Africa Journal of Technical and Vocational Education and Training

From Learner Electrician to Mechatronics Technician: Exploring the Possibilities

Mark L. Gordon

Gauteng Department of Health – Infrastructure Unit &UNISA
Department of Electrical and Mining Engineering, South Africa

Abstract

This paper looks at the possibility of adapting the typical electrician or electrical technician training programme to that of a typical mechatronics technician. The study briefly looks at the necessary theory and some practical requirements for mechatronics technicians gleaned from the point of view of an electrician who has fulfilled the basic requirements of a diploma in electrical engineering. Mechatronics being a relatively new field of engineering may seem unattainable to new entrants into the field. Many learners who are on their way to become certificated (registered) electricians have passed the necessary theory subjects but are unable to easily obtain the required practical training. It may take many months for such learners to find an apprenticeship, internship or on-the-job training. When funding is available costs for training may be excessive and the quality of training may be questionable. Under conditions of high youth unemployment and few job opportunities, learner electricians may equip themselves with the necessary mechatronics skills to enter the job market of mechatronics technician. This paper wishes to answer the following questions: Can a learner electrician upgrade their skills to become a mechatronics technician? What skills are common between a learner electrician and a mechatronics technician? In an environment of scarce resources and underfunding for training is it possible to acquire the necessary mechatronics skills from self-learning and internet access? What mechatronics skills can be gleaned from exposure to typical machinery found in the household and local community? With the advancement of technology and exposure to remote laboratories what opportunities are available for the certification of mechatronics technicians? Within the mechatronics engineering landscape what are some of the innovation and entrepreneurial opportunities available in the context of the continent?

Key words: ***Learner electrician, mechatronics technician, training; certification***

Introduction

Mechatronics is the synergistic combination of mechanical engineering, electrical engineering, electronics, information technology, and systems thinking utilized in the design of products and automation processes (Festo, 2017; Nelson Mandela University, 2017). The mechatronics technician assists the mechatronics engineer (Career Planet, 2017) in the design, construction and integration of mechatronic systems. Joshi (1988) defines mechatronics as a replacement of mechanics with electronics or enhanced mechanics with electronics. There are many examples of mechatronic systems, for example, in modern automobiles, mechanical fuel injection systems are now replaced with electronic fuel injection systems. This replacement has made automobiles more efficient and less pollutant. With the help

ISSN 2518-2722

of microelectronics and sensor technology, mechatronics systems are providing high levels of precision and reliability. By employment of reprogrammable microcontrollers/microcomputers, it is now easy to add new functionality and capabilities to a product or a system, such as a washing machine and microwave oven (Joshi, 1988). This study looks at generic electrician training in the South African context; generic mechatronics systems education; a Comparison between learner electrician and mechatronics technician curricula; home-based mechatronic systems and possible routes to acquire mechatronics skills for learner electricians before concluding. Various pathways to becoming a "qualified" mechatronics technician and engineer are available and are discussed (LabVolt, 2017; MBUSI, 2017; Study.com, 2017; & UTAH, 2017).

Generic Electrician Training

An electrician as defined in Mukora (2008) and DHET (2015), is a person who installs, maintains, or repairs electric devices or electrical wiring. In this study a learner electrician is considered a person who has not yet passed the necessary trade test to register as an electrician. The typical duties of an electrician in the South African context are as in Table 1. These are the typical outcomes in preparation for the trade test (Electrical Training, 2017).

Table 1 *Basic Requirements for the Electrician Trade Test*

Trade Test Requirement	Description of Requirement
Electrical load balancing exercises	Attempt to balance loads across different circuits to reduce circuit overloading
Basic electric circuits	Voltage and current calculations
Fault finding	Basic techniques to test continuity and circuit parameters in an attempt to find faults in circuits and get equipment working
Tubing and wiring (of premises)	Electric reticulation installation, wiring and connections in domestic premises
Wiring regulations (SANS 10142-1) (SABS, 2017)	South African wiring code legislation requirements for registered electricians
Single phase wiring circuits	Simple series and parallel connections
Three phase wiring circuits	Star-Delta 3 and 4 wire connections.
Motors and starters	Motor control centers typically for 3-Phase Induction Motors
Hand skills	Use of hand tools to perform installation tasks.
Intensive Time trials on variety of Tasks	Time trials to minimize tasks applicable to the trade test.

In South Africa once learners have passed the N2 level of study and have successfully completed an appropriate apprenticeship of at least three to five years, they may be eligible to sit for the Trade Test (Electrical Training, 2017).

Table 2 *TVET College Typical Electrical Engineering National (N) Diploma Course Levels N1 to N6*

N1	Z	N3	N4	N5	N6
Mathematics	Mathematics	Engineering Drawing	Electro-Technics	Electro-Technics	Electro-Technics
Industrial Electronics	Industrial Electronics	Mathematics	Industrial Electronics	Industrial Electronics	Industrial Electronics
Engineering Science	Engineering Science or Logic Systems	Industrial Electronics	Engineering Science	Engineering Physics	Engineering Physics
Electrical Trade Theory	Electrical Trade Theory	Engineering Science or Logic Systems	Mathematics	Mathematics	Mathematics
		Electrical Trade Theory or Electro-Technology		Power Machines	Control Systems
					Power Machines

Table 2, shows the typical courses studied by a learner electrician (IDC, 2017). Learners who are unable to obtain an apprenticeship after their N2 studies, study further to the N5/N6 level. These learners are able to obtain the National (N) Diploma Electrical Engineering after fulfilling the prerequisites of applicable training (Mukora, 2008; DHET, 2015).

Generic Mechatronic Systems Education

As discussed above, a typical mechatronics system is characterized by close integration of the mechanical components (e.g. mechanical links, gears), electrical sensors (e.g. sensors for position, speed, light and temperature measurement), mechanical and electrical actuators (e.g. linear and rotating electrical motors, hydraulic cylinders and flow control valves), and computer controllers (e.g. custom- built controllers, personal computers and PLC's) into products and systems

useful to man and society. In order to combine all these elements in an optimal way that is cost effective, flexible, and with the highest performance, mechatronics engineers must have insight into each of these disciplines" (FESTO, 2017; NMU, 2017; Career Planet, 2017).

The mechatronics technician typically performs the tasks in Table 3. (Matrix, 2017),

Table 3 *Typical Mechatronics Technician Duties*

Building of prototypes (under supervision of the mechatronic engineer/system designer)
Checking, servicing and maintaining of electrical and mechanical systems)
Fault finding and system integration
Testing and installation of new and upgraded equipment
Communication with team members
Use of high-tech software and measuring equipment
Record keeping

Mechatronics is closely related to industrial automation and various training programs exist where private companies offer such training (Study.com, 2017). Such companies even offer training programs that satisfy the skills requirements for the newly proposed Mechatronics Artisan Trade Test (UTS, 2017). In these courses artisans and learners in an attempt to become more workplace employable, are equipped with industrial, electrical, pneumatics / AC drives and PLC training.

The author was previously appointed as senior lecturer in the Mechatronics Department at a South African University and was closely involved in the development of the curriculum. The academic offering was at bachelors of engineering level with the subject breakdown (Nelson Mandela University, 2017).

The particular program provides students with a thorough grounding in mathematics, basic sciences, engineering sciences, engineering modelling and engineering design together with the abilities to enable application in fields of emerging knowledge. This study points to the practical skills and training associated with the field and not necessarily the theoretical aspects offered at universities.

Expert companies in the field of mechatronics such as Festo (FESTO, 2017) provide learning system products which include hardware, simulation software, web- based training products, and a broad array of curriculum, combine to provide the educator with the most comprehensive, industrial-based training programs available worldwide.

Technical training objectives include the ability to: analyze functional relationships in mechatronic systems; manufacture of mechanical components; following information and energy flow in electrical, pneumatic, and hydraulic sub-systems; planning and organizing of workflows; commissioning, troubleshooting

and repair of mechatronic systems and communication using industrial network protocols, including DeviceNet™ and ProfiBus. The focus of such courses includes, empowering learners and educators.

The general consensus for the training of mechatronics technicians appears to be concerned with the following topics and acquired skills (Matrix, 2017).

Table 4 *Typical Training Curriculum for Mechatronics Technicians*

Industrial automation
Technical terms
Planning, developing and building automated systems
Technical documentation
Building models and creating simulations
Open and closed-loop control systems
Pneumatic, hydraulic and electrical actuators, sensors and controllers
Using computers as tools for programming and simulation
Programmable logic controllers PLCs
Robotics

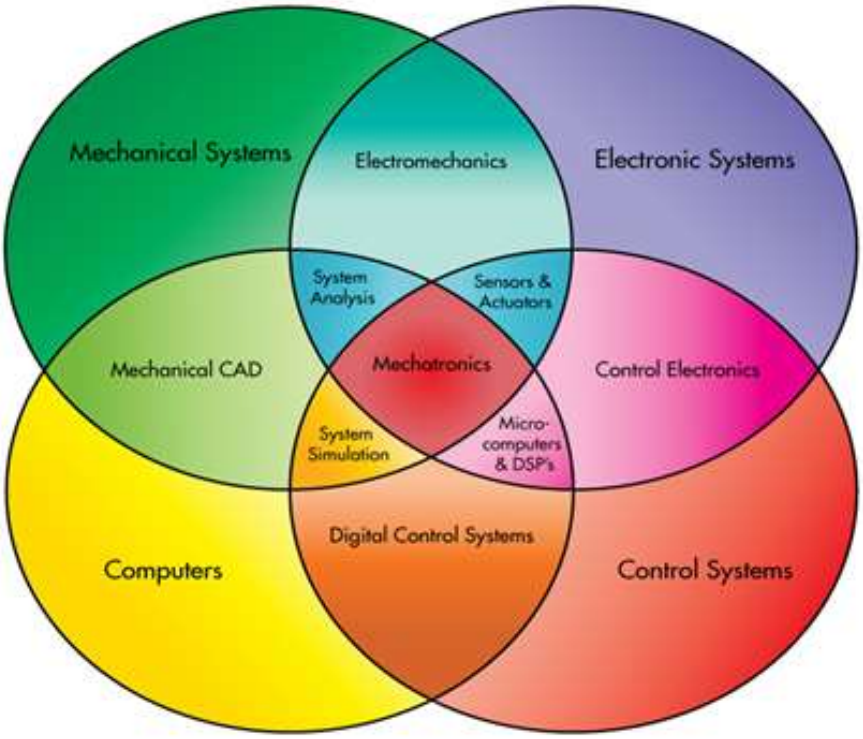

Figure 1. *Mechatronic subject integration Source: Mraz, 2017*

Comparison between Learner Electrician and Mechatronics Technician Curricula

It would appear on comparison of Table 1, 2, 3 and 4 and on looking at Figure 1, that the learner electrician (in this context) lacks the following skills/training/subjects as shown in Table 5.

Table 5 *Apparent Skills Gap between Learner Electrician and Mechatronics Technician*

Simulation software and general programming skills
Communication and industrial networking protocols
PLC and micro-controller programming integration Skills
Sensors and actuators calibration and testing
Systems analysis and integration
Soft skills – verbal and written communication

Home Based Mechatronic Systems

The modern home very often has many mechatronic systems at the disposal

of individuals who are interested in the field. The microwave oven, the washing machine, some audio-visual devices and desktop/laptop computers can also be considered as mechatronic in nature. Here one can consider the use of electronic controls to rotate an object such as a turntable, drum and disc as a mechatronic device. Such devices are commonly encountered in the home or on the scrap heap and can easily be scavenged for mechatronic projects.

Possible Routes to Acquire Mechatronics Skills for Learner Electricians

As can be surmised from this brief study the topic of mechatronics education is quite complicated and varied. Different countries, universities and community colleges have adopted their own methods to equip the future personnel in this field. (Rawashdehl, Nazzal, Kaylani1 &, Loose, 2010), companies (FESTO, 2017; UTAH,

2017); UTS, 2017), In the South African context for the learner electrician who has not been able to obtain an apprenticeship and has acquired the N6 level theoretical training, the author proposes the following route in Table 6 to acquire the skills in Table 5.

Table 6 *Possible Route from Learner Electrician to Mechatronic Technician*

Proposed Acquired Skill	**Skill Description**
Simulation software and general programming skills	Use Open Source CAD software (Electrical and Mechanical Drawing and Design).
Communication and industrial networking protocols	Use Internet and relevant library books.
PLC and micro-controller programming integration skills	Lear relevant programming languages are available on the internet. Inexpensive micro-controllers such as Arduino and Raspberry-Pi provide good introduction to the subject (CircuitDigest.com, 2017).
Sensors and actuators calibration and testing	Inexpensive sensors such as temperature gauges and Hall probes are “freely” available. Stepper Motors are easily obtainable from old printers.
Systems analysis and integration	Inexpensive sensors such as temperature gauges and Hall probes are “freely” available. Stepper Motors are easily obtainable from old printers.
Soft skills – verbal and written communication	Network with like-minded individuals in the Mechatronics field. Communicate, write reports and publish articles.

Summary and Conclusion

To be recognized as a qualified (or certified) mechatronics technician the individual has to comply with certain requirements as in the case of Festo (FESTO, 2017), Siemens Mechatronics Systems Certification Program (LabVolt, 2017), and other recognized service providers and or educational institutions (Summat & Hamlyn-Harris, 2017). This study considers the learner electrician as a candidate for acquiring the skills to become a mechatronics technician via the route of self-study (typically on the internet) and exposure to working with common mechatronic systems found in the household. The learner electrician would need to typically acquire the following skills: Simulation software and general programming skills; communication and industrial networking protocols; PLC and micro controller programming integration skills; sensors and actuators calibration and testing; systems analysis and integration and soft skills – verbal and written communication.

It may be that the Mechatronics Technician of the future (particularly on the African Continent) who is not able to obtain employment in first world companies would be an individual who is self-employed and would have to design and build products for local consumption using custom made protocols and standards.

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