TECHNOLOGY STATION IN ELECTRONICS AT THE TSHWANE UNIVERSITY OF TECHNOLOGY - STRENGTHENING TECHNOLOGICAL INNOVATION ACTIVITIES AMONGST SMES AND STUDENTS

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ABSTRACT

This article focuses on how the competence and capacity within the Faculty of Engineering and the Built Environment, specifically the electronic/electrical discipline, at the Tshwane University of Technology is utilised to support Small Medium Enterprises (SME) as well as student development in a challenging industry environment where the emphasis is on producing innovative products which can serve South African communities. The outputs of innovative products and training provided by the Technology Station in Electronics (TSE), an initiative of the Department of Science and Technology (DST), and academic departments within the Faculty, will be highlighted. Other universities of technology, technology stations and industry can benefit from the challenges and lessons learnt by the TSE in supporting SME and student experiential training in South Africa. The TSE managed to increase SME support from 7 to 37 per annum over a period of 3 years and involved third-year electrical engineering students in 85 of the 87 projects with industry. This contributed towards enhancing the teaching and learning process of students and assisted in the production of user-driven innovation in SMEs.

Keywords:

1. Introduction and orientation

The Department of Science and Technology (DST) initiated the Technology Stations Programme (TSP) to create support for SMEs in targeted business sectors. The Tshumisano Trust, which means "cooperation" or "partnership" (Tshumisano, 2007), was established in 2002 by the DST as a joint venture between government, the German Agency for Technical Cooperation (GTZ) and the then Committee of Technikon Principals (CTP), with the mandate to provide support to the Small and Medium Enterprise (SME) sector through its TSP.

According to Gibson (2007:16) SMEs are the lifeblood of South Africa, not only as a significant employer but also making up at least half of the country's GDP. The Information and Communication Technology (ICT) industry, for example, has long recognised the value of the SME market, but reaching this vast and scattered market has always been a challenge.

The approach of the TSP is a two-way learning process, in which SMEs have an opportunity to improve their operations through technology assimilation and upgrading their innovation capabilities. For the universities of technology (UoT's) this process has the ability to enrich the student's teaching and learning activities by improving UoT's equipment and their real world understanding of the many industry challenges (Mangena, 2007). The purpose of this paper therefore, is to indicate how this two-way learning process is realised by the TSE situated at TUT.

Technology expertise at the universities of technology provides support for skills and product development for SMEs (DST, 2006b:41). At the same time these institutions have the opportunity to engage directly with industry. The TSP aims to strengthen activities in technological innovation and skills upgrading to increase the competitiveness of SMEs in targeted sectors, which include automotive, food processing, electronics, metal value-adding, chemicals, metal casting, composite and moulded plastic (DST, 2006a:66; Mangena, 2007). As part of the fulfillment of this mandate the Technology Station in Electronics (TSE) was established at Tshwane University of Technology (TUT) in 2000, with the primary focus to operate in the electronic, electrical and ICT industries.

From its inception until the end of 2003, the focus of the TSE was on the design and development component of the Product Life Cycle (Figure 1), contributing towards increasing the competitiveness of SMEs in the electronic, electrical and the ICT sector. However, it soon became evident that a chasm exists between electronic designers and electronic manufacturers in targeted industries. Therefore, the TSE management in collaboration with the various stakeholders took a strategic decision to realign the TSE to the manufacturing industries by shifting its focus more towards the production/manufacturing aspect on the idea-innovation chain (Figure 1) for newly designed prototypes and products. Therefore the focus is not just on design and development, but rather on "bridging the gap" between design and manufacturing in the targeted sectors of the station.

During 2004 the TSE established a world-class electronic assembly infrastructure with competent human resources to create the competence and capacity to enable the two-way learning process between SMEs and staff/students at TUT. With this competence at the TSE, SMEs have the opportunity to upgrade their innovation capabilities and to enrich the student's teaching and learning activities at TUT.

This resulted in the TSE integrating its newly established offerings within the Faculty of Engineering and the Faculty of ICT at TUT during the course of 2005. With the competence and capacity in place, the TSE was able to market its newly established services to SMEs and academia in support of their development and growth.

In October 2005 the Electronic Assembly Facility was officially opened by the Minister of Science and Technology (Mr Mosibudi Mangena) and in the same year the station became a member of IPC (Association Connecting Electronic Industries). IPC is a global trade association dedicated to the competitive excellence and success of its 2 700 member companies which represent all facets of the electronics interconnect industries, including design, printed circuit board manufacturing and electronic assemblies (IPC, 2008).

The TSE initiated its first short learning programmes in 2006, focusing on electronic assembly (conventional and surface-mount technologies) and rework solutions and techniques of assembled units. These short learning programmes were presented to industry and students, as well as technical staff from Botswana Technology Centre (BOTEC). From the results and during the training sessions, it was evident that SMEs and students gained relevant knowledge and exposure towards IPC applicability and requirements to the different procedures, functions and assemblies within the electronic assembly environment (surface mount as well as through-hole technologies).

The TSE offered students the opportunity to do experiential training, which formed part of the national diploma qualification, at the TSE by working on projects with industry. It became evident that the TSE had to establish training infrastructure with the relevant training material to provide an industry-focused experiential training programme supported by internship funding (for students) through Tshumisano Trust when students are placed at an SME. The advantages of experiential learning for students in SMEs have also been highlighted by Miles *et al.* (2005:27); Nyman (2006:47) and Kye Woo Lee (2006:278). Two interns with industrial engineering background and a lecturer executed the initiation of the ISO 9001:2000 certification process to enhance the innovative abilities of SME's. In January 2007 the TSE offered a more focused approach to experiential training of students towards specific needs identified by industry and SMEs. As from July 2007 the TSE, in collaboration with the various academic departments, was responsible for implementing a focused and coordinated experiential training programme for the Faculty of Engineering and the Built Environment (TUT), which forms the basis for the pipeline students for the Post Graduate programme and research focus areas in this Faculty. Success thus far has been evident from the development of user-driven innovative products that were produced over a period of 3 years with the support and assistance of the TSE. These will be further highlighted below.

2. IDEA-INNOVATION CHAIN AT THE TSE

The South African National Research and Development Strategy identified the "Innovation Chasm," as the innovation gap that exists between the knowledge generators and the market (R&D Strategy, 2002:24; Mangena, 2007).

The Technology Station in Electronics is positioned to contribute towards narrowing the innovation gap (Figure 1) in the target sectors by providing a two-way learning process, in which SMEs have an opportunity to improve their ability to deliver quality products utilising the competence at the station and simultaneously enriching the student's teaching and learning activities with the infrastructure and projects from industry. Therefore the main objective of the TSE is to assist SMEs to strengthen technology innovation through:

- Product design and development (prototyping)
- Automated electronic assembly (prototyping and small-scale production)
- Rework solutions for electronic assemblies (conventional and surface-mount technologies)
- Specialized and customised training for students and industry
- Experiential training (for mainly TUT students)

To date it has been found that SMEs have utilised the station services and students also benefit from the above as they are involved in the design and development phase as well as during the prototype, pre-production and production phases of a number of projects. Four of these projects are presented in Table 1 and the student and SME involvement are highlighted with the critical analysis of a successful implementation.

The TSE supports the idea-innovation chain as proposed by Hage and Hollingsworth (1997), and this concept refers to the linkages between scientific research and industrial innovation chain (Ballard *et al.*, 1989). The idea-innovation chain consists of networks of organisations involved in the various functional domains (classes of required competences) of the innovation process: basic research, applied research, product development, manufacturing, quality control and marketing. The idea innovation chain does not necessarily imply a uni-directional or linear relationship, not merely a sequential interdependence between its various components (Casper & Van Waarden, 2005:10). However, in some stages of the development of science, as well as in some industries and even in some countries (India, Germany, etc.), innovations may well be organised according to such a linear model of innovation. However, the development of technologies has often predated the scientific knowledge underlying the production processes. As Richard Nielson (1993:7) reminds us, '*The advent of new technologies often leads to scientific work aimed at understanding these technologies*'. With the emergence of science-based industries, a new mode in the production of knowledge has been observed which is characterised by the fact that technology and science are closely intertwined (Gibbons *et al.*, 1994). Thus in this mode of the production of knowledge, innovation is often a process of moving back and forth between invention and/or design, development and testing, redesign and evaluation of market potential (Kline & Rosenberg 1986).

It is this unique process that enabled close to 70 SMEs in Gauteng and Limpopo provinces to produce innovative products with the assistance of engineering students and staff members in the Faculty of Engineering and the Built Environment at TUT.

The TSE applies this idea-innovation chain through utilising the capacity and competence within the Faculty of Engineering and the Built Environment to assist industry with projects, services and training. The experience gained and feedback received from industry through projects, services and training are used to improve the curriculum and research and innovation activities in the Faculty of Engineering and the Built Environment at TUT. Figure 1 below depicts the idea-innovation chain as supported by TSE.

Source: As adapted from R&D Strategy (2002:14); De Wet (2004); Casper and Van Waarden (2005:11).

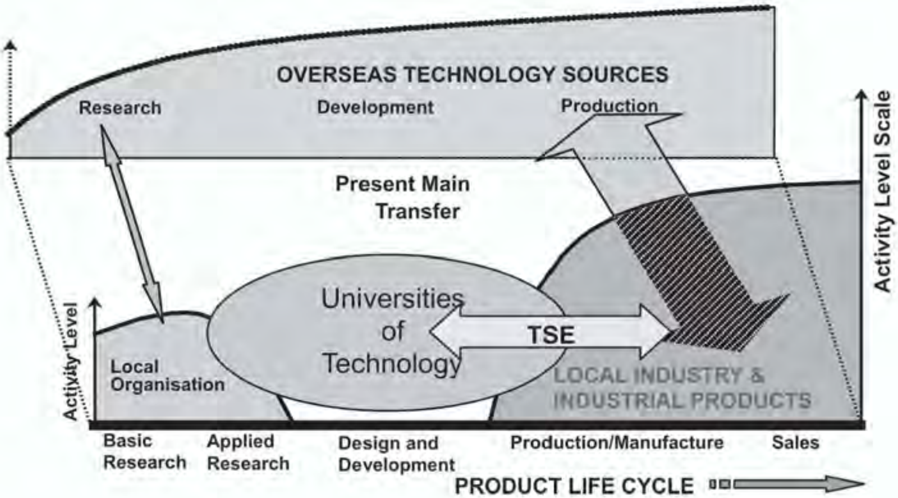

Figure 1: Idea-innovation chain of TSE

3. TECHNOLOGY PLATFORM AT THE TSE

The effective planning of technology platforms is essential for aligning research and development activities at the Station with current and future business strategies, as well as balancing product and process innovations with industry needs. Of critical importance is the development of technology platforms in support of narrowing the innovation chasm, as well as the management of technology investment to support future research and development projects between industry and academia.

In order to narrow the gap between knowledge generators and the market (R&D Strategy, 2002:24; Mangena, 2007), the Technology Station in Electronics established an electronic assembly platform to support the two-way learning process between academia and industry in the electronic design and manufacturing sectors. This electronic assembly platform (see pictures below) created the competence and capacity to do electronic assembly and quality assurance of prototypes and products comprising of through-hole (conventional), surface-mount and the combination of these two technologies, as well as the rework thereof.

Electronic assembly platform

Optical inspection

Student training

Testing and training

It was evident through the projects that the established technology platforms at the station exposed a number of students at various academic levels at TUT to a commercialisation environment from concept to final product. TSE staff experienced an opportunity to gain valuable experience and to mentor students and other staff members on manufacturing optimisation, prototype construction, machine programming and usage, to prepare manufacturing documentation, machine and hand assembly techniques, and testing of the manufactured products. According to the Manufacturing Foresight Report (Watt, 2007), manufacturing is seen as the engine of economic growth of South Africa and has to be in a healthy state and therefore its competitiveness in a globalised world becomes crucial.

The South Africa Country Report (2006) also highlights that the TSP must provide skills development training to SMEs to enhance their innovation capacity and competitiveness, while exposing students at technical universities to practical situations facing businesses. The report further states that the aims of the TSP must be to address product and process technology needs of SME manufacturing and the service industry through technology transfer, development and diffusion and to enrich the R&D capacity of technical universities (SA Country Report, 2006). Therefore, with an established electronic assembly platform, the TSE and TUT are aiming to address the above with SMEs in the electronic, electrical and ICT sectors of the country and at the same time expose students at TUT to these activities.

However, well-defined services created from relevant and needed technology platforms are an essential component to facilitate technology innovation and skills upgrading to increase the competitiveness of SMEs in the electronic and electrical sectors (Clark *et al.*, 2006:36).

The established electronic assembly platforms are the anchor to define the core services offered by the station to address the needs of the targeted sector as well as to fulfill the mandate of the TSP. The following core services are offered as a result of establishing world-class technology platforms linked to competent human resources at the Tshwane University of Technology:

- Project management;
- Sourcing and procurement of materials;
- Surface mount device assembly (pick-and-place);
- Through-hole assembly (conventional);
- Rework solutions, the removal and replacement of components;
- De-panelising (manufacturing optimisation);
- Printed circuit board manufacturing for prototypes;
- Automatic optical inspection for quality assurance/control;
- Specialised/Customised short learning programmes for industry and academia;
- Experiential training for students.

If one critically evaluates these services it can be reported that SMEs make use of all these services provided by the station although to a lesser extent the sourcing and procurement of electronic components. The reason for this is mainly that SMEs feel that the station has to rely on the university procurement system, which does not offer a reliable and speedy response to project procurement needs, and causes a bottleneck on the flow of project activities.

The two-way learning process (Mangena, 2007), in which SMEs improve their operations and TUT enriches the student's teaching and learning activities, needs partnerships between industry, academia and government.

Therefore, the TSE collaborates with a number of academic departments and initiatives within the University as well as various government departments and initiatives to understand and address the challenges of industry in order to narrow the gap between knowledge generators and the market (R&D Strategy, 2002:24).

4. INNOVATION AT THE TSE

This section provides a short description of four of the successful innovation/innovative projects that, since 2004, have been delivered at the TSE to support SMEs and individuals. This is followed by a brief discussion of SME and student involvement as well as a critical analysis of successful implementation of these projects.

Therapeutic bed: The therapeutic bed was co-designed by a quadriplegic who was disillusioned by the products on the market for the disabled. This revolutionary bed actually responds to the voice commands of its owner: rolling him/her over onto his/her side, or bringing him/her to a sitting position, or lifting the bed to a semi-standing position. The bed responds to any language and can even be programmed to detect different tones of a particular command – understanding its owner's moods.

This bed means that there is no more need for quadriplegics to find someone else to help them roll over at night', a simple "roll left" or "roll right" command will do that. A mere voice order such as "light off", "TV on" and "radio on" can take care of these tasks as well. For those who wish to make the bed move by more conventional means, the bed has been fitted with a joy-stick that can initiate the same movements as the voice commands. According to the co-designer, his quality of life has improved considerably since he has started using the bed.

Intelligent Voltage Current Meter (IVI Meter): This is a low voltage and low current meter used by dentists to determine the voltage and current between metallic fillings. These fillings were made from heavy metals which is very harmful to the health of human beings. When a dentist removes these fillings, they prefer to start with those which generate the highest voltages and currents. The IVI meter will assist them in this task.

***'ICT for power optimisation'*:** The Innovation Fund Project IT 6013 entitled '*ICT for power optimisation*', in which a consortium of partners including Tshwane University of Technology, Northwest University and two SMEs - Energy Cybernetics and Alphen GMS - formed a new business venture, Pro Direct Investments 297 (Proprietary) Limited (trading as Ergon Networx) to develop, manufacture and supply to the market a novel bi-directional powerline communications (PLC) network technology know as Net-PODS™ for residential load management (RLM) and automated meter reading (AMR).

EZ Tronics Waste Bin: EZ Tronics waste bin is making an exciting contribution towards tidy and hygienic refuse handling in South-African kitchens. In an equipped kitchen, aesthetically pleasing stainless steel hatches in the counter top open up when waste must be dropped into the bin. Access leaves the hands free and requires no bending or crouching. When closed, the hatches of these thinking units offer a firm stainless steel surface that supply solid support to any load normally placed on kitchen counter tops. Opening simply requires the toe of a foot or shoe to be put in a designated spot near the kick plate below the cabinet. The stainless steel hatches will swing away swiftly and smoothly leaving an unobstructed entrance to allow food remains, vegetable peels, soiled packaging and other waste to be dropped directly into the refuse bin. While the toe remains in place, the bin stays open, but as soon as the toe is moved away, the bin closes with luxurious elegance and a subdued murmur. Should a hand or an arm hinder the bin in its closing, it will reopen immediately, without causing injury. It will then allow the user time to remove the obstruction, before attempting to close again.

Every electronic unit is powered by a mains connection supplemented by a battery allowing continued operation, even during power outages. Power consumption is negligible, however, as it will require thousands of operations to consume one unit (Ah) of electricity.

SME and student involvement: These projects exposed a number of students at various academic levels at TUT to a commercialisation environment from concept to final product. TSE staff experienced an opportunity to gain valuable experience and to mentor students and other staff members on manufacturing optimisation, prototype construction, machine programming and usage, to prepare manufacturing documentation, machine and hand assembly techniques, and testing of the manufactured products.

The product developed in Project IT 6013, Net-PODS™, further contributes towards experiential training at the TSE as well as providing valuable inputs for curriculum refocusing of the experiential training component for future students. Most importantly, this project laid the foundation for similar commercialisation efforts within TUT at the Faculty of Engineering and the Built Environment. Recently, Ergon Networx commenced negotiations with large-scale manufacturers of electronics products, thereby creating capacity and knowledge required to take the product Net-PODS™ to the next level of manufacturing (Youngleson and Jacobs, 2008).

Critical analysis of successful project(s) implementation: The successes of these projects are the result of many factors, but the key is to assemble a team that clearly understands the objectives and has an achievable plan and the skills and talent to execute it. Some of the important critical success factors of these projects are listed below:

- Doing the right projects with the right clients
- A positive relationship with an active and intelligent client
- Strong project management begins with a strong project plan
- All functionality, non-functional requirements, constraints and assumptions must be clearly and unambiguously documented for each project
- Any change to any element of the project(s) must be undertaken within the change control process and all changes have costs
- All project processes must be well documented and in place
- Effective controls and communication must take place on all aspects of projects
- Technical leadership and excellence is critical on any project.

The following table provides a summary of SMEs assisted over past three financial years:

Table 1: Summary of SMEs assisted from 2004/5-2006/7
Source: Jacobs (2007:1)

	2004/5					2005/6					2006/7				
	Apr Jun	Jul Sep	Oct Dec	Jan Mar		Apr Jun	Jul Sep	Oct Dec	Jan Mar		Apr Jun	Jul Sep	Oct Dec	Jan Mar	
Total number of SMEs assisted (excl. individuals)	5	4	4	5	**7**	13	13	13	13	**25**	14	16	14	17	**37**
Female	0	0	0	0	**0**	1	1	2	1	**2**	2	2	1	3	**3**
PDI	0	0	0	0	**0**	3	4	1	6	**11**	5	8	11	13	**13**
Total number of projects	5	9	8	6	**15**	10	17	16	12	**22**	19	21	15	32	**87**
New	1	1	1	4	**7**	7	10	10	9	**26**	15	9	11	26	**61**
Completed	1	2	5	3	**11**	3	7	12	6	**28**	8	18	9	8	**43**
Repeat business	0	0	0	1	**1**	1	5	6	4	**7**	6	6	9	9	**30**

From the above table it is evident that since its re-alignment towards strengthening technological innovation in SMEs and students, the TSE has grown dramatically. This is evident in the increase (from 7 to 37) of SMEs assisted by the TSE over a period of three financial years as well as the increase in the number of projects. The total number of projects has increased from 15 in the 2004/5 financial year, to 87 projects in the 2006/7 financial year. It is important to note that in the third financial year students were involved in 85 of the 87 projects with industry which also contributed towards enriching the teaching and learning process.

Apart from the projects, the TSE is also engaged in training activities like experiential training for students, and short learning programmes for industry and SMEs. The following table provides a summary of the content which was covered in the modules presented to students and SMEs during 2006/7 financial year.

Table 2: Summary of module content

Name of module	Summary of module content
Overview of electronic assembly	An overview of what electronic modules consist of, including which components are used, printed circuit boards, equipment and tools.
Electrostatic Discharge (ESD) control	An introduction to ESD, how it occurs, the risks involved and methods on how to minimise and prevent ESD with regard to personnel, the work area, handling and transport.
Component identification	This module explains the identification of through-hole integrated circuits (ICs), common axial and radial components, complex through-hole components and hardware, surface-mount components, surface-mount IC chip components, Metal Electrode Faces (MELFs), Small Outline Transistors (SOTs) and Discrete Packaging (DPAK).
Handling in electronics assembly	This module concentrates on general handling considerations.
Mechanical assembly of hardware	An introduction of the tools being used, the types of hardware assembled, and the proper methods and procedures of operation.
Electrical test	An explanation of the importance of electrical testing of assemblies, and the proper methods and procedures of operation.
Safety in electronic assembly	This module addresses issues such as personal protection, improper use of tools, improper workstation design and set-up, hazardous materials, improper handling and positioning of materials, muscular skeletal disorders and inadequate housekeeping.
Plated through-hole workmanship standards	The plated through-hole workmanship standards module discusses the acceptance criteria for both class 2 and class 3 products, as well as the visual defect criteria for these classes.
Surface mount technology workmanship standards	This module explains the dimensional criteria for both class 2 and class 3 products. After dimensional criteria the defect criteria are also discussed for both classes.

The modules summarised in Table 3 were presented to a group of Mechatronics Engineering students during experiential training. It is again important to note that 70% is required to pass each module and the results are captured in the following table:

Table 3: Results of Mechatronics Engineering students

Name of module	Number of candidates	Min mark	Ave mark	Max mark	Max	Pass	Fail
Overview of electronic assembly	11	10	16	18	20	8	3
ESD control	11	19	22	24	24	11	0
Component identification	11	29	43	48	50	10	1
Handling in electronics assembly	11	13	17	20	20	10	1
Mechanical assembly of hardware	11	10	16	19	20	10	1
Electrical test	11	12	17	20	20	10	1
Safety in electronic assembly	11	22	24	25	25	11	0

The modules summarised in Table 4 were presented to a group of Electrical Engineering students during experiential training one. It is important to note that 70% is required to pass each module and the results are captured in the following table:

Table 4: Results of Electrical Engineering students

Name of module	Number of candidates	Min mark	Ave mark	Max mark	Max	Pass	Fail
Overview of electronic assembly	26	10	13	19	20	12	14
ESD control	25	11	17	23	24	13	12
Component identification	27	29	40	49	50	22	5
Handling in electronics assembly	27	4	12	18	20	13	14
Mechanical assembly of hardware	27	7	13	19	20	9	18
Electrical test	27	3	13	19	20	11	16
Safety in electronic assembly	27	12	20	25	25	22	5

The modules summarised in Table 5 were presented to a group from industry. As stated before, 70% is required to pass each module and the results are captured in the following table:

Table 5: Results industry group

Name of module	Number of candidates	Average percentage	Pass	Fail
ESD control	16	79%	11	5
Handling in electronics assembly	16	69%	10	6
Safety in electronic assembly	16	81%	12	4
Plated through-hole workmanship standards	16	60%	6	10
Surface mount technology workmanship standards	16	74%	12	4

It is therefore evident from the tables above that electrical and mechatronics students as well as industry attended and successfully completed the training, especially if one focuses on the results of the industry group and the percentages they achieved. This is therefore positive as the results highlight the training needs in specific areas for industry as well as for students. It therefore supports the two-way learning process in which the industry and students improve their operations through skills upgrading provided by the station.

The knowledge gained through industry projects are used to develop and implement new short learning programmes in support of SME skills development as well as curriculum re-focusing of the experiential training programmes. The modules of the training programmes provide a general overview of IPC's standards applicability and requirements to the different procedures, functions and assemblies regarding through-hole and surface-mount assemblies within the electronic manufacturing environment as well as a focused approach towards the skills development needs of SMEs and students.

Lessons learned during the period between 2004/5- 2006/7, can be divided into two categories which are inter-linked with effective technology planning for innovation as well as SME and student training with industry liaison. Both will be explained.

Effective technology planning for innovation is essential for aligning research and development activities with current and future business strategies, as well as balancing product and process innovations with industry needs.

During a study tour to Germany in April 2007 (organised by GTZ), it was evident that successful transfer centres recognise the crucial importance of managing their technology investment to support future research and development projects with industry.

Technology transfer infrastructure plays a critical role to transfer the technologies from universities (higher education institutions) and research institutions to technology users. The study tour to Germany further highlighted that one of the main components of technology development and technology transfer is a well maintained infrastructure. This is supported by a high concentration of highly-qualified manpower in research and development centres within the university, which could also mean that there is a higher possibility of commercialisation of research results or development of high technology. Importantly, technology planning and development can be seen as the process of knowledge acquisition, which can later be used in the design and development of new products that meet market needs. Therefore, effective technology planning and development could be crucial to enable new products to meet their market needs. Proper technology planning at universities (through research focus areas) could more clearly focus technology development needs and efforts to provide a core service to industry (through technology stations) and train students according to industry requirements. Technology planning can also identify general technological advances for current and future product development. This could contribute towards more effectively utilising technology in product development processes and providing products with a competitive edge.

SME and student training with industry liaison: Students with potential should be placed with existing clients (internship) in order to increase capacity and secure future work for the TSE. Students working on SME projects as well as TSE staff and student combinations on industry projects get the work done on brief-on-budget-on-time, which is a much better arrangement than placing lecturers with students on a critical path of a project. Industry tests TSE service offerings with very small projects and gradually increases the size of repeat projects.

The return time from industry to the TSE is six to nine months after the first contact was made by the station staff.

Challenges: Technology initiatives within the university (or/and national system of innovation) could more effectively manage research and innovation operations if we:

- understand how the technology we have pertains to the business needs (industry and academic needs);
- determine the gaps that this technology fails to satisfy;
- identify technology that has become obsolete;
- determine the best approach for developing or acquiring new technology or technology platforms in support of industry and academic (student and lecturer) development; and
- identify opportunities for future technology platform expansion; and
- create new or expanding existing competence and capacity.

Existing technology platforms or initiatives within universities could be used tobring together relevant stakeholders to identify the innovation challenge, develop the necessary research programmes and implement these programmes in support of industry needs and requirements.

The concept of guiding principles for technology platforms should guide potential participants in technology development initiatives. However, technology platforms should be:

- responsive towards major South African challenges;
- a strategic South African initiative;
- industry led;
- well planned and executed; and
- politically well supported.

Marketing (and maintaining) the new competencies and capabilities of the TSE is crucial for future sustainability. SME training, prototyping, turnkey solutions and small volume production needs should align with both academic and industry requirements. ISO Certification is a necessity in order to service our existing and new clients. The growth of short learning programmes (SLPs) as well as the interval of presenting these to industry and academia should be addressed together with the accreditation of SLPs with Merseta, as is supported by Brown (2006:199).

Establishing new qualification(s) in electronic design and manufacturing will be important to consider in future in order to carry out the mandate of government (DST/Tshumisano). The growth and improvement of the human resource capacity and competence within the TSE to improve the service delivery to industry and academia as well as to work effectively within TUT support systems are other challenges that will be addressed by the TSE.

5. CONCLUSION

To maximise the success of university and government investments in research and innovation technology platforms in support of technology development, new product development processes will need more up-front planning and close alignment between industry needs/strategies, technology planning, product research and product development functions. All stakeholders can learn not only from the development of innovative user-driven products but also from the results and challenges which were discussed above.

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