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Title: Determining Major Issues for Initiating a Training and Education Program in Robotics

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Abstract: We delved into the human aspects in Robotics, considered robotics to be one of the key elements in Flexible Manufacturing Systems which are going to be placed in the Factory of the Future, and analyzed and compared different training and education programs so that the main issues for initiating such a program in developing countries could be determined

DETERMINING MAJOR ISSUES FOR INITIATING A TRAINING AND EDUCATION PROGRAM IN ROBOTICS

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Determining Major Issues for Initiating a Training and Education Program in Robotics

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Introduction

The objective of this paper to determine the human aspects in **Robotics,** considering robotics to be one of the key elements in Flexible Manufacturing Systems which are going to be placed in the **Factory of the Future**, and to analyze and compare different training and education programs so that the main issues for initiating such a program in developing countries can be determined.

At the beginning of this study a literature search was conducted. After finding the necessary literature an outline of the study was drawn out. According to that outline the data gathered was analyzed and a synthesis of this data is presented as a final report with this paper.

In the first part of the report the reader is introduced the general definition of Robotics, basic problems in Robotics and familiarized with the terminology. This part presents the synthesis of the data gathered in determining the factors that need to be considered during the process of initiation of a training program and education program. The main issues in this section are design,implementation and operation of Robotics. The second part introduces the Factory of the Future, human aspects in implementation of this new technology and the justification and outlines of the necessary training before and after the implementation. Robotics is considered to be a major element in the Factory of the Future. The third part introduces example training programs and the conclusion part presents the resulting outline of a program which is the synthesis of the example programs discussed and the factors determined throughout the course of the study.

This study can be expanded into the development of the training program whose outline is developed in this paper.

1 Design, Implementation and Operation of Robots

1.1 Robots in Industrial Manufacturing

Robotics is generally defined as one form of industrial automation. Industrial automation can be studied in three categories : fixed automation, programmable automation and flexible automation.

Automobile industry is a place where good examples of fixed automation can be observed. Highly integrated transfer lines are employed for machining operations on engine and transmission components.In fixed automation the cost of the special equipment can be divided over a large number of units andthe resulting unit costs are low relative to other forms of production. However there is a certain risk involved, since the initial investment cost is high, if the volume of production turns out to be lower than anticipated, then the unit costs become greater than the forecasts. Another problem in fixed automation is that the equipment is only designed for a specific product which causes the equipment to be obsolete after the product's life cycle is finished.

Programmable automation is generally employed when the volume of production is relatively low and there are a variety of products to be made. The production equipment in this case is designed so that it can be adapted to variations in product configuration. This adaptability is attained by operating the equipment under the control of ba program of instructions which has been prepared especially for the given product. Because of the programming feature and the consequent adaptability of the equipment, various products can be manufactured economically in small volumes.

The relationship of the above discussed types of automation is illustrated as a function of product variety and production volume in Figure 1 [1].

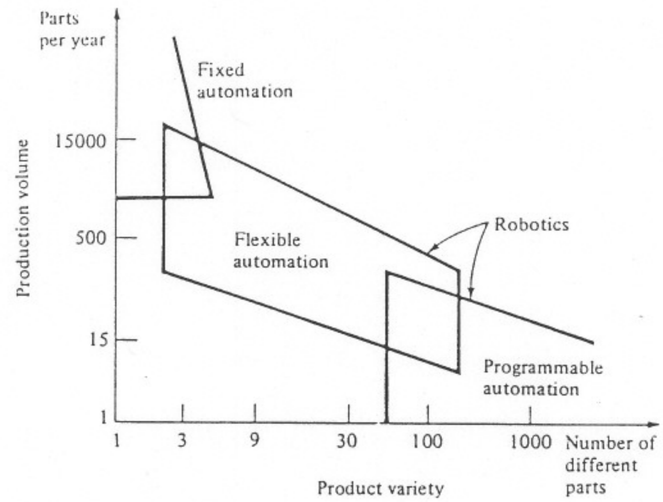

Figure 1. Types of Automation [1]

The third category between fixed automation and programmable automation is called flexible automation. As illustrated by its position in Figure 1, flexible systems possess some of the features of both types of automation. It has to be programmed for different product configurations but the variety of the products is limited when compared to programmable automation and this allows a certain amount of integration to occur in the system.

Of these three above discussed automation types, robotics is more close to programmable automation. An industrial robot possesses certain human-like characteristics. The most typical humanlike characteristic of robots which is widely used is their arms. The robot can be programmed to move its arm through a sequence of motions in order perform some useful task.

Robots being examples of programmable automation are employed in flexible automation and even fixed automation. Such systems consist of several machines and robots which are controlled by a programmable controller.

World robot population by percentage according to the Worldwide Robotics Survey and Directory released by Robotics Institute of America is shown in Figure 2. Table 1 shows total population by nation and by application.[2]

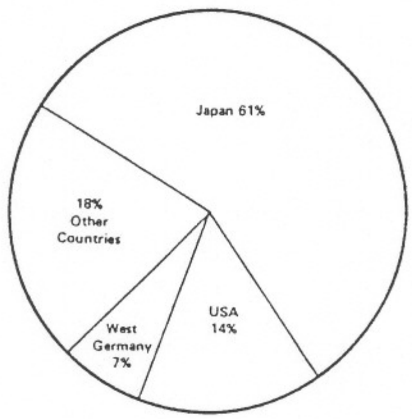

Figure 2. World robot population by percentage [from RIA 1985][2]

	Spot welding	Arc welding	Painting/ coating	Finishing	Assembly	Loading/ unloading	Material handling	Casting	Other	Total
Japan	5806	6036	1456	–	10,737	3690	10,217	1039	2284	41,265
United States	2269	1002	265	203	1,525	783	— 2466 —		887	9,400
West Germany	1560	856	586	22	248	320	194	132	882	4,800
France	560	251	147	45	140	——— 694 ———			173	2,010
Italy	—— 700 ——		—— 200 ——		200	500	——— 400 ———			2,000
Sweden										1,900
Czechoslovakia	25	22	62	120	38	258	800	225	295	1,845
United Kingdom	349	234	167	27	103	165	412	52	244	1,753
Canada	320	72	71	32	20	75	70		40	700
Australia	50	125	10			287[a]			56	528
Belgium	240	45	19	5	4	60	13	2	126	514
Poland	–	42	20	66	29		54	7	27	245
Netherlands	36	61	36	11	7	—— 45 ——		–	17	213
Switzerland	2	8	8	10	20	20	35	5	2	110
Denmark	0	12	13	0	12	8		24	7	76
									World total	67,359

[a]Includes finishing, loading and unloading, and casting applications.

Table 1. Total Population of Robots by Application (End of 1983) [RIA];[2]

With high level of technological sophistication used in industrial robotics, robots have attained many advantages. They are powerful, capable of nearly endless repetitions of a work sequence without interruption, can be operated in extreme environments and unlike man they are not subject to any illness or psychological pressures.

1.2 Robot Cell Design

Industrial robots are generally operated with some other equipment. This associated equipment and the robot form a workcell. Robot workcells can be designed in various configurations. There are three basic types: 1.Robot-centered cell, 2.In-line robot cell, 3.Mobile robot cell [1] .

As illustrated in Figure 3, in the robot-centered cell the robot is located at approximate center of the cell and the equipment is arranged in a partial circle around it.Machining, die casting, plastic molding and other similar production operations for discrete part production are examples of this case.

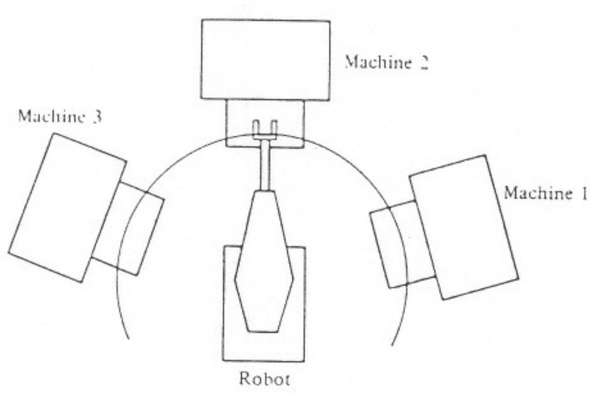

Figure 3. Robot centered cell work cell layout [1]

As illustrated in Figure 4, with the in-line cell arrangement, the robot is located along a moving conveyor and performs a task on the product as it travels past on the conveyor. A common example of this cell is found in car body assembly plants in the automobile industry. Robots are placed along the assembly line to spot weld the car body frames and panels

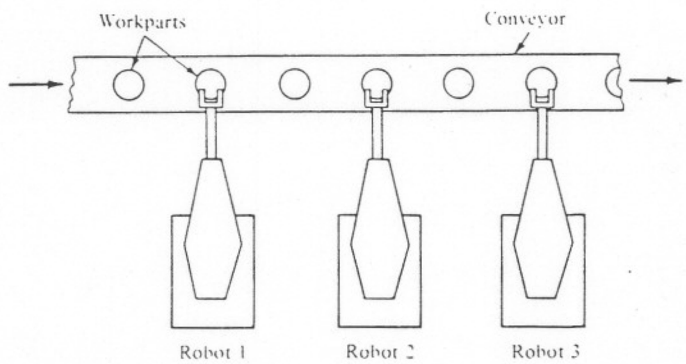

Figure 4. In line robot work cell [1]

The other robot cell design is one in which the robot is capable of moving to the various pieces of equipment within the cell. Figure 5 shows the concept of the track-on-floor system.

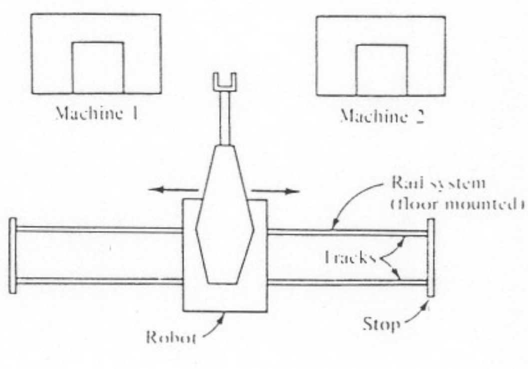

Figure 5. Track on floor system [1]

While designing the robot-cell there are some other considerations.

In order to implement the workcell and interface the robot to the other equipment in the cell, changes will have to be applied to the equipment. Some special fixtures have to be devised to allow the cell operate as a single, integrated mechanism.

For raw workparts that is being delivered into the cell, there has to be a precise pickup location for the robot to get the parts from the conveyor. Also the parts at the pick up location should be oriented in a known way so that the robot can grasp the parts accurately. Also the material handling application should be planned so as to minimize the distances that the parts must be moved.

In cells where more than one type of part is processed, part identification is an other consideration. Introducing optical sensors to the system is one of the solutions.

The robot should also be protected from the environment. In applications like spray painting a means of protecting the robot from the adverse effects of its environment should be provided. Gripper design is also determined while designing the workcell. Special end effectors must be designed for the robot to grasp and hold the workpart. The cell layout must be designed with proper consideration given to the robot's capability to reach the required locations and still allow room to maneuver the gripper.

1.3 Implementing Robotics

While implementing Robotics, a strategy involving many steps has to be applied. At the beginning the plant, management, and the workers have to be familiarized with the technology. In order to catch up with the technology and be capable of making rational decisions on projects in this area, the personnel is encountered with the problem of immediately becoming knowledgeable in this field. In the process of introducing robotics into a firm, management support is very important. Production personnel should also be included in the implementation project for better results. Production operators know manufacturing operations better. Also these people will accept the robot if they have participated in its implementation.

A survey which can be conducted throughout the plant is a very powerful tool in identifying potential applications. In cases like the presence of hazardous or uncomfortable working conditions, the presence of repetitive operations, the presence of difficult handling jobs, or presence of multishift operation are all indicators of the potential of robotic applications. In selecting the application the financial payback and return on investment are the major considerations. To accomplish this analysis the existing operations would have to be studied to determine current production rates and costs and a robot method would have to be proposed in order to estimate its investment costs and operating costs. In addition to the economic criteria, the potential applications should be subjected to certain technical criteria as well. In the case of a new facility being planned but not yet in operation, the same general criteria for deciding on appropriate robot applications can be applied. However, in this case, the applications engineer is not necessarily bound by existing equipment limitations. The project can be designed from the ground up, and a wider variety of alternatives can therefore be considered. The step following is the selection of the robot. The robot selected should possess an appropriate combination of technical features for the application being considered. If a deviation from the required specifications is made, it should be made in the direction of greater robot capabilities rather than less.

A detailed economic analysis is the next step. Based on the documentation of the economic and technical analysis, management must decide whether to proceed with the project or not. If the decision is to proceed a detailed planning and engineering work will be the following act.

2 Factory of The Future

Computer integrated manufacturing, CNC machines, robots, flexible manufacturing systems are all directing the technology of manufacturing toward the fully automated factory of the future. Certain trends are occurring in manufacturing that will shape the factory of the future. These trends are ; shorter product life cycles, increased emphasis on quality and reliability, more customized products, new materials, growing use of electronics, pressure to reduce inventories, outsourcing, just in time production, point-of-use manufacture, greater use of computers in manufacturing. These trends are leading the way toward the computer integrated factory of the future.

2.1 Traditional Manufacturing vs the Factory of the Future

In traditional manufacturing, the manufacturer deals with a large network of suppliers in all parts of the world. Delivery schedules for parts and suppliers are driven by the suppliers not the manufacturer. All parts and supplies are delivered to an inventory-control department. Production departments must wait for parts to be brought to the line.

In the factory of the future manufacturer uses fewer suppliers, located in close proximity to the plant. Manufacturer schedules frequent smaller deliveries to eliminate inventory control costs. Few parts are stored centrally. Inventory is delivered, inspected, and stored where it is used.

In traditional manufacturing departments are organized in clustered jumbles with similar machines in the same department. There is significant work-in-process, with unfinished products and raw materials all over the plant. There are long assembly lines where workers perform discrete highly specialized tasks. Quality assurance is performed at the end of the assembly line. Quality is inspected into the product. There is a high percentage of wasted work and scrap. Finished products go back to inventory-control areas and are stored until they can be loaded and shipped. Separate maintenance department services machines and equipment throughout the plant.

In the factory of the future shop floor is designed into cells to create several small assembly lines. Each cell has the machines required to build a complete product or component. The work in process is reduced due to fewer bottlenecks. There are several shorter assembly lines where workers control and perform many functions. Robots perform many manual tasks. Products are inspected as they move along the line. Workers are responsible for quality within their cells. Quality is built into the product. The percentage of wasted work and scrap is low. Finished products are shipped quickly and regularly. Workers are responsible for machine maintenance within the cell and conduct regularly scheduled preventive maintenance checks on all equipment.

In the case of traditional manufacturing there are many layers of management. There are many job descriptions for highly specialized personnel. Highly specialized training is provided based on single job description. Hourly pay plan is based on seniority. Incentive compensation when used is based on individual production quota. Centralized decision making is employed and problem solving is with power in the upper levels. Relationships are adversarial.

In the factory of the future, however, there are few layers of management. There are few job descriptions in which workers perform a variety of related tasks.

Cross training is required to increase flexibility. Pay plan is based on pay for knowledge and skills based on training completed or skills acquired. Incentive compensation is based on group performance in such areas as production, quality, and innovation.Decentralized decision making and problem solving exist. Power is shared with workers in each cell as well as with management. Relationships are collaborative.

2.2 Effects of Robotics on Workers

The introduction of any new technology will change the way in which organizations recruit their employees. In the case of introducing robotics this change will be experienced too. In the past employees entered businesses immediately after they left school and then set about working their way to the top. In a robotic organization however recruitment is geared to the employee who possesses a strong technological background and interaction and communication skills - skills not generally gained in high school or university programs. Because there is a shortage of people who can cope with the demands of robotics and are willing to begin their careers doing basic clerical jobs, personnel departments will have to work harder, both in their actual recruiting and in ensuring that conditions within the organization are geared to attract such people. Lack of motivation may be a significant problem; change naturally causes resistance, and managers will have to expect delayed schedules, decreased performance, and sabotage.

There are several reasons that a decrease in motivation may occur. With automation, pay increases may be rare. In some cases, take-home pay will decrease. And since human labor is relatively expensive, human services by those of the machine. Upward mobility will be harder to achieve. To prevent dissatisfaction dual career concept should be introduced to create an environment in which highly technical personnel will fell that their abilities and skills are appreciated. Introducing this concept however will cause the managerial positions to be increasingly inaccessible to those with technical training and limited managerial expertise.

Because of the large number of professionals and technical employees, clerical workers will have more trouble getting promoted to professional and managerial positions. Thus career planning will be more difficult and less predictable. The problems involved in implementation of robotics will be considerable, and employees who assume the responsibilities for these activities will expect to be rewarded. Salary increases for these employees might have an ascending effect.

To obtain the required specialists, personnel departments may have to recruit outside their own organization which generally demoralizes those who are currently employed at that organization. Psychological problems will be created for workers because the new technology will break up existing social interactions and will result in worker isolation. This could cause workers to feel more alienation.

Organizations might also experience an increase in employees' social and emotional problems resulting from displacement and the stress of coping with the robotic mentality. Computers currently accumulate employees' second-by-second behaviors and performances; when management utilizes this monitoring information to control workers and make personnel decisions , greater stress and anxiety over careers will result. Some employees will undoubtedly feel that they are slaves to the robots they monitor. When problems occur, they will be of greater magnititude and will present a greater challenge. Those who can not cope will feel increased stress.

A greater motivation may also result from introducing Robotics. Many workers have a much better attitude toward their jobs since robots have been introduced into work processes; that there has been an increased interest in jobs; and that workers have become more alert of, and careful toward, the work processes in which they are involved.

Another issue is that the robotics can seriously reduce job opportunities for the young, unskilled, older and less mobile employees, women, blacks and other minorities. According to the study conducted by the International labor Office in Geneva ; technology in banking resulted in a great loss of jobs. It diminished the need for low-skilled clerical jobs; and it resulted in a specialization of tasks that in turn led to increased depersonalization in the work area. Those who are undoubtedly most adversely affected are those who lack qualifications.

Integration of robots into an assembly process actually makes that system more, not less dependent upon humans. Although some jobs are eliminated and the content of the others changed significantly, technology upgrades the quality of other jobs and creates a considerable number of new occupations. Many of these require skills that are different from or significantly more advanced than those required for the eliminated jobs.

2.3 Managerial Considerations in Implementing the New Technology

According to Gerwin [14] :

"A good fit is the result of a company having developed not only a coherent strategy but also a human and technical infrastructure to support its manufacturing equipment..."

While implementing new manufacturing systems, management has to consider several issues. First of all the management should analyze the skills and experience of the workers and find out if they would be capable of carrying out their tasks after the new system is implemented. The management should figure out the new tasks that will emerge out after implementing the new system. Also the fit between the workers' abilities and the new tasks that will be created should be analyzed. Involvement of the workers to the system design is another positive factor which makes the new system to be accepted easier.

Of the issues that the management should consider the most important one is the training of the workers which will be discussed in detail in the next sections of this study.

In the case of introducing robotics the management should analyze the concerns of the workers about the change. Workers are likely to be most concerned about job security and pay. Introducing robots before resolving such questions is likely to reduce the effectiveness of the introduction. The organization itself should also be analyzed. This is a critical issue and it will help the managers to be aware of the future problems that are likely to appear after the introduction of robots , such as job loss or new job activities. In the case of robotics worker involvement is also necessary. This involvement is likely to increase understanding about the robot and may perhaps lead to greater commitment to the change process. In introducing robots demonstrations that illustrate the operations of a robot can be a powerful communication technique. A feedback mechanism is also vital in monitoring communication effectiveness in introducing a new technology.

First line supervisors should be given the information about the robot and support from upper management in dealing with workers' reactions to the robot. Workers, in times of change , are likely to go to their supervisors more frequently for information and advice. The behaviors of supervisors have a big effect on the success of the robot introduction.

The management should do a careful analysis of the new job activities that has been created with the introduction of the new technology so that they can maximize the fit that was mentioned above ,between job characteristics and the personal characteristics of the worker. A poor fit between a job and a particular worker may have a dysfunctional effect on both the individual and the organization. The question is not just whether the worker can do the new activities but whether the worker can do and prefers these activities. In the case of a poor fit a job redesign or an alternative selection process should be considered.

If the change in activities is from doing to observing, workers may experience more boredom on the job. If this occurs some mechanism to alleviate boredom,such as job rotation may be helpful. Job rotation would increase task variety and build up a backlog of skills for future expansion of robotics.

2.4 Critical Issues in Training the Workers of the Factory of the Future

The movement toward the factory of the future is necessary but it can be difficult, because the new system is so different from the traditional manufacturing. Training is the key to successful implementation of new systems and the new technology.

The factory of the future uses flexible automation where the shop floor is organized into cells, several short lines instead of a few long ones. Each cell can run a specific product or a major piece of a product or they can all run the same product. Within a cell, machines found in many departments now work together under the control of the cell supervisor. As a result, workers in each cell must have the skills to operate a variety of machines, the ability to control the manufacturing requirements of diverse products and the knowledge to manage people, the process, and the various product requirements.

Getting ready for the factory of the future, is a time consuming process but the training is an immediate requirement for the sake of the success of the implementation of the new technology. So early action is needed for training. The project team is the first group of personnel that has to get this initial training.

Automated integration of manufacturing will cause a requirement for both reskilling and deskilling. The job types that are aimed for deskilling are the ones in which the production routine can not be accomplished as well by machines as by human beings. Even these kinds of jobs will be surrounded by computer automation letting monitoring be very easy. There will be some parameters which require the existence of problem solvers. So there is a need for training in both kinds of jobs. During the training it is very crucial to confront the prospective employees with the nature of both jobs. Voluntarily selection of the job will increase the knowledge attained from training.

Before preparing the training program, the risks in implementing the new technology should be analyzed so that the priorities in training can be determined. Getting top management's support will help to expand and fund the training program. Again the involvement of workers in defining the new jobs will lead a good integration.

In selecting people to train volunteers are the ones that should be considered. Major efforts to learn new skills will be needed. Highly motivated people is a must for doing the hard work especially during the start up. People needed have to be initiators.

The middle managers should have the direct responsibility for training because they are the ones that know enough about the unique requirements of their own customized systems and interfaces to manage the training close enough.

In running the training program, a training team where a work sharing environment exists, is a must. Trainers have to look inside as well as outside the organization, especially for people who have done it before. During the transition period, it is important that trainers have to look for simple solutions. Especially since many things are completely new, trainers should look for the solutions that have worked in their organizations as well as in other organizations. In order that the management and the workers can understand the training risks, trainers should be able to speak the language which means that they have to make themselves familiar with the technology and the software.

Scheduling the training program is an other vital issue. Management will desire to see the factory running in a very short period of time. Even with this pressure the trainers should not plan to accomplish a lot in a short time. Also realistic expectation levels should be set.

The factory of the future provides training professionals with the opportunity to manage change in their organizations as well as the opportunity to expand their training skills. In fact, training is one of the key functions in implementing the factory of the future. To succeed training departments must take the lead in preparing for change. Technologic improvements will result in heavy requirements for upgraded training. This continuous improvement implies the necessity of continuous training and higher level of restaffing by hiring in new employees trained elsewhere.

3 Current Training and Education Programs

Proper training, before and after a robot installation, is an important factor in the economic use of robots. The main areas in which training affects the use of robots are; removing the false mystique, properly utilizing the robot's potential, and maintaining the robot for greatest productive life.

The training needed to properly support a robot installation is different from the training needed for other equipment in the industrial realm. The differences can be attributed to several factors, like their newness, their misperception, and the flexibility of their use. Robot training also differs from other training in its potential for giving a return on investment, when properly implemented.

For the best robot installation, people must be trained from areas of the company that may seem remote from the actual use of the robot. The targeted people to give training include; [24]

- Process engineers,
- Tooling engineers,
- Material handling engineers,
- Plant engineers,
- Engineering staff designing the product,
- Maintenance staff,
- Production operators,
- Production supervision,
- Personnel staff,
- Purchasing staff,
- Plant personnel working near the robot who may become uneasy at its presence.

The people who will actually implement the robot and who will daily use it as a part of their work must receive training, on the other hand those who will design the product upon which the robot will work must become familiar with its capabilities.

3.1 Initiating the Training Program

Since many different types of people with different levels and types of education are targeted to be trained, the training program should be consisted of different levels. These levels may be;[24]

- Extensive technical training
- Simple technical training
- Operation training

- Features/economies training
- Awareness training

Extensive level will enable the trainees to repair actually to maintain the robot. But this may not be necessary if there is a service contract with the vendor. However the manufacturing engineering staff who will rely on robot's ability to accomplish a task. Simple level technical training will be for developing skills such as the precursory repair of the robot and its ability to interact with other equipment.

Operational training would include such features as the programming of the robot and the daily operation the robot will undergo when in use. Features/economies education may include the ability of various robots to accomplish the different tasks of the user and the relative merits the robot has for the economic operation of the plant. Awareness training will be a simple explanation of the facts about robots that will allow everyone to judge a robot on its real features.

Table 2 shows the cross matrix of training levels and the people to be trained.[24]

Personnel	*Extensive technical training*	*Simple technical training*	*Operation training*	*Features/ economics training*	*Awareness training*
Process engineers		●	●	●	
Tooling engineers			●	●	
Material handling engineers			●	●	
Plant engineers				●	
Engineering staff designing the product				●	
Maintenance staff	●		●		
Production operators			●		
Production supervision				●	
Personnel staff					●
Purchasing staff					●
Plant personnel working near the robot					●

Table 2 The levels of training expected for different personnel [24]

3.2 Barriers to Successful Training

Training is probably the most abused and misunderstood tool in the industrial tool kit of strategies for achieving greater strategies. Training programs may end up with failure due to similar reasons like the ones listed below; [34,30,29]

- A knowledge gap in the individual/group which was not identified prior to training.
- A language barrier
- Poorly designed training
- Poorly presented training
- Training during commissioning of equipment by engineers who are not trainers
- Very little understanding of the fact that training is forward planning to a sophisticated degree
- The trainee rejected the needs for training and was not properly committed

In order to avoid above situations the below listed principles of training should be carried out. [34,30,29]

- Discussion to be held between the training department, engineers, local training resources and suppliers at the earliest possible opportunity to establish possible training requirements, the resources required and identify the population needing this training
- Discussion with the people requiring training
- Visit to, or by, the supplier to establish outline requirements and/or a visit to the local training resources if beyond our internal capability
- Outline requirements can be established using learning objectives as a means for discussion.

- Training plan produced
- Pilot training course implemented
- Make changes as necessary
- Introduce mainstream courses

Without a common ground for discussion between supplier and customer, a breakdown in communication leading to misunderstanding on the part of the customer is possible. The learning objectives provide this common ground, as it enables management and other lay users to understand more readily the implications of new equipment and what they will need to know and do, creating confidence at every level.

Learning objectives are objectives which state in performance or behavioral terms what is expected to be achieved by the trainee at the end of a specified period of training. Learning objectives enable all parties in the training activity to : [34]

- Understand in precise performance and behavioral terms what can be achieved in a given time and what is expected of the trainee and the instructor.

- Provide an instrument for assessment of the trainee's performance on the course or during the learning experience. The value of doing this is to ensure that a tradesman who fails, understands why and where he has failed. It identifies a training need which we undertake to fulfil by sending him on reinforcement training courses or experience. He can then be planned back into a future course to complete his training.

- Provide the trainee with an instrument by which he can offer his evaluation of the course.

- Provide the instructor with a positive framework against which to work and directly assists in the preparation of any training manuals.

- Ensure the instructor can have the means by which he can counsel the trainee on his performance during training. It allows the trainee knowledge of how well he is doing.

- It allows the training department or supplier to revise or redesign the training if found necessary, as areas of difficulty are immediately pinpointed

Above are the immediate advantages of training. There will at the end of the training exist properly constituted documentary evidence to demonstrate training was carried through to a properly defined standard.

A total system (mechanical)		
Syllabus element	*Duration*	*Learning objectives*
Course objectives	*15 minutes*	*By the end of this period the trainee with the assistance of course instructor will have read through and understood the course objectives. He will be told he is subject to an assessment of knowledge gained and how this is to be done. If there is a failure on the part of the trainee he will be given the opportunity for retraining.*
Description of the line	*Total 2¼ hours comprising 1 hour off job, 1¼ hours on job*	*At the end of the session the trainee will have an appreciation of the line and with the aid of reference material he will be able to:* ● *Identify the main stations and describe their functional responsibility.* ● *Describe the assembly flow process for the total line.* ● *Recognise the name and various component parts which make up the assembly and identify which station is responsible for each subassembly/operation stage.* ● *Identify the spot weld pattern associated with each station and which robot is responsible for welding to achieve that pattern.* ● *From machine cycle diagrams, apply the information given to a typical station.*
Safety procedures and safe access points to the line	*1 hour off job*	*of this session the trainee will be able to:* *At the end of this session the trainee will be able to:* ● *Identify the safety interlocks built into the line.* ● *Know and identify the safe access points at each station.* ● *Describe the safe working procedures necessary to working safety on the line.*

Figure 6 Learning objectives used as an instrument for assessment [34]

Training Evaluation: Dagenham Body and Assembly Operations

Please read this before attending training, fill it in after the event and return to the Training Department, via your Supervisor.

Name:	*Department:*
Date(s):	*Subject:*
Location:	*Supplier:*

		YES	NO
1.	*Did the Course Leader set objectives at the beginning of the course/training? or were you given any prior to going?*		

2. *If so, what were they?*
(If provided in writing, please attach a copy)

	In your opinion were they met			
	Well	*Quite well*	*Partly*	*No*

3. *What did you expect to learn?*	*Did you learn these items*			
	Well	*Quite well*	*Partly*	*No*

		YES	NO
4.	*Was the training/course material relevant?*		
5.	*Was the training/course well presented?*		
6.	*If you have any comments on the training/course, or any other relevant aspects, with a view to future improvements, please write these overleaf.*	YES	NO
7.	*Do you need any further training on this subject: Please identify overleaf.*	YES	NO

Figure 8 Training evaluation form [34]

Conclusion

Many important points from every view point have been underlined throughout the paper. As a conclusion these points have been summarized and put into a program in the form of steps of things to do before, during and after running a training program in Robotics.

Identify Potential Applications, Conduct a survey throughout the plant to identify potential applications. A technical and an economical analysis have to be done before proposing to implement robotics for the operation identified to have a potential. Also figure out the new tasks to be performed after implementing the new system.

Analyze the skills and experience of the workers, Find out if they would be capable of carrying out their tasks after the new system is implemented. Try to find the fit between the workers, abilities and the tasks to be performed. These people will be the candidates to get the training.

Get the workers involved, In implementing a new system try to get the workers involved to get an useful feedback and also to let many scares about robotics to disappear.

Early Act, Implementing new systems is a time consuming process, but training is an immediate act that has to be done.

Select the motivated workers, Major efforts to learn new skills will be needed. Volunteers that has high motivation will be the ones to be considered.

Differentiate training with levels, Since many different types of people with different levels and types of education are targeted to be trained, the training program should be consisted of different levels.

Hold discussions between trainers and other departments, Discussions to be held to establish possible training requirements and to identify the population needing this training.

Scheduling is important, Despite the fact that management will desire to see the new system running in a very short period of time, trainers should not expect to get positive results in a short period of time.

Get feedback during the training, This will help the trainer to revise or redesign the training if found necessary as areas of difficulty are immediately pinpointed.

Continue and upgrade training, Technologic improvements will require an upgraded training. The continuous improvement implies the necessity of continuous training.

Consequently it can be stated that the training needed to properly support a robot installation should be based on the economic, technical and social impacts of robotics. Throughout this paper robotics has been considered a major element of the Factory of Future where automation is the main principle of manufacturing, and many managerial considerations for automation or for the factory of the future have been analyzed to support the study.

Robotics training aims at removing the false mystique, properly utilizing the robot's potential, and maintaining the robot for greatest productive life.

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