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ABSTRACT

In Brazil, electronic technicians are increasingly being asked to perform a number of technical and nontechnical tasks, for which they need complex education and training or multiskilling. The typical tasks faced by electronic technicians require a relatively high level of abstraction and symbolic learning. Required skills cover a broad range of intellectual and technical abilities. Electronics is expected to keep changing, and technicians should be able to keep up with these developments and to learn how to learn. Employers value technicians with general abilities and knowledge subsumed under the general term of trainability. They are also concerned with two major categories of theoretical knowledge: the basic principles behind the functioning of electronic systems and equipment and the specific disciplines that impart knowledge, information, and technical skills in electronics, automation, pneumatics, and mechanics. Both employers and students expect electronics to be a lifelong experience. An analysis of 30 years of curriculum change in the electronics school of Santa Rita do Sapucai shows that pure theory in the 1960s became applied in the 1970s. The critical challenge of multiskilling is to overcome the tension between the employer's demand for increasingly highly qualified technicians and the immediate realities of the workplace where repetitive jobs predominate and limit the extent to which higher skills can be used and developed. (YLB)

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discussion

The skills of multi-skilling

by Ana Maria Rezende Pinto and
Joao Batista Araujo e Oliveira

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Summary

This paper analyses the nature of skills involved in the work and training of electronic technicians in Brazil. These workers are being increasingly asked to perform a number of technical and non-technical tasks, for which they need a complex education and training, or in short multi-skilling. The introduction sets up the context in which these technicians work - a sample of industries in a developing, industrialised country representing various levels of production automation and technological complexity. Based on the tasks in which these technicians are involved, the paper derives the skills required, and discusses the level of theoretical and symbolic complexity involved. Then it moves on to understand the expectations of employers and employees concerning the learning, the use and the development of these skills in the workplace. Finally the paper illustrates how the curriculum of a pioneer technical school created in 1958 has been responding to the changes in the theories, technologies, techniques of electronics. as well as to the changing needs and expectations of employers and employees. The paper concludes by stressing the increasingly complex and multi-faceted nature of the electronics technician job and the corresponding increase in the level and type of education and training required. Being an open-ended field still in its infancy, no level of pre-employment electronics training will suffice to meet the changing realities of the workplace. The critical challenge of multi-skilling is to overcome the tension between the firm's demand for increasingly highly qualified technicians in one side, and the immediate realities of the workplace where repetitive jobs predominate, and thus limits the extent to which the higher skills demanded can be used and developed. Hence the need for high-tech organisations to provide permanent challenging tasks for their highly trained technicians, so that they can continue to learn and develop.

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I. Introduction: The context

This paper is based on follow-up studies with the graduates of the Technical School Francisco Moreira da Costa, located in Santa Rita do Sapucai, a small town in the south of the State of Minas Gerais in Brazil.

The technical school started in 1958 - before electronics was extensively used in industry. It was the fruit of the vision of local educators at a moment when the strategic development plan of industrial modernisation was launched in the country.

The first curriculum of the school was conceived by the most outstanding scientists and engineers in the country, and reflected not only state of the art knowledge in electronics, as well as their expectations about the role of electronic technicians in the emerging industries in Brazil.

Graduates from the technical school went mostly to work for firms in the neighbouring State of Sao Paulo, thus reflecting the cosmopolitan, rather than local, vocation of the school. This is why the study also includes data from a broad sample of industries for which they work, and which are mostly located in the highly industrialised State of Sao Paulo.

Santa Rita do Sapucai was primarily a coffee plantation zone. In the early 1970s, a local industry started to develop in what eventually became the Electronics Valley. Based on the pool of graduates from the school, this industry quickly developed, and is already considered the second electronics park in Brazil. Most of our data come from graduates and employers from these local, but incipient, high-tech industries.

The paper is organised in three parts. The first part is mostly conceptual and analytic, and sets the framework for understanding the actual tasks electronics technicians perform and the skills required. Part two deals with additional expectations of employers and technicians concerning the nature of their work - what adds to the complexity of the tasks and the multiplicity of skills required. In the third part we discuss how the curriculum of the technical school has been responding to changes in the field of electronics, the technological profile of the industries, as well as to expectations concerning the training of multi-skilled workers.

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II.The skills actually used by technicians

The present discussion is based on direct observation, job analysis and interviews with supervisors and managers of firms. Annex I illustrates the distribution of the activities typically performed by electronic technicians. It is divided in two columns, the right column describing the tasks more typical of the first three years of activity, and the column on the left showing the activities of technicians with more than three years of experience. The figure includes all the jobs of all the technicians in the firms sampled, regardless of the specific titles and functions they perform and of the level of technological sophistication of the firms.

The first and obvious remark refers to the difference in the weight incidence of some types of skills more used in the first three years, as opposed to the later part of the career. Newly graduate technicians work more on activities requiring the use of tools, consulting manuals, applying rules, as well as performing tests and measurements. Older graduates are less involved in these and more in activities requiring analysis, research and contacts with the outside world. Maintenance activities are common to both, and have a very high incidence.

There is a clear trend: technicians start working with more concrete activities and progressively engage in more abstract ones. But there are exceptions to this trend - and we need to analyse these exceptions to understand the gist of the argument. First, some newly graduate technicians are directly engaged in R&D activities which require more complex abilities. Second, some of the activities reserved for more experienced technicians, such as contacts with outside clients, do not necessarily involve higher-order intellectual skills, but other human and social abilities to which we will turn later.

The data also show a clear pattern of career progression, and a certain consistency between the tasks performed and the level of skills required. For certain activities (outside contacts, etc.), experience and time with the firm are considered essential. These two observations seem to hold across the various types of firms - and thus might reflect shared perceptions about the abilities of the graduates. But this consistency is not complete. Some firms engage recent graduates directly into R&D activities - and this is not related to the profile of the technicians, but to that of the firm or the work within it. In other words, the exceptions illustrate that a technician is expected to perform a wide range of jobs upon starting their careers and this entails training in a number of varied and highly complex skills.

For our immediate purposes here, it is more important to understand the nature rather than the range of the symbolic activities required of a technician - immediately after graduation or a few years later. We will need to differentiate symbolic from concrete, action-centered activities, and for that we need to understand what "symbolic" means.

A symbol is a means, through which some effects are produced. It generates interpretations for which meaning is not given a priori, and cannot be related to an immediate context (see Zuboff, 19.. p.76). Meaning must be constructed through the manipulation of abstract information. What a technician does in his work is to understand the dynamics of a circuit, a system or electronic equipment. And he does it by constructing meanings through intellectual manipulation and interpretation (of symbols). He has to relate symbolic information to the concrete reality - a malfunction, for example - and he does so by asking questions such as: what is happening? What does this signal mean? This signal, or symbol, is an abstraction. Its meaning needs to be constructed by apply-

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ing hypothetico-deductive reasoning to the information coming from the object. Whatever meaning is constructed it is only remotely related to the daily sense experience and that is why it is abstract.

Two levels of complexity are involved in this process. The first and more simple involves the capacity to relate symbols (alphabet, numbers, measurements, instructions) to the real world. The second refers to the symbols as elements of thinking about abstract functions and relations between variables and systems (op. cit., p. 79).

These two levels of complexity provide some initial hints to help us interpret the tasks of our technicians as a function of time on the job. The first level is closer to the activities of the new graduate: he starts by testing (conformity to a pattern) and applying the symbolic language to the real world. The second level requires a more experienced technician, who is able to deal in a more abstract way with the symbols and their relationships, and to create new information or new knowledge (testing hypothesis, R&D activities).

Let us now examine the nature and the incidence of the activities performed by our technicians. The most typical activities (using conventional tools, components and equipments) require relatively less intellectual effort - even though they require a great deal of specific and technical information. They require identification and understanding of basic rules to operate and use the equipment. We can call these Type I complexity, according to our previous definition.

We must not forget, however, that even in the case of these technicians, the intellectual abilities required to perform their jobs is highly symbolic. They require specific knowledge, the ability to interpret information, to perform measurements, and even to produce information and new knowledge, for example, "read and interpret circuits", "research and identify defects", "read and interpret instructional manuals", "interpret results of measurements". From his first day at work, the technician must be able to transform verbal and numerical symbols into information in order to solve emerging problems. He will need to use numerical and mathematical ability to transform numbers into information and decision. He will need to be able to read in two languages - his own and possibly English - to be able to make sense out of the manuals and instructions related to the equipment, devices and systems. He has to make correct inferences. For these electronic technicians, to perform a job well is no longer synonymous with being dexterous with his hands. Doing a job well means the ability to deal with symbols to solve concrete problems.

In the case of older graduates, the incidence of certain types of activities is correlated with their increased ability to progressively incorporate more complex intellectual activities, such as "to adapt circuits", to "execute projects involving circuits and equipment", or to perform "quality control", not to speak of typical R&D activities. All these activities require the mastery of the principles of the functioning of the equipment, systems or circuits. Some quality control functions, for example, require knowledge of calculus and probabilities. Here we are almost exclusively in the realm of level II complexity.

As noted before, we are dealing with aggregates, averages of industries and tasks. We are also artificially separating individuals into two groups, according to length of service or experience (three years). It is certainly very useful to illustrate the range of skills expected and actually performed by these technical workers. Even though these procedures permit highlighting of some distinctive characteristics of the work of technicians, they may mask a few others.

A first distinction has to do with organisational practices. Firms might prefer to allocate some functions to older employees for reasons which have nothing to do with abstraction or ability to deal with symbols. For example, some companies might prefer to expose only the employees with more knowledge of the firm to their clients. Or they might want the technicians to experiment with the realities of production and maintenance before involving them in planning, quality control or other more sophisticated functions. Here we are talking about a different type of multi-skilling requirement, but which does not necessarily involve more complex symbolic reasoning.

A second distinction masked by the averages shown on figure 1 is even more germane to our discussion. Let us examine the specific case of maintenance. Trouble-shooting - i.e. applying decision rules to specific problem situations - does indeed require symbolic and abstract reasoning - and increasingly so depending on the variety and complexity of the tasks. As we saw in figure 1, this is the most typical function of technicians, younger or older. But this is also the most common source of frustration expressed by employers and technicians, as will be analysed in the next section.

In fact, in many industries in Brazil and abroad some of the maintenance functions are performed by non-diploma technicians, or by operators receiving relatively reduced amounts of training. This is one type of multi-skilling (upskilling of lower level workers) not being analysed here. This upskilling is possible even in the absence of more conceptual and broad-based training, because there is a number of maintenance activities which can be confined to simpler, repetitive problems. The symbolic activities can be reduced to simpler forms, which then can be taught and learned through practice and repetition.

In practice, a number of situations may obtain: non-technicians performing simple maintenance functions; younger technicians performing a range of maintenance functions, from simpler to more complex; technicians performing both operation and maintenance functions - another form of multi-skilling; and older technicians presumably performing more complex maintenance functions besides other functions. In each case different levels of task complexity may be involved, different intensities of work may be required and different combinations of skills (multi-skilling) will be at play.

The discussions so far led to four provisional conclusions. First, the typical tasks faced by electronic technicians require a relatively high level of abstraction and symbolic learning. This level can only be attained through systematic learning, with a sound theoretical basis. Practice alone can only lead to memorisation and execution of a limited range of repetitive tasks.

Second, the skills required of electronic technicians cover a broad range of intellectual and technical abilities. Different companies expect technicians to display most of such abilities immediately after graduation, thus putting additional pressure on the breadth of the training required.

Third, the term "multi-skilling" is utilised in many different ways, and has different meanings, all of which, however, bring in fundamental implications for training and job design. Multi-skilling is represented by the broad range of skills expected of the technicians, as described in Annex I. But it also refers to job enrichment - an operator doing maintenance chores or a maintenance technician working as operator, or involved in quality control or R&D activities. Another meaning is derived from other general abilities and non-technical tasks also expected of these technicians - and which also impacts on training.

A final preliminary conclusion refers to other broad career expectations about electronic technicians. There is an expectation that electronics will keep changing - and technicians should be able to keep up with these developments - and, hence, be able to learn how to learn. Most firms display a typical career pattern according to which technicians are expected to engage in other tasks - including non-technical ones, for which communication, coordination, and other social and group-related skills are essential. These expectations not only require a broad educational background, but they mostly require a general ability to learn, which is commonly called trainability. We will further explore this issue in the next section.

III. Expectations of employers and technicians

Table 1, below, gives an account of the characteristics most valued by employers of the graduates from the Santa Rita electronics school.

Table 1

Characteristics of technicians	Frequency	Percent
Trainability	76	81
Theoretical knowledge	59	63
Interest in R&D activities	34	36
Practical, rather than theoretical orientation	29	30
Knowledge of techniques	11	12
Knowledge of the firm	8	8

Source: 0 Perfil do Técnico de Eletrônica. Santa Rita do Sapucai, 1989. Escola Técnica Francisco Moreira da Costa.

Employers are concerned with two major categories of theoretical knowledge. The first is the basic principles lying behind the functioning of electronic systems and equipment - and which include knowledge of physics and mathematics, among other disciplines. Mastering these basic concepts and principles is considered important, but a second category of knowledge is even more valued by the employers. This is the specific disciplines which impart knowledge, information and technical skills in the areas of electronics and automation, but which also include topics such as pneumatics and mechanics. In other words, a clear majority of employers (63 percent) value students with good academic background. The balance between theoretical and practical knowledge is also a matter of concern, at least for 30 percent of them.

But this is not enough. Employers also want technicians with some general abilities - such as the capacity to read manuals, to read in English, use statistics and probabilities in practical situations, to work effectively in handling groups, to supervise workers, to communicate with clients. Some employers expect schools to develop such skills - others consider it as a function of time and experience or as a responsibility of the firm. These expectations about this other type of knowledge are subsumed under the general term of trainability.

If it is easy to measure theoretical knowledge through diplomas, credentials, grades and tests, the same cannot be said about trainability - which is the major concern of the firms (81 percent). Trainability, in fact, is intimately related to basic education and training, but to the employers, it seems to go beyond that. Some examples might help to clarify expectations about past, present and future learning that the students should acquire.

Concerning knowledge about the contents of the past, some employers - particularly in the less technologically advanced firms - complain that technicians are only learning the new stuff, but failing to learn the old - such as analog circuits.

Other employers expect technicians to be less specialised. The image frequently used is that of the foreman who progressed through the ranks, has an intimate knowledge of the machines and the operations, and learned all the tricks of the trade. Why can't schools prepare students with an open mind, capable of handling all the problems at once, and willing to deal with practical problems as they arise?

Santa Rita offers a unique laboratory to understand the dilemmas of this transition from practical to theoretical learning. As mentioned before, the region had no industrial traditions, and when industries came the school was already there - and many of its graduates were immediately employed. Very few self-made practical technicians were hired. One of them illustrated the limits of such training: "I can handle everything concerned with transistors and analog circuits, but I cannot understand the diagrams. But these new technicians can only operate if they see the diagrams - they do not have a feeling for what is going on ...". In fact, this worker could only operate inductively - sometimes very quickly - but most often by trial and error. Such workers do not possess the critical, abstract skills which would allow them to deal with things such as integrated circuits, where the components are displayed in complex systems which require theoretical knowledge to deal with them. This example illustrates the increasing gap brought in by electronics - and the rupture it presents to those used to the practices and learning habits of the past.

Concerning the knowledge needs of the present, some employers expect the schools to do even more: "We notice that new graduates have no idea about quality and other basic concepts which characterise a versatile professional". Others would prefer to see graduates able to communicate properly, to read manuals in English, or to immediately become effective supervisors or research assistants. In the specific case of Santa Rita, there is also a perceived lack of administrative, marketing and other organisational skills - and some employers would like the technical school to do more in these areas as well.

When it comes to defining the knowledge necessary to deal with the future, the employers are unanimous, at least in the discourse: electronics will come to maturity, it is an ever evolving field. Thus, we need technicians in love with the discipline, open to the learning of new developments, and able to keep up with the state of the art. Between the discourse and the practice, however, there is more than a small cleavage.

As shown in figure 1, most of the jobs - and most of the intensity of the work - are in the area of maintenance; firms expect technicians to be curious, to be willing to advance, to be able to learn on the job, to keep up with the state of the art. But only a few firms, particularly those involved with R&D activities, provide such opportunities. In most of the cases, job enrichment is through a form of multi-skilling which requires the technician to get involved in other activities - some requiring simpler skills, such as routine maintenance or operations - and some involving other non-technical skills. In other words, there seems to be a very fundamental conflict between the expectations of employers concerning training and aspirations of technicians and the actual conditions for personal and technical development they can offer in the workplace. They are well aware that technology-based production cannot do with less than a highly qualified technician; they expect this technician to continue to learn throughout his life. Yet, in many cases, most of them can offer too few opportunities for such learning to occur.

Whether or not the jobs available and the organisation of work in these firms is really able to offer such lifelong learning opportunities is a matter of concern not only for sociologists, but for the technicians who face these jobs. The limited data available on the expectations of students suggest that they also expect electronics to be a lifelong experience. Historically, 30 percent of the school graduates go on to higher education. Job mobility - which is fairly high for these technicians - is more often explained by opportunities to learn and develop in other firms, rather than by salary or other immediate benefits. Some graduates, for example, preferred to leave highly structured

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firms in Sao Paulo to return to incipient firms in Santa Rita in search for such opportunities.

Most of the students soon become frustrated with maintenance jobs - not only because it involves only a limited portion of the learning acquired in the school, but because of what comes with it: work in shifts, relatively high doses of manual work, getting dirty hands. They would also want to avoid the social stigma associated with these kinds of jobs.

A structural tension exists between the students expectations for a lifelong experience, the official discourse of the enterprises which value trainability, the challenges of the changing field of electronics, and the realities of the workplace, where maintenance, repetitive and routine jobs prevail for the majority of the technicians.

The technical school is only too well aware of these tensions. Yet, they perceive their jobs not only as one of responding to industrial demands - but changing the technological level of industry, and hence, the nature of the demand for higher skills. This is particularly true of the Santa Rita school, which preceded industrialisation by 12 years, but whose existence was the enabling factor which made it possible to transform a rural coffee plantation region into the country's second electronics technological park. Understanding skill requirements of new work technologies thus also requires understanding the logic of curriculum development. This is the topic of the next discussion.

IV. Thirty years of curriculum change

The analysis of 30 years of curriculum change in the electronics school of Santa Rita do Sapucaí reveals another important strategy, which is characteristic of leading technical schools. The original curriculum of this pioneer school, created in the late 1950s, reflected the theoretical and technology-oriented leanings of the founder concerning the training of future technicians: Strong academic and theoretical background, state-of-the-art technological disciplines ahead of local market demands, and strong practical, hands-on orientation.

At that point in time (late fifties and early sixties) Brazilian factories were still producing tubes for TV sets, and digital electronics was something that few specialists could understand - even in more developed countries. The curriculum changes introduced over time reflect how the school slowly accommodated itself to market demands without losing its original commitment to remain as a pioneer in anticipating technological changes. Table 3 summarises the major evolution of curricula in the technical school of Santa Rita do Sapucaí from the time of its creation in 1958 to the present. For a detailed discussion see Pinto (1991).

Major fluctuations in the curriculum, over this period of time, can be observed by analysing the distribution of the workload devoted to the so-called basic disciplines (physics and chemistry), the applied disciplines (electricity, electronics, telematics) and specific techniques. Pure theory initially gave way to basic and applied technology, while practical subjects such as drawing were virtually eliminated, reflecting the progressive introduction of integrated circuits. General subjects like language and mathematics remained virtually unchanged during the seventies and eighties, but mathematics was slightly increased in more recent years, reinstating the critical importance of a sound, general background.

To state the matter succinctly: Applied techniques and the fashions of the day were introduced, abandoned, or isolated into end-or course specialisations. At the same time, contents from the pure, basic disciplines were progressively incorporated in the specific technologic subjects. In other words, what was pure in the sixties became applied in the seventies, thus leaving more room to deepen the teaching of basic disciplines, while strengthening the theoretical content of applied subjects.

An important point to retain is the dialectical interaction of the school with its environment. The timing of these curriculum changes did not reflect responses to the demands of the market for specialists in tubes, digital or analogue circuits. They indicated a real concern and anticipation of the new wave of technological changes. This, rather than a blind response to market demands, seems to be the hallmark of excellent technical training institutions.

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Table 2. Thirty years of curriculum change

Outside influences	Curriculum changes
PHASE I 1958-1970	
Infant industrialisation	Strong emphasis on theory (500 hours)
Unclear labour market for graduates	Strong emphasis on drawing
Heavy influence from physicists on curriculum design	Some emphasis on technology (electricity and electronics)
	Clear curricular distinction between science and technology
PHASE II 1970-1976	
High level of economic development	Increased emphasis on mathematics
Development of telecommunications	More emphasis on technology: twice more electricity, 3 times circuit analysis
Transistors begin to replace tubes	50 % less hours on physics, 60% less on chemistry, de-emphasis on drawing
	Clear emphasis on applied topics
PHASE III 1976-1984	
Moderate economic growth	Marginal curriculum changes
Development of informatics sector	More emphasis on language and mathematics
Increased sophistication of industry: more than 700 numerically controlled machines installed by 1978	Starting technical English Search for a balanced curriculum
PHASE IV 1984-1988	
Rapid growth in automation of service sector	More physics & chemistry
Predominance of integrated circuits	More emphasis on understanding logic of circuits, rather than on projecting them
Creation of "electronics valley" in the school's area of influence	More specialised technological subjects: circuit analysis; industrial automation
	Clearer integration of science & technology
PHASE V 1988-present	
More emphasis on feedback from market	More emphasis on applied science
Market survey with graduates and employers pointed to new requirements and expectations, now being considered	More emphasis on general, humanistic education, English and sound maths background More emphasis on creativity and experimental rather than didactic labs

Source: Adapted from Pinto (1991)

V. Conclusion

The reader may wonder whether the paper has the wrong title: is it really discussing the skills of multi-skilled workers? Or is this a discussion of the skills of the conventional electronics technician?

A simple answer would be: both, as the discussion reflects at the same time facts, expectations and interpretations of the education and the professional practice of the electronics technicians.

The skills actually taught and learned at schools are indeed very basic and very broad, at least in the technical sense. Some employers will complain that they are not practical enough, others that they do not include some specific techniques or skills. Overall, however, no major actor in this system would disagree that a good electronics technician needs a very solid basis of theory, including physics and mathematics, as well as specific technical background in the various areas of electronics. The core curriculum of the schools examined easily pass this test.

Where actors might disagree is on matters of curriculum orientation - and here we find more room for disagreement. To a great extent, the disagreement derives from the inconsistent expectations of employers. They want trainable people but cannot offer too many learning and training opportunities. They want people with a high theoretical background - but tell them to perform routine maintenance jobs for most of their time. They want people to keep up with the latest developments in their fields - but their firms can only absorb and incorporate so much new machinery and equipment at a given time.

This is not a new phenomenon, and this tension is likely to remain alive for the time being. Behind it, however, lies a challenge for technical schools not only to keep the right balance between theory and practice - but to build up the right expectations about future job and career opportunities. Another alternative would be for schools to specialise in catering for specific niches of the market but this is certainly not the case of the school under study, which was born with a cosmopolitan vocation. Moreover, we have seen the limits of on-the-job, non-theoretical training in this highly sophisticated field.

But preparing graduates with a work orientation takes more than words: it reflects a central challenge for technical training institutions. The tension between old and new knowledge is real indeed and is permeated by theoretical and laboratory classes - where these issues are faced in very concrete ways. Electronics is not only a matter of training people for troubleshooting malfunctioning equipment in the workplace. But even if it were, this could require understanding the principles of a given phenomenon, systems or equipment, as well as theories underpinning their changing paradigms. Moreover, in the process of advancing electronics knowledge, the actual physical components are becoming increasingly smaller, and their connections less visible, more oriented by scientific principles and less by the sensory and concrete experience. The reality of electronic thinking has to be balanced with the reality of the workplace - and this is no trivial task. In this case, nothing seems to be more practical than a good theory.

The workplace itself is becoming more complex. The supervisor is no longer able to teach the technicians working for him - they have to be able to read manuals, interact with suppliers and clients, discuss with engineers and designers, engage in quality control activities, train their operators. New additional skills are necessary. A far greater number of skills are considered basic: English, statistics, probability, better language and communication

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skills, as well as people-related skills. Technical training becomes increasingly more loaded with these demands - and only part of these skills can be developed on the job. These are indeed basic skills which require a good, sound, basic educational system before they can be further developed by firms. A complex workplace puts more pressure on the technical education system to become more relevant - but not necessarily to produce a finished product.

Much remains to be learned and developed in the workplace. The worlds of work and learning are becoming increasingly mixed. There is a clear convergence from both ends. Multi-skilling is at the heart of this convergence - but is also at the heart of the intrinsic conflicts associated with these two worlds.

Firms have an economic need for multi-skilled technicians regardless of the way they define multi-skills: technical and non-technical, a combination of various technical skills in the same workers, or people able to simultaneously perform production and maintenance functions. This is why they want multi-skilled people, multi-skilled technicians, for which they must provide differentiated salaries, challenging tasks and opportunities to learn.

There is a limit to what schools can do. They can expand their curricula, include new topics, balance theory and practice, increase the relevance of learning, incorporate new industrial habits, involve their teachers and students with realities of the workplace. But today they are asked to provide a sound, better and broader general and technical education. This is how they become productive - and responsive to the needs of technological development.

If schools can learn more or less quickly how to respond and adjust, more formidable obstacles exist for firms to convert themselves into learning organisations. The amazing developments in the area of electronics constitute an opportunity for such developments to occur. They remain the central challenge for firms, industries and entire economies to survive.

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Annex I

Typical tasks of electronics technicians in Brazilian enterprises

1. Activities

2. Time for graduation

- Up to three years
- More than three years

3. Specific knowledge

- Specify electronic components
- Specify equipment
- Identify electronic components

4. Interpretation

- Interpret results of measurements
- Read and interpret schemes
- Trouble-shooting
- Read and interpret technical manuals
- Read and interpret technical norms
- Prepare and organise technical documentation
- Interpret and execute technical drawing
- Perform literature reviews
- Communicate in technical English

5. Tests and measurements

- Perform measurements of systems
- Perform measurements of equipment
- Test and adjust systems
- Test electronic components
- Test and adjust equipment

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6. Application

- Adapt circuits
- Implement small projects
- Implement major projects
- Install equipment and systems
- Provide maintenance
- Provide quality control

7. Production

- Research on new products
- Basic research
- Technological research
- Teaching (electronics)

8. Miscellaneous

- Organise work
- Technical sales
- After-sales services
- Consulting

Source: Pinto, 1990, p. 280

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