taken in submission 3: the design and development of MX Start



6.2 Word cloud of the key themes from Submission 3: The design and development of MX Start

6.3 Process introduction

The Input chapter investigated the possible approaches and strategies to achieve the aim of supporting companies to start and progress on their excellence journeys. It was identified that a tool was the most appropriate method for the output of this research work. This main reason for this choice is the ability of a tool to be accessed by a large number of companies without the need for a large investment of resources.

Chapter 4 defined three key areas to consider in the design of the tool: the content (the level, format and structure of the content), process (how companies interact and use the tool), and operations (how the tool is accessed, maintained and disseminated). It was also specified that the tool should be made up of assessments and reports. The assessment would allow companies to assess themselves against best practice, whilst the report would present the results and enable gaps, and therefore improvement opportunities, to be identified. This chapter will detail the design and development and will begin by reviewing the principle of effective self assessment and feedback.

The tool will be known as MX Start. The name MX Start, reflects the vision of the tool. 'MX' is derived from the abbreviated form of Manufacturing Excellence from the Manufacturing Excellence Awards (MX Awards). 'Start' reflects what the tool is for - to help companies start their Manufacturing Excellence journey. By aligning MX Start with the MX Awards, enables the MX brand to be built upon. In future further support could be developed to bridge the gap between MX Start (the start of the improvement journey) and the MX Awards (recognition that companies have reached an advanced stage of excellence).

6.4 Self assessment

The definition of self assessment used by this work is that of Ford and Evans who define self it as *"the holistic evaluation of organisational processes and performance using little*

external assistance" [80]. MX Start will help companies to assess themselves across all aspects of manufacturing.

Whilst the subject of the assessment is a company, a company as an entity cannot take an assessment. An assessment has to be taken by an individual or number of individuals. These individuals will be employees or owners of the company. Simon states that companies can learn in one of two ways:

a) *By the learning of its members*
b) *By ingesting new members who have knowledge the organisation didn't previously have*

[81]

The focus of this research is on the first method; that of helping an organisation to learn through the learning of its employees. Therefore for this research work, the self in self assessment will refer to the individuals who use MX Start to understand what manufacturing excellence is and where they can implement it, in order to improve their organisation.

6.4.1 The types of self assessment

There are several different types of self assessment. Crisp uses the broad categories of:

Diagnostics assessment – where an assessment task is used to identify the current situation and identify gaps. Learning can be improved through this assessment.

Formative assessment – where an assessment task helps identify how the user can improve. Learning can be improved through this assessment.

Summative assessment – where an assessment task makes a judgement / grades the responses. Learning is not usually improved.

[82]

For MX Start the type of assessment will be both diagnostic and formative. The diagnostic element will enable companies to understand how they perform against manufacturing excellence to identify gaps. The formative part will facilitate their understanding of what best practice and how they implement it in order to make improvements.

6.4.2 Separating recognition from improvement

By focusing on formative and diagnostic assessment, this allows MX Start to focus on improvement rather than recognition. Tito Conti, a founding member of the EFQM model, believes that the term self assessment has become hijacked by existing improvement tools, particularly those associated with awards such as the EFQM model and the Manufacturing Excellence Awards [83]. Conti believes there are two forms of assessment: award assessment and true self assessment. True self assessment is that where the use is solely by the company for the purpose of improvement. Award self assessment is also for recognition and involves third party input into the assessment process.

Shepard explores the role of assessment in learning in a classroom based environment. Shepard agrees with Conti. Shepard believes that assessment for learning should be separated from external reward or "high stakes" testing, as it encourages the wrong behaviour where participants may be encouraged to distort scores and answers without a corresponding improvement in learning [84]. This sentiment is also shared by Boud who believes there can be tension between assessment and learning, particularly when the purpose is summative [85]. Therefore the sole focus of MX Start is on improvement to encourage the right behaviours by users to learn, identify opportunities and adopt best practice.

This emphasis on the formative purpose of the assessment does not rule out use of aspects such as summative tool like scoring. Scoring of the assessment could provide a diagnostic element for the company, as it would enable them to identify gaps and weaknesses. The importance is that this score is not used for any other purpose than for the company to learn from it (by identifying gaps).

6.4.3 Principles of effective formative assessment

The scope of this work is to provide support to the UK manufacturing industry. Of the 303,245 manufacturing enterprises in 2009, 99.5% of them employ under 250 people [20]. Therefore the majority of manufacturing companies in the UK can be considered small and medium enterprises (SMEs). Sturkenboom et al looked the case of self assessment in SMEs, and set out the four aspects below that self assessment needs to comply with:

1. *It should not be too complex*
2. *It should give direction for what has to be done*
3. *It should focus on action instead of scoring*
4. *It needs to support the company in implementing the key elements*

[86]

Therefore MX Start needs to have a simple design. The focus should also be on how the company can improve rather than just measuring where they currently are. The second and fourth points set out by Sturkenboom et al regard the information that the assessment provides [86]. . Shute describes formative assessments as: *"information communicated to the learner that is intended to modify the learner's thinking or behaviour for the purpose of improving learning"*[87]. Therefore there is a need to consider what information will be fed back to companies. This feedback will be key to encouraging and supporting them to make improvements.

Sadler identifies three conditions that are required for feedback to be beneficial. The three aspects a learner must understand are:

1. the standard (or goal, or reference level) being aimed for
2. the comparison between the actual (or current) level of performance with the standard
3. the appropriate action which leads to the closure of the gap

[88]

These principles are key to the objective of MX Start. The dissemination of best practice can be considered helping users to understand the goal of achieving manufacturing excellence. Companies then need to understand where their gaps are and what they can do to close them in order to make improvements.

Feedback can be directive (outlining what needs to be corrected) or facilitative (providing comments and suggestions to guide learners to their own solution) [87]. For MX Start, the emphasis should be on facilitative feedback in order to help guide companies on their excellence journey. As the Context chapter highlighted, excellence and best practice can be influenced by aspects such as industry, size and maturity. Therefore there is not a single solution or model that is best for all manufacturing companies. Directive feedback therefore, would be difficult to provide to users of MX Start without manual intervention to customise this information to each specific circumstance. There are not sufficient resources to carry out such customisation. Therefore the information provided in the feedback of MX Start should give guidance so that companies can tailor this advice to form their own solutions.

Goodman et al conducted a study regarding the specificity of feedback, which is *"the level of information presented in feedback messages"* [89]. The more specific the feedback the more directive it is. Goodman et al found that the more directive the information, the greater benefit for performance and learning. However, they also found that the endurance of the benefit was negatively affected by the greater specificity. Learners were less encouraged to explore and use their own information processing skills to generate solutions. The approach of MX Start is self – directed and there is a need for companies to seek out and develop their own solutions to make improvement. Facilitative feedback is therefore is most appropriate for the research aims. The limitation is that the direct benefit on performance improvement is restricted. However this is outweighed by the long term view of encouraging the right behaviours and skills for companies to progress on their own journey beyond the use of MX Start.

In summary, the three design areas of content, operation and process must consider:

- Ensuring the tool is formative with an emphasis on improvement
- The simplicity of design
- Ease of use
- Ease of understanding
- The explanation of what the standard (manufacturing excellence) is
- Comparison of the users performance against the standard (identify gaps)
- Help companies understand what they might do to close the gap
- Use of formative and facilitative feedback to support and encourage further learning and improvement

The next sections will outline the design decisions for each of the three key areas of content, process and operations.

6.5 Content design

The key elements to consider in the content design are:

a. Structure of the tool (modular, one individual assessment, tiered assessments)
b. Structure of the question (open or closed)
c. Structure of the answer (multiple choice or free text)
d. Length of assessment

The definition of manufacturing excellence selected in the Content chapter was that of the Manufacturing Excellence Awards (MX Awards). The awards process, and therefore the assessment, is focused on distinguishing excellence for the purpose of recognising and rewarding it. Therefore the content required realigning with the purpose and focus of MX Start to help companies improve.

The process of aligning the content to MX Start can be found in Submission 3: Chapter 3. The outcomes of this process included a reduction of the amount of content, in order to concentrate on the key areas of best practice. It was decided that MX Start would be

modular. Therefore the tool would be made up of eight individual assessments. This means that companies can choose the assessment or assessments which they feel are most relevant to them. For example, a company that is make-to-print and does not engage in product design, could choose not to complete the product innovation assessment. A modular design also provides a more manageable assessment approach for companies by breaking the overall assessments into smaller sections. The eight assessments are:

1. Customer Focus
2. Product Innovation
3. Process Innovation
4. Logistics and Resource Efficiency
5. People Effectiveness
6. Business Development and Change Management
7. Financial Management
8. Information and Communications Technology

The individual assessments are divided into sections. This division provides more information to companies regarding what the important areas of best practice are within the assessment and also facilities identifying areas of weakness, not just individual questions of weakness.

Dividing the assessments into sections also provides an opportunity for customisation. Whilst the overall content of an assessment may be relevant for a company, not all the areas within that assessment may be applicable or as important as the others. Therefore, there is scope to allow companies to rate each of the areas depending on the importance of that section to their particular circumstance. This allows them to assess themselves against their own required level of performance in addition to that of manufacturing excellence.

The assessment uses multiple choice answers. This means that questions have a pre-determined answers response. The benefits include that it facilitates the simplicity of the assessment, the ability to provide meaningful comparisons, the mitigates companies to interpreting the questions in different ways, and it takes minimal time and effort for

companies to complete [90],[91]. Overall, the use of multiple choice answers minimises the complexity of the assessment.

MX Start requires the ability for companies to compare themselves against a standard. The design considerations specified that users need to be aware of what the standard is they are assessing themselves against. By setting out the answer in a series of statements that companies can select from facilitates this aim. The multiple choice answers are therefore structured on a scale from poor to best practice. Companies can then select the statement of practice that most closely aligns with their policy, practice or performance. This integrates the standard of excellence within the answers choices. Thus making companies aware of the standard they are comparing themselves against. This then starts the dissemination of best practice from the first interaction with MX Start.

Given the formative emphasis, it was decided the statements rather than questions would be used in the assessments. Direct questions may lead companies to feel they are being judged and could encourage inflation of answers to make the company look better. The use of statements avoids the concept that the assessment is for judgement purposes or is a form of test, which could have led to companies feeling they need to give a correct answer rather than a truthful one. Therefore companies compare and assess themselves against a statement using pre-determined multiple choice answers. For example, instead of the question: *What are the key buying criteria used by your customers?,* this is instead the statement: *You understand the key buying factors used by your customers.* In order to answer this statement, companies would be required to select from the statements: *No, To some extent, Yes*.

6.6 Process design

The key elements considered in the process design were:

a. Content of the report
b. Visual aids (use of graphs and tables to support understanding)

c. Generation of the report (user compiled, automatically generated, compiled by an external expert)

The report supports the formative self assessment by providing facilitative feedback. The tiered approach of the multiple choice answers provides the opportunity for feedback at each of the level on the best practice scale. This allows the feedback to be customised to the specific level a company has benchmarked themselves as being. Guidance is then provided at each level on the best practice scale to help companies identify what they might do or need to consider to progress to a higher best practice level.

With an average length of twenty questions per assessment, the opportunity for feedback was considerable. However the design considerations noted the need for a simple process and for a low resource intensive process from the perspective of a user. Therefore the feedback statements are as short and simple as possible to comply with these considerations.

Feedback statements were therefore written for all 525 multiple choice answers. The feedback statements were generated by the author and Dr John Garside. Dr Garside wrote the original self-assessment audit for the MX Awards. He has been involved in the process for over ten years, and therefore could provide considerable expertise and knowledge of manufacturing excellence and how companies might be guided along their excellence journey.

Scores accompany the feedback statement. Whilst scoring is often associated with summative evaluation, it can be used for formative purposes, for example, highlighting gaps and facilitating comparisons. MX Start uses scoring to facilitate such aspects. Therefore in addition to the descriptive comparisons (through the multiple choice answers and feedback) the scores help companies identify gaps by converting the assessment results into numbers. The number can be used to measure gaps, which then would indicate potential improvement areas. There are three aspects used to measure gaps:

1) The gap between best practice and the answer chosen by the company

2) The gap between best practice and the performance in an assessment section
3) The gap between the importance rating given to an assessment section and the performance in the section

The first two methods enable gaps to be identified between the company's current status and excellence. The difference between the two is the level of content. Each assessment is made up of sections, which contain a number of question statements. Therefore the section gaps would provide companies will an indication of the overall areas for improvement. The section can then be looked at in more detail using the gaps identified at the individual question level.

The third method enables a comparison between the company's current status and where they would like to be, by comparing how important they perceive the section is with the performance attained in that section. Where the importance score is greater than the assessed section score, then this would indicate a possible area for improvement. This method helps customise the analysis of data to the company's own context, thus provide more meaningful information to the company.

6.6.1 Visual aids

The report contains visual aids to help companies interpret their results and identify gaps. There are three visual aids used:

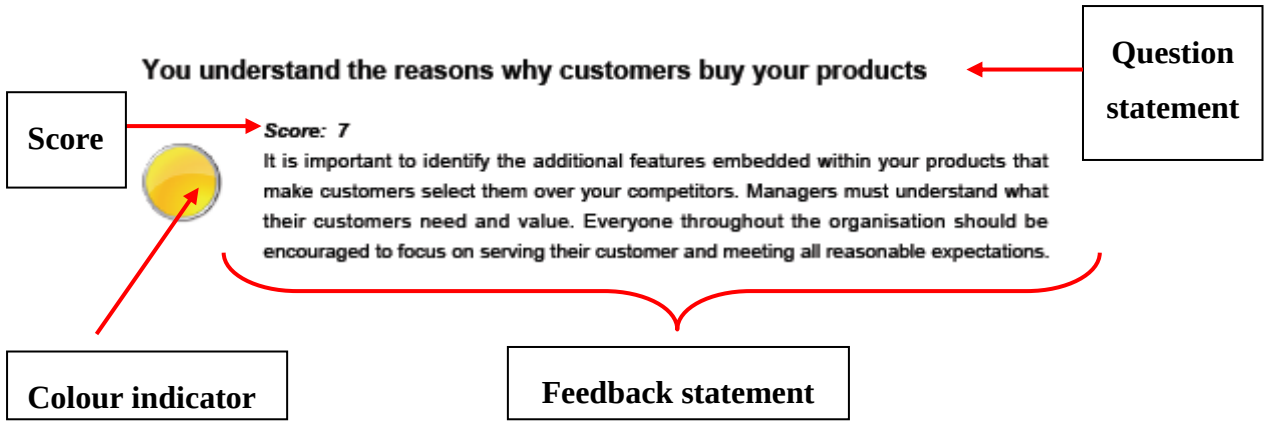
1) Red-Amber-Green indicators
2) Radar diagram
3) Table of results

To accompany the scores and formative feedback statements, a colour indicator is used so that companies can easily distinguish where improvement opportunities are. Red-Amber-Green indicators are used for this purpose as it is a simple system that is easy to recognise

without the need for extensive explanation. Red indicates a key opportunity for improvement, amber indicates an opportunity for improvement and green indicates an area of best practice.

In summary, the feedback given to companies for each individual question statement of the assessment includes a score out of ten to measure the gap, a colour indicator to denote the opportunity for improvement and a feedback statement to provide guidance for improvement. An example of this is given in Figure 6-1.

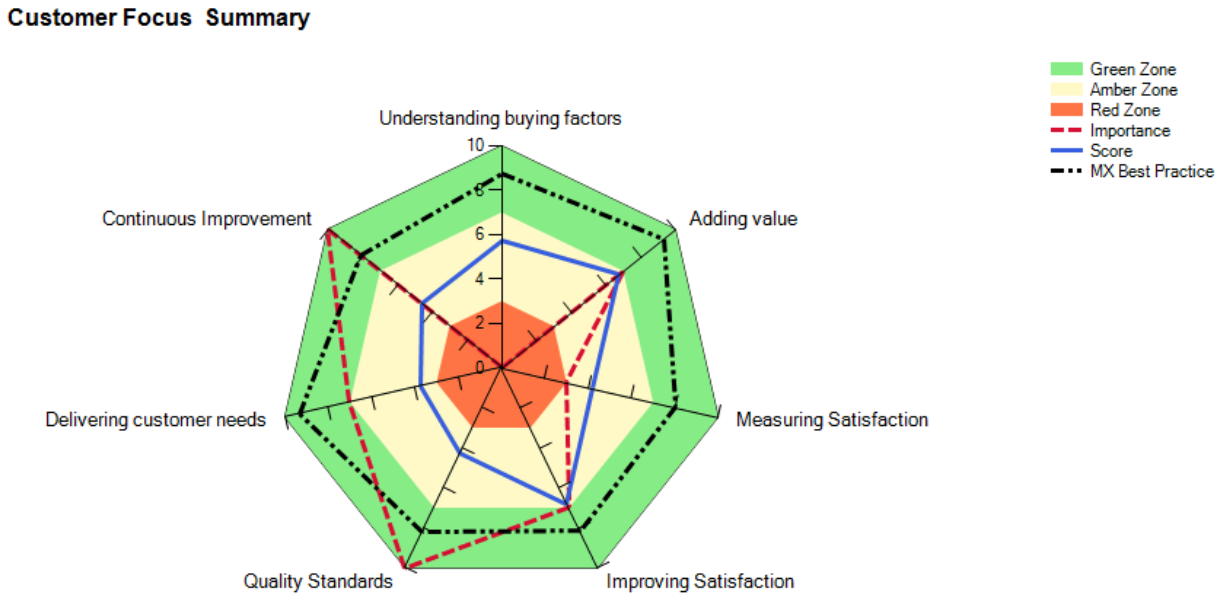
Figure 6-1 Example of the feedback response provided to MX Start users



6.6.1.1 Radar diagram

The radar diagram presents the results of an assessment at the section level. An example of the diagram is shown in Figure 6-2. By comparing the score (blue line) and importance rating (red line) of each section, companies can identify potential improvement areas. The larger the gap between the importance and score, the higher the priority for improvement. For example, in Figure 6-2, the importance of the section Quality Standards exceeds the performance score; this is also the case for Improving Satisfaction section. The gap for the Quality Standards section is larger, indicating that this should be a higher priority target for improvement.

Figure 6-2 Example of the summary radar diagram for the Customer Focus Assessment of MX Start



The MX Best Practice line (shown in black) is the average result from the top five companies of the MX Awards. As MX Start matures, there is potential to include other best practice comparisons that might be more meaningful for companies. This could include a comparison against companies in their industry, of their size or in their region. However until sufficient data is collected through the MX Start assessments, these comparisons cannot be made.

6.6.1.2 Table of results

An accompanying table of results is used to aid the understanding of the radar diagram. It might not always be obvious from the radar diagram which, if any, gaps are larger. An example of such a table is shown in Table 6-1. The table presents the data shown in the diagram in a numerical form and also provides an indication of key improvement areas. Large gaps between the importance and the score are indicated as a 'Priority for Improvement' and highlighted in red, smaller gaps are identified as a 'Potential Priority' and shown in yellow. This helps companies analyse the results to interpret where the most important or the largest areas for improvement are.

Table 6-1 Example results table for the Customer Focus Assessment of MX Start

Section	Importance	Score	Priority for Improvement	MX Best Practice
Understanding buying factors	0	5.8		8.73
Adding value	7	6.8	Potential Priority	9.32
Measuring Satisfaction	3	4.2		8.04
Improving Satisfaction	7	6.8	Potential Priority	8.17
Quality Standards	10	4.3	Priority	8.18
Delivering customer needs	7	3.8	Priority	9.35
Continuous Improvement	10	4.6	Priority	8.10

6.6.2 Resource library

The aim of MX Start is to support companies to start their journey towards manufacturing excellence. The feedback provided in the report is designed to be formative and therefore help provide guidance to companies that will enable them to start making improvements. The detailed feedback given in the report is short so not to overwhelm the company with too much information and to promote them to explore and seek out more information themselves. This then encourages the company to support themselves along their journey towards excellence.

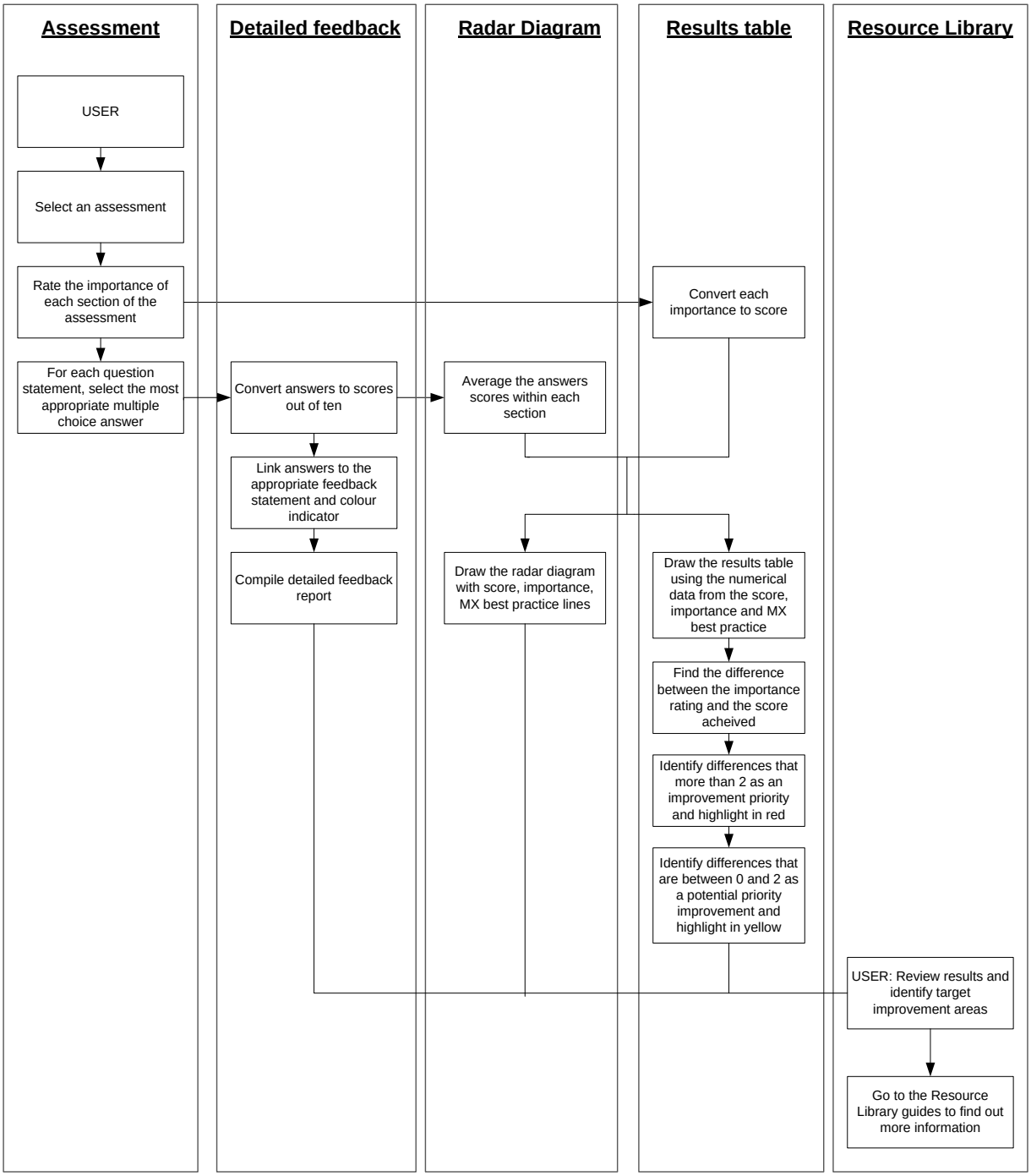
The disadvantage of the self-directed approach is that companies may not know where to find more information. Therefore it was decided that MX Start will also contain a resource library to provide more information. Access to the resource library would be free of charge and optional for companies. Therefore they choose if they want to use it to support their journey towards manufacturing excellence.

The library contains guides that are aligned with each section of the assessments. The guides provide details of key issues, factors for success and to avoid, and the benefits the improvement could bring to the company. The author did not write the guides, instead they were written by Dr John Garside and Judy Walton because of their extensive experience and knowledge of the manufacturing industry.

6.7 Report generation

The report of MX Start is automatically generated. The multiple choice assessment style facilitates this as it enable relationships to be established between the answer, score, feedback statements and colour indicators. The process the links the assessment, with the feedback, visual aids and resource library is shown in Figure 6-3.

Figure 6-3 Outline of the MX Start process



6.8 Operations design

The key element considered in the operations design was the tool platform and in particular by which means could the tool could be disseminated and accessed by any manufacturing company in the United Kingdom.

A web based system was selected as the most appropriate approach. It provides a mechanism that can reach a large number of companies at a low cost, therefore enabling the tool to be provided free of charge to users. Therefore this helps MX Start to achieve the research objective to enable any and all manufacturing companies to access the support. The limitation of using a web based system is that companies need to be able to access the internet to use MX Start. In 2009, 91% of companies (with more than ten employees) had internet access [92]. Therefore, there is a high percentage of companies who have the capability to access MX Start through the internet. The ability to access the internet is unknown for those companies with less than ten employees. However, 73% of households have internet access at home, therefore it is possible that in a small business if there is no company internet access then the individuals within the company could have the opportunity to access the website at home [92].

The use of a website also enables content to be modified and updated in real time. This is a benefit because, as discussed in the Context chapter, the definition of manufacturing excellence is dynamic and evolves over time. Therefore by being online, this ensures all companies are using the most up to date version of MX Start. It also facilitates content being added or removed, therefore allowing MX Start to evolve over time to ensure the tool remains relevant and could also allow the tool to grow and develop.

A website also enables the assessment data to be collected into a database which can be used in future to provide further comparisons between companies such as by size, industry or region. Information can be captured on the website and filtered through company characteristics to enable competitive benchmarking to be added to the tool once sufficient data is collected. This comparison would be anonymous or could take the form of the industry average to ensure the privacy of data collected is upheld.

6.8.1 Developing the concept

Whilst a website is the best approach in terms of the dissemination, data collection, and the ability for updates; it required significant resource to establish in the design phase. In order to validate and test the concept of MX Start, it was first developed on a spreadsheet software package. This provided a low cost approach to test the content and process of MX Start before being implemented as a web based system.

MX Start is aimed at the manufacturing companies. An opportunity arose to test the concept with the Manufacturing Advisory Service in the West Midlands (MAS-WM). MAS formed part of the Governments best practice support as part of the 2002 Manufacturing Strategy [6]. The remit of MAS is to provide advice for manufacturing small to medium enterprises(SMEs) to diagnose problems and identify opportunities to increase their competitiveness [6]. The UK manufacturing industry is made up of 99.5% SME companies [20]. Conducting a pilot with MAS therefore provided access to manufacturing companies and in particular SME's, who are the majority of companies in the manufacturing industry. For the pilot, the MAS advisors were trained in the use of MX Start. The advisors used the tool on their initial visits with companies, to facilitate the identification of potential improvement areas.

As part of the pilot, feedback was generated through author visiting three companies directly, progress reviews with the advisors, and individual emails and telephone calls with the advisors. This feedback encompassed comments about both the content and process of the assessments and reports.

The opportunity for the pilot arose in a short space of time. Therefore preparation for the pilot concentrated on readying the tool for a live test in an industrial environment. However this meant that there was not a formal feedback collection system in place. This was an advantage as the feedback received through the channels mentioned above, could be rapidly implemented and an updated version sent out for further testing. Therefore the development cycle was very responsive to the feedback and changes could be evaluated to understand their

effectiveness. The limitation of the lack of a formal system meant that the changes were not formally documented as the priority was given to the implementation and development. Therefore the individual specific changes made were not formally captured, however the feedback led to improvements in the following areas:

- Refining the content – correction of spelling and grammar errors, revision of the question and answer statements where realignment was required
- Improving the ease of use – simplifying the process, particularly the integration of the assessments and reports
- Improving the aesthetics – developing the MX Start brand with use of colours and images

At the end of the pilot, over two hundred companies had completed three or more of the assessments of MX Start.

6.8.1.1 MX Footprint

As a result of the pilot, MAS in the West Midlands (MAS-WM) were interested in continuing to use MX Start to support their activities to increase the competitiveness of the manufacturing industry. They were also interested in developing an additional assessment, specifically aligned to their diagnostic needs and funding streams. This led to the development of MX Footprint. This is an assessment that is for use by MAS to complement their activities. The content was generated by the author and MAS, and is a simplification of MX Start. The report produced does not provide the detailed written feedback as the MAS advisors provide this guidance in person.

MX Footprint is an example of facilitated transfer. MAS provide the feedback and support to interpret the results of MX Footprint and help companies to improve. This completes the third approach to dissemination as identified by O'Dell and Grayson, with assessment and

feedback reports being self-directed and the resource library providing the knowledge service [70].

6.8.2 MXStart.co.uk

The pilot validated the concept of MX Start with respect to the content and process. The next step was to transfer the tool online. MX Start can be found at www.mxstart.co.uk. The author established the overall content, aesthetics and logic of the MXStart.co.uk, and project managed the technical developments to achieve the full specification required.

The website is free of charge. This lowers the barrier for access, because companies need to only invest their time in using the tool. To access the assessments and report, users must first register for an account. Registration is free and collects contact details of the company and key characteristics of the company. This information can be used in future to provide further comparisons against the average performance of others with similar characteristics such as size and industry.

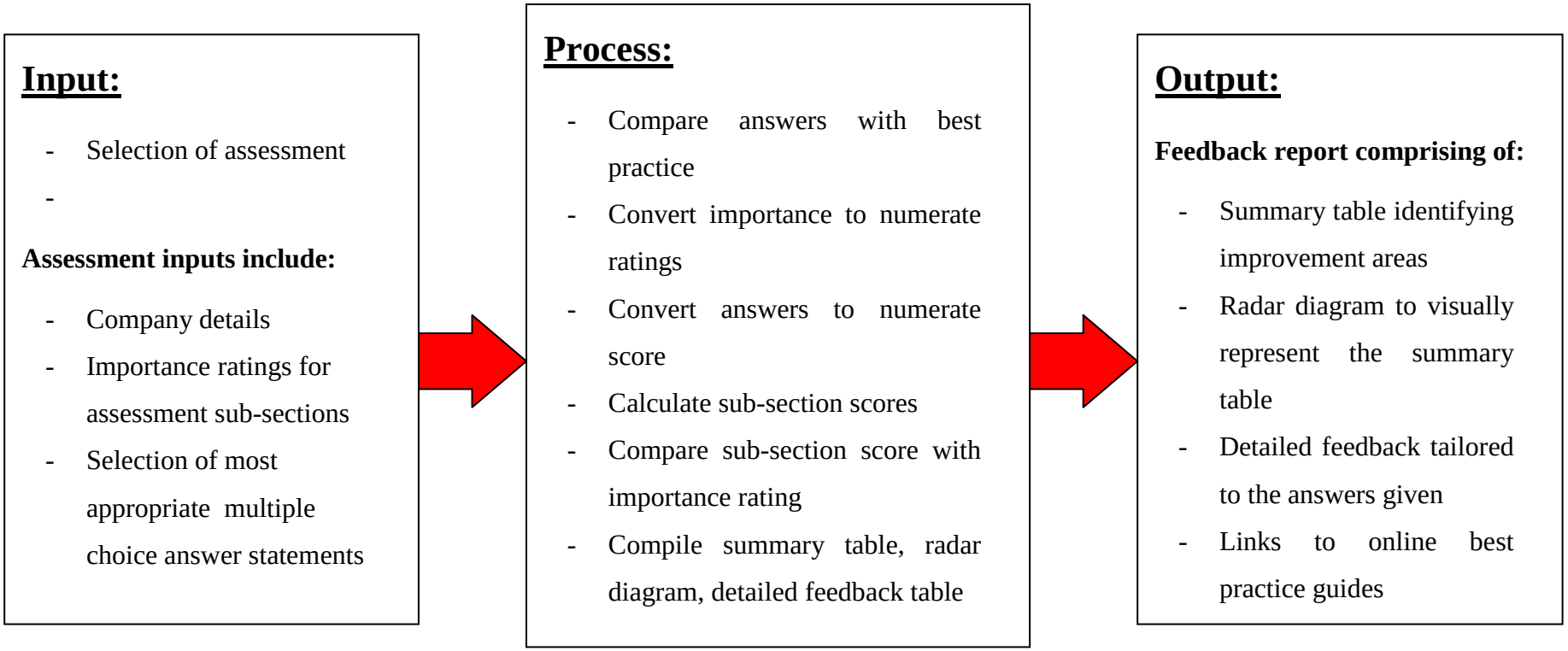
The web based system of MX Start allows any manufacturing company with an internet connection to access the support provided from anywhere in the UK. This fulfils the objective to be able to help any UK manufacturing company to improve.

The website also allows companies to leave and return to an assessment at any point. Therefore if a company has limited time, they can complete an assessment in small sections. . This provides flexibility for the use of MX Start.

6.9 Process summary

MX Start is made up of three elements: the assessment, feedback report and resource library. The required input, process and output that encompass these elements are shown in Figure 6-1.

Figure 6-4 The MX Start process from a company perspective



The assessment is formative to help companies understand what best practice is and to encourage them to reflect on their own practices. This is achieved by using question statements with multiple choice answers. The multiple choice answers use a best practice scale which companies compare themselves against the manufacturing excellence standard.

The feedback report presents the results from the assessment and provides feedback to encourage and guide improvement. The results from the assessment are presented using visual aids including a radar diagram, summary table and colour indicators. These enable companies to easily identify where improvement opportunities are and helps them to prioritise key areas to focus on. The feedback is facilitative and provides more information regarding best practice and provides guidance for companies to help them improve.

The resource library provides more information regarding best practice and how a company might improve to progress along their excellence journey. The links to the library are provided in the feedback report and companies can choose whether to use the library. This provides companies with access to more information without overwhelming the assessment and report elements of the tool.

A pilot was conducted with the Manufacturing Advisory Service in the West Midlands. Over two hundred companies took part in the pilot. The feedback was used to validate the concept and develop MX Start, particularly refining the content, ease of use and aesthetics. This led to MX Start being adopted by MAS-WM, supporting their activities to improve the competitiveness of the manufacturing industry.

A website was chosen as the most appropriate approach to disseminate MX Start. This enables a large number of companies to use MX Start at a low cost, allows the tool to be updated in real time to ensure it remains relevant, and makes it possible for data to be collected that could increase the future opportunities for benchmarking.

7 Product, *evaluating MX Start*

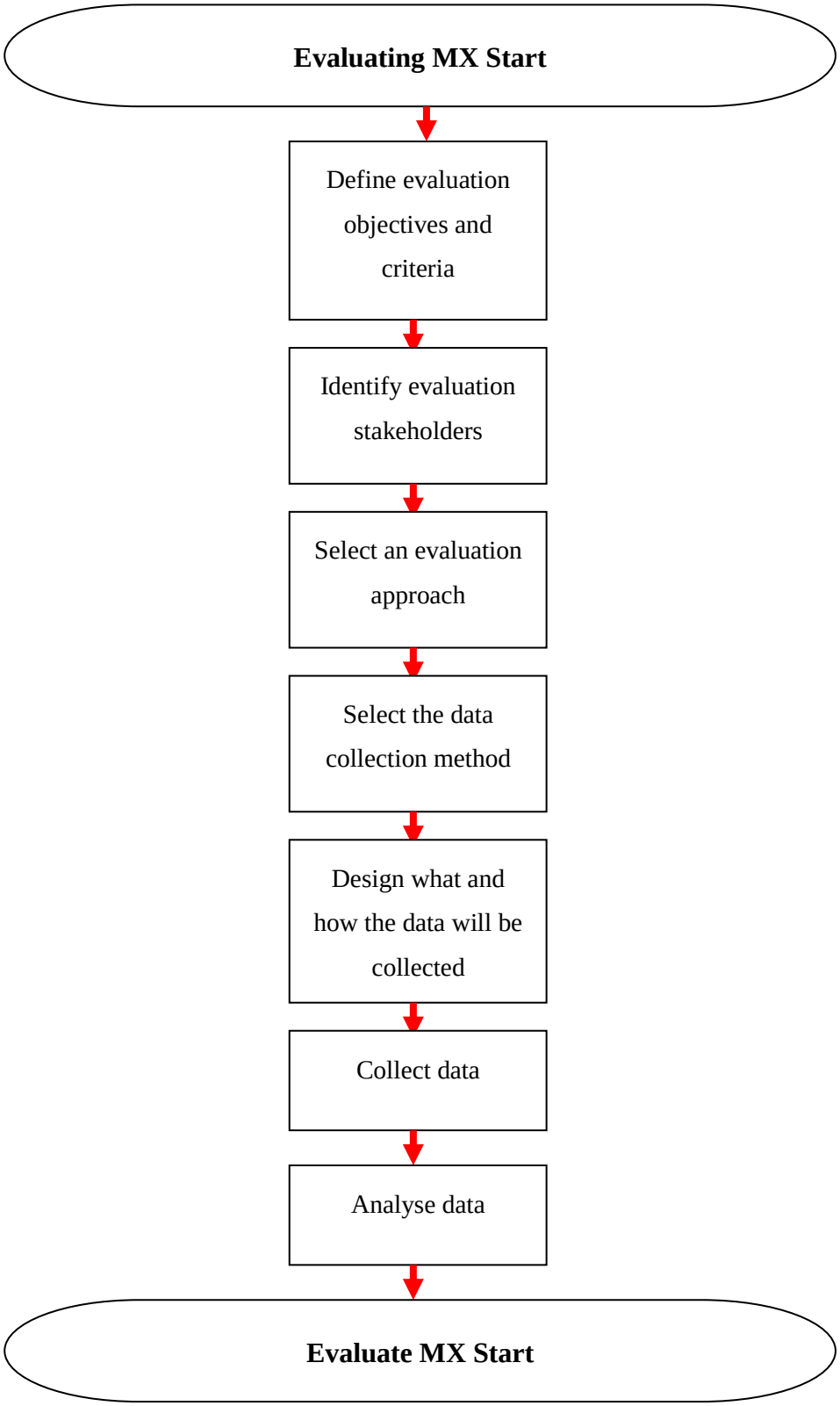
Objectives:

- To design an evaluation strategy for MX Start
- Analyse the results from the data collected from the evaluation

Outputs:

- Draw conclusions regarding the effectiveness of MX Start
- Recommendations for ongoing work to develop MX Start
- Recommendations for further work within this field

7.1 Flow chart of the approach taken in submission 4: Evaluation design



7.2 Word cloud of the key themes from Submission 4: Evaluation design

7.3 Product Introduction

This chapter outlines the evaluation design of MX Start and presents the results.

The evaluation will formally collect opinions on the tool in order to assess whether it has achieved its objective to support manufacturing companies to start their journey towards manufacturing excellence. This is therefore a summative evaluation to judge the effectiveness of the tool. Formative evaluation has already been carried out as part of the pilot of MX Start.

MX Start will continue beyond the timeframe of this research. Thus, whilst the main objectives for the evaluation are summative, formative assessment will also be of value for identify future developments that would benefit the tool.

7.4 Define evaluation criteria and objectives

This evaluation aims to understand the value of MX Start. This section will focus on the content the evaluation needs to focus on.

7.4.1 MX Start utilisation

In the Input chapter, and as discussed in submission 2, it was identified that utilisation is key to disseminating best practice. Westbrook and Boethel identified the five key issues that influence utilisation: content, context, users, medium, and source [78]. These five aspects can provide structure and content for the evaluation. Table 7-1 specifies how each of the issues can be related to the evaluation of MX Start.

Table 7-1 Utilisation aspects to consider in the evaluation of MX Start

Aspects to consider in determining the value of MX Start	
Content	• The ease of which the content can be understood by companies • The extent to which the content is relevant to users' needs • The extent to which the content is perceived to be credible
Context	• The extent to which MX Start offers benefits over similar tools. This is difficult to measure directly as it will depend on the specific tools a company has used. If the evaluation captures the tools that a particular company has used, then this could form criteria for comparison of the data between companies.
Users	• The extent to which the tool is relevant to users' needs
Medium	• The cost effectiveness of the tool • The extent to which the tool is easy to use
Source	This aspect will not be considered. The purpose of this evaluation is not to evaluate the credibility of University of Warwick, IMechE or MAS. The focus of the evaluation is on the output of this research work. The credibility of the source can be partially covered by the content aspect.

The content of the evaluation must therefore consider the content, relevancy and medium of MX Start as well as understanding the value it contributes.

7.4.2 The outcomes of MX Start

In addition to the utilisation values noted above, there is also a need to evaluate the ability of MX Start to meet its objective of disseminating best practice and support manufacturing companies to start their excellence journey. Therefore there is a need to evaluate the outcomes of companies using the tool.

The outcomes are aligned with the research objectives. Therefore the outcomes that need to be assessed are:

- the ability of MX Start to disseminate best practice

- the ability of MX Start to help companies identify areas for improvement
- the ability of MX Start to encourage companies to make improvements / seek out further resources to support making improvements

7.5 Stakeholder identification

The evaluation of MX Start should include the key stakeholders for the tool. This section will outline these stakeholders and how they need to be considered in the evaluation process.

7.5.1 The Manufacturing companies

The target users of MX Start are manufacturing companies in the UK. Therefore the evaluation must include manufacturers.

7.5.2 The Manufacturing Advisory Service

The Manufacturing Advisory Service in the West Midlands is made up of a team of expert advisors. These advisors use MX Start as part of their manufacturing review when they first visit a manufacturing company. The advisors can provide an expert perspective on the use of MX Start. They also have knowledge on engaging with manufacturing companies with and without the use of MX Start and therefore are well placed to comment on its effectiveness.

By including the MAS advisors in the evaluation, means the number of companies reflected in the evaluation will be more than that the number of companies who take part. This is because the advisors opinions and perspectives on the success of MX Start will be based on their experiences of using the tool. The advisors would have used MX Start with a number of companies. Therefore their evaluations will be based upon the collective effect of using the tool with a number of companies. Whilst a manufacturing company can provide their sole perspective, the advisors can provide a more holistic evaluation based on their expert opinion and experiences of numerous manufacturers.

7.5.3 Institution of Mechanical Engineers

The Institution of Mechanical Engineers (IMechE), and in particular the Manufacturing Excellence Awards (MX Awards), provided the original inspiration for this research. The MX Awards have been established since 2000 and a significant number of IMechE members have been involved in its development and the assessment process. However the IMechE has not had significant involvement in the design and development of MX Start. Therefore the IMechE members can provide another perspective for evaluation for MX Start. They understand the value that the external perspective the MX Awards process provides but are also aware of the limitations of such a labour intensive tool. Therefore their input will be influenced with how the innovative approach of MX Start compares with the MX Awards.

7.6 Data collection method

The evaluation of MX Start will entail collecting primary data from the stakeholders identified in section 7.5. There are two broad approaches of data collection, quantitative or qualitative.

Thietart et al notes that there is a convention that investigation is associated with qualitative approaches and verification with quantitative, but dismisses this idea, agreeing with Glaser and Strauss that both approaches are useful for both verification and generation of theory [23], [93]. Authors such as Datta and Niglas, recognise that in practice the distinction between the two approaches is not as clear and there is benefit in using a mixture of the approaches [94], [95]. A mixed approach would be beneficial for evaluating MX Start. Quantitative methods are appropriate to evaluate the extent to which MX Start has met its original goals and qualitative methods would allow understanding of the impact and areas to develop further.

English et al, in recognition that approaches can be quantitative, qualitative or both, outline three design frameworks:

1. **Experimental and quasi-experimental**
   - *a true experiment where program effects can be determined by comparison with equivalent or control groups. It requires a high degree of control of where, when, how and to whom an intervention is carried out. Quasi experiments adjust to the constraints of a program setting.*
2. **Survey and naturalistic**
   - *tend to be more descriptive and is good for obtaining information on the perceptions of a programs context, processes and outcomes. It can involve surveys, interviews or observations to allow detailed exploration of issues*
3. **Ex post facto**
   - *for studies that are retrospective rather than prospective. The evaluation study focuses on a program that has been in operation for some time, and are initiated and conducted over a relatively brief period.*

[21]

Experimental frameworks are not appropriate for the evaluation of MX Start. Due to the nature of the tool and the stakeholders involved, there is not sufficient control over where, when, how and to whom the tool is used by. An ex post facto approach is also unsuitable. Kowalski explains that a key feature of the ex post facto approach is its comparative nature, where the results of a program are compared with previous results [22]. Whilst the evaluation of MX Start is retrospective, it is not possible to conduct a comparative study without significant time being spent with each company to assess the situation before the use of MX Start. The timeframe and resources available do not allow such an evaluation to take place. Therefore, survey and naturalistic approaches are the most appropriate for this evaluation.

Self administered questionnaires will be used to collect the data. This will enable the data to be collected anonymously to promote candidness of the participants and to mitigate bias. The author will be taking on the role of evaluator. The research and development of MX Start has led to the author spending a significant amount time of time with some of the key stakeholders who will potentially take part in the evaluation. Therefore without anonymity, these stakeholders may be reluctant to give their true opinion as they would be able to be

identified. The anonymity provided by a self administered questionnaire mitigates the opportunity for this bias if the stakeholders are aware they could evaluate the tool without their answers being linked back to them.

7.7 Questionnaire design

There are two main types of question open and closed. Open questions allow participants to answer in a free manner. Closed questions provide a range of answers or responses for participants to choose from.

Benefits of open questions include that the researcher is not required to know how the participants will answer the question, participants can express their answer in their own words, it reduces the influence that may result due to predetermined answers and it is easier to design [96]. Benefits of closed questions include the ease of analysing the data, the ability to provide meaningful comparisons, the reduction in the ability for participants to interpret the questions in different ways, and they are less burdensome for participants to complete [90],[91].

The questionnaires for the MX Start evaluation will contain a combination of closed and open questions. The closed questions will use a rating scale to collect summative data regarding the extent to which MX Start has achieved the research objectives. Open questions will be used to enable formative evaluation, probing the outcomes that have resulted from companies using the tool and the future opportunity.

The questionnaires used for the evaluation of MX Start are shown in Appendix 9 and Appendix 10. One questionnaire is designed for companies who have used the tool, the second questionnaire is for manufacturing experts who have used the tool with companies or are commenting on the potential use of MX Start with companies.

7.8 Analysis strategy

The planned sample is for between fifteen and thirty manufacturing participants. As previously discussed the involvement of the MAS advisors, who have used the tool with several companies, means that the number of companies reflected in the evaluation could be many more.

The reason for the small sample size is linked to the objective of MX Start. MX Start is aimed at supporting companies at the beginning stages of their journey towards excellence. These companies, particularly those in the surviving stages of their excellence journey, are likely to have limited time and resources and therefore a larger sample size might be difficult to attain.

The sample in the evaluation has not been chosen in order to infer conclusions about the wider population of the manufacturing industry Instead the objective of the evaluation is to assess the extent to which those who have used or reviewed MX Start, perceive it to have achieved its objectives. Therefore when analysing the data, descriptive rather than inference statistics will be used. Descriptive statistics are concerned with the measures of central tendency (central values), the spread (dispersion) and the distribution (range) [97]. Therefore the data can be analysed using information regarding the mean, median, mode, standard deviations and by understanding the shape of the data.

The qualitative data collected through the open questions will require processing to turn the data collected into useful information. This will entail content analysis to analyse and interpret the free text collected. For this evaluation inductive content analysis will be used. This means that once the data is collected, the author will look for dominant themes rather than preselecting the themes [98]. It is unlikely that the sample size will be sufficient to go beyond the description of main categories contained within the qualitative answers. However if there is sufficient amounts of data this could be further explored. This could involve quantitative analysis similar to above if the categories are mutually exclusive and therefore can form a basis for counting [97].

7.9 The results

The next sections will analyse and discuss the results collected from the MX Start evaluation.

7.10 Profile of the evaluation sample

Thirty three participants evaluated MX Start. This sample was made up of twelve companies and twenty one manufacturing experts.

Table 7-2 and Table 7-3 provide information regarding the size of the participating companies in terms of number of employees and turnover. This work considers SME's to be those companies with fewer than two hundred and fifty employees, and under £50 million turnover. Therefore nine companies who evaluated MX Start are SME's. SME's account for 99% of the manufacturing companies in the United Kingdom [20]. This evaluation did not require a representative sample of the population. However it is beneficial to have a high number of SME's included. This is not just because this is a reflection of the manufacturing industry, but also because small companies are more likely to have restricted resources. Thus the comments regarding the ease of use and cost versus benefit of MX Start will be of particular interest.

Table 7-2 Size of the companies who took part in the evaluation by the number of employees

Number of employees	Number of participants
0-20	5
21-50	2
51-100	1
101-250	1
251-500	1
500+	2

Table 7-3 Size of the companies who took part in the evaluation by turnover

Turnover	Number of participants
£0-£1million	5
£1-£5million	3
£5-£10million	1
£10-£50million	1
£50-£100million	0
£100million +	2

Of the companies who completed the assessment, seven had received support from the Manufacturing Advisory Service, one company had used the World Class Manufacturing Checklist and four had received no support at all. There are no companies who have used the Manufacturing Excellence Awards included in the sample. This may be a reflection of the objective of MX Start and the opportunity identified at the start of this work. Those companies entering the MX Awards are predominantly entering to be recognised for their excellence. Therefore because MX Start is focused on improvement without the potential reward for recognition, previous entrants may not have been interested using the tool as it is not aimed at them.

Of the manufacturing experts who participated in the evaluation, nine were affiliated with MAS, eleven with the IMechE and one expert was not associated with either organisation. Therefore there is a balance between evaluations completed by those who have experience in using MX Start as an improvement tool (those associated with MAS) and those with experience of using the concept of manufacturing excellence to distinguish and recognise companies.

The raw data collected as part of the evaluation can be found in Appendix 8 and 9 in submission 4. A summary of the quantitative results collected can be found in this report in Appendix 11. The scores given in the quantitative results are all marked out of ten, on a scale

from zero to ten. Therefore companies have the option to select the central value, which can be considered a neutral response.

The results from the manufacturing companies and experts (experts are referred to as individuals in the results) can be seen separately, in order to identify any difference between the two opinions, as well as together.

7.11 Results and analysis of the Content Evaluation

The content evaluation of MX Start included whether it was relevant, easy to understand and credible. Descriptive statistics of the results can be found in Appendix 12 and includes box plots, steam and leaf diagram and details of the central tendency, spread and distribution.

Regarding the relevance of the content, both the assessment and feedback results are skewed towards them being highly relevant. All responses given are above the neutral point of five. For the assessment, the mean is 8.5 with the median and mode at 9. For the feedback the mean, median and mode are all 8. This indicates therefore that the content of both the assessment and feedback is perceived to relevant rather than being unsuitable.

Comments regarding the relevance include positive responses to the inclusive view of what manufacturing entails. One company highlights an opportunity to include content specifically on Sustainability. Submission 3 discussed whether there should be an assessment for this area. The decision was made to include individual sustainability questions within assessments but not to devote an entire assessment to the subject area. Sustainability is an emerging area and it was felt that the rapid developments could mean the content becoming out of date before there was an opportunity to revise it. There is potential to include such an assessment, or an assessment in any other emerging key area for manufacturing, in the future.

Two companies raise concerns about the generic nature of the content, noting that assumptions are made within the content and questioning whether some content can be applicable to all companies. This is an acknowledged limitation of MX Start. Therefore

there is an opportunity to provide a way for companies to highlight content that may not be appropriate for the whole industry or where best practice may be expected to differ between them. This feedback can also be included when updating the content as part of the annual review of the manufacturing excellence definition.

Regarding the easy of understanding of the assessments questions, the results are skewed towards the positive response of being easy to understand. For the assessment, two responses are marked as neutral, whilst six responses gave the highest mark of ten. For the feedback, one company gave a score of 4, therefore indicating a slight difficulty in understanding. The mean, median and mode are all 8 for both the ease of understanding the assessment and feedback. This indicates overall the ease of understanding both the assessment and feedback is perceived to be easy, as opposed to difficult.

Three comments received from companies highlighted that some questions could be clearer in their meaning. However despite these comments the lowest score given was five, which indicated a neutral response. One comment highlighted that some companies interpret the same phrase in different ways, for example, the term skills audit. This indicates an opportunity to support the ease of understanding of the content by including a glossary to provide definitions of terms. This could form part of the resource library and form an additional way to support companies to understand the content of MX Start and best practice.

The distribution is positively skewed for the results of the credibility of MX Start. One manufacturing expert perceived the content to be neutral in its credibility. The central values of the results include a mean and mean of 8 and a mode of 9, indicating that the content was felt to be trustworthy.

7.12 Results and analysis of the Ease of Use evaluation

The descriptive statistics of the results regarding the ease of use of MX Start can be found in Appendix 13 and includes box plots, steam and leaf diagram and details of the central tendency, spread and distribution.

The shape of the results is skewed towards MX Start being easy to use, with a mean and median of 8. One company gave a score of 3, indicating that MX Start was not easy to use. However this was the first manufacturing expert to use the website. The pilot was conducted using a desktop software package and therefore the formal evaluation was the first time feedback has been collected on the ease of use of the web based system. The initial launch of the website highlighted some issues, including broken links to web pages. The comment provided by this participant indicated the process was not clear and there was confusion regarding the button to use to start the process. Therefore this outlier may be a result of the initial problems of MX Start when the website was first made available. However the website continued to be developed during the evaluation period. This was not good practice for collecting the results, as it is difficult to directly compare responses as the comparison may not be like for like. However the feedback regarding ease of use was important to respond to immediately in order to ensure the website and its partners, the IMechE, WMG and MAS-WM, maintained credibility. Therefore a number of comments collected as part of the qualitative evaluation were able to be acted upon immediately in order to resolve the issues. These actions included:

- Ensuring the links on the website worked
- Simplifying the registration process
- Making the instructions easier to follow
- Use of icons to make the process and logic of MX Start easier to follow
- Providing a clearer link to the terms and conditions

Two comments gathered from the evaluation raised the issue of the importance ratings. The way that MX Start identifies priority improvement areas is based on a pre determined gap between the importance rating and score. Therefore it is possible for companies to have all areas of the assessment identified as being a priority. This would not help companies to determine where they should invest their resources to improve. This could be detrimental to the company starting their journey towards excellence as resources are likely to be limited and it would not be possible to target all the areas. Companies therefore could be overwhelmed with the possibilities for improvement. Therefore a future improvement opportunity for MX Start is to redesign the method of identifying priority areas. This could

entail ranking the areas based on the size of the gap. This could not be included in the immediate improvement actions for the website because it required the website code to be amended. This is a major change and therefore this improvement will be included when there is a next significant update of MX Start and is an area for future development.

7.13 Results and analysis of the Cost versus Benefit

The descriptive statistics of the results regarding the cost versus benefit of MX Start can be found in Appendix 14 and includes box plots, steam and leaf diagram and details of the central tendency, spread and distribution. This section aimed to understand whether companies felt they received value from using MX Start. The evaluation included aspects regarding the resources required to use the tool, whether it increased the companies' knowledge of best practice and how this could be implemented, whether it enabled improvements opportunities to be identified and whether it motivated companies to make improvements.

The distribution of answers regarding the resource required to invest in the tool range from 0 through to ten. The shape of the responses are skewed towards suggesting MX Start can be considered a low resource intensive approach with a mean of seven, median of eight and mode of nine. The scores given by the manufacturing experts regarding the resource intensity are more positively skewed than the companies. The tool is designed for companies and effort is required on their part to interpret the results into meaningful information and relevant actions, this is not required of the manufacturing experts. This may be the cause of the difference in results. Therefore whilst the design of MX Start considered the need to minimise the resources required to use it, it does still require some investment of time and effort from the company in order for them to gain benefit.

Feedback from the evaluation acknowledged that the process of MX Start is as resource intensive as a company wants it to be, and the more effort they put in, the more benefit they are likely to get out. This is a limitation of the self-directed approach, but is also an advantage for helping companies to progress on their excellence journey in the long term. Despite this requirement from companies, the overall results were positively skewed towards MX Start being considered a low resource intensive approach to manufacturing support.

With regard to increasing the knowledge of best practice, the results are positively skewed towards knowledge being gained. Two companies gave low scores indicating little new knowledge was gained. A comment provided by a company acknowledged that they gave a neutral score as they were in the mature phase of their excellence journey. Therefore the opportunity to provide new knowledge in such a company would be limited. Therefore the value in terms of the knowledge that MX Start can impart to companies is dependent on their existing knowledge. Those at the beginning stages could therefore be expected to gain more benefit from the process, than those at the advanced stages of excellence. Thus it would not be expected that every company would learn through the use of MX Start. The overall results show that most of the evaluation sample did learn, thereby it can be assumed that the dissemination of best practice can be achieved through using MX Start.

The results regarding the extent to which MX Start helps companies understand how best practice could be implemented in the company are spread across a wide range. The overall results are skewed towards MX Start being helpful, however five answers were either neutral or on the side of being unhelpful. No company scored this factor above an eight. A theme of the qualitative answers collected from this section was the need for higher specificity on what has to been done. These comments could be expected due to the facilitative feedback provided in the reports, rather than directive feedback. This feedback does not give companies direct instructions of how to implement best practice. MX Start intends for only guidance to be provided to companies which they must then tailor to their own circumstances. It provides a guide for what must be done, but the specific details of how it must be carried out are the responsibility of the company. Therefore it would be expected that the results to this question would be scored lower than other questions, demonstrating the feedback is facilitative.

The distribution of results regarding the ability of MX Start to enable companies to identify improvement opportunities was positively skewed towards having a high potential. The range of scores are from two to ten. As none of the participants gave a score of zero, this means that they all identified at least one opportunity to improve. Therefore MX Start can be considered to be successful in terms of the objective to support companies to identify improvement opportunities.

All of the qualitative answers collected on the potential impact of MX Start, commented on the ability of the tool to help companies identify areas for improvement. This was an open question and no prompts were provided to indicate what answers might be expected. This is further evidence that MX Start has met its objective to support companies to identify improvement opportunities.

The results regarding the ability to encourage companies to make improvements are skewed toward companies being encouraged. Two neutral answers were given and one company indicated they were not motivated at all. The remaining answers indicated that the participants were to some degree motivated to make improvements. It is not clear why one company was not motivated. However explanations could include they were not ready to change, they did not agree with the results, not enough information was provided or MX Start was not effective for their company. MX Start has acknowledged limitations and a tool balances the ability to share information and shape behaviour with the resources available. Therefore whilst the opportunity to use the tool is available for all, it is not expected that MX Start will be effective for every company.

An open question was asked only to the company participants, concerning whether they were motivated to make improvements in areas they had previously overlooked. Out of the ten companies who responded, six responded with a yes. Three companies suggested that it could help given the right conditions, such as if the resources were available, if it is identified as a key area of importance, and what other improvement activities are taking place. The final company gave a negative response because they already had an improvement programme at place. These comments indicate that MX Start has achieved the objective to motivate companies to improve but the ability to then act on this motivation is dependent on factors outside the control of MX Start.

7.14 Formative evaluation

The evaluation asked the participants to identify how MX Start could be improved. There are three key themes suggested by the feedback:

1) Improve the ease of use of the website, for example, simplifying the registration process, enabling the content from the resource library to be downloaded and improving the instruction.
2) Improve the content; this includes phrasing of questions/answers/feedback to be reviewed and suggestions for additional areas to be covered such as sustainability
3) Increase the ability of the tool to be customised, for example by industry sector or size

The first two themes concern the refinement of the process and content. Several of the website functionality improvements were addressed during the evaluation, including the simplification of the registration process and improvement of instruction. The content suggestions will be reviewed as part of annual update process with the MX Awards, to ensure the suggestions are applicable and accepted by a range of manufacturing experts and companies.

The third theme presents the most opportunity for improvement. The generic nature of MX Start has been an acknowledged limitation throughout this work. However it was required in order to fulfil the objective for the support to be accessible and relevant to all manufacturing companies. As MX Start matures and the data collected increases, the opportunity for customisation will be reviewed. This could include enabling companies to benchmark against others in their sector, region, and size. This would enable companies to use MX Start to conduct competitive benchmarking in addition to generic benchmarking. This would increase the relevancy of the results to an individual company. This could reduce the effort required to interpret the data into meaningful information, thereby increasing the value MX Start can provide.

7.15 Product summary

This chapter outlined the formal evaluation approach to assess how successful MX Start is in meeting the research objectives.

Self administered questionnaires were used in order to encourage honesty and candidness of those taking part in the evaluation. The evaluation sample included manufacturing companies as these are the intended end users of MX Start, and manufacturing experts, who have used MX Start with companies or who

Thirty three questionnaires were collected. The overall results indicate that MX Start does achieve its objectives to increase the knowledge of best practice, help companies to identify improvement opportunities and motivate and encourage them to make improvement. There are opportunities for MX Start to develop. This includes refining and expanding the content, increasing the ability of the tool to be customised to an individual company, and improving the usability of the website.

8 Discussion

MX Start is the output of this research. It is a tool designed to support manufacturing companies start their journey towards manufacturing excellence through identifying key improvement areas, disseminating best practice and providing facilitative feedback to guide them to start making improvements.

8.1 MX Start, the tool

MX Start is made up of:

- Eight assessments in key manufacturing areas, containing:
  - 160 question statements
  - 525 multiple choice answer options
- Automatically generated feedback report linked to the assessment, containing:
  - Radar diagram
  - Summary table
  - 525 feedback statements options
- Resource library, containing:
  - 74 best practice guides

Table 8-1 provides an overview of how these elements support companies on their excellence journey.

Table 8-1 How the elements that make up MX Start achieve the research objectives

Assessments	Provide companies with an approach to compare themselves against best practice and therefore begin to understand what best practice might entail. The modular design allows companies to tailor the use of the assessments to their needs by prioritising the assessments they perceive to be more relevant to them.
Question Statement	Encourage companies to reflect on their business practices. The use of a statement rather than a question helps to emphasise the assessment is focused on improvement rather than a test with right and wrong answers.
Multiple choice answer	The multiple choice answers are scaled from poor to best practice. Companies select the answer that is most relevant to their practice. This informs them what is considered to be best practice whilst encouraging them to think where their company is on the best practice scale.
Feedback Report	Supports the assessment by providing the results. The results identify improvement opportunities by highlighting where the gaps are to best practice and provides guidance on what might be done to close this gap.
Radar diagram	Provides a visual aid showing the company's performance against their assigned importance ratings and manufacturing best practice. Where the importance and / or best practice exceeds performance, this indicates a potential area for improvement.
Summary Table	Presents the information from the radar diagram in a table. It helps companies to prioritise improvement areas by differentiating on the size of the gaps between their score, their desired score (importance rating) and best practice.
Feedback Statements	Provides guidance specific to each of the multiple choice options, to provide information regarding what a company might do to progress to the next best practice level. It does not give direct instructions in order to encourage companies to develop their own solution and seek further help
Resource library	Contains more information regarding best practice and what a company might do to improve. It is an optional resource, enabling the information in the assessment and report to be kept brief and reduce the burden of information provided to companies in the first two stages
Best practice guides	Provide a further source of information on best practice and how a company might achieve it. Aligned with each section within the assessment and can be the first stage in companies seeking out information to support their improvement journey

The basis for the design was to provide a formative assessment with facilitative feedback to support companies to star their journey towards excellence.

8.1 Formative Assessment

The assessment is designed to be formative. It is made up of question statements, and multiple choice answers.

The assessment is made up of statements rather than questions to help prevent companies thinking that there is a correct answer and to reinforce the purpose of the assessment for improvement. The question statements emphasise that the assessment is for comparing a company against best practice to help them improve, not to test or judge them for the purpose of reward. The use of statements helps to promote companies to be honest in their answers as the aim is to enable them to identify where they are on the excellence journey, not where they should be.

The multiple choice answers are scaled from poor to best practice. This starts the learning process from the outset. It makes companies reflect on where they are on the excellence scale and also highlights what best practice is.

Companies select the multiple choice question that most closely fits their business policy, practice or performance. Companies can choose one answer from a selection of up to five multi choice statements. This maximises the learning opportunity for the company at the assessment stage, whilst minimising the time resource required to complete an assessment.

The use of multiple choice answers means that companies are not free to give an answer in their own words and must select from a predefined list. As the list is scaled from poor to best practice it is clear which answer represents excellence. Companies are free to select any answer, and therefore it is possible for them to always choose the best practice option. This

reduces the capacity for learning as the company is not reflecting on where they are on their excellence journey. However as the assessment and the accompanying feedback report is only for the use of the company, there is no benefit in companies completing the answers in this way. Thus there is no incentive for companies to fill in the answers dishonestly or inaccurately. However there is no verification of their answers to prevent them doing so. MX Start is limited in its effectiveness if answers are not truthful. This is because the appropriate opportunities for improvement will not be accurately identified and the feedback provided may not be appropriate. Therefore a limitation of MX Start is the reliance on companies completing the assessments accurately in order to gain the most benefit. The self-directed approach however mitigates the risk of the inflation of answers as the company will only be dishonest with themselves.

In submission 1, it was identified that the definitions of manufacturing excellence entailed policies, practices and performance aspects. The question statements making up the MX Start assessments are predominantly concerned with practices and policies, with the minority of statements regarding performance. The reason for this apparent imbalance is due to the limited number of performance measures that are universally applicable to all manufacturing companies. Whilst the content of the performance measures may be applicable to all, the scale for the answer options may vary across industries. For example, the levels of investment in product innovation may vary between a low technology industry and a high technology industry. Therefore what is excellence for a low technology industry may be poor for high technology. This led to the majority of question statements being concerned with practice and policy rather than performance. In future, there is scope to add assessments that are concerned with a particular industry, enabling greater tailoring of the content and therefore greater inclusion of metrics aligned to that particular sector. This is a future opportunity for MX Start when it has matured and collected sufficient information on individual industries.

8.2 Modularisation

The eight individual assessments of MX Start are modular. The modular design of MX Start allows companies to select the order and number of assessments taken. This enables

companies to prioritise the assessments they feel would benefit them the most. Thus companies can customise the way they use MX Start through their selection of assessments. This also means that if an assessment is not relevant to their business context, then they can choose not to complete it. For example, the Product Innovation assessment may not be appropriate for a make to print business and therefore they can choose to not complete this assessment.

A modular approach also means MX Start is made up of eight smaller sections rather than one large one. This reduces the amount of time a company needs to spend on the tool, before they receive their results. This helps balance the cost versus benefit opportunity. Therefore companies must only invest a short amount of time completing an assessment before they receive the tangible output of their report containing their results and facilitative feedback.

The modular approach also enables content to be added to MX Start. For example, MX Start does not include an assessment on Sustainable Manufacturing. This is an emerging area of excellence and in future will be increasingly key to a manufacturing business. Due to the modularity, an assessment can easily be added on such a content area without burdening companies with additional time commitments. As MX Start matures, there is opportunity to increase the topics covered by the tool. This could include specialised areas specific to industries or business models which would increase the relevancy and customisation of MX Start.

8.3 Customisation

An advantage of MX Start is that it provides support to any manufacturing company. However this results in the disadvantage that the support provided is generic. To develop a tool that provides specific support tailored to a particular manufacturing company would require a significant amount of resources. The limited resources available for MX Start therefore, means that it is not possible to provide such customised support.

The lack of specificity of the support and feedback provided by MX Start can also be considered a benefit. By providing generic feedback encourages companies to interpret it themselves thereby thinking through solutions and improvement approaches that could work for their particular business. A number of companies provided feedback in the evaluation that suggested MX Start would benefit from directing companies how to improve. However this reduces the problem solving and analysis skills a company must apply in order to develop an improvement solution. This may mean that they are less likely to be able to support themselves to make future improvements without being told specifically what to do. MX Start therefore encourages companies to help themselves to improve.

The process of MX Start does help companies start the process of tailoring the information generated in the report. There are two methods for this customisation. Firstly the modular design of the assessments enables companies to decide the order and how many assessments to take. Secondly, the importance ratings enable companies to identify the areas that are most important to them. Each assessment is divided into sections. Companies specify how important each section is to their business on a five point scale. This enables them to compare themselves against where they would like to be (how important they rate the section), in addition to comparisons against best practice. The gaps identified between the section score and the importance rating highlight the potential areas for improvement. This provides a customisable approach to the gap analysis.

In addition to the benefit of customising the gap analysis, further benefits include facilitating companies to reflect on what is important to their business. The assessment therefore helps companies to consider what is key to their competiveness, as well as comparing how they are performing against best practice. This increases the learning opportunity for companies using MX Start as it allows companies to analyse and understand where they are and where they need to be competitive.

The limitation of the importance ratings is that it relies on companies knowing what is important to their business. Therefore it requires the person completing the assessment to understand how and where the company is competitive or could be competitive. Inaccurate identification of what is important could lead to incorrect areas being identified for

improvement. This may be a particular issue for companies in the beginning phase of their excellence journey as they may not understand what is key to their business competitiveness. The dual gap analysis between the importance rating assigned by the company and best practice mitigates the issue. A company can use a combination of the two to identify improvement areas. For example, if a company does not rate an area as important, and scores low in this area, it will not be highlighted as an opportunity for improvement when comparing against where they would like to be. However, it will still be shown as a gap between where they are and where excellence is. Therefore it will draw attention to the potential to improve to become excellent in that area.

8.4 Facilitative Feedback

The feedback report supports the learning from the assessment. It provides visual aids to help companies understand their results. Graphs, tables and colour indicators are used to ease understanding and clearly show where companies could potentially improve.

The report also provides facilitative feedback. To increase the dissemination of best practice, and therefore the learning opportunity for companies, feedback statements are provided for each of the questions in the assessment. These statements are short and facilitative. This means that they do not give specific instructions regarding what companies should do but instead provide guidance. This is not the most efficient method of feedback to help companies improve their competitiveness. Directional feedback is more efficient as it would instruct companies on exactly what to do to improve. By using facilitative feedback, this encourages companies to seek out further information and support for themselves. This helps companies to learn the behaviours required to continue their improvement journey beyond the support MX Start can provide. The advantage of directive feedback therefore is only beneficial in the short term. MX Start aims to provide longer term benefits by being a sustainable way to help companies improve and progress on their excellence journeys.

An additional advantage of the feedback statements is that they are short. Therefore companies do not need to invest a significant amount of time to read them. Companies can

then prioritise the areas they want to find more information about and seek this out. Therefore there is not an overload of information to digest in the report.

8.5 The resource library

The resource library contains guides that are linked to the assessment sections. These guides provide more information to help companies start their improvements by outlining key issues, success factors, and factors to avoid.

The benefit of the resource library is that it contains more information that can be optionally used by companies to help progress on their excellence journey. The library provides further resources to support the facilitative feedback given in the report. Thus the report does not over burden companies, however if they require more information, then the resource library may fulfil this need. The feedback report contains web links to the relevant guide in the resource library. Companies can click on the link and be taken to the appropriate guide on the website, thereby minimising the time they have to spend searching out more information.

The resource library currently contains guides aligned with each of the assessment sections. However there is opportunity to expand this library to include links to further support such as videos, workshops, training, and other websites that may help manufacturers. As MX Start matures, this provides an area for ongoing work to find further resources and linking this to MX Start. This would provide a central location for information, which companies could use to support themselves to make improvements.

8.6 MX Start utilisation

Utilisation, as defined by Westbrook and Boethel is the goal of dissemination [78]. Utilisation is the concept that disseminated information is used to make changes, improve and influence decisions. For MX Start to help and encourage companies to improve, the tool first

needs to attract them to use the tool. The five utilisation areas identified by Westbrook and Boethel are: User, Source, Content, Context and Medium [78]. Within these areas the key aspects relevant to MX Start are the cost effectiveness, capacity, accessibility, relevance and format. Table 8-2 outlines what needed to be considered and how this has been included in the development of MX Start.

Table 8-2 Utilisation aspects that needed to be considered and how MX Start considered them

Format	**What**	The definition of Manufacturing Excellence selected in the Context chapter was formatted to distinguish excellence, rather than promote improvement. The format needed to be easy to understand and realigned for the objective of MX Start.
	How	The content was restructured to be formative. The use of a best practice scale for the multiple choice answers helps companies to understand what best practice is as they complete the assessment of MX Start
Relevance	**What**	Due to the scope of this work to provide support to any manufacturing company, the ability of the content to be relevant to all companies needed to be considered.
	How	The eight assessments that make up MX Start are modular. This allows companies to tailor which assessments they complete and in which order. MX Start allows companies to rate how important each section of the assessment is to their business, therefore allowing them to tailor the tool to their own circumstances. The performance is then compared against this importance rating to identify key improvement areas.
Ease of use	**What**	Due to the limited resources available, companies need to be able to use and gain benefit from MX Start on their own.
	How	The website has been designed to promote ease of use, with a simple assessment process that automatically generates a report that a user can download instantly. Visual aids are used to help companies easily identify areas for improvement.
Access	**What**	The aim of MX Start was to provide support to UK manufacturing companies, and therefore access needed to be available nationwide
	How	The website, www.mxstart.co.uk, provides a mechanism for any company, anywhere to gain access to MX Start providing they have internet access.
Capacity	**What**	The approach needed to be able to cope with the potential number of users (303,245 manufacturing enterprises [20])
	How	The website is not limited to certain users or numbers of users, and therefore provides sufficient capacity to cater for all manufacturing companies to use.
Cost	**What**	With limited funding for the future of MX Start, the approach needed to be cost effective to operate and run, to ensure access is free of charge to manufacturing companies.
	How	The website requires minimal costs to run (renewal of the domain name and hosting costs). However there is a need for manual input to ensure the content remains up to date to ensure the relevance criteria remains fulfilled.

8.7 MX Start, a process

A tool was chosen as the most appropriate dissemination approach to achieve the research objectives. However, the nature of MX Start has changed during the design and development phase. The term 'tool' no longer accurately describes what MX Start is. Instead MX Start can be considered a process, *"a set of interrelated activities needed to accomplish a specific task"*[99]. The MX Start process is made up of three activities: completing an assessment, reviewing the generated feedback report and finding out more information using the resource library. These activities are designed to help companies start their journey towards manufacturing excellence through the identification of improvement areas and the dissemination of best practice.

8.8 The pilot

The pilot was a key to the design of MX Start. It enabled MX Start to be tested in an industrial environment by over two hundred companies in the West Midlands. The feedback from this process led to improvements regarding the ease of use, content, and aesthetics.

The pilot was important to gain insight into MX Start's usefulness and effectiveness from the perspective of manufacturing companies. The opportunity to conduct the pilot with MAS arose quickly and therefore there was insufficient time to put in place a rigorous mechanism for formal collection of feedback from the companies. However the benefits of working with MAS and the access to companies this provided was deemed of greater advantage than the disadvantage of the feedback collection method. The MAS advisors who used MX Start with the manufacturing companies, collected feedback on issues, errors and opportunities for improvements. This feedback was then passed on via email, phone calls and at progress review meetings. This method of feedback enabled a quick response to be made. Improvements and developments could be implemented rapidly and an updated version of MX Start sent out to the MAS advisors. This ensured a continued cycle of reviewing the feedback and implementing changes during the development phase. Therefore there was opportunity to improve the way the pilot was conducted in terms of the rigour in which the

feedback was collected. However the informal approach provided the benefit of a fast and responsive development cycle to continually improve and test MX Start.

8.9 The success of meeting the research objectives

The formal evaluation of MX Start identifies that it fulfils the overall research objective to develop a tool to support UK manufacturing companies to start and progress in their journey towards manufacturing excellence.

The objective to disseminate best practice to manufacturing companies is achieved through the assessments, reports and resource library. The feedback report achieves the aim to identify where and how companies can implement best practice. This is facilitated by the use of a radar diagram, summary table and colour indicators to provide visual indications of the improvement opportunities.

The objective to enable any and all manufacturing companies to access this support is achieved through the web based system which is free of charge. The website can be accessed from anywhere in the UK and has the capacity to support a large number of companies.

The final objective for encouraging and motivating companies to improve was demonstrated as being achieved through the formal evaluation, in which the overall results indicated were skewed towards companies being encouraged to improve.

The remit of the Manufacturing Advisory Service includes supporting manufacturing companies to increase their competitiveness. Therefore the purpose of MAS is aligned with the goal of this work. The achievement of MX Start being adopted by MAS-WM, is a strong indication of the success of this research in achieving the objectives. Therefore, by MX Start being incorporated in the activities of MAS, following extensive testing and development of the tool, provides evidence of its effectiveness.

The ability of MAS to provide support to the whole of the manufacturing industry is restricted by the capacity constraints of the number of advisors and funding available. Therefore MX Start is a complimentary form of support that enables companies to help themselves to improve and therefore is not restricted by such resource constraints.

8.10 The visions of MX Start

The vision of MX Start is to be a resource for supporting UK manufacturing companies on their journey towards manufacturing excellence through providing accessible and flexible support to manufacturing companies from the start.

The vision of the tool, and how it will operate, has changed over the course of the research. Figure 8-1 provides an overview of the three key visions of the tool.

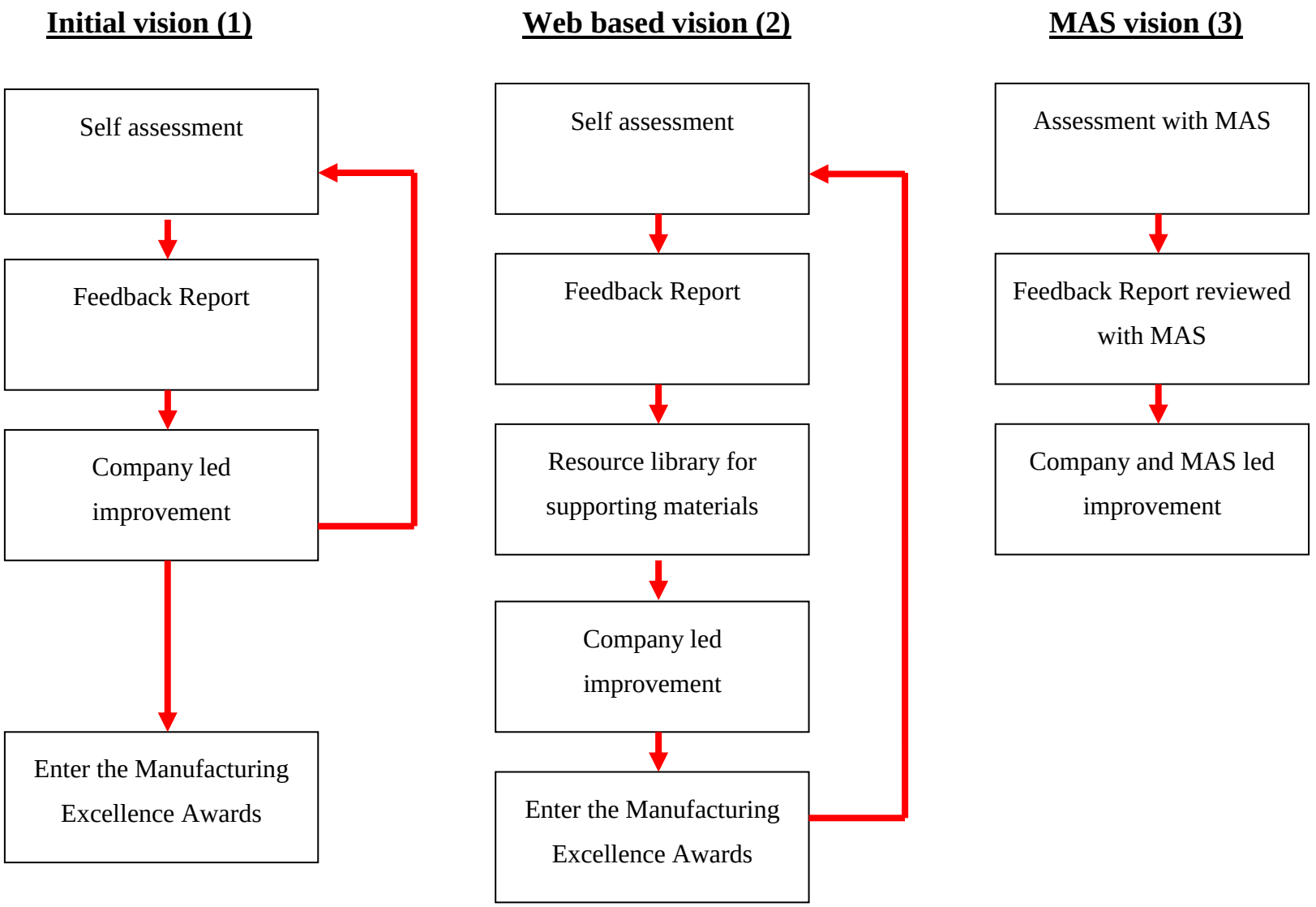
The initial vision (1) encompasses the two stage assessment and report process. Once companies have been through the process the vision is that companies will be encouraged and motivated to make improvements. MX Start can be used in an iterative cycle of assessment, feedback, improvement, where each cycle allows the previous improvement to be verified and the next opportunities to be identified. If companies feel they are of a sufficient standard after being through this cycle, then they may choose to enter the MX Awards and potentially be recognised for their excellence.

As this work matured, the opportunities for MX Start were explored and this led to vision 2. The concept builds on the first vision and adds another step of a web-based resource library. The resource library provides additional resources and information to support the assessment and reports. This is a benefit because if companies require more information to build on the short facilitative feedback contained in the reports, the library provides companies with further help if they need it. The library is expandable, this enables more resources to be added to it, such as videos and training documents. Therefore over time MX Start has the potential to become a comprehensive source of help for companies.

The MAS vision (3) is not an alternative vision to the web based concept, instead it is an accompanying approach. The Manufacturing Advisory Service in the West Midlands was involved in the original pilot of MX Start and supported its development. The third approach therefore is for MX Start to be used in conjunction with support from MAS. By using MX Start in this way, companies can benefit from the expertise and knowledge within MAS to support making improvements. Therefore using MX Start in this way allows facilitated transfer of best practice. After an initial cycle, companies could then use the second vision themselves to continue on their excellence journeys.

The three visions of MX Start can operate in conjunction with each other, providing a multifaceted approach to providing support to the manufacturing industry. The second vision of the website, offers the most appropriate approach for satisfying the research objectives as it enables any and all manufacturing companies access to the support. The first vision is difficult to disseminate to a large number of companies without a significant amount of resource. However it does provide companies without access to the internet an approach to use the tool. The third vision is only available through MAS in the West Midlands. Opportunities for providing the expertise nationally are being explored however this requires funding that is beyond the levels available to MX Start currently.

Figure 8-1 The different visions of MX Start



8.11 The MX Start maturity model

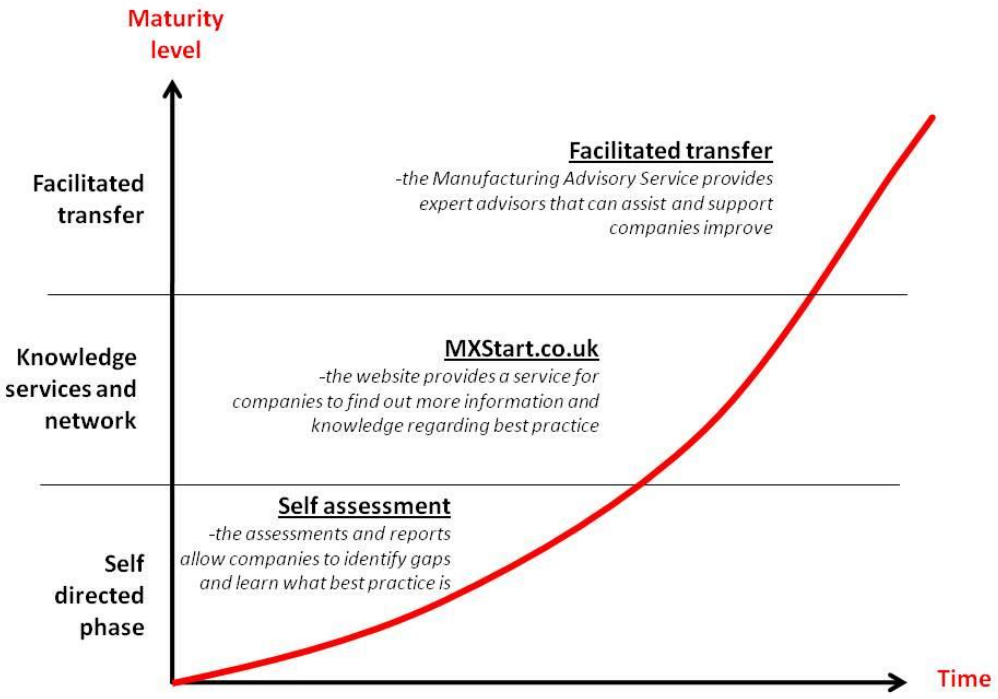
The three approaches to transferring best practice as defined by O'Dell and Grayson, aligns with the three visions of MX Start [70]. Figure 8-2 shows the MX Start maturity model, which links the approaches and the visions together.

The model shows that this research initially concentrated on the self –directed phase of best practice transfer. This enabled manufacturers to help themselves to improve by using the assessment and feedback report to learn more information about best practice, understand where they are on their excellence journey, and to identify where and how they might improve.

The next stage involved building a knowledge service. This is the resource library that contains a searchable database of information that companies can use to support themselves to make improvements. The resource library is in its infancy, only containing best practice guides aligned with the assessment content, but as mentioned previously it can be expanded as MX Start matures. Companies could contribute to this content themselves, for example, by sharing their experiences and lessons learnt, therefore building the knowledge network.

The final stage in the development, is facilitated transfer. The collaboration with MAS in the West Midlands enables MX Start to be used by a company in conjunction with an advisor. This enables the advisor to give direct feedback and support companies to interpret the feedback received when using MX Start. The advisor can tailor the additional support and feedback they provide to each company, increasing the relevancy to the company. This interactive approach is more likely to shape behaviour of the company, as the model by Ollerearnshaw et al shows in Table 5-1 on page 71, and therefore this increases the ability to influence them to make changes [72].

Figure 8-2 MX Start maturity model



8.12 The link between assessment and learning

It has been assumed that there is a link between assessment and learning. However, Tsang notes that in organisational learning the link between them may not be clear [100]. He classifies three conditions associated with organisational learning: change in cognition, change in potential behaviour and change in actual behaviour. It is possible in organisational learning for none, one, two or all three of these conditions to be met at the same time. However , in order for companies using MX Start to make sustained improvements, all three conditions must be fulfilled. The company must understand the rationale of why a change should be made, in order to change the mind set or cognition. This then must be realised as a potential for change and finally the change must be implemented.

It is a bold assumption therefore to assume that an MX Start assessment will lead to learning and that this in turn will lead to improvement. Tari found that difficulties in gaining benefit from a self assessment process include the lack of commitment, lack of resources, and knowing where to start [101]. For MX Start to impact the manufacturing industry, it is

dependent on the individual or individuals who use the tool realising the need for change, and having sufficient time, power, resource and expertise to implement such a change. These aspects are out of the control of what MX Start can ultimately influence and therefore present a limitation of this work. Companies may identify improvements but may not want to or be able to act on them. The knowledge network and facilitated transfer approaches that are being developed as MX Start matures may provide additional support to overcome this barrier.

8.13 Unique aspects of the MX Start support

The aspect that set MX Start apart from other manufacturing support available is the specific focus on companies helping themselves. The focus on self help enables MX Start to be low cost, both in terms of the resources needed to use and run it.

Many existing support frameworks such as the MX Awards and the EFQM model are also linked an opportunity for reward and recognition, which can confuse or hinder the focus on improvement. Other support available can be expensive, resource intensive, or not be universally accessible by manufacturing companies. MX Start overcomes these issues by being universally available to all manufacturing companies, free of charge and with a sole focus on improvement. It also provides a platform to add additional support. During this research, best practice guides were added, linking the assessments and feedback to further support. This support was written not by the author, but by industry experts, demonstrating the opportunity for MX Start to bring together support from different perspectives and to become a comprehensive support resource for the manufacturing industry.

The ethos of MX Start is to help companies to help themselves. This is achieved by providing a process for self assessment and identification of improvement areas, coupled with feedback and access to a library of resources. The website provides a platform for support that can be easily added to. The long term vision is for manufacturers to contribute to building the resource library themselves. This would be achieved by companies adding their recommendations, making training material available, and sharing their own best practices.

This would enable MX Start to grow without the need for significant resources and would enable companies to not only help themselves, but other companies too.

The low operating costs mean that MX Start is not subject to potential funding issues and therefore this increases the longevity of the tool. Also, the ability to use the review process of the Manufacturing Excellence Awards to update the content and definition of excellence also minimises the resources required to ensure the tool remains up to date and relevant. Therefore MX Start is a sustainable approach for providing manufacturing support whilst also ensuring the process is free of charge for companies.

8.14 The website

The use of MX Start is dependent on companies having an internet connection. In 2009, 91% of companies (with more than ten employees) had internet access [92]. The objective of this work was to provide support that is available to all manufacturing companies. However, the 91% of companies with capability to access the website is an acceptable compromise, because the website enables the support to be free of charge, therefore eliminating cost as a barrier to access. The collaboration with MAS also provides a non web based approach to provide support that could be used by the 9% of companies who may not have access.

The use of a website to provide support may cause some companies concern about security. The assessments and reports are stored on the website. Companies may be concerned that other parties could get hold of this information. The honesty of the answers given in the assessments is key to MX Start being able to successfully help companies identify opportunities. Therefore it is important for companies to acknowledge their weaknesses as well as their strengths. However companies may not be willing for others to access this information, because this could detrimentally affect their business. For example, customers may be deterred from buying their products due to any perceived weaknesses. Therefore steps have been taken to secure the website. Companies must login using their own password. The assessments and reports are stored under this account, and cannot be accessed by other users. As MX Start develops, any additional comparisons, such comparisons with specific industry sectors or size, will use anonymous data.

9 Conclusions

The manufacturing industry is a vital part of the economy. A review of the competitiveness of the industry has shown there is opportunity for improvement to increase the ability of companies within it to compete globally. Adoption of best practice provides companies with an approach to help them improve and increase their competitiveness. Existing support provided to the manufacturing industry can be difficult to access, require significant investment of resources to access or can be exclusive to a specific part of the industry.

A need therefore was identified for a method of support to be developed that any company could take advantage of in order to support themselves to make improvements. MX Start provides a process for achieving this in the form of a web based system that is freely available and free of charge. Manufacturing companies can use this system to support themselves to make improvements and progress towards manufacturing excellence.

By using the MX Start assessment, manufacturing companies can increase their knowledge of best practices and gain a better understanding of where they are on their excellence journey. The feedback report generated from the assessment enables them to identify areas they can improve and to act on this information using the feedback provided as guidance. The report is linked to the resource library, where additional resources can be found if more information is required to support companies to make improvements.

Additional benefits that a company may gain include being motivated and encouraged to make improvements. However this is dependent on factors such as their wiliness to change, and where they are on their excellence journey. MX Start is designed to be of greater help to those companies in the beginning stages of their journey towards excellence. Therefore the effectiveness of the process is dependent on how advanced a company is on their excellence journey.

MX Start is web based and provides an easily accessible and free of charge resource for manufacturing companies. The ability to continue to add content to the website, combined

with the low ongoing costs, means that there is the opportunity for MX Start to continue to develop and contribute further to supporting the manufacturing industry to improve.

MX Start has been validated by an industry based pilot and formal evaluation. The main achievements of the research can be summarised as follows:

- Development of a process to support manufacturing companies to make improvements
- Industrial testing and development, involving over two hundred companies in a pilot with the Manufacturing Advisory Service in the West Midlands
- Making this process web based to allow easy access to the support for any manufacturing company
- Adoption and development of MX Start by the Manufacturing Advisory Service in the West Midlands
- Increasing the dissemination approaches of MX Start from a self directed approach to also include a knowledge network and facilitated transfer to maximise the opportunity to support manufacturers to make improvements

10 Further work

The future opportunities for this work fall into three areas:

1) Customisation of the content of MX Start
2) Wider dissemination of MX Start
3) Further advancement along the maturity model by further developing the knowledge service and facilitated transfer approaches

10.1 Customising MX Start

The aim to provide support to any manufacturing company led to the content of MX Start being generic. This allowed the content to be relevant and applicable to any company, but this reduced the ability of the information provided to be specific and tailored to a company. There is no one rigid definition of excellence and therefore the ability to provide flexible best practice information tailored to a particular company's circumstances would provide more meaningful information to them. This could reduce the amount of time a company needs to invest in interpreting the results, enabling greater time to be dedicated to implementing the actions the results suggest.

The web based system lends itself to this purpose. As companies use the tool, more data is collected. This enables a database to be compiled. Currently companies can compare themselves against best practice. However the database provides a means for the results to also be compared against for example, companies in their industry, size or region. This would enable competitive benchmarking in addition to the generic benchmarking MX Start currently provides.

As MX Start matures further, the next steps could progress further from not only customising the results, and therefore the output of the process, but also enable each company to tailor the assessments, and therefore the input of the process.

10.2 Disseminating MX Start

MX Start has so far been dependent on the champions of the work, the MAS and the IMechE, to disseminate MX Start to the manufacturing industry. This has been successful in reaching over two hundred companies to date. However these companies are a small percentage of the total manufacturers in the UK and were also mainly located in the West Midlands region. The online version of MX Start provides the ability for MX Start to reach manufacturing companies across the United Kingdom.

The website, www.mxstart.co.uk provides a mechanism for companies to access and use MX Start. However, for companies to use MX Start, they must first know it is available. Therefore ongoing work for MX Start must include outlining the dissemination strategy to inform companies that the tool is available.

10.3 Advancing the knowledge service and facilitated transfer approach

The main focus of this research work has been on the design of the self-directed approach of MX Start. The MX Start maturity model shown in Figure 8-2 on page 147, outlined that as this research has progressed the additional best practice transfer approaches of a knowledge network and facilitated transfer, have been developed. The opportunity for these approaches have not yet been fully explored.

The knowledge network is the resource library that is available through the website. It consists of best practice guides that are linked to the assessment sections. These are text based information sheets that outline the main issues, key factors for success and factors. From Ollearnshaw et al's model on best practice dissemination as shown in Table 5-1 on page 71, the information sheets share information but there is limited ability for them to shape behaviour. The opportunity for further work includes developing the resource library further and including different mediums for the resources to expand the capability to influence the behaviour, and therefore of companies further. This could include adding videos, compiling a calendar of relevant events such as fairs, workshops and presentations,

and linking to other web based manufacturing support resources. By increasing the resources available, this increases the support provided to companies to encourage and facilitate them to make improvements.

There is also opportunity for the resource library to grow by enabling users of the website to generate content themselves. For example, companies could provide case studies or add comments and reviews of the resources in the library. The user generated content could help support the first identified opportunity for further work of enabling greater customisation because companies could provide tailored information on their experiences. This could benefit companies who are having similar issues or who are in similar circumstances, to gain further insight in order to help them make decisions and guide them to make improvements. However the specificity of user generated content may be limited because companies may not be willing to provide details of how they have achieved competitive advantage or to make any issues publically known.

The facilitated transfer approach is provided through MAS in the West Midlands. Therefore this support is provided in one region. The ability of facilitated transfer is limited by the need for resources, including funding and expertise. Therefore whilst facilitated transfer is desirable due to the greater effectiveness to influence behaviour and therefore encourage improvement, the ability to provide such support is limited. Further work for advancing MX Start capability includes exploring the collaboration with MAS to understand the opportunity to increase the use of MX Start in other MAS regions.

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Appendix 1 Government's Manufacturing Strategy Pillars for success [34]

1) **Macroeconomic Stability:** allowing businesses to plan for the long-term

2) Investment: supporting investment in capital equipment and processes, leading edge technology, skills development, and Research and Development

3) Science and Innovation: helping manufacturers exploit the UK's strong science base to create innovative, high value products

4) Best Practice: helping companies to raise productivity through continuous improvement and 'lean manufacturing techniques'

5) Skills and Education: supporting the development of a skilled and flexible manufacturing workforce

6) Modern Infrastructure: providing effective transport and communications networks

7) Right Market Framework: providing the supportive business environment that manufacturing needs to compete globally

Appendix 2 Technology levels of manufacturing sub –sectors [102]

Based on the Organisation for Economic Co-operation and Development (OECD) classification of technology classes based on the relative research and development of manufactured products, the technology, the manufacturing industry is divided into these four groups:

	Manufacturing sub sectors included
High technology	Pharmaceuticals Office, Accounting and Computing Machinery Radio, Television and Communication Equipment Medical, Precision and Optical Instruments Aircraft and Spacecraft
Medium High Technology	Chemicals (excluding Pharmaceuticals) Machinery and Equipment n.e.c. Electrical Machinery and Apparatus n.e.c. Motor Vehicles, Trailers and Semi-Trailers Railroad Equipment and Other Transport Equipment n.e.c
Medium Low Technology	Coke, Refined Petroleum Products and Nuclear Fuel Rubber and Plastic Products Other Non-metallic Mineral Products Basic Metals and Fabricated Metal Products Building and Repairing of Ships and Boats
Low Technology	Food Products, Beverages and Tobacco Textiles, Textile Products, Leather and Footwear Wood, Products of Wood and Cork Pulp, Paper, Paper Products, Printing and Publishing Manufacturing n.e.c.

Appendix 3 Literature definitions of excellence

Peters and Waterman Jr's Eight Attributes of Excellence [59]

1. A bias for action
2. Close to the customer
3. Autonomy and entrepreneurship
4. Productivity through people
5. Hands on, value driven
6. Stick to the knitting (staying close to the business the company knows)
7. Simple form, lean staff
8. Simultaneous loose-tight properties (being centralised in such aspects as core values, but also decentralised in such aspects as autonomy)

Hayes and Wheelwright's World Class philosophies and approaches [62]

1. Encourage extensive training and human resource development
2. Relentlessly pursue improvement in production processes
3. Pursue excellence in product quality
4. Emphasise the role of manufacturing technology in achieving long term advantage
5. Recognise the need for stable employment and worker-manager respect
6. Long term considerations take precedence over short term

Lascelles and Peacock's Characteristics of World Class Performers [61]

1. Strong leadership
2. Motivated employees
3. Extremely high customer satisfaction ratings
4. A strong and/or rapidly growing market share

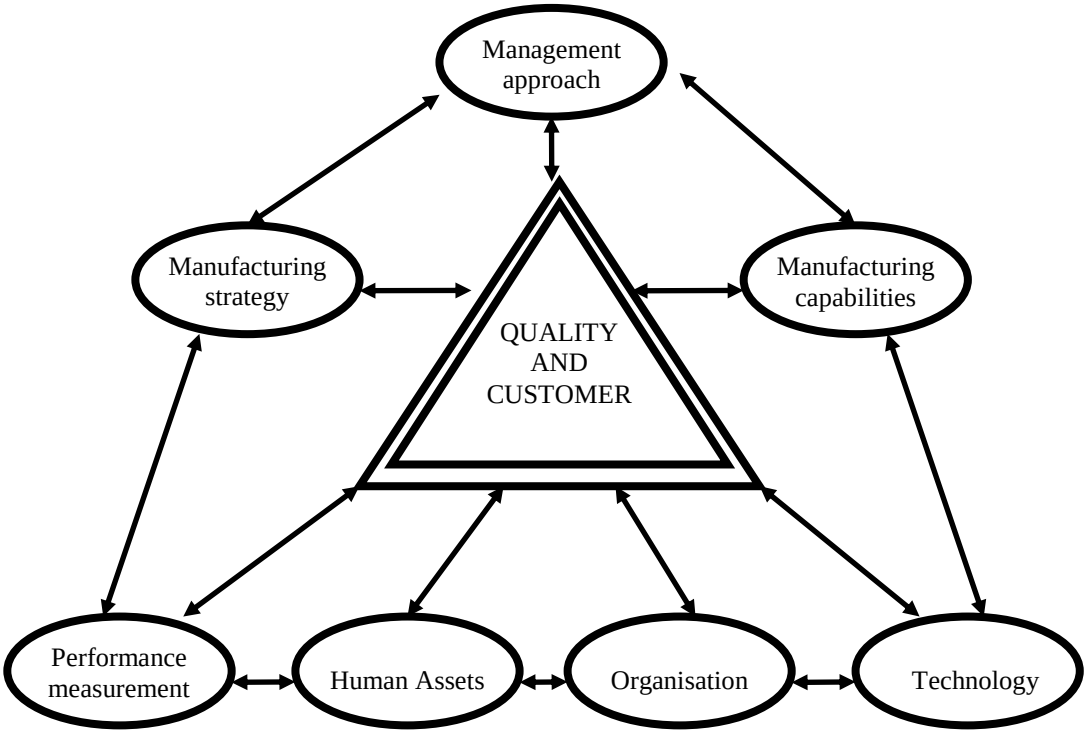
5. Highly admired by peer group companies and society at large

Voss's areas of world class manufacturing (practice and performance) [64]

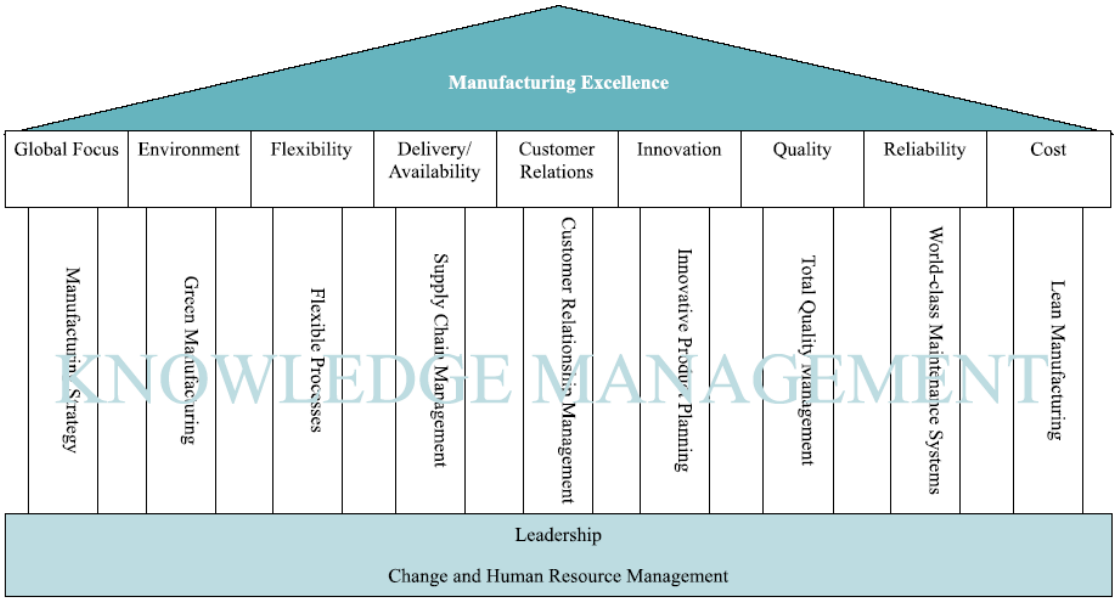
1. Total Quality
2. Concurrent Engineering
3. Lean Production
4. Manufacturing Systems
5. Logistics
6. Organization and Culture

Appendix 4 Models / frameworks of excellence

Roth's World-class manufacturing framework [68]

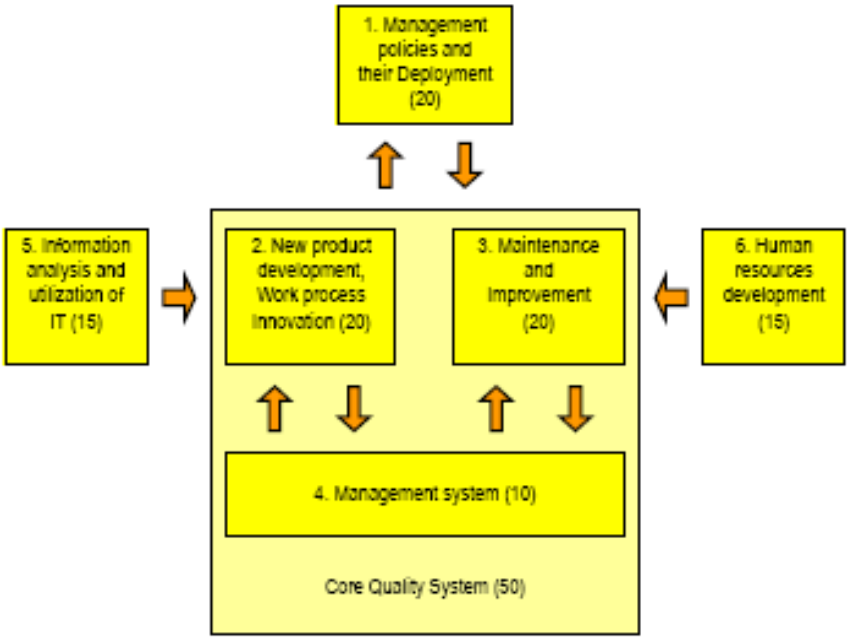


Sharma and Kodali's Framework for Manufacturing Excellence [67]

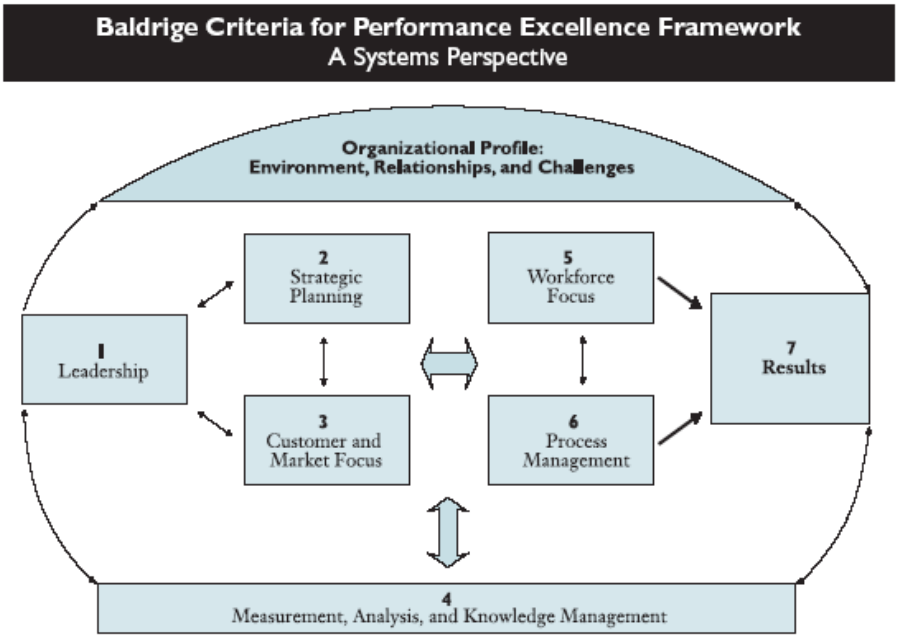


Appendix 5 Excellence Awards

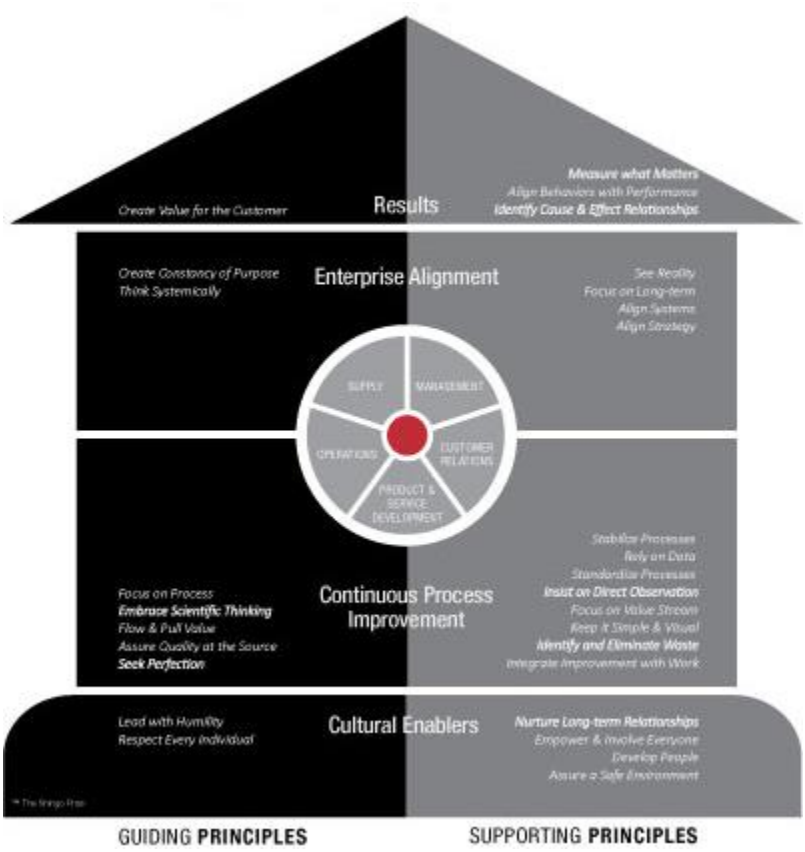
The Deming Prize: relationship between the categories and points [103]



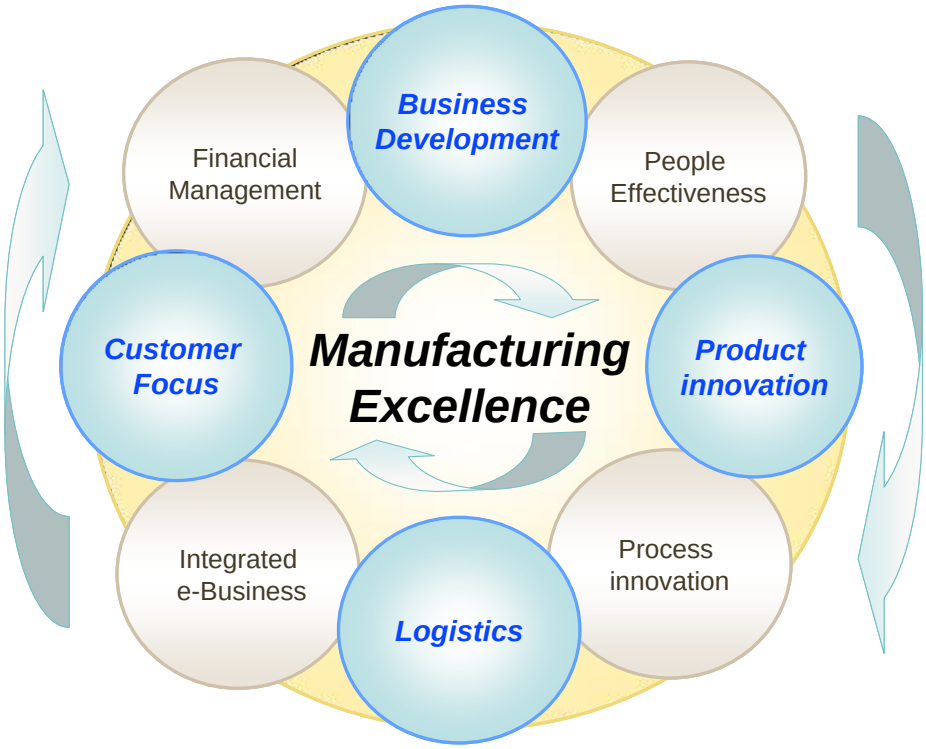
The Malcolm Baldrige National Quality Award Framework [104]



The Shingo Principles of Operational Excellence [105]



Manufacturing Excellence Awards model



Appendix 6 Classifications of benchmarking

Design: authors own, source: Fong et al [1] and also the British Quality Foundation, Camp [2], Zairi [3], Mittelstaedt [4], Cox et al [5] and Lema and Price [6]

Who:

Internal: comparing within one organisation the performance of similar units or processes

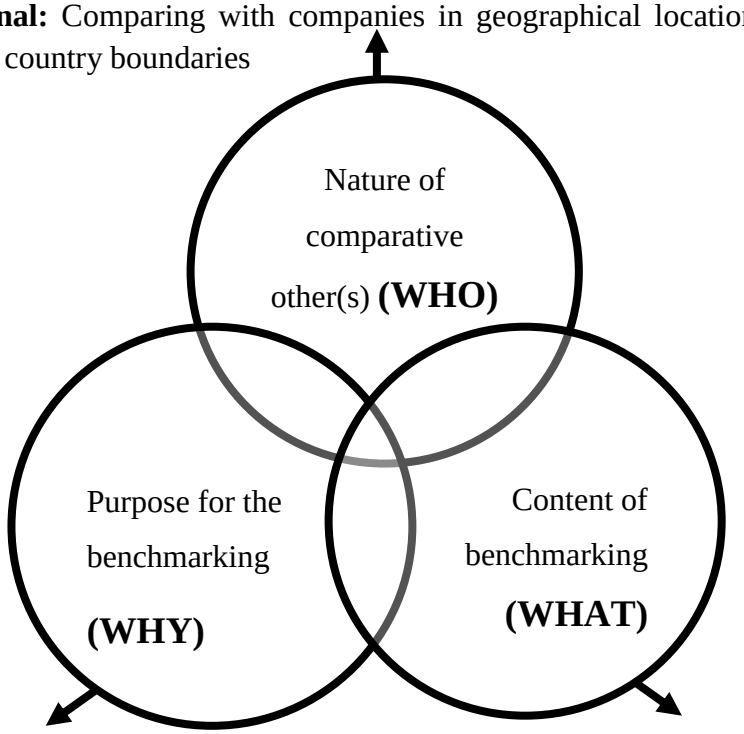
External:

Competitor: Comparing with direct competitors

Industry: Comparing with other companies within the same industry, including non competitors

Generic: Comparing with an organisation beyond the boundaries of the company

International: Comparing with companies in geographical locations outside of the company's country boundaries



Why:

Competitive: Comparison for gaining superiority over others

Collaborative: Comparison for developing a learning atmosphere and sharing of knowledge

Measuring gaps: identify areas and opportunity for improvement

Increasing awareness: increasing awareness of new and innovative approaches

What:

Process: focuses on improving critical processes and operations

Functional: application of the process benchmarking that compares particular business functions

Performance: Concerned with outcome characteristics, based on quantifiable measures

Strategic: Assessment of strategic aspects

Appendix 7 Issues in the dissemination process [77]

Source

- Perceived competence
- Credibility of experience
- Credibility of motive
- Sensitivity to user concerns
- Relationship to other sources trusted by users

Medium

- Physical capacity to reach intended users
- Timelines of access
- Accessibility and ease of user
- Flexibility
- Reliability
- Credibility
- Cost effectiveness
- Clarity and attractiveness of the information package

Context

- Relationship between outcomes and existing knowledge
- Current issues in the field
- Competing knowledge or products
- General economic climate

Content

- Credibility of research and development methodology
- Credibility of outcomes
- Comprehensiveness of outcomes
- Utility and relevance for users
- Capacity to be described in terms understandable to users
- Cost effectiveness
- Research design and procedures

User

- Readiness to change
- Format and level of information
- Level of contextual information
- Perceived relevance to own needs
- Dissemination media preferred
- Information sources trusted

Appendix 8 Comparison of existing manufacturing improvement support tools

	The MX Awards	Manufacturing PROBE	WCM Checklist
Cost	Free of charge	Charge	Free of charge
Process	Self assessment Site visit Feedback Report	Self assessment Site visit Management Report	Self assessment Self produced report
Main focus	Reward and recognition	Improvement	Improvement
Time	Annual basis	Continual	Continual
Accessibility	Electronically based (word processing package)	Electronically based	Web based
Source	Academic and Professional Institution collaboration	Professional (lobbying) organisation, academic and business collaboration	Consultancy
Format of information (assessment)	Free text to open questions	Multiple choice with free text option to open and closed questions	Multiple choice answers to closed questions
Structure of assessment	Ten sections (modular approach)	Nine sections	One section
Length of assessment	262 questions (time varies from 4 – 180 hours)	Unknown (time recommended 3- 4 hours)	20 questions
Format of report	Text and score based feedback	Graphical representations and comparisons of results	Self produced report comparing scores
Comparisons	None	With relevant industry/sector	With other countries
Main method of transfer	Feedback contained in report	Anchorage statements and driver note in the assessment	Structured multiple choice answers in the assessment
External input?	External assessment received based on merit	External assessment can be requested at a cost	No formal link, but additional resource available through the consultancy

Appendix 9 MX Start for evaluation for companies

MX Start Evaluation for companies

This evaluation is for manufacturing companies who have completed at least two sections of MX Start. MX Start is the outcome of a research project conducted by WMG at the University of Warwick. It is a benchmarking tool designed to support manufacturing companies on their quest for continual improvement, through identifying opportunities for change based on acknowledged best practice indentified by the UK and German winners of the Manufacturing Excellence Awards. If you have any questions or would like to know more information about MX Start, please contact Heather McDougall, telephone 0247 65 75957 or email h.s.mcdougall@warwick.ac.uk This evaluation is made of up nineteen questions and should take around 15 minutes to complete.

---

*Required

Eligibility to complete this questionnaire

This questionnaire is being completed by a manufacturing company *

☐ Yes
☐ No, please contact h.s.mcdougall@warwick.ac.uk if you would like to receive a copy of MX Start and take part in this evaluation

This questionnaire is being completed by a company who has completed at least two relevant sections of MX Start *

☐ Yes

☐ No, please complete two sections of MX Start before completing this evaluation

Overview

Please tick the most appropriate option for your business

1) How many employees are there in your company? *

☐ 0 - 20

☐ 21 - 50

- ☐ 51 - 100
- ☐ 101 - 250
- ☐ 251 - 500
- ☐ 500 +

Other ☐

2) What is your turnover?

- ☐ £0 - £ 1 million
- ☐ £1 million - £5 million
- ☐ £5 million - £10 million
- ☐ £10 million - £50 million
- ☐ £50 million - £100 million
- ☐ £100 million +

3) Which manufacturing support resources have you used in the past three years?

- ☐ None
- ☐ The Manufacturing Excellence Awards
- ☐ The Manufacturing Advisory Service (MAS)
- ☐ The EFQM model
- ☐ Manufacturing PROBE
- ☐ World Class Manufacturing Checklist

Other:

Content

Please rate the following characteristics regarding the content of MX Start on a scale of 0 - 10

4) How relevant to your business were the assessment questions?

	0	1	2	3	4	5	6	7	8	9	10	
Highly unsuitable												Highly relevant

5) How relevant to your business was the feedback provided in the report?

	0	1	2	3	4	5	6	7	8	9	10	
Highly unsuitable												Highly relevant

6) How easy to understand were the assessment questions?

	0	1	2	3	4	5	6	7	8	9	10	
Difficult to interpret												Easy to understand

7) How easy to understand was the feedback provided in the report?

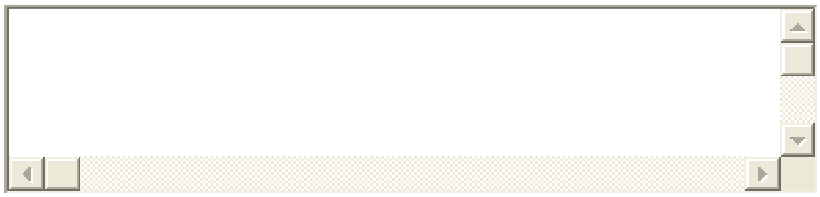
	0	1	2	3	4	5	6	7	8	9	10	
Difficult to interpret												Easy to understand

8) How credible do you perceive the content of MX Start to be?

0	1	2	3	4	5	6	7	8	9	10

Not credible												Trustworthy

If you have any further comments regarding the content of MX Start, please provide them below:



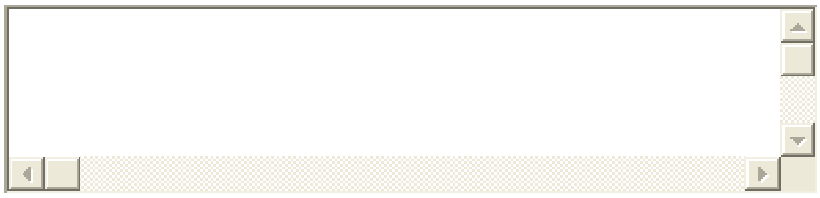
Usability

Please rate the following characteristics regarding the ease of use of MX Start on a scale 0 -10.

9) How easy was MX Start to use?

	0	1	2	3	4	5	6	7	8	9	10	
Very difficult												Very easy

If you have any further comments regarding the usability of MX Start, please provide them below:



Cost / benefit

Please rate the following characteristics regarding the cost / benefit of Mix Start on a scale from 0 -10.

10) How resource intensive (in time and effort) was the process of using MX Start?

0	1	2	3	4	5	6	7	8	9	10

Highly resource intensive												Low resource intensive

11) To what extent did MX Start help increase your knowledge of best practice?

	0	1	2	3	4	5	6	7	8	9	10	
No new knowledge gained												Significant amount of new knowledge gained

12) To what extent did MX Start help your company identify improvement opportunities?

	0	1	2	3	4	5	6	7	8	9	10	
No opportunities identified												Many opportunities identified

13) To what extent did MX Start help you to understand how best practice could be implemented in your company?

	0	1	2	3	4	5	6	7	8	9	10	
Not helpful												Very helpful

14) After using MX Start, was your company encouraged to make improvements?

	0	1	2	3	4	5	6	7	8	9	10	
Unmotivated to make improvements												Highly encouraged to make improvements

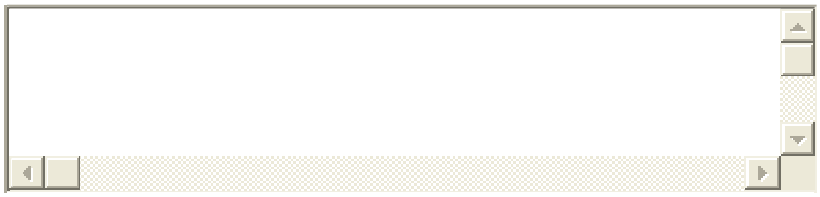
15) How valuable did you find the process of using MX Start?

	0	1	2	3	4	5	6	7	8	9	10	
Completely useless												Very valuable

16) How would you rate the overall benefit your company gained compared with the resources you needed to invest in MX Start?

	0	1	2	3	4	5	6	7	8	9	10	
Resources vastly outweigh the benefit B	○	○	○	○	○	○	○	○	○	○	○	Benefits vastly outweigh the resources

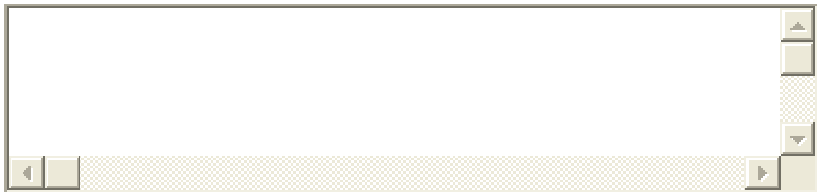
If you have any further comments regarding the cost / benefit of MX Start, please provide them below:



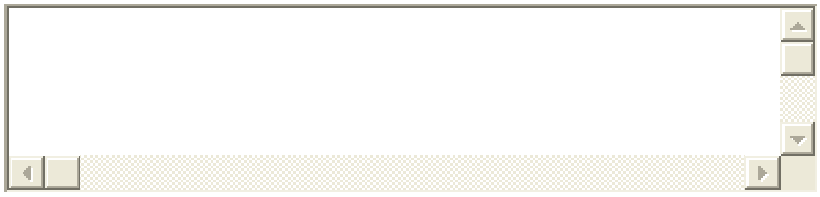
Impacts and opportunities

This section asks questions regarding the specific impact that using MX Start has had on your company and how the tool could be improved

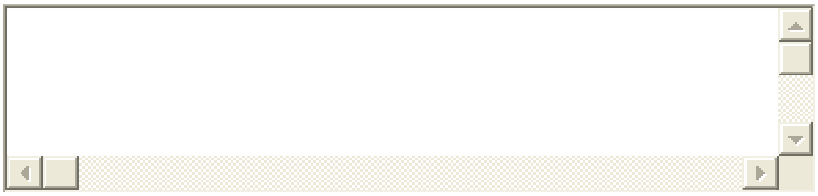
17) What has been the impact of using MX Start?



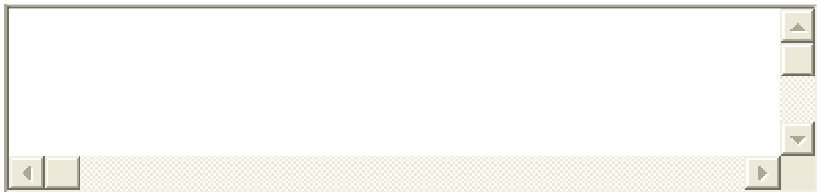
18) Has MX Start been a motivator for improvements in previously overlooked areas?



19) How could MX Start be improved?



If there is anything further you would like to contribute to the evaluation and development of MX Start, please add your comments below:



Thank you

Thank you for completing the evaluation of MX Start and contributing to its future development. If you would be prepared to take part in a follow up interview, please provide your contact details below:

Contact name:

Contact telephone number:

Contact email address:

Appendix 10 MX Start evaluation for individuals

MX Start Evaluation

This evaluation is for individuals who are evaluating MX Start on behalf of the IMechE / MAS / MX Awards / MX Germany. In order to be able to complete this evaluation, please familiarise yourself with the content and process of using MX Start. MX Start is the outcome of a research project conducted by WMG at the University of Warwick. It is a benchmarking tool designed to support manufacturing companies on their quest for continual improvement, through identifying opportunities for change based on acknowledged best practice indentified by the UK and German winners of the Manufacturing Excellence Awards. If you have any questions or would like to know more information about MX Start, please contact Heather McDougall, telephone 0247 65 75957 or email h.s.mcdougall@warwick.ac.uk This evaluation is made of up sixteen questions and should take around 15 minutes to complete.

---

*Required

Eligibility to complete this questionnaire

This questionnaire is being completed by an individual familiar with the content and process of MX Start. *

- ○ Yes
- ○ No, please email Heather McDougall h.s.mcdougall@warwick.ac.uk if you would like to receive a copy of MX Start and take part in this evaluation

Overview

Please tick all that apply**1) Are you affiliated with any of the organisations below?**

- ☐ The Manufacturing Advisory Service (MAS)
- ☐ The Institution of Mechanical Engineers
- ☐ The Manufacturing Excellence Awards (UK)
- ☐ The Manufacturing Excellence Awards (Germany)
- ☐ None of the above
- ☐ Other: _____ **Content**

Please rate the following characteristics regarding the content of MX Start on a scale of 0 - 10

2) How relevant to the manufacturing industry are the assessment questions?

	0	1	2	3	4	5	6	7	8	9	10	
Highly unsuitable												Highly relevant

3) How relevant to the manufacturing industry is the feedback provided in the report?

	0	1	2	3	4	5	6	7	8	9	10	
Highly unsuitable												Highly relevant

4) How easy to understand were the assessment questions?

	0	1	2	3	4	5	6	7	8	9	10	
Difficult to interpret												Easy to understand

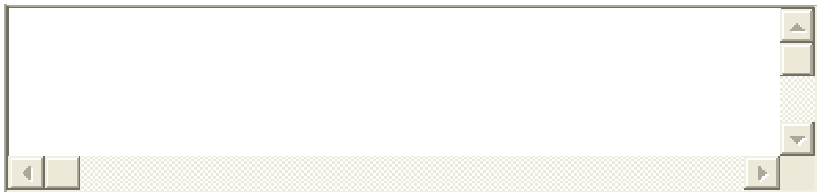
5) How easy to understand was the feedback provided in the report?

	0	1	2	3	4	5	6	7	8	9	10	
Difficult to interpret												Easy to understand

6) How credible do you perceive the content of MX Start to be?

	0	1	2	3	4	5	6	7	8	9	10	
Not credible												Trustworthy

If you have any further comments regarding the content of MX Start, please provide them below:



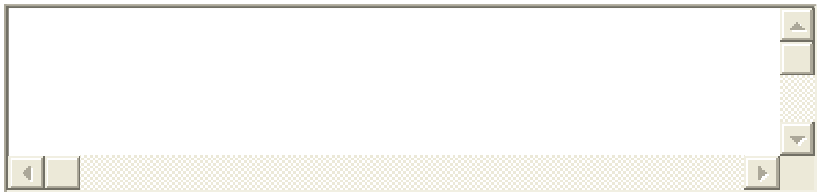
Usability

Please rate the following characteristics regarding the ease of use of MX Start on a scale 0 -10.

7) How easy was MX Start to use?

	0	1	2	3	4	5	6	7	8	9	10	
Very difficult	○	○	○	○	○	○	○	○	○	○	○	Very easy

If you have any further comments regarding the usability of MX Start, please provide them below:



Cost / benefit

Please rate the following characteristics regarding the cost / benefit of MX Start on a scale from 0 -10.

8) How resource intensive (in time and effort) do you believe the MX Start process is for manufacturing companies?

	0	1	2	3	4	5	6	7	8	9	10	
Highly resource intensive	○	○	○	○	○	○	○	○	○	○	○	Low resource intensive

9) To what extent can MX Start help increase the dissemination of best practice to the manufacturing industry?

	0	1	2	3	4	5	6	7	8	9	10	
No potential to disseminate best practice	○	○	○	○	○	○	○	○	○	○	○	High potential to disseminate best practice

10) To what extent can MX Start help manufacturing companies identify improvement opportunities?

	0	1	2	3	4	5	6	7	8	9	10	
No potential to support	○	○	○	○	○	○	○	○	○	○	○	High potential to support

identification of improvement opportunities												identification of improvement opportunities

11) To what extent can MX Start help manufacturing companies to understand how they could implement best practice?

	0	1	2	3	4	5	6	7	8	9	10	
Not helpful	○	○	○	○	○	○	○	○	○	○	○	Very helpful

12) After using MX Start, to what extent could manufacturing companies be encouraged to make improvements?

	0	1	2	3	4	5	6	7	8	9	10	
Unmotivated to make improvements	○	○	○	○	○	○	○	○	○	○	○	Highly encouraged to make improvements

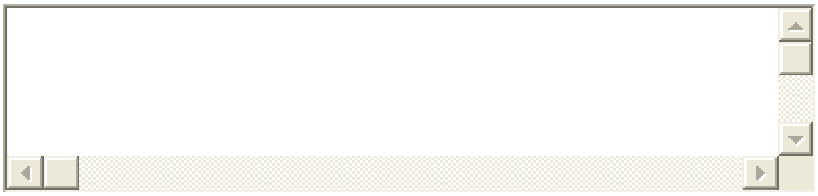
13) How valuable could the process of using MX Start for manufacturing companies?

	0	1	2	3	4	5	6	7	8	9	10	
Completely useless	○	○	○	○	○	○	○	○	○	○	○	Very valuable

14) How would you rate the overall potential benefits for manufacturing companies compared with the resources needed to invest in using MX Start?

	0	1	2	3	4	5	6	7	8	9	10	
Potential benefits vastly outweigh the resources	○	○	○	○	○	○	○	○	○	○	○	Potential resources vastly outweigh the benefit

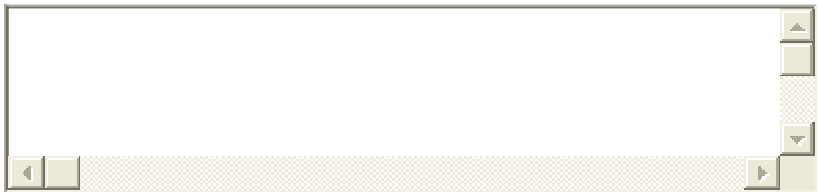
If you have any further comments regarding the cost / benefit of MX Start, please provide them below:



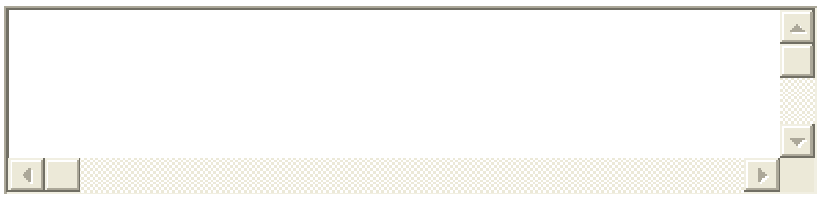
Impacts and opportunities

This section asks questions regarding the specific impact that using MX Start has had on your company and how the tool could be improved

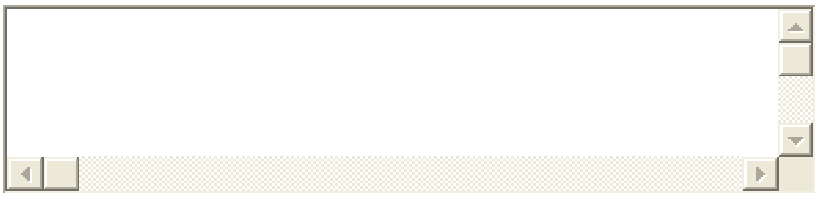
15) What do you think the impact of using MX Start is for manufacturing companies?



19) How can MX Start be improved?



If there is anything further you would like to contribute to the evaluation and development of MX Start, please add your comments below:



Thank you

Thank you for completing the evaluation of MX Start and contributing to its future development. If you would be prepared to take part in a follow up interview, please provide your contact details below:

Contact name:

Contact telephone number:

Contact email address:

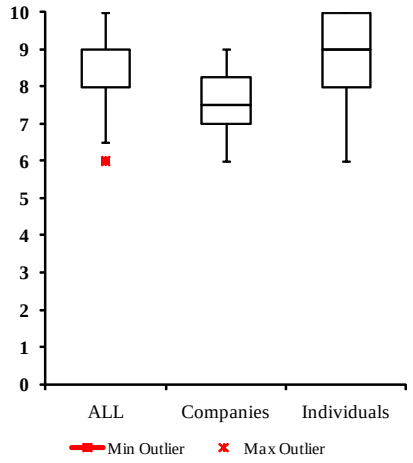
Appendix 11 Quantitative Data collected during the evaluation of MX Start

Question	Company rating out of 10												Individual rating out of 10																					
How relevant to your business were the assessment questions?			9	7	9	8	6			7	8	7	9	8	6	9	7	10	8	9	10	10	9	8	10	8	10	8	10	9	10	9	8
How relevant to your business was the feedback provided in the report?			8	7	9	8	6	8	7		9	7	9	8	6	7	7	9	8	10	10	10	9			8	8	7	9	8	8	9	8
How easy were the assessment questions to understand ?			9	6	10	8		7	8	10	6	5	8	9	5	9	6	8	10	10	8	10	6	8	6	8	9	8	9	10	8	7	9
How easy was the feedback provided in the report to understand?	4	10	9	7		8	6	8	8	8	9	7	9	8	7	8	9	8	9	10	9	10	7	5		8	7	7	9	9	7	8	8
How credible do you perceive the content of MX Start to be?	7	10	9	7	10	8	7	8	9	9	8	7	9	9	5	8	7	10	5	9	9	9	9	9	10	8	10	8	9	8	7	8	6
How easy was MX Start to use?	6	10	10	7	10	8	6			10	7	8	7	10	3	10	7	7	5	10	9	9	7	8	5	8	8		9	10	8		8
How resource intensive (in time and effort) was the process of using MX Start?*	8	0	9	8	10	6	6	8	9	4	8	7	9	9	7	9	8	7	7	9	9	10	5	7	5	6	8	9	8	7	9	6	5
To what extent did MX Start help increase your knowledge of best practice?*	2	10	3	7	10	7	6	7	8	8	8	7	8	9	5	7	8	10	6	10	10	9	6	6	10	8	9	8	6	9	7	6	10
To what extent did MX Start help you to understand how best practice could be implemented in your company?*	3	8	5	7		8	8	8	8	6	8	6	8	8	5	8	8	6	4	10	10	9	7	6	10	7	10	8	7	8	8	6	4
To what extent did MX Start help your company identify improvement opportunities?*	2	7	5	7	7	7	7	8	8	8	9	7	9	9	8	8	6	9	6	9	9	9	7	10	10	8	10	9	7	8	9	8	10
After using MX Start, was your company encouraged to make improvements?*	0	7	5	8	8	7	6	9	9	8	7	7	8	8	7	9	7	7	5	9	8	8	6		10		9	9	7	8	7	7	6
How valuable did you find the process of using MX Start?*	3	8	6	7	9		6	8	7	9	7	7	9	8	6	8	9	10	5	10	10	9	6	9	10	8	8	9	8	8	10	7	8
How would you rate the value you have gained from using MX Start?*	2	8	5	7	9	8	7	9	8	9	7	7																					

Appendix 12 Analysis of the Content Evaluation Results

How relevant to your business were the assessment questions?

Box Plot



Stem and Leaf

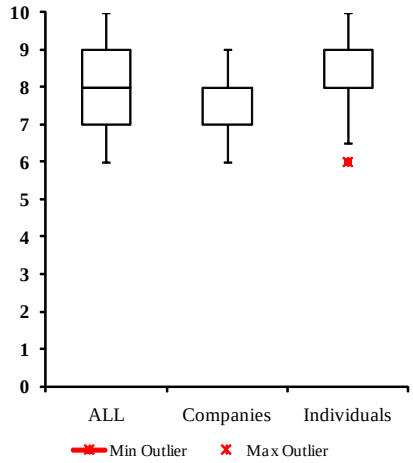
10	X X X X X X X
9	X X X X X X X X
8	X X X X X X X X
7	X X X X
6	X X
5	
4	
3	
2	
1	
0	

Data table

	ALL	Companies	Individuals
Lowest value	6	6	6
Lower quartile	8.0	7.0	8.0
Median	9	7.5	9
Upper quartile	9.0	8.3	10.0
Highest value	10	9	10
Interquartile range	1.0	1.3	2.0
Upper Outliers	0	0	0
Lower Outliers	2	0	0
Mean	8.5	7.6	8.8
Median	9	7.5	9
Mode	9	7	10

How relevant to your business was the feedback provided in the report?

Box Plot



Stem and Leaf

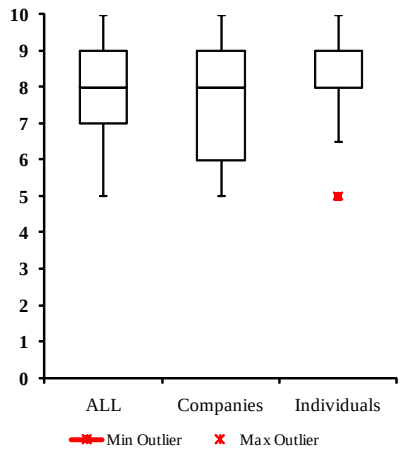
10	X X X
9	X X X X X X X
8	X X X X X X X X X X
7	X X X X X X
6	X X
5	
4	
3	
2	
1	
0	

Data table

	ALL	Companies	Individuals
Lowest value	6	6	6
Lower quartile	7.0	7.0	8.0
Median	8	8	8
Upper quartile	9.0	8.0	9.0
Highest value	10	9	10
Interquartile range	2.0	1.0	1.0
Upper Outliers	0	0	0
Lower Outliers	0	0	1
Mean	8.1	7.7	8.3
Median	8	8	8
Mode	8	8	8

How easy were the assessment questions to understand?

Box Plot



Stem and Leaf

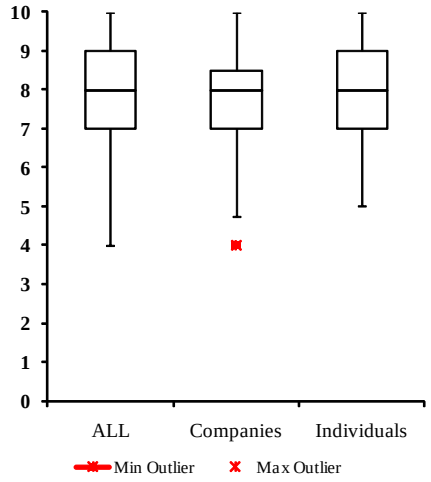
10	XXXXXX
9	XXXXXX
8	XXXXXXXXX
7	XX
6	XXXXX
5	XX
4	
3	
2	
1	
0	

Data table

	ALL	Companies	Individuals
Lowest value	5	5	5
Lower quartile	7.0	6.0	8.0
Median	8	8	8
Upper quartile	9.0	9.0	9.0
Highest value	10	10	10
Interquartile range	2.0	3.0	1.0
Upper Outliers	0	0	0
Lower Outliers	0	0	4
Mean	8.0	7.7	8.1
Median	8	8	8
Mode	8	6	8

How easy was the feedback provided in the report to understand?

Box Plot



Stem and Leaf

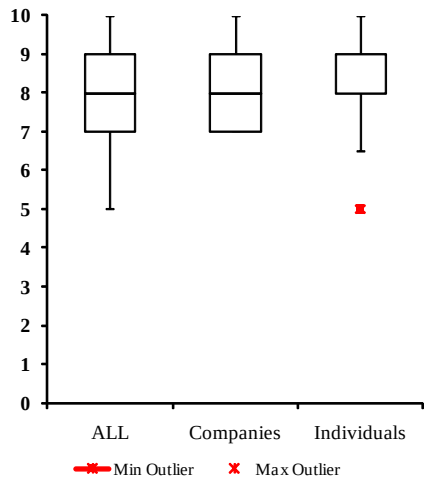
10	X X X
9	X X X X X X X X
8	X X X X X X X X X X
7	X X X X X X X
6	X
5	X
4	X
3	
2	
1	
0	

Data table

	ALL	Companies	Individuals
Lowest value	4	4	5
Lower quartile	7.0	7.0	7.0
Median	8	8	8
Upper quartile	9.0	8.5	9.0
Highest value	10	10	10
Interquartile range	2.0	1.5	2.0
Upper Outliers	0	0	0
Lower Outliers	0	1	0
Mean	7.9	7.6	8.1
Median	8	8	8
Mode	8	8	9

How credible do you perceive the content of MX Start to be?

Box Plot



Stem and Leaf

10	X X X X X
9	X X X X X X X X X X X
8	X X X X X X X X
7	X X X X X X
6	X X
5	
4	
3	
2	
1	
0	

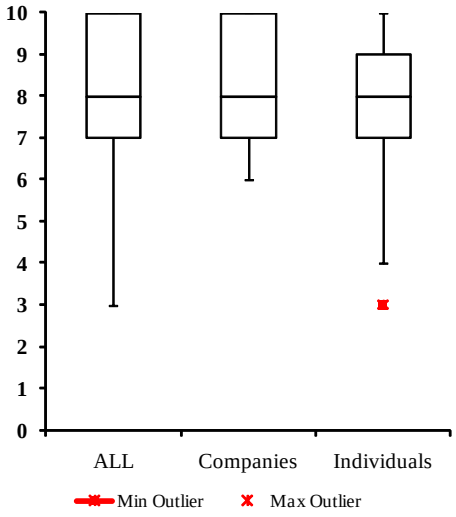
Data table

	ALL	Companies	Individuals
Lowest value	5	7	5
Lower quartile	7.0	7.0	8.0
Median	8	8	9
Upper quartile	9.0	9.0	9.0
Highest value	10	10	10
Interquartile range	2.0	2.0	1.0
Upper Outliers	0	0	0
Lower Outliers	0	0	3
Mean	8.2	8.3	8.2
Median	8	8	9
Mode	9	7	9

Appendix 13 Analysis of the Ease of Use of MX Start Results

How easy was MX Start to use?

Box Plot



Stem and Leaf

10	XXXXXXXX
9	XXX
8	XXXXXXX
7	XXXXXX
6	XX
5	XX
4	
3	X
2	
1	
0	

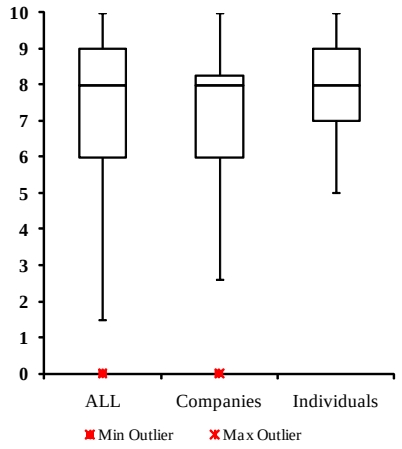
Data table

	ALL	Companies	Individuals
Lowest value	3	6	3
Lower quartile	7.0	7.0	7.0
Median	8	8	8
Upper quartile	10.0	10.0	9.0
Highest value	10	10	10
Interquartile range	3.0	3.0	2.0
Upper Outliers	0	0	0
Lower Outliers	0	0	1
Mean	7.9	8.2	7.8
Median	8	8	8
Mode	10	10	8

Appendix 14 Analysis of the Cost versus Benefit of MX Start Results

How resource intensive (in time and effort) was the process of using MX Start?*

Box Plot



Stem and Leaf

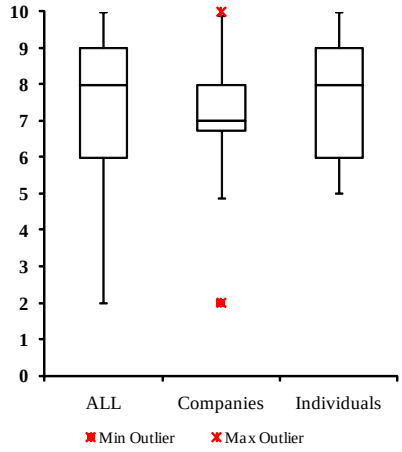
10	XX
9	XXXXXXXXX
8	XXXXXXX
7	XXXXXX
6	XXXX
5	XXX
4	X
3	
2	
1	
0	X

Data table

	ALL	Companies	Individuals
Lowest value	0	0	5
Lower quartile	6.0	6.0	7.0
Median	8	8	8
Upper quartile	9.0	8.3	9.0
Highest value	10	10	10
Interquartile range	3.0	2.3	2.0
Upper Outliers	0	0	0
Lower Outliers	1	1	0
Mean	7.3	6.9	7.6
Median	8	8	8
Mode	9	8	9

To what extent did MX Start help increase your knowledge of best practice?*

Box Plot



Stem and Leaf

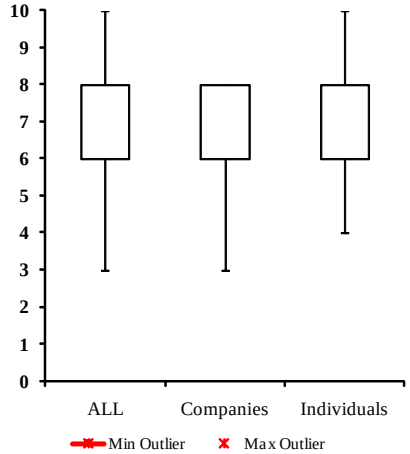
10	XXXXXXX
9	XXXX
8	XXXXXXX
7	XXXXXX
6	XXXXXX
5	X
4	
3	X
2	X
1	
0	

Data table

	ALL	Companies	Individuals
Lowest value	2	2	5
Lower quartile	6.0	6.8	6.0
Median	8	7	8
Upper quartile	9.0	8.0	9.0
Highest value	10	10	10
Interquartile range	3.0	1.3	3.0
Upper Outliers	0	2	0
Lower Outliers	0	2	0
Mean	7.6	6.9	8.0
Median	8	7	8
Mode	10	7	10

To what extent did MX Start help you to understand how best practice could be implemented in your company?*

Box Plot



Stem and Leaf

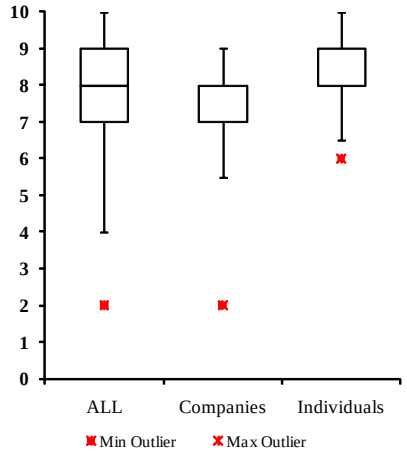
10	XXXX
9	X
8	XXXXXXXXXXXXX
7	XXXX
6	XXXXX
5	XX
4	XX
3	X
2	
1	
0	

Data table

	ALL	Companies	Individuals
Lowest value	3	3	4
Lower quartile	6.0	6.0	6.0
Median	8	8	8
Upper quartile	8.0	8.0	8.0
Highest value	10	8	10
Interquartile range	2.0	2.0	2.0
Upper Outliers	0	0	0
Lower Outliers	0	0	0
Mean	7.3	6.8	7.5
Median	8	8	8
Mode	8	8	8

To what extent did MX Start help your company identify improvement opportunities?*

Box Plot



Stem and Leaf

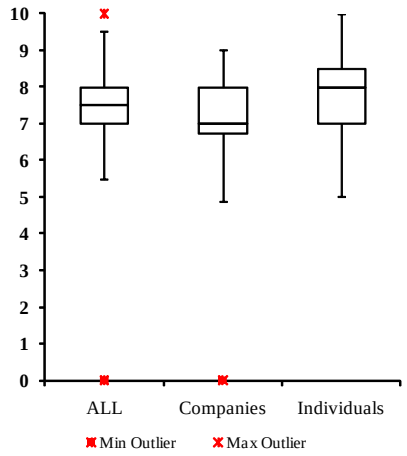
10	XXXX
9	XXXXXXXXX
8	XXXXXXXX
7	XXXXXXXX
6	XX
5	XX
4	X
3	
2	X
1	
0	

Data table

	ALL	Companies	Individuals
Lowest value	2	2	6
Lower quartile	7.0	7.0	8.0
Median	8	7	9
Upper quartile	9.0	8.0	9.0
Highest value	10	9	10
Interquartile range	2.0	1.0	1.0
Upper Outliers	0	0	0
Lower Outliers	1	2	2
Mean	7.9	6.8	8.5
Median	8	7	9
Mode	9	7	9

After using MX Start, was your company encouraged to make improvements?*

Box Plot



Stem and Leaf

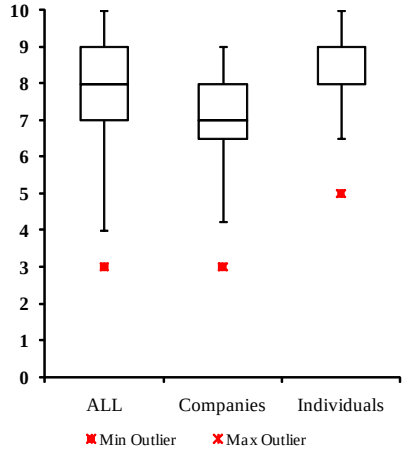
10	X
9	XXXXXX
8	XXXXXXXX
7	XXXXXXXXXX
6	XX
5	XX
4	
3	
2	
1	
0	X

Data table

	ALL	Companies	Individuals
Lowest value	0	0	5
Lower quartile	7.0	6.8	7.0
Median	7.5	7	8
Upper quartile	8.0	8.0	8.5
Highest value	10	9	10
Interquartile range	1.0	1.3	1.5
Upper Outliers	1	0	0
Lower Outliers	3	1	0
Mean	7.3	6.8	7.6
Median	7.5	7	8
Mode	7	7	7

How valuable did you find the process of using MX Start?*

Box Plot



Stem and Leaf

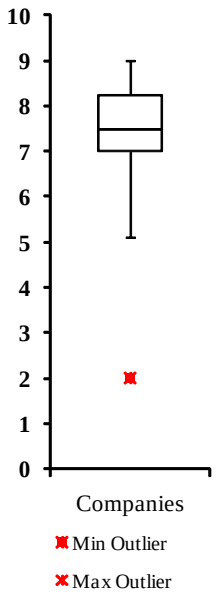
10	XXXXX
9	XXXXXXX
8	XXXXXXXXX
7	XXXXX
6	XXXX
5	X
4	
3	X
2	
1	
0	

Data table

	ALL	Companies	Individuals
Lowest value	3	3	5
Lower quartile	7.0	6.5	8.0
Median	8	7	8
Upper quartile	9.0	8.0	9.0
Highest value	10	9	10
Interquartile range	2.0	1.5	1.0
Upper Outliers	0	0	0
Lower Outliers	1	1	3
Mean	7.9	7.0	8.3
Median	8	7	8
Mode	8	7	8

How would you rate the value you have gained from using MX Start?*

Box Plot



Stem and Leaf

10	
9	X X X
8	X X X
7	X X X X
6	
5	X
4	
3	
2	X
1	
0	

Data table

	Companies
Lowest value	2
Lower quartile	7.0
Median	7.5
Upper quartile	8.3
Highest value	9
Interquartile range	1.3
Upper Outliers	0
Lower Outliers	2
Mean	7.2
Median	7.5
Mode	7