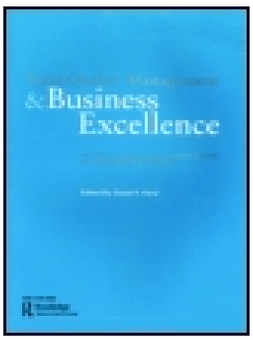

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Discreetly embedding the Shingo principles of enterprise excellence at Abbott Diagnostics manufacturing facility in Longford Ireland

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From 2005 to 2011 Abbott Diagnostics Longford's reagent manufacturing facility was primarily focused on transferring products from its sister site in Chicago and ramping up production. Thereafter, the organisation set about establishing a Lean Framework which would connect its many systems and tools and empower every employee in the organisation to improve their processes to achieve sustainable results and ensure that strategic objectives were achieved. The Shingo Model and its Guiding Principles were seen as fit-for-purpose with respect to guiding Abbott Diagnostics Longford's structural and cultural transformation. Abbott Corporation and its Diagnostics Division already had many excellent systems, tools, and behavioural expectations which aligned well with the Shingo Principles. This instrumental case has been used by the authors to explore how the Shingo approach can be implemented in an effective way, as well as to address how improvement activity can subsequently be transferred between different group sites. A series of framework and models are discussed regarding how both of these activities can be managed effectively.

Keywords: Shingo prize; Shingo principles; enterprise excellence; Lean management system; BE SCILLED

Introduction

At the heart of most successful organisations there is a focus on improvement. In most cases organisations focus on a specific version of improvement, such as Lean (Samuel, Found, & Williams, 2015; Womack & Jones, 1996), Six Sigma (Schroeder, Linderman, Liedtke, & Choo, 2008; Swink & Jacobs, 2012), or other variations on these approaches such as Just in Time, Toyota Production System, Total Quality Management, Continuous Improvement, Agile, or World Class Manufacturing. The degree of success in implementing and sustaining these approaches is quite variable (Bhasin & Burcher, 2006; Schonberger, 2007). However, what they all have in common is that the primary focus of activity revolves around the implementation of a series of diagnostic and improvement tools (for instance, see: Bicheno & Holweg, 2009).

There has been a major focus in the literature on how to apply these methods, with the majority of this focused implicitly on a single site. It is perhaps only in the last two decades that researchers have started to focus on multinational corporations and the transfer of practices inter-organisationally (Maritan & Brush, 2003; Netland & Aspelund, 2014). Commenting on this, Netland & Aspelund (p. 391) suggest, 'the ability to learn within international networks offers a potent source of competitive advantage . . . the latest

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trend for process improvement sees MNCs [Multinational Corporations] going from plant-specific improvement projects to multi-plant improvement programmes'.

In this paper the authors seek to understand gaps in the literature with respect to application of the Shingo Model and managing multi-site knowledge transfer. These two specific gaps are explored through the use of a single instrumental and longitudinal case. In doing so, an attempt is made to contribute to the literature as well as to provide a set of practical recommendations to industry.

Literature review

Improvement literature

There is an extensive literature on improvement approaches and particularly on the application of Lean. Excellent summaries can be found in: Bhasin and Burcher (2006), Stone (2012), Bhamu and Sangwan (2014), and Samuel et al. (2015). What is evident in this literature is that Lean and similar approaches have evolved over time from merely a simple search for waste reduction (see, for example, Womack & Jones, 1996) to a more holistic approach involving a focus on the original technical 'hard' features and the later inclusion of more human 'soft' features (Bortolotti, Boscari, & Danese et al., 2015; Hines, Holweg, & Rich, 2004).

An evolutionary model is presented by Hines et al. (2004) where leading Lean organisations moved through:

- 1980–1990: Awareness focusing on cells and assembly lines
- 1990 –mid-1990s: Quality focusing on the shop floor
- Mid-1990s –2000: Quality, cost, and delivery focusing on value streams
- 2000+: Value system focusing on strategy deployment and learning

This evolution towards more enabling activities and people has continued after this latter publication, for instance, Liker and Hoseus (2008) and Shook (2010). This can also be seen in the Lean Iceberg Model of Hines, Found, Griffiths, and Harrison (2011) where the visible aspects of Lean such as tools, techniques, and technology, as well as process thinking, are combined with a number of hidden, or 'below the water', areas such as strategy deployment, leadership, and behaviour and engagement.

This theme has been further developed by the Shingo Institute at Utah State University (Shingo Institute, 2014). Their work is named after, and highly influenced by, the work of Shigeo Shingo. Dr. Shingo is credited with a major contribution to the development of the Toyota Production System (TPS) when he worked with Toyota. This achievement was recognised by Utah State University when Dr. Shingo was awarded an honorary doctorate in 1988. The Institute, which was formed by this point, had sought to develop a more holistic and sustainable approach to Lean than is commonly found in organisations, and it commented:

> One of Dr. Shingo's little known, but perhaps most important contributions, was his understanding of the relationship between concepts (principles), systems and tools. Unfortunately, over the years, most of us have gravitated to and exalted the tools associated with effective operations and have paid too little attention to the power of the principles. (Shingo Institute, 2014)

The Shingo approach therefore includes the well-established Lean focus on the customer (results) and tools, but has extended this to include wider systems (such as order fulfilment, strategy deployment, and people lifecycle management), culture, and guiding

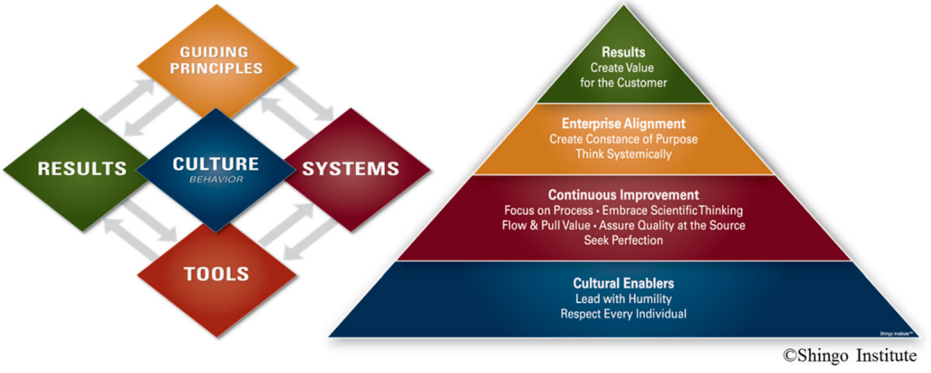

Figure 1. The Shingo Model and Shingo Guiding Principles (source: Shingo Institute, 2016).

principles (Figure 1). These guiding principles are divided into four dimensions: results, enterprise alignment, continuous improvement, and cultural enablers. The approach is therefore both more systematic and holistic than many Lean approaches favoured by organisations.

As we have noted above, in most Lean organisations the focus is on achieving results for the business and its customer base using a series of tools and techniques (Figure 2(A)). At this point the focus is on trying to bring these tools together more coherently to look at the wider system. The classic approach to this is the value stream mapping (VSM) of the order fulfilment system as described and popularised by Rother and Shook (1998). However, most organisations fail to understand the need to look at other wider delivery systems such as order creation and new product development, let alone core enabling systems such as leadership standard work, and learning and development. Hence, most

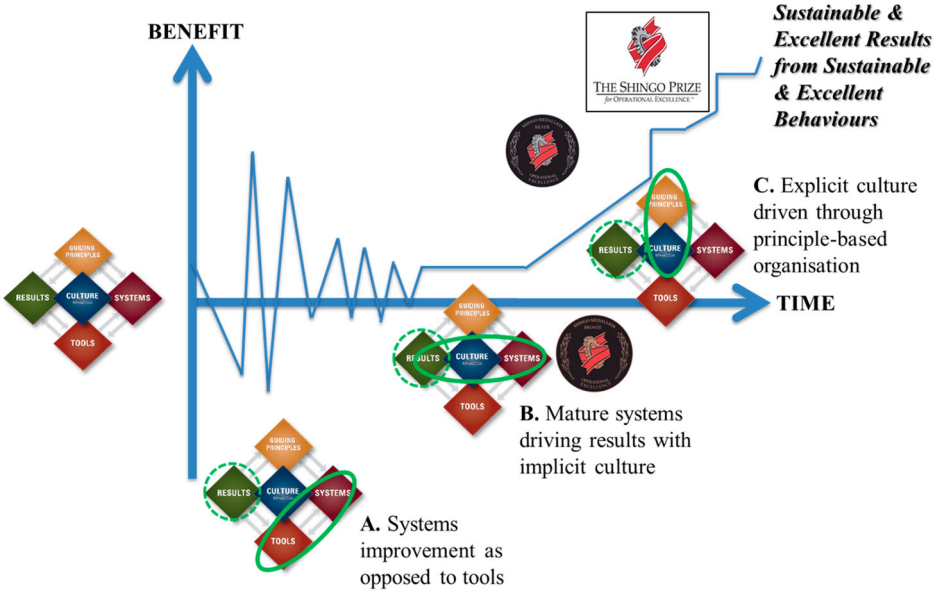

Figure 2. The Shingo Model, Lean maturity, and benefits (source: S A Partners, 2016).

Lean organisations are struggling with the first phase of Lean implementation. This struggle typically involves looking at these systems through a purely technical or 'hard' process viewpoint.

A small number of Lean organisations have overcome this hurdle and reached a second stage of evolution (Figure 2(B)). Here they are seeking to integrate these 'hard' Lean systems with the development of an appropriate culture. This often involves Lean people with an operations background working with change management people with a 'soft' HR background. This is often very difficult as the language, style, and methods are often very different.

In a very small number of organisations this gap between these 'hard' and 'soft' areas has been bridged by the use of a set of guiding principles (Figure 1) that have been used to devise a set of ideal behaviours that can be used to drive an appropriate culture (Figure 2(C)). This culture allows organisations to design their delivery and core systems from both a 'hard' and 'soft' perspective. They then employ a set of appropriate tools within these systems. We do see some Lean organisations purporting to rely on a set of Principles, often based around the classic 5 Lean Principles of Womack and Jones (1996). These are often displayed on posters across the site. However, we rarely see these principles driving any changes in behaviour and so are often little more than decorative wallpaper.

At this point, there is a scant literature on this Shingo approach and what exists is largely in practitioner journals celebrating individual organisations winning a Shingo Prize (for example, Hogan, 2009; Richey, 1996). These prizes are awarded by the Shingo Institute to organisations that have successfully undertaken a rigorous external assessment of their sites, and that demonstrate a culture where the Shingo principles of operational excellence are deeply embedded into the thinking and behaviour of all leaders, managers, and associates.

Research gap 1

Can we help fill the gap in the academic literature by demonstrating the implementation of successful and sustainable change based on the application of the Shingo Prize approach?

Multi-site transfer and improvement

The study of improvement activity on a multi-site basis is in its infancy with a range of researchers calling for further research (for example, Ansari, Fiss, & Zajac, 2010; Inkpen, 2008; Maritan & Brush, 2003). However, an excellent contribution and summary of the current literature is provided by Netland and Aspelund (2014). They define multi-plant improvement programmes (p. 392) as 'the systematic process of creating, formalising and diffusing better operational practices in the intra-firm production network with the aim of increasing competitiveness'.

Such activity is usually centre-led (Goel & Chen, 2008) and designed to improve group-optimising behaviour. It is, however, widely viewed as hard to achieve (Bohn, 1994; Boscari, Danese, & Romano, 2016; Ferdows, 2006; Maritan & Brush, 2003). The difficulties involved are numerous and have been seen to include:

- Recipients' lack (or willingness) of absorptive capacity (Bortolotti et al., 2015; Ferdows, 2006; Maritan & Brush, 2003).
- The heterogeneity of sites (Centre for Creative Leadership, 2014; Maritan & Brush, 2003; Netland & Aspelund, 2014).

- The sheer complexity involved (Senge, 1990; Szulanski, 1996).
- The fact that much of the knowledge required is tacit or 'soft' skills (Bortolotti et al., 2015; Liker, 2004).
- An often neglect of the local context such as maturity and stage of development (Boscari et al., 2016).
- The existing relationship between the local site and headquarters (Kostova, 1999; Van Wijk, Jansen, & Lyles, 2008).
- Local or national culture (Centre for Creative Leadership, 2014; Hines et al., 2011; Hofstede, Hofstede, & Minkov, 2010).

In contrast a number of researchers have attempted to provide guidelines on how to be successful in multi-site improvement (Aoki, 2008; Bessant & Francis, 1999; Kostova, 1999; Maritan & Brush, 2003). Netland and Aspelund (2014) helpfully categorise these various success factors (SFs) into four key strategies:

1. Fostering a dedicated management.
2. Building a deeply rooted improvement culture.
3. Creating suitable channels for knowledge and practice transfer.
4. Involving empowered teams in the ongoing improvement process.

The same authors also discuss a two-by-two matrix for subsidiary response to a multi-plant improvement programme which charts the degree of practice conformity versus the degree that the practice is institutionalised. We will return to a discussion of this later in the paper.

The last major element of research within this area is around the specific mechanisms for the transfer of knowledge. Whilst there does appear to be confusion in the literature about the 'why', 'what', and 'how' of knowledge transfer (Ferdows, 2006), there is a body of literature suggesting which mechanisms to use to transfer knowledge. A good summary of this is provided in Boscari et al. (2016). Within this literature the following features most widely:

- Training (Ferdows, 2006; Kostova, 1999; Shook, 2010).
- Pressure (Kostova & Roth, 2002; Kotter, 1995).
- Formal audits (Netland & Ferdows, 2014).
- Plant visits and tours (Boscari et al., 2016).
- Standard texts in hardcopy or intranet (Boscari et al., 2016; Inkpen, 2008).
- Advisors (Inkpen, 2008; Shook, 2010).
- Short-term assignments and interns (Inkpen, 2008).

Research gap 2

Can we help provide guidance on how to manage multi-site transfer of improvement knowledge particularly from the recipient's point of view?

Methodology and limitations

The methodology employed in this research was the use of a single instrumental case. This approach is both popular and widely used in business research and useful for theory

building (Eisenhardt & Graebner, 2007). The research methodology in this study is qualitative, and conducted over a longitudinal period (Yin, 1989).

In this case it was required because of the need for a flexible and holistic research design (Hakim, 1987) that involved a combination of different methods in order to deal with the complexity and variety of data (Hartley, 1994; Yin, 1989). The study used a single organisation in a single location as its instrumental case (Stake, 1998), where that instrumental case facilitates the understanding of more general issues.

Principles of action research and learning were applied (Eden & Huxham, 1996) with one of the researchers acting as an embedded manager, whilst the other acted as an independent researcher who could validate the findings of the embedded manager. Limitations of the research are detailed in Table 1.

The case organisation: Abbott Diagnostics Longford

Background

Abbott is a global, broad-based healthcare company devoted to discovering new medicines, technologies, and ways to manage health. It is committed to helping people live the best possible life through good health. For more than 125 years, Abbott has introduced various products and technologies to the world – in nutrition, diagnostics, medical devices, and branded generic pharmaceuticals – that create more possibilities for more people at all stages of life. Today, 74,000 Abbott employees in more than 150 countries are working to help people live longer and better.

The Longford site is one of two Abbott Diagnostics manufacturing facilities in Ireland. It was established in 2004 on a 20-acre greenfield site on the outskirts of the town. The 135,000-square-foot building was specifically designed to allow the most efficient flow of product through the value stream – from raw material receipt to finished goods shipment. More than 350 employees in the facility design, develop, and manufacture *in vitro* diagnostic products, also known as 'reagents', for distribution to laboratories and hospitals around the world. The product portfolio includes diagnostic reagents for the

Table 1. Research limitations and mitigation.

#	Concern	Cause	Countermeasure
1	Small survey size	Requirement for detailed longitudinal insight into the case	Use of several qualitative methods and use of multiple researchers
2	Lack of generalisability	Single case study	Instrumental case organisation
3	Co-ordination of research team	It was not possible for both researchers to take part in every step of the longitudinal research process	A split between one embedded and one independent research, although not without limitations, did allow for the value of an inside-out as well as an outside-in perspective
4	Cultural bias of researchers	The authors are based in the 'Celtic fringe' (Brittany, Cornwall [England], Ireland, Scotland & Wales) of Europe with its own unique epistemological perspective	Testing of the research findings at an international conference in Copenhagen

detection of thyroid, fertility/pregnancy, cardiology, renal, and metabolic markers. Manufacturing began in March 2005, and the first product was shipped in December 2005.

Site start-up and product transfers

From 2004 to 2007 the Longford site was focused on the transfer of the manufacture of all key diagnostic reagent products from its sister site in Lake County (outside Chicago), Illinois, USA. During the years 2008–2011 Abbott Diagnostic's manufacturing network configuration was streamlined and complexity was significantly reduced to best meet long-range plan and capacity requirements. Abbott Diagnostics Longford was then required to export product to the United States, which involved establishing and maintaining compliance with US Food & Drug Administration (FDA) requirements. These activities fostered a culture focused on delivering quality, compliance, operational excellence, and supply chain results, as well as project execution and the development of employees focused on continuous improvement.

An objective to create a sustainable continuous improvement culture

In 2011 the fully operational manufacturing facility shifted its emphasis to becoming a process-focused organisation that would deliver world-class results valued by its internal and external customers. The objective was to create a sustainable continuous improvement culture (Kelly, 2016). As the Longford site is part of the Abbott Diagnostics Division, it is governed by global Abbott systems such as world-class environment, health, safety, and energy (EHS&E), and quality management systems. However, the site still had the autonomy to create additional local business systems to support the attainment of their short-, medium-, and long-term objectives as agreed through the annual Divisional long-term planning process. Furthermore, there was no prescriptive Divisional approach to Operational Excellence.

Existing systems and cultural enablers fundamental to operational excellence

Abbott's proactive EHS&E management system has been successfully applied at Abbott Diagnostics Longford. As of July 2016, the facility has accumulated 3649 lost time accident-free days. In addition, it has significantly lowered its carbon footprint by reducing energy consumption (energy usage fell by 23% between 2012 and 2015, whilst production output increased by 68% over the same period), eliminated waste going to landfill, and created an on-site biodiversity garden. Furthermore, creating an awareness of the benefits of physical activity encourages all employees to become more active, and the site provides a supportive workplace environment for doing so.

The approach to ensuring the quality of Longford's products reflects the Diagnostics Division's overall quality policy – 'To improve healthcare by providing high quality, safe and effective diagnostic products' – and its quality system which integrates seven major subsystems: management, design and development, purchasing controls, product documentation, documentation and records, production and process controls, and corrective and preventative actions. Corporate social responsibility (CSR) is also a key focus of Abbott Diagnostics, and Longford employees volunteer more than 2000 hours each year to the site's many CSR initiatives.

Mid-level managers at Abbott Diagnostics Longford have participated in Abbott Ireland's annual multidivisional Leadership Excellence Programme (LEP) with the objective

of developing managers for higher level leadership roles within the organisation. As a prerequisite for LEP certification, Longford attendees are challenged to choose projects that focus on culture and strategy rather than just cost improvement. This not only takes middle leaders out of their comfort zone and gives them real development opportunities, it also yields valuable outputs that can shape the future of the Longford site. Examples of LEP projects that have been fundamental to operational excellence in Longford include:

- The creation of site-specific behavioural standards that were developed by the employees.
- The establishment of an APPREC8 employee-centric reward and recognition scheme where employees openly recognise each other on thank-you cards for displaying behaviours that exemplify the site's behavioural standards. This is supported by quarterly awards and an annual Site Director's award for the employee who most personifies the behavioural standards.
- The development of the Longford site's vision of 'World-class performance in everything we do'.
- The development of the Longford site's strategy map and balanced scorecard (Kaplan & Norton, 2000) which supports its vision and identifies customer loyalty and business performance as value propositions.
- The establishment of a small, autonomous, and culturally focused Business Excellence team and a Customer Systems Technical Support team, to help realise the stated value propositions.

Choosing the Shingo model

Given the site's stated vision of 'World-class performance in everything we do', the new Business Excellence team had to develop its own vision and strategy which would establish a roadmap to achieving world-class operational excellence. Firstly, however, the team had to define 'operational excellence' and decide what it meant by 'world-class'. After much research, the team decided that the Shingo Model for Operational Excellence addressed both concepts. Attendance of the site leadership team at Shingo Principles of Operational Excellence Workshops and extensive benchmarking activities confirmed the view that the Shingo Model was fit for guiding cultural transformation at Abbott Diagnostics Longford. A key reason why the management team chose the Shingo approach over other approaches was the fact that they saw that its principles-based approach integrated a great deal of the best management thinking of the last 50 years with clear influences from the:

- Lean community such as James Womack and Dan Jones,
- Total Quality community such as W. Edwards Deming and Joseph Juran,
- Leadership community such as Jim Collins and Steven Covey,
- Systems community such as Tom Peters and Peter Senge,
- Toyota company such as Kiichiro Toyoda and Shigeo Shingo

Lean management system

Abbott Diagnostic Longford has hence created its Lean Management System which flows as follows (Figure 3):

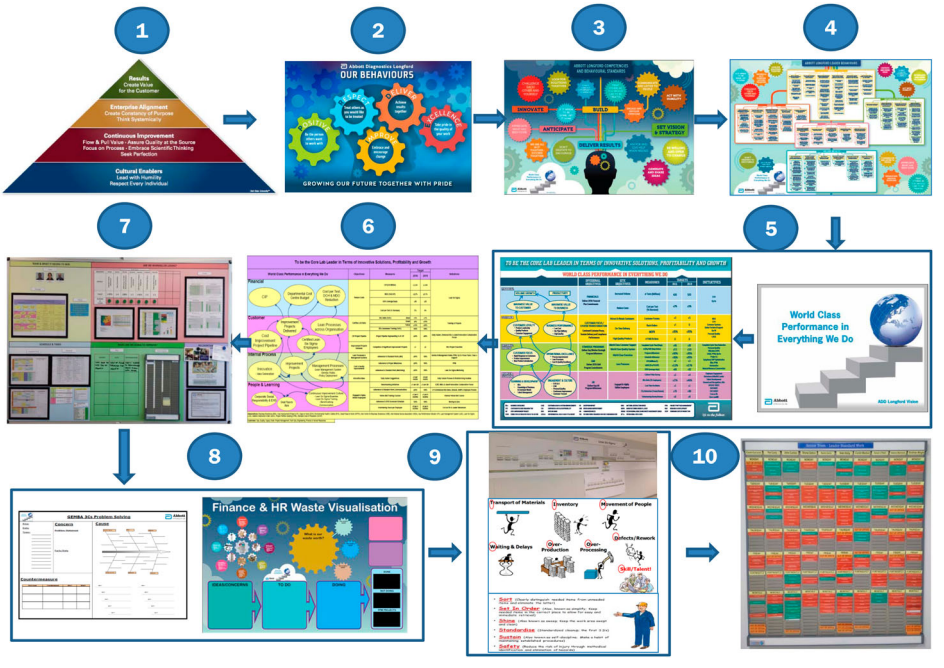

Figure 3. Abbott Diagnostics Longford Lean Management System.

1. Shingo Principles.
2. Site Behavioural Standards.
3. Abbott Corporate Competencies.
4. Leader & Individual Contributor Behaviours.
5. Site Vision & Strategy.
6. Departmental/Team Strategy.
7. Team Visual Management and Daily Huddles.
8. Problem Solving (Quality Corrective Action & Preventative Action System, Lean Management System Root Cause Analysis, Lean Six Sigma DMAIC Projects and Daily Kaizen local improvements).
9. Lean Tools (6S, VSM and TIMWOODS Waste Identification).
10. Leader Standard Work and Lean Management Walks.

Defining the culture and associated behaviours

To avoid confusing employees with the introduction of new 'Shingo Behaviours', much effort was spent identifying and connecting existing Abbott behavioural expectations to the Shingo Principles. In fact, the Longford Behavioural Standards align very well with the Shingo dimensions of operational excellence as they specify that everyone in the organisation needs to respectfully work together to deliver customer-focused results whilst finding ways to improve the work. Furthermore, Abbott has five long-established corporate core competencies that also readily align to the four Shingo dimensions of operational excellence (Table 2).

Each Abbott competency is supported by expected leader and individual contributor behaviours. Abbott Diagnostics Longford managers use these core competencies to assess whether prospective recruits are a good organisational fit. Interview questions are

Table 2. Linking the Shingo dimensions of operational excellence to the Abbott core competencies.

Abbott core competency	Shingo dimensions
Build	Cultural enablers
Innovate	Continuous improvement
Anticipate	Continuous improvement
Set vision and strategy	Enterprise alignment
Deliver results	Results

designed to determine whether candidates have an aptitude for, and experience in, these competencies. Employee behaviours are formally assessed against these competencies, with constructive feedback provided throughout the performance management process. Furthermore, Abbott Diagnostics Longford has translated the corporate leader behaviours for each core competency into Longford-specific leader behaviours. These provide unambiguous behavioural expectations for managers at Longford and can be used to give regular informal behavioural feedback, as well as formal feedback when explaining individual competency performance scores. Figure 4 illustrates the deployment of Abbott's behavioural norms for the innovate competency into a set of local behaviours developed by and for the Longford site managers.

Vision and strategy

Abbott Diagnostics Longford's functional departments have developed their own local vision and strategy maps/balanced scorecards by aligning their goals to the site strategy. Departmental goals are formally agreed on an annual basis and cascaded throughout the organisation. All departments contribute to site initiatives and develop their own department-level initiatives that support the attainment of their goals. The departmental strategy maps/balanced scorecards form the basis for visual management and give employees a

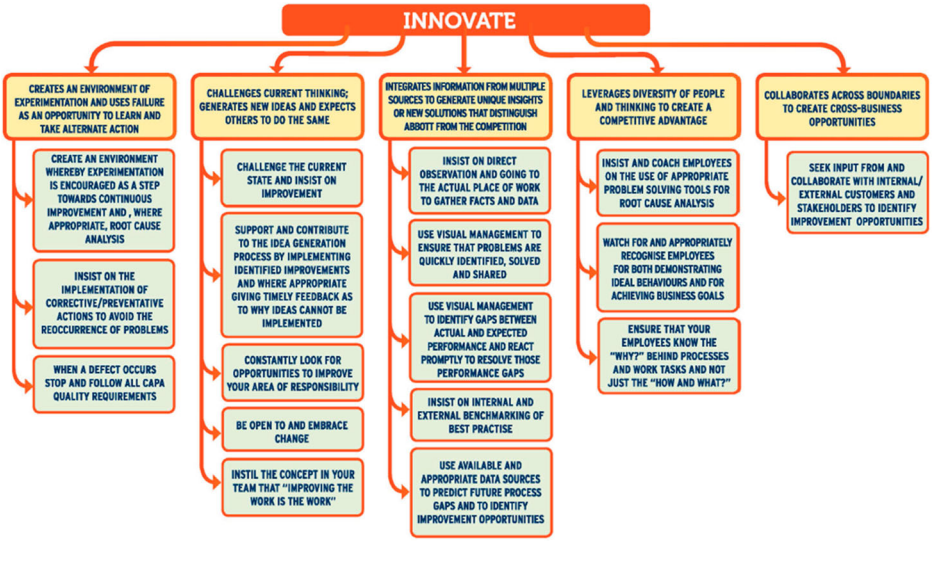

Figure 4. Behavioural Deployment of the innovate competency to Longford managers.

clear line of sight into how their jobs are linked to both site and departmental strategy, enabling them to work in a coordinated and collaborative fashion.

Daily accountability and management oversight

Longford's Lean Management System (LMS) drives effective behaviours through various tools that monitor, measure, and sustain the employees' endeavours throughout the site. The approach has been developed by the local team and has been designed to create a lean culture (Mann, 2015). Leader Standard Work (LSW) ensures that all managers spend an appropriate amount of time during Gemba walks reviewing and addressing area performance, coaching employees, and encouraging active participation in problem solving. LSW not only details the task frequency and a timetable for action, it also outlines how the task should be completed and why it is required. In Longford, LSW T-card boards display the weekly standard work schedule for individual mangers. The T-cards, which are red on one side and green on the other side, are flipped over from red to green to visually indicate the completion of the standard work task. Therefore, LSW is a completely transparent process and managers are fully accountable for the timely completion of the agreed tasks.

Each functional area maintains standardised visual management boards that facilitate work transparency and real-time communication to ensure that problems are promptly exposed and addressed. Compliance with LSW ensures that the boards are regularly updated and reviewed. At a glance, the boards communicate who is on the team and what it means to 'win' in keeping with the local vision and strategy, the team's daily and weekly schedule and tasks, and their performance. Furthermore, root cause analysis outcomes, which are recorded on the boards, reveal what the team is doing to improve. According to the 1-, 3-, 10-second rule, someone viewing the site's visual boards should be able to tell in one second whether the team is winning or losing, note in three seconds the team's performance trends, and see in 10 seconds what the team is doing to improve. Since high performance is synonymous with teamwork, another very important element of the board is local employee recognition.

The boards are reviewed at daily team huddles and at weekly middle and senior management Gemba performance review walks. During the walks the entire value stream is reviewed with all functional areas represented. Area and value stream performance is discussed with a focus on expected future performance and planned activities. The walks are also an opportunity for functional areas or process owners to request support from other functional areas when obstacles need cross-functional input for resolution. When performance does not meet expected targets, managers also look for evidence of root cause analysis.

Furthermore, several support function transactional processes have been standardised and responsible-accountable-consulted-informed charts are used to assign roles and responsibilities. The site has also standardised its meeting calendar to ensure attendance at critical cross-functional meetings.

An essential component of Longford's LMS are the daily huddles that every team conducts in front of its visual management board and which promote enterprise alignment. Items on the standardised agenda include EHS/6S, quality, previous day's performance, scheduled tasks, daily kaizen, and communication.

Problem solving

When a gap between actual and expected performance is identified, immediate action is taken. Each work area owns the gap and initiates problem-solving activities (3Cs –

Concern, Cause, Countermeasure) to determine the root cause and implement effective corrective actions. More complex problems are solved using the define-measure-analyse-improve-control (DMAIC) Six Sigma methodology or kaizen events.

Abbott's Quality System decrees that when a requirement is not fulfilled, an exception report must be entered into the electronic Corrective Action/Preventative Action system. This highly structured system ensures that problems are defined, affected items are identified and restricted for use, an investigation is initiated to determine root cause, resolution plans are developed and implemented, and the effectiveness of the solution evaluated. Furthermore, once a root cause is identified, its global impact is assessed.

At Abbott Diagnostic Longford respect for every individual in the organisation is paramount and efforts are made to harness the power of all employees by involving them in daily kaizen (continuous improvement) activities. The goal is a continuous cycle of generating, prioritising, and implementing ideas that will yield improvement. The Longford site has refined its employee suggestion schemes over the years. The current daily kaizen card-based process addresses previous shortcomings (Graban & Swartz, 2012). The visual and interactive nature of this process enables employees and managers to see all the ideas being generated and to track their status in terms of both progress and barriers to implementation. It also enhances local engagement and ensures recognition for individuals and teams who have successfully implemented ideas. The use of daily kaizen supports the development of Longford's continuous improvement culture by empowering employees to have complete autonomy over improvements and problem solving related to their own work areas. This process may sometimes require the use of problem-solving tools and, where necessary, DMAIC. It also provides the input to local teams' continuous improvement huddles.

To support employee empowerment and education throughout the facility, Abbott Diagnostics Longford's Lean Six Sigma Programme was changed to focus on training as many employees as practical to a basic (Yellow Belt) or intermediate (Green Belt) level of Lean Six Sigma competency, rather than training only a few site experts (Black Belts) who would be primarily responsible for delivering improvements. The site developed its own one-day Yellow Belt course to teach the fundamentals of Lean thinking and the Six Sigma DMAIC problem-solving methodology. Following their training the students complete a project and make a presentation on the improvements and lessons learned during poster sessions that are open to all employees. A Lean Six Sigma awareness training programme was also developed for all employees, and many managers have been formally trained in advanced coaching.

Eliminating waste

The management at the Longford site encourage all employees to focus on reducing all waste, including that which is hidden in financial standards. These are among the various systems and tools used to help identify and eliminate waste:

- Waste visualisation – visually exposing the TIMWOODS eight wastes: Transport, Inventory, Motion, Waiting, Over-production, Over-processing, Defects, and Skills of employees. These are linked to daily kaizen efforts.
- Process and VSM – visually mapping a process or a product's production path from supply to ship, while including information flow and highlighting non-value-added steps.

- Day in the life of (DILO) studies – monitoring employee activities when performing tasks while recording times for each step and identifying non-value-added process activities.
- Gemba walks – observing work and/or processes while coaching improvement.
- Distress inventory reduction process – visualising all distressed inventory and conducting root cause analysis when waste is identified.
- Material usage variance reduction process – visualising all positive and negative variance from the pre-defined quantities of materials required per process order and root cause analysis when significant variance is observed.

Results

Abbott Diagnostics Longford has generated cost savings totalling more than $22 million across all areas of spend over an 8-year period. This is a direct result of their Shingo-focused Lean improvement activity. Cost improvements have resulted from a reduction in raw material and energy usage, automation, batch size optimisation, and multiple process improvement projects targeting the complete value chain. By 2014 the site had seen a 576% growth in test volume, increased unit output per direct labour hours by 807%, and reduced cost per unit manufactured by 60%. Furthermore, non-conformance rates were reduced by 77%, lead times fell by 38%, and there was a 69% reduction in distressed inventory while inventory holding decreased by 27%.

High morale is reflected in the site's excellent employee attendance record of at least 98%, and 419 employees were promoted internally between 2007 and 2014, attesting to the success of career mentoring and coaching programmes. Furthermore, the site has provided several operational excellence workshops for the staff of hospitals that use Abbott Diagnostic products and who are trying to introduce or reinforce Lean principles.

For its numerous outstanding achievements, the facility has been recognised both internally and externally. For example, the site is a four-time winner (in 2009, 2011, 2013, 2014) of the Abbott Global EHS&E Energy Plant of the Year Award, a competition open to about 60 plants globally; and was runner-up three times (in 2007, 2008, 2010).

In 2015 the site received the following prestigious external awards:

1. Irish Medical Devices Association (IMDA) 'Medtech Company of the Year' in Ireland for its innovative approach to product and service development.
2. Irish Centre for Business Excellence (ICBE) 'Business Excellence Award' which recognises outstanding contributions for growing and transforming an organisation whilst openly sharing that knowledge and best practices with member organisations of the ICBE Network.
3. The Shingo Institute at the Jon M. Huntsman School of Business, Utah State University, Shingo Prize for Operational Excellence.

The Shingo Institute also presented Abbott Diagnostics Longford with a special award for 'Behavioural Excellence for Safety' at the Shingo Award ceremony in April 2016. As of 2016 Abbott Diagnostics Longford has been awarded significant new business, and this will substantially increase both the size of the facility and the number of its employees. Sustainment of the site's well-established LMS and culture of employee empowerment will become even more important to drive the ideal behaviour and robust processes consistent with its vision of 'World-class performance in everything we do'. Learnings from

the Longford site's Lean deployment have been used in the development of the Abbott Diagnostic Division's 'Pinnacle' operational excellence assessment model.

Discussion and contributions

In this paper the authors set out to address two research questions:

1. Can we help fill the gap in the academic literature by demonstrating the implementation of successful and sustainable change based on the application of the Shingo Prize approach?
2. Can we help provide guidance on how to manage multi-site transfer of improvement knowledge particularly from the recipient's point of view?

The application of the Shingo prize approach

In this case study, we have described how Abbott Diagnostics Longford used a Shingo style approach. It has clearly been very successful in terms of the impressive results it has achieved, as well as the recognition that it has received. The approach it chose was a 10-point Lean Management System. The approach has many parallels with the BE SCILLED model shown in Figure 5 (Hines, Taylor, & Walsh, 2017). The BE SCILLED model has been presented as an advanced version of Lean and is described within the context of Vale's Shingo journey at their Clydach site in Wales. The model is made up of five elements:

1. A core central 'Culture of Continuous Improvement' principle element.
2. A core operating PLAN system of 'Behavioural and Strategy Deployment'.
3. A core operating DO system of 'Continuous Improvement'.
4. A core operating CHECK system of 'Leadership Standard Work'.
5. A core operating ACT system of 'Learning & Development'.

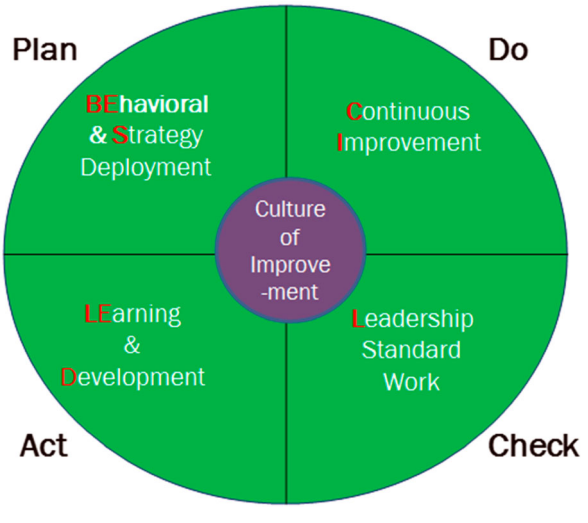

Figure 5. BE SCILLED Model of Core Operating Systems (Source: Hines et al., 2017).

Although Abbott Longford has not used the BE SCILLED model to guide its implementation, its Lean Management System approach is very similar. A comparison of the Abbott Lean Management System and the BE SCILLED model is provided in Table 3. Note that in Shingo terminology the Principle elements of the LMS occur first (#1), followed by the Systems (#2–7), the tools within these Systems (#8–9), and finally the checking and acting elements of the Lean Management System (#10).

It would appear that key to the site's success has been due to its rigorous and disciplined application of this approach, which is reinforced by the checking of the application of the LMS by the managers within their Lean Management Walks. This also acts as a focal point for recognition of local team members when things go well; and the coaching and development of these individuals when improvement opportunities are identified.

This integrated approach is in stark contrast to the more typical Lean approach based around the simple use of tools involved episodic kaizen events. The LMS has therefore successfully integrated the core systems required, we believe to create sustainable success. Again, this is in contrast to most lean transformations that do not create a core integrated operating system.

Multi-site transfer of improvement knowledge

As mentioned earlier, Abbott has several Divisions and indeed the Longford site is only one site within the Diagnostic Division. Abbott is not just concerned with the improvement of one site, but rather all the sites and the company as a whole. It can therefore be seen to be following the perspective of Netland and Aspelund (2014, p. 392) in creating a 'systematic process of creating, formalising and diffusing better operational practices in the intra-firm production network with the aim of increasing competitiveness'. However, in this case, as opposed to much of the literature (Goel & Chen, 2008), the focus and main driving activity has been on a site-level perspective.

Before discussing the multi-site transfer of improvement activity, it is worth considering why the Longford Lean approach has been so successful within this divisional and group structure. To do this we will refer back to the seven difficulties that we summarised in the literature section together with the four SFs provided by Netland & Aspelund (2014). A summary of these and the researchers' observations is shown in Table 4.

Table 3. Abbott Lean management system and BE SCILLED model.

#	Approach	Element of BE SCILLED	PDCA element
1	Shingo principles	Culture of continuous improvement	Plan
2	Site behavioural standards	Behavioural and strategy deployment	Plan
3	Abbott corporate competencies	Behavioural and strategy deployment	Plan
4	Leader and individual contributor behaviours	Behavioural and strategy deployment	Plan
5	Site vision and strategy	Behavioural and strategy deployment	Plan
6	Departmental/team strategy	Behavioural and strategy deployment	Plan
7	Team visual management and team daily huddles	Continuous improvement	Do
8	Problem solving	Continuous improvement	Do
9	Lean tools	Continuous improvement	Do
10	Leader standard work and lean management walks	Leadership standard work, learning and development	Check and act

Table 4. Summary of why Abbott was successful in overcoming difficulties (D) and achieving success factors (SF).

#	Difficulty area	Comment
D1	Recipients' lack of absorptive capacity	Absorbed group and divisional guidance but developed own implementation approach
D2	The heterogeneity of sites	Single site only
D3	The sheer complexity involved	A simple approach was adopted based on a set of integrated systems simply displayed through visual management
D4	The fact that much of the knowledge required is tacit or 'soft' skills	Much of the approach was developed locally hence requiring less tacit skill transfer
D5	An often neglect of the local context such as maturity and stage of development	The approach was single site so this was not an issue
D6	The existing relationship between the local site and headquarters	There was a very good relationship, partly due to the ongoing success of the site and partly due to their freedom to act largely independently in their Lean journey within group and division guidelines
D7	Local or national culture	The approach was single site so this was not an issue
SF1	Fostering a dedicated management	Driven by local site management team and CI manager
SF2	Building a deeply rooted improvement culture	The culture was driven by the Shingo Guiding Principles and their deployment into the largely site-developed LMS
SF3	Creating suitable channels for knowledge and practice transfer	As this was site based this was achieved more simply through the LMS
SF4	Involving empowered teams in the ongoing improvement process	This was a central part of the LMS which enabled a high degree of local autonomy, problem solving and decision-making

The Longford management appear implicitly to have overcome the various difficulties and achieved each of the four success criteria outlined by Netland & Aspelund (2014). It is clear from Table 4 that there were two over-riding reasons for the success. First, was the development of a Shingo-inspired lean activity centred around the LMS as we have discussed above. This involved the combination of existing systems with new ones, hence finding an effective balance of continuity and familiarity with challenge and development. Second, was the close relationship between the site and the wider division and group. It is clearer that the broader group providing both strategic and behavioural direction whilst allowing a great deal of autonomy to the Longford site in how to deploy this on the site.

A review of the various activities within the Longford LMS (Table 5) shows that the non-site influences for the approach come from Abbott Corporate, Abbott Diagnostic Division, the Shingo Institute, and the wider Lean literature. Also, implicit in the approach are the learnings that the site team has gained from other Irish Abbott sites (inside and outside of their Division), benchmarking other organisations (Kelly, 2016), and their study of the Lean literature. If we look at this within the context of the BE SCILLED model, they have managed to overcome a whole series of difficulties discussed in the literature above and create a culture of continuous improvement.

They have been guided by Abbott and its Diagnostics Division in WHAT they need to do and WHY they need to do it, but have been allowed a significant degree of autonomy in

Table 5. Summary of origin of approach at Abbott.

#	Approach	Origin
1	Shingo principles	Shingo Institute
2	Site behavioural standards	Site
3	Abbott corporate competencies	Abbott (Corporation)
4	Leader and individual contributor behaviours	Abbott (Corporation) but Site deployed into more specific behaviours
5	Site vision and strategy	Site (consistent with strategy of Division)
6	Departmental/team strategy	Site
7	Team visual management and team daily huddles	Site
8	Problem solving	Site – largely from lean literature
9	Lean tools	Site – largely from lean literature
10	Leader standard work and lean management walks	Site – from lean literature

HOW they have gone about doing it. Hence they have deployed their own set of site-specific behaviours and strategies from group guidelines. They have also developed excellent systems to ensure that they are effectively deployed into improvement activity. The activities of the managers in their Lean Management Walks and other activities within the LSW ensures that the behaviours are live, the strategy is made real, and the improvements benefit the business and the employees.

Another important point discussed in the literature is around the success of taking such approaches across different sites. Netland and Aspelund (2014) developed a two-by-two matrix for a subsidiary response to a multi-plant improvement programme as shown in Figure 6. Here, the vertical axis indicates the degree of practical conformity, that is 'global standards' where all sites do it the same way and 'local contingencies' which involves local modification. The horizontal axis is the degree of practice institutionalisation, that is the degree to which the practices are deeply embedded or not. They label the four boxes of the matrix Adopt, Adapt, Act, and Avoid. They posit that the Adopt (top

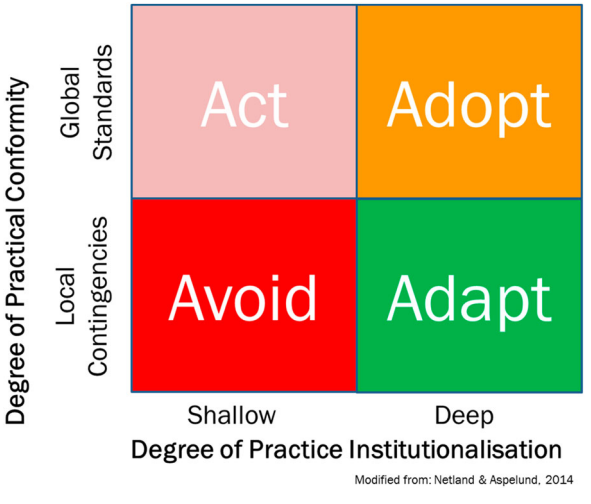

Figure 6. Framework for subsidiary responses to multi-plant improvement programmes (Modified from: Netland & Aspelund, 2014).

right hand box) 'represents the theoretical ideal of an improvement programme . . . [Adoption] means that the subsidiary embraces and implements the transferred improvement practice in full (Netland & Aspelund, 2014, p. 395)'.

They go on to discuss the Act box in terms of acting or pretending to adopt and follow Baxter and Hirschhauser (2004) in terming these 'pink factories' in reference to the expression of seeing the world through rose-tinted glasses. In Figure 6 we have modified the Netland & Aspelund original through the extension of this colour coding. However, we disagree that the theoretical ideal is Adoption. In fact, Netland & Aspelund have identified that the literature is inconclusive about where multinational corporations should seek Adaption and where it should enforce Adoption.

Judging by the evidence from the Longford case a key success factor was the high degree of local autonomy on HOW they went about implementing the approach. This was, in the first instance, because there was no rigid and prescriptive Divisional systematic approach to improvement. However, we would argue that this was to the advantage of the Longford sites as its infectious continuous improvement culture was only possible because it had a high degree of autonomy. As a result, we believe that to be successful the parent company should only provide an outline for the improvement system together with the top level deployment of WHAT needs to achieved and WHY. We therefore refer to the bottom right hand Adapt box as Green (How can we learn from you), with the top right Adopt box as Amber (Beware and Take Corrective Action), the top left Act box as Pink (Rose-Tinted Glasses), and the bottom left Avoid box as Red (Pull the Andon cord).

Much of the literature on multi-site improvement is concerned with discussions about what should be emulated and how might this be emulated. It is our view that it is important to start with a set of Principles to work from, in the Longford case the Shingo Guiding Principles. We then believe it is important to develop a set of appropriate core operating Systems for the industry and site, and to then develop a set of appropriate Tools.

When we come to make inter-site transfers, some of this involves the transfer of tacit knowledge and some of the knowledge is more explicit (Bortolotti et al., 2015). Many of the more recent authors on Lean also suggest that practitioners should pay more attention

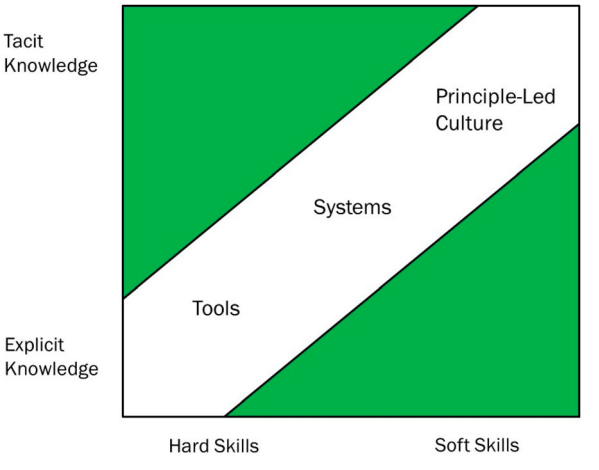

Figure 7. Knowledge, skills, and Shingo deployment.

to the transfer of 'soft' skills. In Figure 7, we have attempted to bring these two concepts together with the Shingo-based Principles, Systems, Tools approach. We regard the Principles area as largely around 'soft' skills, such as the development of behaviours and culture. Here knowledge is likely to be highly tacit. It is not easy to give a short answer to 'how do I increase the *respect for every individual* in my business', nor is there a simple tool to do so.

In the case of Systems, it is possible to be more prescriptive (explicit) by defining an approach to identify what your Systems are, and indeed to suggest a number of core operating systems as in the BE SCILLED model. In developing and applying these, again a combination of both tacit and explicit knowledge is required. In the case of Tools (such as the fishbone, 6S, and kaizen cards used in Longford) knowledge transfer can be quite explicit and the tools can be regarded as 'hard'. As a result, knowledge transfer can be more effective here through traditional methods such as the teaching of yellow and green belt courses.

Hence what is required, we believe, is a combination of tacit and explicit knowledge transfer. In many cases, traditional multi-site knowledge transfer is highly explicit and consists of a series of centrally driven classroom courses and manuals. These are probably quite effective at transferring explicit hard Tool knowledge, but poor at transferring System knowledge, and of almost no use in transferring Principle-based knowledge.

So unfortunately, multi-site transfers of improvement activity and the knowledge required is not easy or straightforward. Lastly, there is one more complicating factor that should be taken into account, namely the stage of development of the receiving site (Boscari et al., 2016). In our case study, the site was quite mature and to a large extent sought out and developed its own knowledge. However, this is not the typical approach. As a starting point for a wider academic discussion, we have suggested that the activity required will depend on the stage of development as well as whether the knowledge to be transferred is tacit or explicit. We would like tentatively to suggest the contents of Table 6 as a starting point for this debate.

Conclusion

In this paper the authors have sought to use an instrumental case of Abbott Diagnostics in Longford, Ireland, to answer research questions on the application of the Shingo approach as well as on multi-site transfer of improvement activity.

The case demonstrated a highly successful approach to Lean that appears to have the basis of being highly sustainable. The approach started with a focus on the development of a continuous improvement culture, based on the Shingo Principles. In order to deploy this a Lean Management System was developed by the site with effective behavioural and strategic input from the parent company. However, the LMS and the Systems and Tools within it were largely developed by the site team itself. The approach appears to be a classic Shingo application and is seen to closely mirror the BE SCILLED model based on a similar Shingo application at Vale in Wales, UK.

A number of reasons are discussed as to why the Longford case was successful, principally including the local development of the 'green' adaption approach. The site also found a way to develop and disseminate tacit and explicit knowledge within their LMS. Based on this experience some important lessons can be taken for multi-site improvement methods along the lines of the tentative knowledge transfer model. What is for sure is that

Table 6. Stages of transfer of knowledge.

Stage	Description	Explicit knowledge	Tacit knowledge
1	Complete ignorance	• Change ready	• Change Ready
2	Awareness	• Benchmarking • Awareness talk (What/Why)	• Experience Sharing (How)
3	Theoretical knowledge	• Benchmarking • Education course (What/Why/How) • Gap analysis • Manual (What/Why) • Background reading	• Manual (how – tricks of the trade)
4	Practical knowledge	• Benchmarking • Master class course • Pilot implementation (project support) • Gap analysis • Staff exchange	• Benchmarking • Master class course • Pilot implementation (mentoring support) • Gemba walks • Peer networking • Staff exchange
5	Sensitivity knowledge	• Benchmarking • Roll out implementation (project support) • Staff exchange	• Benchmarking • Roll out implementation (mentoring support) • Gemba walks • Peer networking • Staff exchange
6	Expert knowledge	• Cross cultural workshop • Flexing the standard workshop	• Cross Cultural Workshop • Flexing the standard workshop

any such journey will not be easy, but if done well it will be highly worthwhile for those doing it, with impressive results and a true culture of continuous improvement as at Abbott Diagnostics Longford.

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