

Integrating Education into Maintenance Operations: an Irish case study

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Abstract: In industry, an increased need for further education past the traditional apprenticeship is recognised. There is a known issue with aging maintenance workforce and loss of tacit knowledge through retirement. This paper investigates the skills and knowledge required for the modern maintenance workplace and how this might be implemented in a technician population. Potential educational and pedagogical solutions are offered in this paper, as well as a practical example. Finally, a specific course of learning is suggested.

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1. INTRODUCTION

With the advent of Industry 4.0 and 5.0, it is more important than ever to maintain skills among any technical population. “The basic principle of Industry 4.0 is that by connecting machines, work pieces and systems creating intelligent networks along the entire value chain that can control each other autonomously. Some examples for Industry 4.0 are machines that predict failures and trigger maintenance processes autonomously or self-organized logistics that react to unexpected changes in the production” (Kopacek, 2018). The adage of people no longer remaining in one profession for their entire career is true in that the skills required of any working population now compared to those required even a decade ago are very different. However, one technical population that don't tend to be part of many formal training schemes, in Ireland at least, is the maintenance technician group. Time served craftsmen are often deemed to be sufficiently learned once they come out of their time and aside from the occasional equipment specific activities, formal training programs are rarely implemented comprehensively. Even when formal training programs are implemented, they often take the form of “monkey see, monkey do” or a buddy system, with one technician showing the new technician some of what s/he knows, until the new technician is deemed to know enough to function on his or her own. This is also referred to on-the-job-training (OJT) There is limited research in ongoing cost-oriented maintenance education and training programs internationally, and even less so in Irish based entities. Research in the area is most easily accessible in the aviation fields and even then, focusses on specific training techniques rather than the development of a system to support specific and changing requirements. (Walter, 2000). In 2018 Doyle-Kent et al

established that knowledge development, retention and transfer is of critical concern in Irish high-tech companies. This work investigated how a traditional Irish engineering education, facilitated the effective transfer of this tacit maintenance knowledge with potential low-cost options (Doyle-Kent et al, 2018). There are several elements to be considered in technician training systems: the tacit knowledge each technician holds and how to capture it, the equipment specific training that must be given on each newly encountered equipment set, the non-technical training required for all employees or for specific subsets of employees, abnormal or rarely occurring breakdown information or upgrades to equipment, as well as softer skills such as project management, communication skills or formal problem solving techniques. Most training for technicians looks mainly at new equipment, occasionally looks at problem solving or technical issues, but rarely encompasses all of the above issues in a consistent manner. This paper follows the process a medical devices company based in Ireland used, as they determined such a training program was needed and who and what should be included in this program.

2. BACKGROUND

The medical devices company has been based in Ireland since 1980. The factory has gone through several periods of growth in that time, with the most recent the opening of a 200-million-euro expansion project two years ago (2017). As is normal, however, on several occasions in that history, the employees have also pay-cuts and/or redundancies. There have been several waves of technological advance during the four decades of operations, leading to the current situation, where there are predominately three generations of production equipment types on the premises. There are

approximately 1,300 employees on site, with 150 maintenance technicians. Of these, more than 120 are technicians working on the production lines on 3 separate shift systems (one part of plant works on a 4 shift, 12 hr cycle, one works on a more traditional Monday to Friday 3 shift cycle, with two more shifts covering the weekend). The shift systems have developed over time according to the needs of the plant. Throughout this time, the maintenance technician group has maintained a strong union presence, and the relationship between the company and the union has been adversarial at times.

With the advent of the most recent expansion and newest technology wave, and with further expansion in a reasonably short period of time considered likely, the senior management team, including the engineering director, determined the need to establish a formal, extensive technician training program, both to formalise the training technicians receive in general, but also to provide a structure to support all required technician training.

There is a training management system (TMS) implemented on site for all employee groups except the operators. This system records the date of any training held, the content of the training, who attended, any assessments that need to be completed and any recurrent or refresher training needed and when. For training other than computer-based training, however the information must be input manually to the system. For historical reasons, the technicians were later to adopt this training system than other employee groups and some elements of their training, particularly the environmental, health and safety (EHS) based training is still managed outside of the formal computer-based system at the time of this study. Equally, a competency matrix had been used in the past to track technician training requirements, but this had not been updated in some time and was not reflective of the current needs of the business.

Several criteria were set down for the beginning of this project: the training must be delivered in house, in a structured, formal way, with clear assessments associated with each piece of training; the training must be free or extremely low cost; the training must adhere to a structure that could be adapted to future equipment as needed; the technicians must record their attendance at training and all assessments must be recordable in the TMS.

3. TRAINING SYSTEMS IN INDUSTRY

According to Bartlett and Ghoshal (2002), it's the human capital and not the financial that must be the starting point and ongoing foundation for a successful company strategy. Priorities have changed and the biggest challenge is to attract and keep talented people and the knowledge that they possess. They highlight that in today's economy this is the most constraining and most strategic factor for managers. It could be remarked that companies are at war for talent and as

individuals with specialised knowledge, skills and expertise are reorganised as the scarce strategic resource, human resource (HR) professionals become players in the design, development and delivery of a company's strategy (Bartlett, C.A. and Ghoshal, S., 2002.)

Table 1. The evolving role of human resources (Bartlett, C.A. and Ghoshal, S., 2002.)

	Competition for products & markets	Competition for resources & competencies	Competition for talent & dreams
Perspective on Employees	People viewed as factors of production	People viewed as valuable resources	People viewed as "talent investors"
HRs role in strategy	Implementation, support	Contributory	Central
Key HR activity	Administering of recruitment, training and benefits	Aligning resources and capabilities to achieve strategic intent	Building human capital as a core source of complete advantage

3.1 In house maintenance technician training

A formal technician training steering committee was set up, including the engineering director, the human resource director, the training and development manager, the maintenance manager, the training team member assigned to the project and the maintenance and reliability engineer. The directors and managers were to establish the guidance for the program and the training team member and engineer were to design and develop the system within the parameters determined by the committee. It was determined that the system must support the current needs, but also be adaptable for future requirements: in essence, the training system must remain a live system, adjusting and developing as the needs of the plant change. It was also decided by the committee to focus on the latest generation of equipment installed in the newest area of the site as this was seen to be the greatest priority. Technicians elsewhere on site had up to several decades of experience working on the older equipment, whereas the team in the newest area was also mainly new to site with little to no experience on similar equipment. The immediate focus for the training system, to be treated as a pilot project, would be only those technicians working on the newest equipment group, and the training would be aimed at allowing the technicians to reach a reasonable level of competence on the equipment in the medium term.

3.2 Focus group

This limited the initial group of technicians to be exposed to the project, approximately thirty, mostly very new to site (employed for less than 2 years), but with 2-3 technicians who had been working for the company for longer than five years. To keep costs low, it was decided that the process

engineers responsible for the equipment in question should help determine the content of the training and deliver the training.

3.3 Competency training system

It was decided to divide the initial competency training into levels, as shown in Table 2 below.

Table 2. The current company training system

Level	Description
0	Basic, equipment layout, major modules, connections to power, other equipment
1	Safety aspects, isolation from power sources, LOTO,
2	Manual contents, planned maintenance, regular work required on the equipment
3	Troubleshooting, problem solving, infrequent maintenance training
4	Expert training on specific technology, e.g. robots

The training was designed to take a technician from never having seen the equipment before, to competently maintain and troubleshoot the equipment over a course of nine months. It was understood at the time by the steering committee that this was the beginning of a structure rather than the end result of a comprehensive system for technician training.

3.4 Logistics of training organisation

The content for levels 0-2 was developed and the training sessions were agreed with production colleagues, since the technicians would not be available for other work during the training sessions. The first timetable was set up during the summer of 2017, with the intention of training commencing in August that year. Two different days per week were selected for the training sessions, in discussion with the engineers and to accommodate the different shift patterns throughout the plant. While the new equipment was primarily located in the new area of the plant, 2 lines were located in older locations, meaning all 3 shift patterns had to be accommodated. The premise of the timetable was that the four-shift cycle would attend training on a particular day in the week if they were on day shift, the three-shift cycle had a different day and the weekend shifts would attend the training on the day they could accommodate during the week. Each weekend technician must work one day during the week, but this day can vary from technician to technicians and from week to week, making timetabling the weekend technicians difficult. While the structure and the content were reasonably straightforward to develop, based heavily as it was on the equipment manual up to level 2, other issues raised themselves when the time came to implement the training program.

3.5 Obstacles

As always with a project such as this, roadblocks appeared. These are summarised in the following paragraphs, as well as Figure 1, with the actions taken to surmount them and some lessons learned from the process.

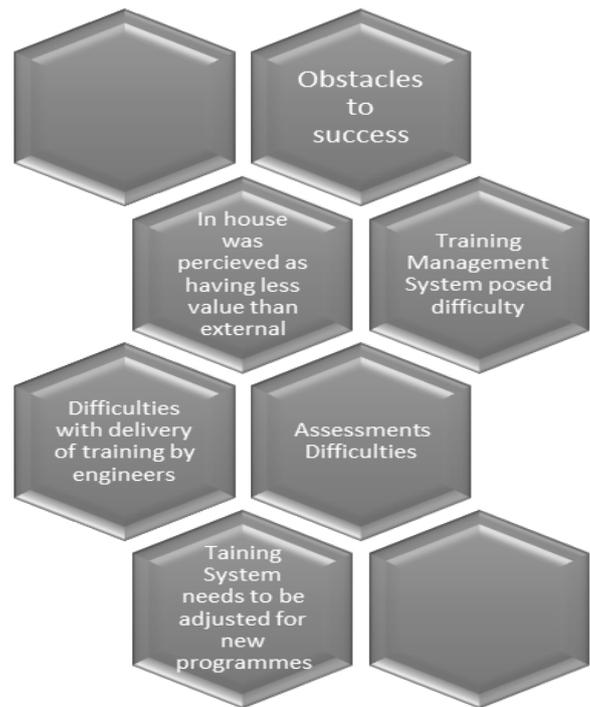


Figure 1. Summary of the Obstacles to the success of the in-house training programme

It became apparent that in-house training is less valued than external or vendor training. This meant attendance at training sessions was low and sporadic. Efforts were made to show defined benefits of the training, both in terms of personally to the technicians and to the business, which appeared to address this issue. Presenting the training as valuable and important to progression helped increase the priority the training was given by both technicians and managers. Fundamentally, making competency on the training topics a pre-requisite for working on the new equipment, which was more attractive than working on the old equipment, changed the general attitude to the program.

Not all technicians were comfortable with using the training system, something that wasn't understood until much later in the program. Because the TMS had been used for several years for the technician group, it was thought there was a good understanding of the system among the group. Some basic training on the TMS was implemented to address this and proved successful.

While the process engineers were content to develop and guide the content of the training, when it came time to deliver the training, several issues were raised, mainly to do with the engineers' ability to train and the time spent on training sessions. These were addressed in several coaching sessions over the course of three months and training on how to train was provided to both engineers. One participated in the training, the other didn't.

Once training had commenced, several issues were identified with the assessments on the TMS. Partly these were due to inexperience by those setting up the assessments, partly these were systemic issues. This knocked the confidence of the technicians in the system, which took some time to recover and delayed the progress of the training plan. However, much was learned about the different types of questions available and how to make the process more efficient next time.

While the four-level process described above would be adequate for most equipment needs, it was recognised by the steering committee that it was not suitable for all technician training needs and other elements would need to be included in the system. To construct an effective system for all types of training and requirements, more would be needed.

For example, several major machine faults showed the need for the system to allow for specific training on one particular issue. The development of troubleshooting guides showed the need for training to support such activities and to ensure the technicians understood both how to use the troubleshooting guides and how to implement the steps outlined in them. For some expert level training, it was shown that the skills were not present on site, so vendor training would have to be implemented and captured.

For new equipment, or new technicians, the longer term, gradual increase of knowledge outlined in the four-level structure above was deemed to work, albeit after implementing the lessons learned to be discussed later. Several important criteria was deemed essential for all technician training however: all training must be recorded in the TMS; most training should include an element of assessment; all training, including external or vendor training, should have detailed content outlines included in the TMS; toolbox talks and regular site communications should be included in the training system, especially for training on situations such as an EHS incident, but still follow the same criteria as the rest of the training system; a shorter process should be implemented for once-off training on a specific issue, such as a particular technique needed to correct a certain issue.

4.0 DISCUSSION

While after two years, the majority of required technicians are progressing at an acceptable pace through the initial training program designed, several important lessons were learned as a result of this pilot.

The reluctance of the engineers to engage with the training and the coaching and adjustments required for them to feel able to deliver the training program was a surprise to the steering committee. This training program was seen as the primary tool for ensuring these engineers could progress from day-to-day problem solving to more value-add work such as the ongoing improvements required of any equipment. However, the engineers saw this task as not desirable and it was very difficult to change this viewpoint. Equally, the engineers' manager was not consulted at the beginning of the process, leading to some clashing priorities later on. For future similar initiatives, it would be vital to include the process engineers or those chosen to implement the process at a much earlier stage and allow them as much freedom within the structure as possible. Kitchen et al. (2002) outlines in detail the effects of effective and ineffective communication on change management processes, regardless of the method of communication used.

Given the regular comments and complaints from the technician group regarding the lack of a training program, the reluctance on behalf of some technicians to take part in the training program was surprising. However, on reflection, there is literature to support this phenomenon (Beard et al. 2012, Davey, 2002, Hedge et al. 2012, Dench et al. 2000) While younger employees are more open to the idea of lifelong learning in the workplace, in older populations, this is less accepted, and the idea of confronting new technology and ideologies can be daunting. This is not to say that all older technicians regard further learning with suspicion, but that there was a nervousness or hesitation in some of the population, since it had been so long since they engaged in any formal training or learning. While there is a mix of ages within the technician population in this organisation, because of the length of their service, the opinions of older technicians are granted a greater weight than their younger colleagues, which may have influenced the antipathy exhibited by some technicians towards this training.

There is also the strong possibility that although the technicians have been asking for training, external and vendor training are seen as more valuable than in-house training. This is perhaps because of the historical greater emphasis placed on attending training which has been obtained at financial cost, rather than the in-house training, which could after all, be re-organised again and again, during the employees' normal working hours. In-house training is generally seen as less attractive anyway, given it takes part during the working day, and includes no perks such as time away from site, going abroad, free lunches, etc.

It is thought that a greater inclusion of the technician group in future development of the program could help with some of the above issues. While it would not be possible to include the whole technician group in every decision to be made, a subset might be included in an extended committee type environment to facilitate greater understanding of the types of training available, the reasons behind the different types of training being developed and the need for certain types of

training to take place more often than others. This subgroup is currently under development.

A level of resentment has been displayed by some technicians over the course of the program because the operators training system is very different, with designated trainers assigned to each shift being the major area of contention. It would not be possible within the organisation to implement the exact system used in the operator teams, with one trainer per shift, because there are too many areas of expertise included in the technicians' area of responsibility to allow one person per shift to cover all of them. However, a modified system is currently being explored, whereby technicians might be considered SMEs on certain equipment groups and train their colleagues according to defined content and oversee assessments to declare the trainee competent. This would need to be the subject of a union discussion with the company, since it is a major change to not consider all technicians absolutely equal in the organisation. Equally, there would be a cost associated with this and the magnitude of this cost would doubtless be seen very differently from the company and the union perspectives.

Technicians were not happy with the level of "book learning" included in the initial program as opposed to hands-on learning. While some of the initial program included training on HMIs and other equipment specific functions, it was felt the training was too focussed on the manual and didn't include enough information on actual tasks the technician might be required to do. This is being addressed in the level 3 training currently being developed and with work instructions and other documentation required for the equipment. However, this leads to the issue of who will train the technicians on this issue, since the engineers are not allowed to handle tools. It is thought it might be necessary implement vendor-based training for certain activities for the first group of technicians, to allow the internal training to be developed after that. This leads to some of the same issues discussed in the previous paragraph regarding technician trainers. In recent months however, virtual reality options, videos and similar options have begun to be explored for hands on tasks or for tasks that are rarely performed, to allow the technicians to follow a task as they do it, rather than read and interpret from written instructions what needs to be done.

The length of time to implement the training program was too long. Partly this was because it was a pilot and the structure and program were being developed as things were discussed and decided, but partly it was because of the unforeseen obstacles experienced. Some of these obstacles will now be addressed for the next stage of the project, but no doubt others will appear to take their place. A brainstorming activity is planned in the near future to address any such obstacles. The effect of this delay is that some of the training content had already been covered by the technicians themselves as they had to work on the equipment while waiting for training sessions to be available, further supporting the idea that the in-house training is not as valuable as other sources.

Several times during this pilot, issues have arisen that needed

to be communicated to the technician population. This was generally done via email, with no guarantee that the technician would read or understand the issue at hand, because implementing a new training item for such things was seen as too onerous. A training item has been developed for engineers and other interested parties to show a short process for enabling training to be extended to the whole technician group or a subset of that group as needed. This will hopefully alleviate fears that training must always be long term, detailed, time consuming to assemble and deliver.

Several important areas had been left out of the initial training program, mainly because it was heavily based on the equipment manual. Planned maintenance, spares and isolation procedures were not included initially, but content is now being written to address this issue. Several specific issues are being included in the level 3 training for this equipment group for now but may be included at level 2 in future deliveries.

5.0 CONCLUSION

What are effective methods to engage such employees in further education and learning?

The structure originally designed for the training program worked very well for imparting and testing knowledge on new equipment up to a certain level. This level includes basic machine layout, common alarms, timers and parameters to be set, the flow of material and product through the machine and similar activities. It did not support specific issues that needed to be communicated quickly, or demonstration of hands on tasks difficult to capture adequately on paper. It also does not capture the softer skills required of the modern technician such as effective communication skills, advanced problem-solving techniques, report writing, etc. The original structure had to be expanded to include these and other issues that arose during the pilot program, to allow the training structure to meet the requirements originally set out.

The competency matrix is a useful tool, but it must be kept current and reflective of the needs of the business to feed into the technician training system. A program of work to achieve this has been outlined and will be completed in the coming months.

What are the important obstacles to these technicians engaging in such activities?

One size definitely does not fit all when it comes to technician training and several options must be available for any given training need. While cost oriented maintenance would not allow copious, consistent and continual expensive external training programs, where the expertise does not exist in-house, such courses must be considered, before the lack of knowledge causes more expense in lost production or equipment failure. Equally, for some needs, education facilities should be considered. Whether it is a company specific module or a longer-term training program to prepare

a technician for increased responsibilities, the local college or Institute of Technology (IOT) can be extremely helpful, and most are only too happy to engage with local industry to ensure their needs are being met. Meetings with the local IOT were set up to address these requirements and a tentative flexible upskilling programme was discussed. The modules can be seen below. Further discussions, including the maintenance professional body, MEETA, are required to progress both the content and delivery modes for this new programme.

Table 3. Maintenance modules with the local IOT.

Proposed Modules for Maintenance upskilling
Project Management
Financial Management for Engineers
People & Communication Skills
Creative & Problem-Solving Skills
Statistics and Probability
Systems Analysis for Engineering
Safety Management Systems
Cost Oriented Automation
Project with placement
Electives- multiples

Equally, not all training needs require a comprehensive, extensive training program with multiple assessments and signoffs: sometimes a short presentation or written instruction is sufficient to meet the need. Guidance for what training type would suit what requirement needs to be developed and trained out to those who need it. For example, for a major breakdown that caused multiple hours lost production, an in-person training session or toolbox talk where the technicians can ask questions and clarify details might be appropriate, whereas for a new work instruction clearly outlining a straightforward part replacement, online training might be appropriate or possibly a supporting video.

How are such obstacles overcome, on an individual or group basis in an industrial setting?

The inclusion of engineers and technicians in an earlier part of the process is essential to gain buy in to the whole process and to allow them some semblance of control over content and delivery methods. This will also allow the training to be more flexible and appropriate.

Regular reviews of content and delivery methods must be part of the structure to allow for regular updates to reflect the changing needs of the business.

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