ADVANCING CDIO COMPETENCIES FOR TECHNICIANS – A PROFESSIONAL DEVELOPMENT FRAMEWORK

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ABSTRACT

Technicians in educational institutions are finding their role expanding beyond laboratory and resource equipment management. Technicians are also required to support teaching faculty in facilitating students' learning.

In the context of CDIO, technicians are now actively designing and conducting the laboratory practical assignments, as well as developing e-learning materials for blended learning. While project supervisors provide the technical know-how for students who are synthesizing C-D-I-O concepts for their final year projects, technicians work as the interface between the material world and the symbolic world of academic scientists and engineers; effectively serving as the bridge that connects the two. In doing so, technicians are facilitating, at the practical level, the work of the scientists and engineers who provide the theoretical concepts of the disciplines.

This paper firstly frames the key pedagogic knowledge and skills needed for Technicians to develop the necessary teaching competencies to thrive. It details how the knowledge and skills were derived through engagements with various stakeholders and summarizes the teaching and learning framework which has been developed specifically for Technicians.

Secondly, to complement the competency framework, a development roadmap was developed, which provides the support to meet the needs of the technicians.

To ensure that all stakeholders' needs are best met, a validation exercise was conducted, with input from technicians and their reporting officers, to confirm that the competencies and the professional development framework will achieve the learning goal - essentially the capability to meet the requirements of this role extension.

Finally, the paper outlines the plan for further implementation and evaluation, which will be essential for its development and improvement in a continually-changing educational landscape.

KEYWORDS

Professional Development, Technicians, Life-Long Learning, Standards 9, 10

INTRODUCTION

Technicians (TEs) play an important role in teaching and learning activities across all schools in Singapore Polytechnic (SP). In a Gatsby report (2012), TE's are seen to play crucial roles in the development of teaching and learning in institutions. More importanty, their role has expanded from simply getting practical equipment ready for students to use to now actually undertaking teaching classes and providing technical assistance, feedback and mentoring to students in the CDIO classroom.

Before COVID-19 struck, TE's roles in SP in teaching and learning were mainly confined to helping out in practical sessions where they might answer a few questions that students may have or simply providing ad-hoc technical advice when students needed help in their Final Year CDIO projects. Once teaching and learning had to shift online, TEs found themselves deployed to aid in the development of online teaching materials such as developing online lectures and deveoping interactive online learning artefacts.

As TEs in the institution begin to grow into their teaching and learning roles, a formal framework that describes the competencies needed to be effective designers and instructors was needed. Additionally, there was also a need to have a professional development roadmap to complement the framework to help TEs to attain these competencies.

LITERATURE REVIEW

Over time and especially during the COVID-19 pandemic, the role of TEs have continue to be expanded especially in the area of teaching and learning. While project supervisors provide the technical know-how for students who are synthesizing C-D-I-O concepts for their final year projects, technicians are now working at the interface between the material world and the symbolic world of academic scientists and engineers; effectively serving as the bridge that connects the two. In doing so, technicians are facilitating, at the practical level, the work of the scientists and engineers who provide the theoretical concepts of the disciplines. (Barley, 1996).

In a recent report commissioned by the Higher Education Funding Council (HEFCE, 2010), it was suggested that 'the technician role is increasingly growing to include the demonstration of concepts and theory, and is ultimately moving towards an active teaching role, away from "pure technicians" roles'. Vass-Gavin (2021) supports this view by asserting that TEs have the ability to transform the workplace and are "often the glue that hold the whole department together." This is a view that has been supported as well by government agencies especially from the UK suggesting that a shortage of technicians is hampering the work of UK-based researchers in university science and engineering departments and that there is a need to better identify and support the development of TEs in teaching and learning (THES 2008, 2009).

The drive to support and recognise the importance of the technician role is further led by the Gatsby Foundation in their seminal report "Technicians under the Microscope" (Lewis & Gospel, 2013). Shapin (1989), suggests that despite their vital role, technicians have frequently been described as an "invisible workforce" and there is a need to better support them in their development, a call echoed by Vere (2021).

The importance of technicians and the need to support them can be best summarised in a quote from the work of Bechky (1994) where it is pointed out:

"If the academic department is an engine, then technicians are the engine oil that keeps the department running smoothly."

To rationalise the development of TEs, it needs to be done in a structured and deliberate manner. According to HEFCE (2010); ongoing training for technicians still tends to be provided in a rather piecemeal fashion that often appears to be related more to the emergent requirements of teaching and research than to the long-term career development needs of individual technicians.

In other words, TEs will benefit if there was a dedicated framework and pathway that specifically focuses on their development. Lewis & Gospel (2015) echo the call for this to better support technicians as they increasingly take on expanded roles.

Taking a cue from past experiences and the research into professional development, rather than seeing professional development as something done to and for Technicians, it is important to frame professional development more in terms of a process of empowerment (Gilbert, 1994) and transformation (Tippins, Nichols, & Tobin, 1993).

This is consistent with what has been advocated by Howe & Stubbs (1997) who argue that professional development for educators should be driven through a process of creating experiences where participants are empowered to direct their own professional development, using tools which are given to them, to construct knowledge and meaning in a supportive social environment.

With this in mind, to better support the development of TEs in teaching and learning skills in SP, the authors are committed to supporting the development of TEs by provding a competency framework that focuses on identifying the relevant and current teaching and learning skills and a professional development framework that will help them build these skills. At the same time, the TEs should be given the autonomy to drive and direct their own professional development.

CONSTRUCTING THE COMPETENCY FRAMEWORK

Before developing the competency framework, the development of TEs was done in an ad-hoc manner. For example, if there was a practical that the TE was supposed to take over and the supervisor wanted the TE to "learn the ropes", then they would either shadow an experienced TE (Rony et al, 2019) or they attend a short professional development course.

Often enough, while these professional development episodes conducted usually earn good enough evaluation scores, many TEs did suggest that they wanted a more thoughtful and meaninful learning experience that would allow them to contribute more effectively to teaching and learning in the institution. TEs also indicated with the learning environment changing at break-neck speed, they also wanted to learn new and emerging education technology tools and applications to help them level up. While job shadowing is known to be effective, it requires extensive resources and follow up work that most mentors are unable to provide.

It would have been easy to simply adopt and adapt the current exisiting teaching and learning competency framework for academic staff but considering the unqiue nature of the TE's job profile where teaching and learning is not their full-time job, it would not be prudent to simply "transplant" the competencies directly for the TEs to adopt.

Hence, adapting the procedures implemented by SkillsFuture Singapore, a governmental agency that has created numerous skillsframeworks for various occupations and referencing existing frameworks within Singapore Polytechnic, we decided to conduct a focus-group session where we would:

- Ask TEs to describe the teaching and learning roles that they do on a daily basis
- Map the identified teaching and learning activties into knowledge and skills
- Group these skills into identified teaching and learning domains
- Write the competencies and required performance for these identified domains

References to other competency frameworks were also done to ensure that the full gamut of competencies for teaching and learning would be considered. Feedback provided at the International CDIO Conference in Iceland, 2022 Roundtable was also referenced. Please refer to Figure 1 below for the sample template that was used.

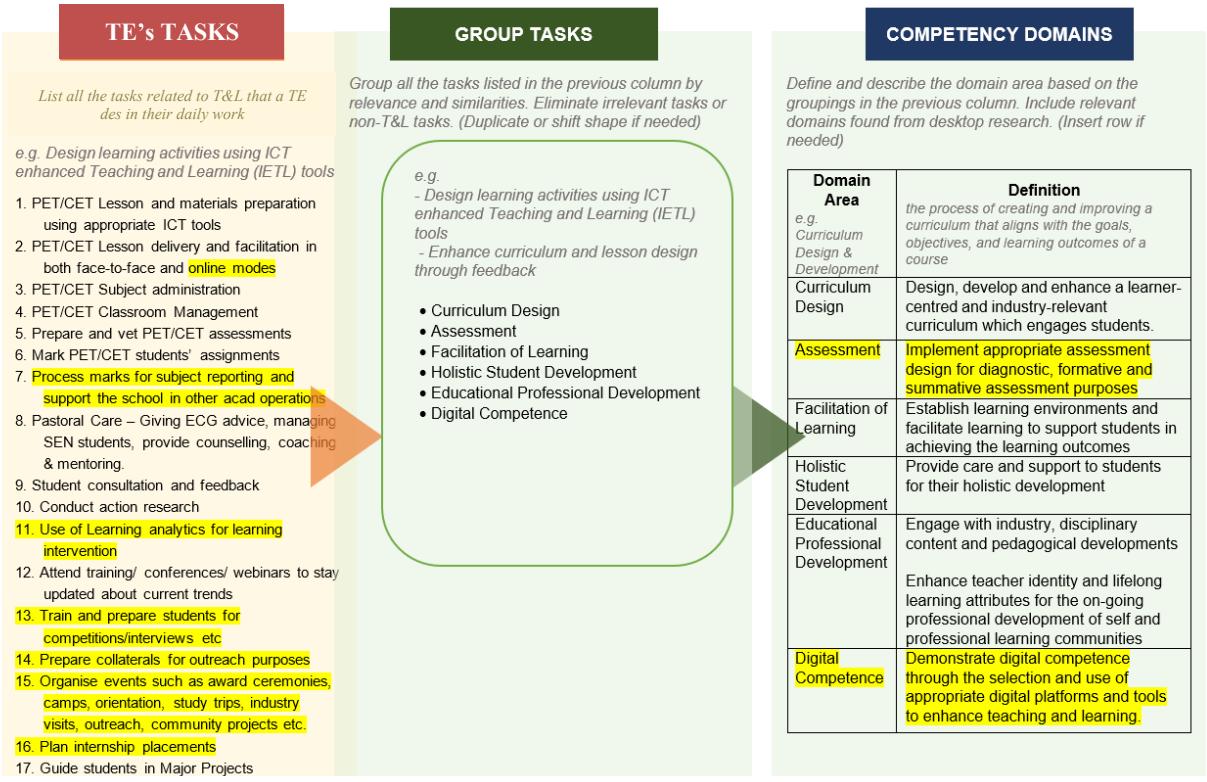

Figure 1. Sample Template to Understand TE Job Roles

A total of 25 TEs and 5 supervisors were invited to these focus group sessions. The sessions for TEs and supervisors were separate as we wanted to ensure that the TEs would be comfortable relating their teaching and learning experiences and to share their development needs in a non-threatening environment.

During the engagement sessions with the TEs, they were encouraged to talk about their work responsibilities in the area of teaching and learning. Key teaching and learning activities were then noted. Facilitators also took the opportunity to clarify if TEs were responsbile for undertaking key tasks in summative assessments. Most of the TEs commented that they do

NOT take part in summative assessment activities but they are required to carry out day-to-day formative assessment activities to check for student understanding. Summative assessment activities are usually left to the programme co-ordinators.

Facilitators also spent time asking about their professional development needs and probed how TEs equipped themselves with the necessary knowledge and skills to be successful in helping students in the CDIO classroom. (Please refer to Appendix 1 for the questions that were used for the focus group discussions)

Subsequently, these activities are then broken down into the specific knowledge and skills that TEs would need to be able to carry out the teaching and learning activities.

When engaging the supervisors of these TEs, the supervisors contributions were largely aligned with what the TEs talked about in their daily work in teaching and learning.

A summary of the key findings that was used to guide the development of the framework and the professional development roadmap is provided below in Table 1.

Table 1. Summary of Key Findings

Key Findings	**Implications for Framework & Roadmap**
TEs need knowledge and skills to translate existing coursework materials and resources into meaningful learning experiences for students	The framework should ideally be looking at competencies that require TEs to translate existing resources and processes rather than for them to create new resources and teaching and learning processes
TEs want to know just enough to be useful and impactful in the learning environment	The training programme has to be concise and meet the specific needs of TEs. It will not be possible to use existing T&L frameworks and ask TEs to comply
TEs need assistance to help motivate students especially when TEs have to compete with social media and other technological applications on mobile devices	TEs acknowledge that they need assistance in managing student learning in light of emerging technology, hence the framework and roadmap should have an emphasis on these competencies
TEs are interested in having the ability to connect and build meaningful student relationships	There is a need to include opportunities for TEs to build these complementary skillsets along the "technical" teaching and learning competencies
TEs would like to be acknowledged for the teaching and learning work the undertake which is not part of their core work	This seems to lean more towards a policy issue and will be brought up with Human Resources

COMPETENCY FRAMEWORK FEATURES

Taking the findings from the focus group discussions, the authors then embarked on a journey of developing the framework and the roadmap that will help define the knowledge and skills needed and the programmes that needed to be developed to alow the TEs to grow in their role in a paced and meaningful manner.

The key idea here was to establish a baseline standard that all TEs should have when embarking on teaching and learning activities in Singapore Polytechnic.

Taking the cue from previous Teaching and Learning Frameworks, the authors grouped the knowledge and skills identified into competency domains. As a result of the focus group discussions, a total of 5 competency domains was established.

The competency domains identified were:

- Learning Design and Development
- Facilitating Learning
- Manage Student Learning
- Formative Assessment
- Reflective Practitioners

Definitions were also developed to clearly explain what these competency domains refer to. From the competency domains, the competencies that would make up the domain were developed through aligning with existing frameworks or creating new competencies that would fit the nature of the work that TEs are doing.

The most challenging component that was developed as part of the competency framework was that of the performance descriptors or the performance statements. There was a plenty of deliberation and reflection before the statements were crafted. Essentially, the authors wanted to ensure that the statements were:

- Accurate in describing the actual work that TEs undertake
- Relevant to the work that TEs undertake in teaching and learning
- Pitched at the correct level to ensure that TEs have a reasonable standard to aspire to
- "Buildable" and would allow for future expansion of the framework once all TEs obtain the basic competencies

Please refer to Table 2 below for an example of one of the competency domains with the corresponding competencies and the performance statement. Please refer to Appendix 2 for the full Teaching and Learning Framework.

Table 2. Example of Comptency Domain in the Teaching and Learning Framework

Teaching and Learning Competency	
Competency Domain 2: Facilitating Learning	
Definition: These competencies focus on equipping Technician Executives with the ability to facilitate learning in a variety of learning environments and to support students in achieving the intended learning outcomes	
Competencies	**Performance Statements**
Facilitate Effective Learning	• Facilitate effective learning for lab demonstrations & classroom learning using a variety of methods • Facilitate student learning for industry based projects based on established CDIO protocols • Use a variety of questions
Using Technology to Facilitate Learning	• Conduct lab demonstrations and classroom learning in an online and face-to-face environment • Use a variety of identified EduTech tools to facilitate learning

Lastly, there was deliberation on whether digital fabrication competencies and CDIO competencies would be needed to be explicity put as a competency domain or to keep the framework solely focusing on teaching and learning baseline competencies with digital

competencies and CDIO cometencies integated within each performance statement. As not every TE engaging in teaching and learning work focuses on digital fabrication, the final decision was to create an annex for the framework that details the digital fabrication skills and to put it as a potential elective for TEs who are actively engaging in such work to undertake this development. Please refer to the next section on Professional Development Roadmap.

As for CDIO specific skills, this will be integrated within the performance statements and for TEs who want to deepen their understanding, can do so by selecting the CDIO elective track in the Professional Development Roadmap.

PROFESSIONAL DEVELOPMENT ROADMAP

Upon completion of the draft competencies framework, the authors wanted to provide a simple to interpret and reference professional development roadmap that would address the key competencies and at the same time give TE's autonomy in deepening their knowledge and skills based on their own identified needs. Rony et al (2019) suggested that professional development programmes that is successful "encourages employee empowerment in carrying out work independently and with high self-confidence'"

The provision of choice and autonomy should hopefully, encourage TEs to plan for their own professional development in a nuanced and paced manner that would take into account their interest areas.

The roadmap adopts the core module and electives approach. This means, TEs are recommended to take a core moduule that will equip them with the most essential teaching comptencies spelt out in the TE framework.

According to McDonald et al (2013) the flipped learning approach to professional development is an effective and efficient approach to adopt for professional development programmes. Hence, the authors have decided to propose to the development team the suggestion to conduct the professional development experience using a flipped learning methodology.

In this instance, all TEs who undertake any kind of teaching and learning work, will need to attend and and pass the core module which is made up of a total of 48 hours. This core modules will ensure that all TEs will be equipped with the most essential competencies as spelt out in the teaching and learning framework.

Upon completing the core modules, TEs have the choice to either stop or deepen their knowledge in 3 elective tracks. These elective tracks were concieved after the authors identfied what were key critical competencies that TEs needed to be successful in teaching and then allowing TEs to focus on other areas of teaching and learning that they were interested in.

For example, not every TE, as part of their teaching and learning work, undertake the development of asynchronous lectures or develop artefacts for online learning. Hence, it was decided to create a elective track for education technology for TEs interested in deepening their competencies in this area. Similar to the core modules, elective modules will be conducted in a flipped learning format supported by opportunities for hands-on learning during the face-to-face component of the flipped learning experience.

Please refer to Figure 2 for the Professional Development Roadmap.

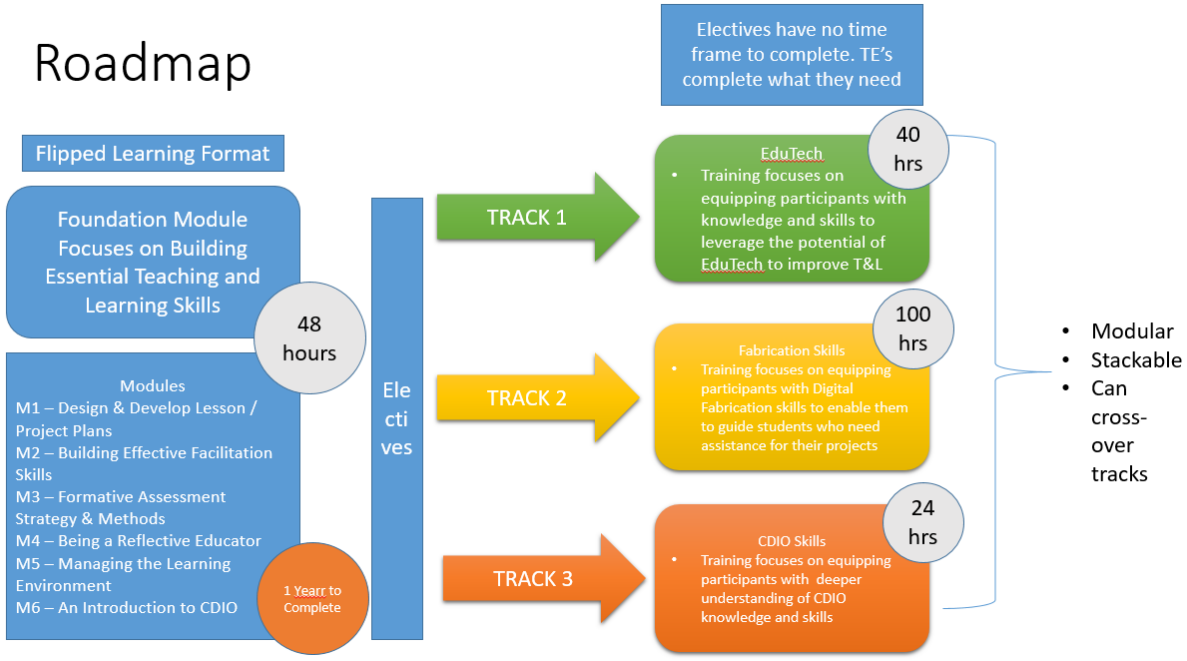

Figure 2. Proposed Professional Development Roadmap

VALIDATING THE FRAMEWORK & THE PROFESSIONAL DEVELOPMENT ROADMAP

Once the necessary stakeholders were consulted to create the competency framework as well as the roadmap, there was a need to validate both artefacts.

A validation exercise was designed and carried out to seek the views of both TEs and the supervisors of TEs to provide feedback and suggestions for improvement. A total of 25 TEs and 5 supervisors were invited to participate in the validation exercise.

A focus group approach was selected and TEs and supervisors participated in separate focus groups to allow both sets of particpants to speak and share their thoughts freely.

The objectives of the validation exercise were as follows:

1. **Relevance**
   TEs and supervisors find the competency descriptors in the Framework and the Roadmap relevant to their work in teaching and learning

2. **Clarity**
   TEs and supervisors find the descriptors clear and adequate to help them develop their teaching and learning skillset

3. **Usefulness / Usability**
   TEs and supervisors find the framework and roadmap useful to identify areas for development

4. **Concerns**
   TEs and supervisors share concerns about the framework (for FAQ when rolled out later) that staff may have and how the concerns could be addressed

Facilitators first gave the framework to the participants and then provided some context and background on how the framework and roadmap was developed. Facilitators then provided the objectives and explained how the validation exercise was to be carried out.

Firstly, participants were provided the Teaching and Learning Competencies Framework and then asked to read it.

Secondly, they were given post-it notes to make specific comments relating to the competencies and the performance statements on whether the statements were relevant and clear.

Thirdly, the Professional Development Roadmap was shared to the participants and they were also given an opportunity to write specific comment relating to relevance and clarity.

After the participants finished writing their comments, facilitators asked questions relating to usability and concerns that participants might have on the framework and the roadmap. Responses were then collated and participants thanked for participating.

Table 3 summarises the responses and the action taken by the authors based on the feedback from the validation exercise.

Table 3. Summary of Responses from Validation Exercise

Objective	Response	Suggested Improvement	Action Taken
Relevance	An overwhelming majority of both sets of participants mentioned that the framework and roadmap was timely tor TEs and they found both the framework and the roadmap relevant	• Both TEs and Supervisors commented that TEs do not actually develop new artefacts (e.g. Lesson Plans) but rather translate existing artefacts • Supervisors proposed another elective track that allows TEs to deepen their knowledge and skills in pedagogy	• Revise competencies with specific statements on development and update it to better reflect the work that TEs undertake • Propose another elective track that deepens knowledge and skills in pedagogy
Clarity	Majority of both sets of participants found the statements in the framework clear and easy to understand and the professional development framework easy to follow and understand	• Provide a glossary of teaching and learning terms that some TEs may be unfamiliar with • Provide synopsis to the different modules that would be offered to give users a preview	• Draft Glossary is currently being developed • Draft synopsis is also being developed together with the developers

Table 3. (Cont'd)

Usefulness / Usability	Majority of both sets of participants found the roadmap useful as it offered "just-in-enough" for the core modules and also considered potential participants' interests through the electives track Supervisors also expressed satisfaction that any new TEs intending to develop themselves in T&L, now have a ready resource to reference While TEs expressed satisfaction in usefulness, they wondered how they can track their own progress when they undertake the programme	• Provide a simple "how-go" guide for users to help them better understand the professional development roadmap • Consider providing a simple tracking approach for TEs	• "How-To" guide will be developed once the framework and roadmap is implemented • To consider developing a tracking approach for TEs
Concerns	TEs expressed a major concern that this framework might be used to evaluate them on their teaching and learning performance TEs wanted to know if they wanted to progress beyond the identified competencies, how would they do it Supervisors expressed their concern if this framework would be made compulsory for ALL TEs to comply to and what their role as a reporting officer would be	As the concerns for the framework and the roadmap are mainly policy issues, the authors will work closely with the department of Human Resources to address these issues before it is implemented	Facilitators assured participants that this framework, for now, will ONLY be used to identify gaps in T&L skills and to provide a solution for TEs to address these gaps, There is no intention to make this an evaluative tool to measure TEs performance in T&L

NEXT STEPS

The immediate next steps would be to make the necessary changes suggested and implement the competency framework and the roadmap. Thereafter, there would be the necessary administrative processes that would help support the impementation that will also need to be put in place. Examples of such features would include a tracking system for attendance and completion of the various programmes and a system that allows for regular reviews and improvements to the framework and the content to the programmes.

Developers have been consulted to begin design and development work for the core modules as well as the modules for the elective track.

Other possible activities include expanding the competency framework which was developed solely for Professional Development purposes to be part of the institution's formalised job scope for TEs. This will require the participation of the institution's Human Resources division and will also need to be discussed and approved at the management level.

Artefacts like recording forms for TEs to track and identify gaps in their own learning can be some useful artefacts that can also be built to support the framework and roadmap.

CONCLUSION

TEs continue to play an important role in supporting CDIO teaching and learning activities in the institution. As they continue to grow into new teaching and learning areas, it is important that we continue to support their growth and development in a meaningful and paced manner.

The competency framework and the professional development roadmap would hopefully be these tools that can help TE's plan ahead and assist them in equipping themselves with the most relevant competencies to build their confidence and skills as they continue to support teaching and learning endeavours in the institution.

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BIOGRAPHICAL INFORMATION

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Appendix 1

Questions used for Focus Group Discussion

- Using Teaching and Learning as a context, can you please describe a typical day for yourself as a TE engaging in teaching and learning
- Please think about the T&L work that you do right now. Can you please describe the tasks that you do
- What are some of the skills that you think you need to be able to carry out these Teaching and Learning Tasks
- What are some possible training that you think will help you in your T&L work?
- What kind of support do you think you will need to support you in your work?

Appendix 2

Technician Executive Competency Framework for Teaching and Learning

Teaching and Learning Competency	
Competency Domain 1: Learning Design & Development	
Definition: These competencies focus on equipping Technician Executives with the ability to design learning in a variety of contexts ranging from laboratory work, classroom teaching, teaching in specialised learning spaces, creating online learning, and module or final year projects	
Competencies	**Performance Statements**
Design & Develop lesson plans / project plans that align with learning outcomes, students' learning needs & module syllabus	• Write constructively aligned lesson plans for different learning contexts • Write project training plans for student projects • Integrate CDIO standards into lesson / project plans • Design and develop a flipped learning lesson • Implement lesson plans provided by module co-ordinators • Implement project supervision plans provided by module-co-ordinators
Apply appropriate teaching & learning methods and technologies that meet required student learning outcomes	• Implement teaching and learning methodologies suggested by module co-ordinators • Integrate EduTech features available in the Learning Management System into lesson / project plans
Create Asynchronous Learning Packages	• Assist lecturers to design and create Asynchronous lectures based on stated specifications using identified tool • Propose Asynchronous lecture designs

Teaching and Learning Competency	
Competency Domain 2: Facilitating Learning	
Definition: These competencies focus on equipping Technician Executives with the ability to facilitate learning in a variety of learning environments and to support students in achieving the intended learning outcomes	
Competencies	**Performance Statements**
Facilitate Effective Learning	• Facilitate effective learning for lab demonstrations & classroom learning using a variety of methods • Facilitate student learning for industry based projects based on established CDIO protocols • Use a variety of questions
Using Technology to Facilitate Learning	• Conduct lab demonstrations and classroom learning in an online and face-to-face environment • Use a variety of identified EduTech tools to facilitate learning

Technician Executive Competency Framework for Teaching and Learning – cont'd

Teaching and Learning Competency	
Competency Domain 3: Manage Student Learning	
Definition: These competencies focus on equipping Technician Executives with the ability to support students in achieving the intended learning outcomes	
Competencies	**Performance Statements**
Motivate Students to meet the Desired Learning Outcomes	• Apply SP's Intrinsic Motivation Framework to motivate students • Use a range of extrinsic motivation methods to motivate students
Manage the Learning Environment	• Use a range of classroom management techniques to ensure a safe learning environment
Build Mutually Respectful Relationships with Learners	• Use a range of techniques and methods to build strong and healthy relationships with students
Manage Socio-Emotional Needs of Students for more Effective Learning	• Identify potential socio-emotional needs of students • Identify and inform relevant stakeholders on the social-emotional needs of students in a variety of learning environments

Teaching and Learning Competency	
Competency Domain 4: Formative Assessment	
Definition: This competencies focus on equipping Technician Executives with the ability to implement formative assessment in their teaching and learning	
Competencies	**Performance Statements**
Use formative assessments in teaching	• Conduct formative assessments to check for student understanding • Use formative assessment data to identify further learning gaps
Collect relevant learning data	• Collect data as directed by module co-ordinator in module plans • Use the ALeRT approach to collect relevant learning data

Teaching and Learning Competency	
Competency Domain 5: Reflective Practitioners	
Definition: These competencies focus on equipping Technician Executives with the ability to manage their teaching and learning identity as well as providing them direction on how they can continue to hone and improve their craft as learning facilitators	
Competencies	**Performance Statements**
Engage in regular reflective practice	• Engage in reflective practice using a choice of approach and method