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Universal design of workplaces through the use of Poka-Yokes: Case study and implications

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Abstract:

Purpose: Employment plays an important part in many people's lives beyond merely providing income, since continued participation in work can have many therapeutic benefits for workers defined as disabled. However, disabled workers face a range of barriers to employment, despite legislation intended to improve workplace accessibility emphasizing adaptations to the workplace, which many employers often find difficult and expensive.

The Poka-Yoke approach was developed in the manufacturing industry as a way of improving productivity by reducing errors using often very simple adaptations. This paper argues that, as Poka-Yokes are designed to make life easier and improve the performance of workers without impairments, they are closer to the philosophy of Universal Design than to Accessible Design, and offer an easy and inclusive way of making work more accessible for all kind of workers.

Design/methodology/approach: This paper provides a case study demonstrating the use of the Poka-Yoke approach in a sheltered work centre for disabled; highlighting how they served to improve accessibility to work by fulfilling Universal Design principles.

Findings: Our research allows us to demonstrate the great potential of Poka-yokes for gaining accessibility to the workplace. The real application of this approach,

both in sheltered work centres and ordinary companies, can contribute to improve the high unemployment rates of disabled people.

Research limitations/implications: The proposal is innovative and was applied in one specific company. Thus, a range of customized Poka-yokes would be desirable for different industrial sectors.

Practical implications: Managers of sheltered work centres, and also of ordinary companies, can realize about the great potential of Poka-Yokes as an easy means of gaining flexibility and accessibility.

Originality/value: There are very few papers relating lean manufacturing tools and disability. Our approach analyzes the benefits of this approach for the labour integration of disabled people.

Keywords: lean production, high involvement work practices, sheltered work centers

1 Introduction

Work plays a central role in the majority of adult lives at many socioeconomic levels. It maintains income and contributes to individual identity and social status. There is emerging evidence that continued participation in a work role has therapeutic benefits. From the point of view of employment, the term "disabled person" refers to those people whose opportunities to obtain and maintain a suitable job and to progress within that job are remarkably lower than the general population due to a mental or physical deficiency (Lopez Pino et al., 2005).

Over the last three decades, the legal frameworks and regulations for the disabled have been significantly modified. Many governments have implemented policies aimed at promoting the right of the disabled to integrate as fully as possible into society. In this sense, social and employment integration of the disabled has received special attention in most international regulations, e.g. the Universal Declaration of Human Rights, the Charter for the nineteen eighties from Rehabilitation International, the Program for Worldwide Action from the UN in 1988, or the European Social Charter in 1981.

In view of the above, various attempts are being made to further the integration of these citizens in society. Several countries deal with this problem through different

integration approaches and the awareness regarding this issue goes beyond the public and governmental spheres. Indeed, under the concept of Corporate Social Responsibility (CSR), an increasing number of companies are becoming concerned with this matter (Kotler & Lee, 2005). Since 1990, Social Responsibility has found increasing interest in the literature. Although in certain forums there are doubts as to whether this boom is just a passing trend, certain indicators reveal that we are facing a real change of paradigm in which companies are seen as responsible for something more than merely obtaining maximum profit (Guthey et al., 2006).

In this scenario, the employment of disabled workers is seen as a way of including the interests of society in the company goals. In fact, work in the competitive workforce may be a significant source of enhancing adaptive skills for people with disabilities and, thus, greatly adding to the success of community living and socio-labour integration (Stephens et al., 2005). In this sense, the second global report 2007 about Discrimination presented as part of the International Labour Organization Declaration relative to the fundamental workplace principles and rights (ILO 2007), suggests that governments and companies adopt non legislative regulations (not as social wellbeing policies, but as a question of human rights and social integration). Additionally it proposes that the active policies, actions and programs about labour markets should combat the discrimination of workers with disabilities in three ways: (1) Via the formulation of policies and regulations against discrimination in the workplace; (2) Via an increase in the opportunities for people liable of being discriminated to find a job; (3) Via an improvement of the hiring procedures in public and private sectors (Miralles et al., 2010).

But despite the great legislative efforts made by multiple national and international institutions, total social-employment integration of people with disabilities still seems far away. This fact confirms the perception that the solution has to come not only from legal regulations via governmental measures, but also by overcoming the prejudices about the capabilities of the disabled, and by the genuine commitment of companies to include integration programs in their operation strategies and models. Furthermore, the incorporation of disabled people to many productive activities generates added value to a company, as well as society as a whole, which is particularly timely given the current pensions crisis and ageing population.

1.1 Aim and structure of the paper

Miralles et al. (2010) analyzed the global benefits of certain Operations Research/Management Science tools that, if applied correctly, have a positive impact on accessibility to work. Following this argumentation, this paper aims to

show the great potential of one of the tools presented in Miralles et al. (2010): the Poka-Yokes. It will be demonstrated how this management tool, initially designed to minimize errors and maximize profit, also helps to achieve social-employment integration in the most efficient possible manner, thus allowing the incorporation of CSR practices in companies.

The structure of the article is as follows: in the next section, a literature review shows the differences between Universal Design and Inclusive/Accessible Design and states the philosophy of the proposed approach. Then a review on the Poka-Yokes and its potential is discussed. Section 3 shows a case study where this approach was implemented with success in five different workstations, each one applying different Poka-Yokes. Finally, Section 4 discusses the results achieved in the case study and Section 5 summarizes the general conclusions and the further research proposed.

2 Literature review

This section reviews literature on the two main themes of the paper: Universal Design and the workplace; and Poka-Yokes which might help to achieve this.

2.1 Universal Design and the Workplace

In many countries, a range of legislation to improve employment among the disabled has been enacted, such as the Americans with Disabilities Act (ADA) or the Disability Discrimination Act (DDA) in the UK. Bell and Heitmueller (2009) argue that, far from improving employment rates among the disabled, both the ADA and DDA may have worsened it, due to the increased cost burden placed on employers. The view reflected in this legislation is one that Saito (2006) defines as Accessible Design, of special adaptations to accommodate workers with disabilities so that barriers to access are eliminated. While in principle this a laudable aim, many companies, even with the institutional help they may receive, cannot afford it, particularly given the higher absenteeism of disabled workers due to health problems, which can leave expensive adapted workplaces standing empty (Miralles et al., 2007). Special adaptations can also be a source of resentment among non-disabled colleagues (Cleveland et al., 1997); reduce Quality of Life by calling attention to the otherness of a disabled worker (Lemaire & Mallik, 2008); and companies often pass on the cost of adaptation to disabled workers in the form of lower wages (Jones & Latreille, 2010).

Saito (2006) highlights Universal, or Inclusive, Design as an alternative to the Accessible Design philosophy embedded in current legislation. Universal Design seeks to avoid the need for special adaptations by designing products and environments that can be used by the largest proportion of the population possible. This approach emphasises capability rather than disability, arguing that disability and exclusion arise from poor design, and that design which requires a low capability threshold benefits everyone, not just the disabled (Clarkson et al, 2003). In this sense Universal Design is focused on seven core tenets (Centre for Universal Design, 1997):

- Equitable use: The design is useful and marketable to people with diverse abilities.
- Flexibility in use: The design accommodates a wide range of individual preferences and abilities.
- Simple and intuitive use: Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
- Perceptible information: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
- Tolerance for error: The design minimizes hazards and the adverse consequences of accidental or unintended actions.
- Low physical effort: The design can be used efficiently and comfortably, and with a minimum of fatigue.
- Size and space for approach and use: Appropriate size and space is provided for approach, reach, manipulation, and use, regardless of the user's body size, posture, or mobility.

In practice, it is recognized that the diversity of the human race makes truly Universal Design virtually impossible, and that some degree of design exclusion is inevitable, but that this should be kept to a minimum as far as possible (Clarkson et al., 2003). This paper takes Universal Design as its core philosophy. The argument is not that there should be eliminated but that, so far as possible, adaptations should be designed to benefit as many workers as possible, regardless of disability. There is a surprising lack of literature in this area: whereas research

groups such as the Helen Hamlyn centre (Myerson et al., 2009) are making inroads into inclusive workplace design, their focus is on the design of the work environment and not on the design of the work itself.

2.2 Poka-Yoke

The Poka-Yoke (a Japanese word that means mistake-proofing) technique was first developed in 1961 by Shigeo Shingo. Poka-Yoke uses devices on process equipment to prevent the human or machine errors that result in defects, or to inexpensively inspect each item produced to determine whether it is acceptable or defective. Poka-Yoke-designed manufacturing devices are one of the bases of Shingo's zero quality control concepts, which means that the defect rate in a production system is zero. Poka-Yoke design can dramatically decrease the risk of producing defectives products (Shingo, 1986). The Poka-Yoke philosophy also aims to make work easier and prevent errors caused by monotony or other process-related causes.

In many productive environments, there is a tendency to equate speed with productivity. Traditional engineering processes are designed to increase the efficiency of an operation by enabling people and machines to work faster, and processes are usually complicated to achieve greater speed; yet it is these complications which cause many of the errors people and equipment make, resulting in more defective products.

By contrast, the Poya-Yoke philosophy aims to increase productivity by simplifying processes, making them more efficient, reducing the number of errors that need to be corrected, and increasing the overall efficiency of the system. Poka-Yoke can be used wherever errors can occur and can be applied to any type of processes and helps workers to be "right first time", enhancing the quality of the product and the overall output of the process. Poka-Yoke supports efforts to eliminate waste caused by: over production, inventory, waiting, transportation, motion, over processing, quality defects, reprioritization and also waste caused by people's skills. Most importantly, Poka-Yoke was developed with the aim of making work easier for workers without disabilities, and as such demonstrate the value of often simple adaptations tailored to the job at hand.

It is often assumed that adaptations to support the diversity of situations faced by disabled workers present a huge challenge for designers. In fact, the extra intellectual effort needed to overcome disability often results in a better final design for both the disabled and non-disabled users. In this paper, we argue that

Poka-Yoke represents a suite of simple and relatively inexpensive ways of improving access to work and the productivity and performance of disabled and non-disabled workers, and a powerful tool for implementing Universal Design in the workplace.

3 A representative case study

This section will describe a case study where the potential of Poka-Yokes as a means of work integration is demonstrated. The case study was developed in a Sheltered Work Centre for the Disabled (henceforth SWD) close to the city of Valencia (Spain) that assembles different kinds of products. SWD are a model of socio-labour integration that tries to move away from the traditional stereotype that considers disabled people as unable to develop continuous professional work. Like any other private firm, a SWD competes in real markets and must be flexible and efficient enough; the only difference being that their staff must have 70% of workers with some kind of disability.

The SWD in this case study assembles and packages electrical/electronic devices and metal/plastic products, and taking on any opportunities that become available in the market. Although the company once employed more than 160 workers, crisis has forced it to reduce its staff to 92 workers, where 82 suffer some kind of disability; including some 40% with physical disabilities, about 55% of them with some mental disability, and the remaining 5% with some cognitive impairment. The company's main deals come from big international companies, who contract the SWD services for assembling certain products. The SWD usually receives raw material and components from its supplier, and returns the assembled product. Fulfilling the client's requirements in both cost and quality are critical to receiving future orders. Only by a performing well can the SWD get new contracts for new products, and potentially provide more jobs for the disabled.

In fact, this labour integration formula has been very successful in decreasing the former very high unemployment rates of the Spanish Disabled. Despite this, it is in conventional companies where the true social–employment integration of the disabled should take place: while SWDs effectively provide very necessary work to these people, they do not contribute so much to societal normalization (Miralles et al., 2010). It is important to recognise that this case study was developed in a SWD because it provided access to a diverse workforce for the purpose of our experimentation: our long term goal is to demonstrate the potential of Poka-Yokes for labour integration in ordinary companies.

3.1 Initial situation

Initially, the SWD used individual workplaces, designed without any particular consideration for disabilities, so that only a few employees could complete the entire assembly process for most of the products efficiently. Most workers were efficient in some steps of the assembly process, but had difficulties with one or more operations, which made their quality yield and their efficiency low. For workers with mental disabilities it was even more difficult, since most of the assembly processes also included jobs that required high concentration and/or capabilities that they lacked.

Consequently, the SWD could only assign a subset of tasks to each individual according to his/her limitations, resulting in a low flexibility of the workforce where the SWD was not able to adapt to demand fluctuations or new requirements from clients. In many cases, the SWD was unable to capitalise on increased demand for a client's product, due to the lack of flexibility in its workforce.

3.2 Focus of the research

In order to test the validity of our proposal, the SWD's furniture assembly & packaging section, with a staff of twenty workers, was analyzed. The capabilities and limitations of every worker were studied using bimanual analysis and learning curves (Smunt and Watts, 2003) to evaluate their flexibility and locate possible incompatibilities with the required assembly tasks at each workstation. The five workstations with most incompatibilities were selected for use as a pilot study. Twelve of the twenty workers had difficulty with the tasks at one or several of the five workstations.

Nr.	Kind of disability	WS1	WS2	WS3	WS4	WS5
1	Mental	■				
2	Mental		■	■	■	
3	Mental	■	■	■	■	
4	Mental					
5	Mental					
6	Mental	■				
7	Mental					
8	Mental	■				
9	Mental		■			
10	Mental/Physical	■	■	■	■	
11	Physical	■	■	■	■	
12	Physical	■	■	■	■	

Table 1. Initial situation of the five workstations analyzed

Focusing on these twelve workers we got the initial data in Table 1, where the shaded cells represent the actual possible work assignments, and the non-shaded

indicate the existence of limitations due to the disabilities of the person involved (barriers to employment). This table focuses only on the twelve workers who encountered problem, although the Poka-Yokes discussed below would also improve the yields of the other eight workers.

3.3 Introduction of Poka-Yokes to the workstations

This section describes the Poka-Yokes introduced at each of the five workstations studied. This description will address those parts of each process that presented a barrier to workers, as well as the final result and the benefits after applying our approach.

Workstation 1

The first workstation was dedicated to packing different kinds of screws and parts in plastic bags. The problem encountered in this activity was the requirement to count the amount of parts and components as they were placed in the bag. So far the actual method was to count in 10s until the required amount was reached. But almost the half of the workers studied made mistakes quite often.

The solution was simple but effective: a board with as many cells as parts necessary (Figure 1). When the board is full the worker puts the contents into the bag and has his work done with no errors.

Figure 1. Poya-Yoke designed for counting parts in WS1

An alternative solution evaluated was simply weighting the parts: this method was useful in some cases, but encountered difficulty when there were mixed product parts with different weights. In some of these cases the solution came by integrating both strategies: having boards for some products and weighing other ones. With these complementary strategies the Poka-Yokes designed made the workstation accessible to the whole staff (Table 2).

Workstation 2

The second workstation was devoted to bending corner protectors for the furniture. The work is not complicated, but only workers with big hands and accurate motor capabilities could do it efficiently.

The Poka-Yoke that was designed in this case consists of a matrix where the protector, once reclined, is easily bent giving it the right corner shape (Figure 2).

Figure 2. Poya-Yoke designed for bending protectors in WS2

A second version of this Poka-Yoke enables the bending of the protector with a single hand (albeit less efficiently than with two hands), which makes this workstation accessible to one-armed workers or those with side-mobility problems. Indeed, under the initial conditions, this workplace was inaccessible to half the workers analyzed, but with the Poka-Yoke in place, all were able to perform this job. In fact, this Poka-Yoke improved the efficiency of all the workers including those already able to access the workstation, in line with the Universal Design philosophy, as will be discussed in section 4.

Workstation 3

In this workstation the raw material is composed of rolls of stickers that have to be cut and packed in sets of varying sizes (Figure 3). This required a high concentration from the worker, and was the cause of many errors, since the number of stickers in each set depended on the product and varied among 2, 5, 10, 14 or 25…

In this case the Poka-Yoke consisted of a template where the roll of stickers is easily unfurled. This template has a mark indicating the place where the roll should be cut for containing the right amount of stickers; having a different mark for each amount required.

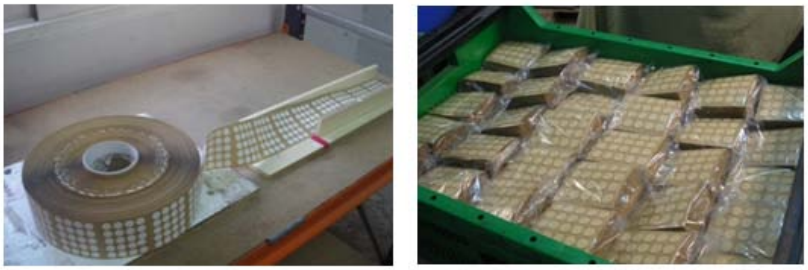

Figure 3. Poka-Yoke designed in WS3 (left) and end product to assemble (right)

Although the work became more comfortable for everyone, in this case the Poka-Yoke improved the accessibility for just two workers (Table 2), whereas for five workers the new workflow designed continued being difficult. For these workers, however, it has to be noted that by the end of the study, their learning curves were converging to quite acceptable yields.

Workstation 4

In this workstation, furniture components were assembled. Part of the assembly process included the use of an automatic screw driver to fix two of the components (Figure 4). The problem was that some operators had complications when aiming the screw driver.

Figure 4. Successive motions of the worker using the Poka-Yoke designed in WS4

This problem was solved by inverting the activity process, which is part of the Poka-Yoke philosophy, and fixing the device instead of the product. The automatic screw driver is now fixed, and the worker takes the components to assemble to a template that guides the screw to the machine. Once located the operator pushes and the machine screws automatically until it reaches the end of its thread.

This new workflow design made the workstation accessible to four workers (Table 2), and also made the process much easier/efficient for the other workers.

Workstation 5

This workstation assembles lamps of different shapes and models for general furniture and kitchens. Initially, this workstation design was not inclusive at all, and none of the twelve workers analyzed were able to perform the required tasks at acceptable rates (Figure 5).

Figure 5. Former workplace (left), and actual workplace (right) including several Poka-Yokes

In this case several strategies were combined to improve the overall accessibility of the workstation, based on a selection of Poka-Yokes from Shingo (1986):

- The workstation used to be untidy (left picture of Figure 5) and a lot of time was lost looking for parts. In the revised workstation (right picture of Figure 5), components are located in assembly order and in coloured-coded containers.

- Two separate screw drivers with different heads are provided, each the colour of its corresponding screws container. This way, there is no need to change the screw driver head every time a different screw is required, while the risk of taking the wrong screw driver is minimized.

- The fixing of a three-phase wire was an impossible operation for many workers, making this workstation inaccessible to them. A Poka-Yoke that leads every cable easily to the right position was designed and introduced.

- A rolling device was included for the rolls of stickers, so that they can easily be delivered. The stickers themselves were also redesigned, so that their shape indicated where they should be placed.

- For more complex end products, the parts and components are now provided in previously pre-arranged “kits”; this prevents the worker missing parts, but implies an “auxiliary” operator doing the extra work of arranging components into these kits.

4 Discussion

Table 2 summarizes the results achieved, where shaded cells denote those workstations that were initially accessible (as per Table 1), and "OK" denotes a workstation not previously accessible to a given worker that has been made accessible by the introduction of Poka-Yoke.

Nr.	Kind of disability	WS1	WS2	WS3	WS4	WS5
1	Mental		*OK*			
2	Mental	*OK*				*OK*
3	Mental					*OK*
4	Mental	*OK*	*OK*			
5	Mental	*OK*	*OK*			
6	Mental		*OK*	*OK*	*OK*	
7	Mental	*OK*	*OK*		*OK*	
8	Mental		*OK*		*OK*	
9	Mental	*OK*		*OK*	*OK*	
10	Mental/Physical					*OK*
11	Physical					*OK*
12	Physical					

Table 2. Comparison of the initial and final situations

The best indicator of the quality of our approach is the decrease in inaccessible workstations, which could be considered barriers to employment. Taking the five workstations and twelve workstations under consideration, there were initially 37 incompatibilities, meaning that 61.7% of available assignments were not possible.

Following the introduction of Poka-Yokes, an additional 21 possible work assignments became available. Only 15 incompatibilities remain, meaning that just 25% of available work assignments were not possible. This is a substantial improvement not only in the accessibility of the work involved, but also in the flexibility of the work force. As more workers are able to operate at each workstation, it is easier to move workers around in response to illness or changes in demand. Furthermore, this gain of capabilities supposes fewer incompatibilities and thus more flexibility when balancing assembly lines; as it is exposed in Miralles et al. (2008) or Costa and Miralles (2009).

Let us now consider how the proposed approach has satisfied the principles of Universal Design:

Equitable Use: All five of the workstations conform to this principle. Adaptations are specific to the workstation, not the worker, and are therefore the same for all workers at each task; the adaptations offer a more equitable split of work, as they increase the range of workers able to use each workstation as shown in Table 2

(though they do not offer 100% inclusion); and the adaptations typically improved the performance of those already able to use the workstation.

- Flexibility in Use: Whether Poka-Yoke support this principle is contentious: after all, many Poka-Yoke prevent errors by constraining the users' flexibility. Alternatively, it could be argued that the five Poka-Yokes described above provide alternative ways of performing the required tasks and those workers are free to ignore them and work in the old way for some or all of the tasks if they prefer.

- Simple and Intuitive Use: This is one of the core principles of Poka-Yoke, and several of the guidelines for doing this provided by the Centre for Universal Design (1997) are illustrated in the Poka-Yokes proposed: the use of visual guides for counting in WS1 and WS3; and the introduction of kits, the three-wire guide and separate screwdrivers at WS5 eliminated much of the complexity involved in these tasks.

- Perceptible Information: Making information more visible is key to the solutions presented in WS1, WS3, and WS5, where visual counts; colour coding of screws and screwdrivers; and shaped stickers make it easy to see where things should go without the need for great literacy or close inspection.

- Tolerance for Error: By definition, Poka-Yokes are designed to minimise errors. All 5 workstations feature some element of error-reduction, either by making differences immediately obvious (WS1, 3 and 5), or by making guides that are easy to follow (WS2 and 4).

- Low Physical Effort: The Poka-Yoke at WS2 and WS4 are both designed to reduce the physical effort required to carry out the required operations, by reducing the fine motor control required.

- Size and Space for Approach and Use: This issue is not explicitly addressed by the Poka-Yoke, having more to do with the general layout of each workstation and the surrounding environment.

In this way, the Poka-Yoke approach has helped to realise the principles of Universal Design in the workplace. While the adaptations proposed have improved the accessibility of the work for disabled workers, they also offer improved efficiency to those who are already able to carry out the required tasks. In this sense, they do not represent a unique cost for each disabled worker, but an

investment in the workforce, with improved efficiency helping to cover the costs of implementation. In fact, in this case study the total implantation cost was extremely low compared to the high improvement, both in productivity and flexibility, of the whole furniture assembly & packaging section.

To conclude it has to be noted that Poka-Yoke method was originally developed for use in a manufacturing environment, and that is the context in which it has been applied here. However, the Poka-Yoke approach has found implementation in a range of environments, and its potential for implementing Universal Design principles in other types of work should be considered.

5 Conclusions and further research

This paper has illustrated that Poka-Yokes are a potential tool for implementing Universal Design in the workplace, the core benefit being that - by increasing the ease of a task - they offer benefits to all workers, not just those with disabilities. It is important to recognise that this approach does have limitations: as Table 2 illustrates, while access was improved, the Poka-Yokes introduced could not make all tasks accessible to every worker, emphasising Clarkson et al. (2003) point that total inclusion is difficult and minimising exclusion is a more realistic aim. Having established the potential of Poka-Yokes as a tool for improving workplace inclusion, the key challenge is in developing ways of making this approach easy to implement without the need for specialist expertise.

Further research will be concentrated on two areas: on the one hand, being able to estimate how a given Poka-Yoke will impact inclusion rates (one clear option is to adapt the Cambridge University's Exclusion Calculator (Clarkson et al., 2003)). On the other hand, to design a practical methodology outlining the steps a company should take to develop and deploy appropriate Poka-Yoke in the workplaces.

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References

Bell, D., & Heitmueller, A. (2009). The Disability Discrimination Act in the UK: Helping or hindering employment among the disabled?. *Journal of Health Economics,* 28, 465–480. http://dx.doi.org/10.1016/j.jhealeco.2008.10.006

Centre for Universal Design (1997). Universal Design Principles. http://www.design.ncsu.edu/cud/about_ud/udprinciplesshtmlformat.html#top - Accessed 28th April 2010.

Clarkson, P.J., Coleman, R., Keates, S., & Lebbon, C. (2003). *Inclusive Design: Design for the Whole Population*, London: Springer.

Cleveland, J.N., Barnes-Farrell, J.L., & Ratz, J.M. (1997). Accomodation in the Workplace. *Human Resource Management Review,* 7(1), 77-107. http://dx.doi.org/10.1016/S1053-4822(97)90006-1

Costa, A.M., & Miralles, C. (2009). Job rotation in assembly lines employing disabled workers. *International Journal of Production Economics,* 120, 625-632. http://dx.doi.org/10.1016/j.ijpe.2009.04.013

Guthey, E., Morsing, M., & Langer, R. (2006). CSR is a management fashion. So what?. In: Morsing, M., & Beckmann, S.C. (Eds.). *Strategic CSR Communication. Copenhagen: DJØF Publishers,* 39-60.

ILO (2007). 96th Session 2007 Report I (B). Equality at work: Tackling the challenges. http://www.ilo.org/wcmsp5/groups/public/dgreports/dcomm/webdev/documents/publication/wcms_082607.pdf - Accessed 25th May 2010.

Jones, M.K., & Latreille, P. (2010). Disability and Earnings: are employer characteristics important?. *Economics Letters,* 106, 191-194. http://dx.doi.org/10.1016/j.econlet.2009.11.017

Kotler, P., & Lee, N. (2005). Corporate Social Responsibility: doing the most good for your company and your cause. *Hoboken, NJ: WileyandSons*.

Lemaire, G.S., & Mallik, K. (2008). Barriers to Supported Employment for People with Developmental Disabilities. *Archives of Psychiatric Nursing,* 22(3), 147-155. http://dx.doi.org/10.1016/j.apnu.2007.06.014

Lopez Pino, C.M., & Seco Martín, E. (2005). Discapacidad y empleo en España: su visibilidad. *Innovar,* 15(26), 59-72.

Miralles, C., Garcia-Sabater, J.P., Andrés, C., & Cardos, M. (2007). Advantages of assembly lines in sheltered work centres for disabled. A case study. *International Journal of Production Economics,* 110, 187–197. http://dx.doi.org/10.1016/j.ijpe.2007.02.023

Miralles, C., Garcia-Sabater, J.P., Andrés, C., & Cardos, M. (2008). Branch and bound procedures for solving the assembly line worker assignment and balancing problem: Application to sheltered work centres for disabled. *Discrete Applied Mathematics,* 156, 352–367. http://dx.doi.org/10.1016/j.dam.2005.12.012

Miralles, C., Marin-Garcia, J.A., Ferrus, G., & Costa, A.M. (2010). OR/MS tools for integrating people with disabilities into employment. A study on Valencia's Sheltered Work centres for Disabled. *International Transactions In Operational Research,* 17, 457-473. http://dx.doi.org/10.1111/j.1475-3995.2009.00727.x

Myerson, J., Bichard, J.A., & Erlich, A. (2009). *New Demographics, New Workspace: Office Design for the Changing Workforce*. UK: Gower.

Saito, Y. (2006). Awareness of universal design among facility managers in Japan and the United States. *Automation in Construction,* 15, 462–478. http://dx.doi.org/10.1016/j.autcon.2005.06.013

Shingo, S. (1986). *Zero Quality Control: Source Inspection and the Poka-Yoke System*, Productivity Press. (translated by A.P. Dillon).

Smunt, T.L., & Watts, C.A. (2003). Improving operations planning with learning curves: overcoming the pitfalls of 'messy' shop floor data. *Journal of Operations Management,* 21, 93–107. http://dx.doi.org/10.1016/S0272-6963(02)00088-8

Stephens, D.L., Collins, M.D., & Dodder, R.A. (2005). A longitudinal study of employment and skill acquisition among individuals with developmental disabilities. *Research in Developmental Disabilities,* 26, 469–486. http://dx.doi.org/10.1016/ j.ridd.2003.12.003