Improvement of teaching and learning of Chemistry through digitalization pedagogy

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The Department of Chemistry has been unsuccessful in adopting and integrating technology in teaching since 2011 due to the lack of a framework for training teachers in skills and competencies required to successfully implement digitalization pedagogy, engage students and improve student success.

The overall aim of this study was to implement a framework that will improve teaching of online modules and ensure that students engage meaningfully with the online modules. To achieve the level at which teachers in the Department of Chemistry can adopt and integrate technology in teaching, a training framework based on Arena, Blended and Connected learning design was developed and implemented over two weeks via online webinars. The second objective was to develop online modules that encourages students to engage with learning content synchronously and asynchronously. To achieve this, an online module template based on scaffolding of learning content model that breaks up the learning content into smaller chunks, was developed and implemented for 39 modules that were taught online for the period 1 June to 30 November 2020 using MyTUTor, a BlackBoard-based learning management system and virtual learning environment.

All teachers in the Department of Chemistry successfully transformed the chemistry curriculum into digital learning content that is student-centred. All the online modules had a uniform look and feel and were easy to use for synchronous and asynchronous learning. There was a significant improvement in the engagement with MyTUTor by teachers and students in the Department of Chemistry.

The results indicate that 66% of the online module overview page included a welcome message and teacher contact details, 47% gave a module outline with a purpose statement and assessment plan. All modules had the latest study guide and timetable, 79% of the modules had content organized in smaller chunks using scaffolding, 50% of the modules used online assessments. The most significant improvement was 93% of the registered students were actively using MyTUTor and spent an average of 8 h/week engaged with learning content.

Keywords
Digitalization pedagogy, transformative pedagogy, virtual learning environment, chemistry, online modules, teacher training framework
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### Abbreviations

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<tbody>
<tr>
<td>ABC</td>
<td>Arena, Blended and Connected</td>
</tr>
<tr>
<td>DHET</td>
<td>Department of Higher Education and Training</td>
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<tr>
<td>FEBE</td>
<td>Faculty of Engineering and the Built Environment</td>
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<td>FoS</td>
<td>Faculty of Science</td>
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<tr>
<td>IDP</td>
<td>Individual Development Plan</td>
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<td>ISP</td>
<td>Institutional Strategic Plan</td>
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<tr>
<td>LMS</td>
<td>Learning Management System</td>
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<tr>
<td>OECD</td>
<td>Organization for Economic Co-operation</td>
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<td>RQ</td>
<td>Research question</td>
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<tr>
<td>SCSR</td>
<td>Senate Committee for Success Rate</td>
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<tr>
<td>TLT</td>
<td>Teaching, Learning and Technology</td>
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<tr>
<td>TPACK</td>
<td>Technological Pedagogical and Content Knowledge</td>
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<tr>
<td>TUT</td>
<td>Tshwane University of Technology</td>
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<tr>
<td>STEM</td>
<td>Science, Technology, Engineering and Mathematics</td>
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<td>VLE</td>
<td>Virtual learning environment</td>
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1. Introduction

Familiarity with subject knowledge alone is not enough for teachers to engage in effective and pedagogically meaningful instructional practices. Modern curriculum delivery requires teachers to do their best to find innovative ways that not only facilitate but also optimize students’ learning to the greatest extent possible. According to Seery (2013b), the incorporation of technology in teaching is now ubiquitous but such is the amount of possibilities that it can be overwhelming, therefore in considering the incorporation of technology in teaching, a potentially useful method is to consider what it is that needs to be addressed, and how technology can be used to help in that scenario. The intervention must be driven by pedagogy rather than technology.

A virtual blackboard is a learning management tool and virtual learning environment (VLE), designed to act as a virtual learning space for students to access teaching and learning resources, share work, collaborate, co-create and communicate with each other and with their teachers. According to e-learning literature (Rosell, 2020; Bates, 2015; Salmon, 2011) the learning management tools can assist teachers to:

- Improve results
- Increase engagement
- Encourage new and repeat enrolments
- Remove geographical barriers
- Reduce teacher marking and preparation time
- Open communication channels
- Develop community
- Improve the overall experience for both students and teachers

A virtual learning environment supports pedagogical approaches such as flipping the classroom and active learning. According to Deslauriers et al. (2019) despite active learning being recognized as a superior method of instruction in the classroom, most university Science, Technology, Engineering and Mathematics (STEM) teachers still choose traditional teaching methods. A study by Roach (2014) aimed at introducing a flipped learning to increase interaction and active learning in economics reported a significant number of students (76%) responding that flipped learning helped them learn and 94% of students responded that this class was more interactive than other courses they had taken. Results from a scoping review (O’Flaherty and Phillips, 2015) on the use of flipped classrooms in higher education indicate that there is indirect evidence of improved academic performance and student and staff...
satisfaction with the flipped approach but a paucity of conclusive evidence that it contributes to building lifelong learning and other 21st Century skills in under-graduate education and post-graduate education.

A recent development project undertaken in Module 3 of the Haaga-Helia MBA-Education Management Programme for TUT Directors and Supervisors, revealed that teachers in the Department of Chemistry used MyTUTor, a Blackboard-based VLE, mainly for “dumping” PowerPoint slides of the learning unit, sending announcements to students and sharing the latest study guide. This observation is not in-line with the newly approved Tshwane University of Technology’s Teaching, Learning and Technology (TLT) Strategy and does not support student-centred learning. Findings from the development project motivated the project for this MBA thesis.

There has been a steady improvement in the success rate of subjects in the Department of Chemistry, from 56.2% in 2011 to 68.6% in 2019. Since 2013, the success rate has improved significantly to above 65% and has normalized around 69%. In 2015 and in 2018, the department managed to achieve success rates above 70%, 71.3% and 71.49%, respectively. The success rate for the last 9 years, obtained from the TUT management information system (MIS) annual report generated every year for reporting to the Department of Higher Education and Training (DHET) of South Africa, is provided in Figure 1.1 below.

![Figure 1.1: % success rate for the Department of Chemistry in the past 9 years](image)

The improvement in success rate can be attributed to interventions that were introduced in the Department of Chemistry as early as 2011. Some of the interventions are detailed below and
include collaborating with Dutch Universities (University of Groningen and University of Amsterdam and Wageningen University) in 2011 through a Nuffic funded project. Colleagues from the Dutch universities assisted the Department of Chemistry teachers with developing a blended learning approach through workshops held at TUT during October 2011. The collaborative workshops included using MyTUTor, developing modules outcomes, learning activities and assessments (See Appendix 1 for some activities from the E-Chemistry module that was used for training). The training equipped chemistry teachers with basic competencies to use the VLE. In 2012, community of practices (CoP) also known in the Department of Chemistry as Subject Groups were established. The purpose of the CoPs was to facilitate collaboration, co-creating and sharing between teachers in the Department of Chemistry. These CoPs have been a success and still exist to date in the department. From 2015 to date, the DHET has provided the university with funding that can be used by academic departments to support success rate improvement interventions such as purchasing educational tools and resources to improve teaching, learning, tutoring, mentoring and training of teachers, amongst other activities funded. The Department of Chemistry has since 2015 introduced compulsory tutorials in high-risk subjects (Chemistry I, Physical Chemistry II, Physical Chemistry III, Inorganic Chemistry II, Organic Chemistry II) and appointing tutors to assist with tutoring of students in those subjects. High-risk subjects are classified as those subjects with a success rate of less than 60% according to the Senate Committee for Success Rate (SCSR) resolution to improve the graduation rate of students at TUT. In addition, the success rate improvement funds were used in the Department of Chemistry to appoint postgraduate teaching assistants (assist with preparation and monitoring of laboratory practicals as well as teaching and assessing laboratory skills), to purchase chemistry models (used in Organic Chemistry and Physical Chemistry for the learning of concepts such as bonding and molecules) and videos (supplementary learning of chemistry concepts such as matter, chemical bonding, stoichiometry, chemical reactions, etc.). Several teachers have also undertaken teacher training courses and workshops using this funding. Despite all these interventions, the findings from the development project indicate that teachers and students in the Department of Chemistry are not using the VLE effectively for meaningful teaching and learning.

In an attempt to enhance the teachers’ competence in using MyTUTor VLE for teaching and learning in the Department of Chemistry, to improve student engagement and quality of learning that ensures deep learning, this thesis aims to develop and implement a framework for digitalization of teaching and learning using MyTUTor VLE which will be underpinned by building competencies of teachers in the use of technology.
This project is, therefore, important for the realization of strategic goals of the Tshwane University's 2020 – 2025 Institutional Strategic Plan (ISP). Pillar 1 and Pillar 4 as set out in the TUT ISP underpin the strategic goals as follows:

**Pillar 1:**
*Future-ready graduates who make a positive societal impact*

**Goals**
- Deliver research-informed, high-quality teaching and learning experiences to our students.
- Equip our students with knowledge, skills and attitudes to be enterprising and responsible citizens.
- Deploy creative and innovative educational practices in our programmes.
- Engage our students as active participants in their learning experiences.

**Pillar 4:**
*Digitally-Advanced University*

**Goals**
- Deploy digital and smart technologies to enhance student learning experiences, facilitate knowledge creation, increase engagement and accelerate technology transfer.
- Deploy digital technologies to strengthen our internal capabilities to foster sound University governance and deliver effective services.

The Department of Chemistry also stands to benefit from the implementation of the framework developed in this project. The envisaged benefits include: teachers who are competent in digital pedagogy, offering a digitally transformed curriculum, student-centred learning, meaningful engagement with curriculum and improved student success.

### 1.1 Research Objectives

#### 1.1.1 Outcomes

The envisaged development outcomes of the thesis project are:
- Improved competencies in the use of technology, digital pedagogy and digital tools by the teachers in the Department of Chemistry
- Development of MyTUTor online modules that engage students for effective learning
- Implementation of student-centred teaching and learning using MyTUTor VLE
- Improved engagement with MyTUTor online modules by students
1.1.2 Research questions

The research questions (RQ) to be answered for the outcomes are:

**Outcome 1:** Improved competencies in the use of technology and digital tools by the teachers in the Department of Chemistry

*RQ 1:* Can a training framework be developed and implemented to upskill and improve the competencies that the teachers in the Department of Chemistry require to teach effectively using MyTUTor?

**Outcome 2:** Development of MyTUTor online modules that engage students for effective learning

*RQ 2:* Can the Chemistry curriculum be successfully converted into interactive digital modules that engage students and encourage effective learning?

**Outcome 3:** Implementation of student-centred teaching and learning using MyTUTor VLE

*RQ 3:* Can MyTUTor online modules encourage students to engage with learning content actively and collaboratively?

**Outcome 4:** Improved engagement with MyTUTor online modules by students

*RQ 4:* Can the digitalized student-centred curriculum improve the usage of MyTUTor by students?

1.2 Scope

The scope of the thesis will include the following tasks:

1.2.1 Developing a teacher-training framework for upskilling teachers' competencies in integrating technology in teaching.

1.2.2 Determining the learning outcomes of the training.

1.2.3 Developing a template for MyTUTor online modules with a framework that allows scaffolding and chunking of learning content.

1.2.4 Inviting all teachers in the Department of Chemistry, to participate in training for gaining competencies in using MyTUTor functionalities and digital tools for teaching and learning.

1.2.5 Involving the Faculty of Science Instructional Designer for the design of the MyTUTor template and training of teachers.
1.2.6 Conducting a quantitative post-survey of the usage of MyTUTor by students and teachers.

The study will not conduct a perception study to solicit reflective abilities of teachers and students about the use of MyTUTor, since findings of the development project have already indicated that MyTUTor is not adequately used for teaching and learning. For instance, half (56%) of the teachers communicated relevant messages about the module to the students (announcements about changes to the teaching or assessment schedule, uploaded supplementary learning material such as videos, tutorials, etc.). However, the communication is one-way from teacher to the students. Only 53% of the modules used relevant learning resources such as PowerPoint presentations, notes or assessments. The PowerPoint presentations, are however, not interactive, are not video-presentations and do not have a voice recording of the teacher. Only a handful of modules used MyTUTor for assessment purposes and used videos as a tool for anchored-instruction.
2. Theoretical Framework

2.1 Description of the Context

The Department of Chemistry is in the Faculty of Science (FoS) at Tshwane University of Technology (TUT) and is one of the biggest academic departments in terms of number of undergraduate students enrolled, number of programmes offered, number of modules taught and human resources. In addition to teaching the core subjects of the in-house programmes, the department also offers different modules as service subjects to other departments within the FoS and at the Faculty of Engineering and the Built Environment (FEBE). The list of modules included in the study and offered in-house and as service subjects is provided in Appendix 2.

In 2020, the Department of Chemistry enrolled 756 students (711 undergraduate and 45 postgraduate students). The department currently employs 32 full-time academic (25 teachers), technical (4) and administrative and support staff (3) from different cultural backgrounds, with age ranging from 32 to 65 years. Three teachers have completed the Haaga-Helia Vocational Teacher Education Programme, one has completed an online Instructional Design short course offered by the University of the Witwatersrand (WITS) and three have completed an online Teaching with Technology short course also offered by WITS. The teachers are suitably qualified to teach the subject matter, 17 of the 25 (68%) hold a PhD in Chemistry, 7 (28%) hold a Masters in Chemistry and one holds a Bachelor degree in Pharmaceutical Sciences.

A developmental project that I completed in Module 3 of the Haaga-Helia Education Management Programme for TUT Directors and Supervisors, motivated this study. The project titled “MyTUTor usage for learning and teaching in the Department of Chemistry” was a quantitative desktop study with the following objectives:

- To establish the number of modules active on the MyTUTor platform for teaching and learning;
- To conduct an evaluation of the layout, course content, communication and assessment of each active module using the VLE platform for teaching and learning;
- To establish the number of students who are actively using MyTUTor for learning; and to
- To identify development needs and recommend a learning and teaching approach that will support student centred learning.
Findings from the study revealed that the majority of teachers in the Department of Chemistry used MyTUTor, a VLE, mainly for "dumping" PowerPoint presentations of the learning content, for sending announcements to students and sharing the latest study guide. Even though 53% of the online modules contained PowerPoint presentations, the content was, however, not interactive, did not engage the students and did not encourage collaborative or inquiry-based learning. At the end of the study, it was clear that a digitalization pedagogy framework must be developed, for the improvement of teaching and learning in the Department of Chemistry using MyTUTor.

From the findings of the developmental project, it can be concluded that learning in the Department of Chemistry is largely teacher-centred based on the behaviourism learning theory described by Yilmaz (2011). The teacher-centred instruction, is perceived to have a negative impact on developing higher cognitive skills of students, encourages dependency on the teacher and memorizing content (Kompa, 2012). For the Department of Chemistry to produce future ready graduates, as stipulated in Goal 1 of the TUT 2020-2025 Institutional Strategic Plan (ISP), the passive learning methods currently used must be replaced by an active learning pedagogy to prepare learners for their role as global citizens in the future world of work.

2.2 Literature Review

2.2.1 Professional Development of Teachers to Enhance Digital Skills, Practice and Pedagogy

According to the Organisation for Economic Co-operation (OECD) Learning Framework 2030, the world is facing unprecedented social, economic and environmental challenges driven by accelerating globalization and a faster rate of technological developments. A case in point is the recent corona virus pandemic, which forced universities worldwide to suspend all on-campus activities and move to online learning or distance learning either with or without any digital tools. The online article “How Universities are Embracing Online Learning During the Coronavirus Outbreak” reports that “while adapting to this new normal, universities have quickly evolved their digital tools and platforms to ensure uninterrupted educational delivery to their isolated students”. Teachers were expected to transform the way they teach, moving from the traditional contact model to an interactive on-line learning model (Linney, 2020). Due to the changing nature of learning and teaching, there is a growing need for on-going professional learning to equip teachers with skills and competencies needed to adapt to the
ever-changing student demographic and knowledge base, the speed of technological and societal changes (Ngatoro, 2018).

In a review by Mumtaz (2000), studies reveal a number of factors, which influence teachers’ decisions to use ICT in the classroom. These factors include, amongst others, access to resources, quality of software and hardware, ease of use, incentives to change, support, polices, commitment to professional learning and background in formal computer training. It would seem then that the quality of digital pedagogy is strongly correlated with how the professional development approaches at a university respond to the needs of teachers.

According to the TUT Policy on Performance Management and Development (2017) “The employee and his or her line manager shall jointly develop an Individual Development Plan (IDP) to address any competency or other gaps that would impact on the employee’s performance. The IDP is a reflection of the training and development needs of an individual and there is no guarantee that such training will be made available in any given year. There shall accordingly be no rights or expectations in this regard. The IDP must be sent to Human Resources Development by no later than 31 August of each year”.

Upskilling teachers in the Department of Chemistry with competencies that will allow them to integrate technology in teaching for effective learning was part of the IDP that all teachers signed together with the line manager for 2020.

At government level, the South African Department of Basic Education together with the Department of Higher Education and Training (DHET), have developed the “Integrated Strategic Planning Framework for Teacher Education and Development for 2011-2025”. The framework proposes a range of education and development opportunities for teachers and student teachers aimed at improving the quality of teaching and learning in South African schools and universities (DHET, 2011). In 2007, the Department of Education published “The Guidelines for Teacher Training and Professional Development in ICT”. The guidelines were developed for universities and colleges, to be implemented in the Initial Professional Education of Teachers and Continuing Professional Teacher Development curricula with the ultimate outcome of development of the ICT knowledge and skills of teachers to enhance the educational experiences of learners. This implies that all teachers should acquire relevant and appropriate ICT knowledge and skills, and be able to integrate ICT appropriately in teaching, learning and administration. The ICT development levels included in the framework are presented in Figure 2.1. The adaptation and appropriation levels focus on the knowledge,
skills and values to integrate ICT into teaching and learning. Continuing professional development of university teachers can ensure that the teachers’ competence is at adaptation level to effectively add value to the learning process and experience of students, student engagement and the achievement of curriculum objectives.

Figure 2.1: The Teacher Development Framework (adapted from "The Guidelines for Teacher Training and Professional Development in ICT", Department of Education, 2007)

The Australian Government undertook an initiative called Teaching Teachers for the Future, to improve the preparation of future teachers with integrating technology into their practice (Chittleborough, 2014). The study included 28 pre-service chemistry teachers that adopted a technological focus. The results showed that technological knowledge improved the fundamental pedagogical knowledge necessary for teaching chemistry content. All the pre-service teachers demonstrated an understanding of the role of technology in teaching and learning and reported an increased skill level in a variety of technologies.

On the contrary, Tømte et al. (2019) attributes the influence of external processes (government policies and international trends) and internal processes (leadership and staff development) on the digitalisation of teaching and learning in Denmark and Norway higher education landscape. The two countries have a similar education system, however, there was more reported use of technology in teaching and learning in Denmark than Norway. According to the authors, staff development and awareness-raising in Denmark correlate with the use of
digital technology in teaching and learning initiated from government in collaboration with academic leaders.

According to Brown, Conole and Beblavý (2019), there is no 'one size fits all' supply-driven or demand-led model of teacher professional learning (TPL). However, TPL can take a range of formats including: formal courses and masters programmes, specialised and tailored workshops, peer support and mentoring, examples of good practice in innovative learning interventions and use of digital technologies, portfolios of professional practice, teaching and learning conferences, and opportunities for teachers to share and discuss their practice, team-based professional learning and the development of communities of practice.

2.2.2 Transformative Pedagogy

A comprehensive book “Teaching in a Digital Age by Bates (2015) gives a detailed description of fundamental change in education, epistemology and teaching methods, media and technology, modes of delivery and open education, ensuring quality in teaching in a digital age, institutional support as well as scenarios that stimulate imagination and thinking about barriers to change, and the real and exciting possibilities of teaching in the future.

Transformative pedagogies include higher levels of pedagogical practice, are learner-centred, engage higher order thinking skills and include a variety of interactions between learners, content and teachers. The teacher facilitates the students’ identification of questions and develops with them a plan for answering their questions. While the teacher’s own expertise remains a valuable resource, the teacher also employs a wide variety of resources and interventions to help students understand the questions they need to ask and change or deepen their own prior knowledge. The teacher challenges students to uncover facts and concepts in interdisciplinary contexts and build knowledge by observing, hypothesizing, experimenting, and discovering (Khedkar and Nair, 2015).

According to Hamlin (2015), to support pedagogy, the instructional technology system should be capable of supporting a transformative learning pedagogy. This means it should allow for the integration of authentic learning activities as well as learning activities that support collaboration, discourse and reflective thinking by students. The South Africa’s Department of Basic Education Professional Development Framework for Digital Learning (DoBE, 2018) further corroborates that the use of digital tools and resources in transformative pedagogies
enhance deep learning. According to the framework, among many factors to be taken into account when assessing the pedagogical context are:

- Thinking skills
- Information management
- Interactions between learners, teachers and content

At the core of good teaching with technology are three core components: content, pedagogy, and technology. These three knowledge bases (content, pedagogy, and technology) form the core of the technology, pedagogy, and content knowledge (TPACK) framework (Koehler and Mishra, 2009) illustrated in Figure 2.2. The TPACK framework encourages teachers to design pedagogically sound learning activities that maximise the impact of both digital tools and content resources on teaching and learning in a given context (DoBE, 2018). Howard et al. (2020) supports the use of the TPACK framework as it can provide a focus on learning and pedagogy that is typically missing from conceptions of online learning. It is safe to say that TPACK is the basis of effective teaching with technology (Koehler, 2012) and is an essential component of transformative pedagogy (Jan and Chen, 2010). Therefore, teaching successfully with technology requires continuous evaluation of the dynamic equilibrium among all TPACK components as well as continuous training of teachers and adequate ICT support by the university.
There are seven key interdependent dimensions to the TPACK Framework, which are explained briefly below:

**Content Knowledge (CK):** teachers' knowledge about the subject matter to be learned or taught (Koehler, 2012).

**Pedagogical Knowledge (PK):** teachers’ deep knowledge about the processes and practices or methods of teaching and learning. They encompass, among other things, overall educational purposes, values, and aims (Koehler, 2012).

**Technology Knowledge (TK):** knowledge of and about technology (Howard et al., 2020).
**Pedagogical Content Knowledge (PCK):** the transformation of the subject matter for teaching. PCK guides the teachers’ actions when dealing with a specific subject matter in the classroom (Jang and Chen, 2020).

**Technological Content Knowledge (TCK):** knowledge about how the subject matter and technology influence or constrain each other. Teachers must be able to choose a technology relevant to a specific subject matter (Koehler, 2012).

**Technological Pedagogical Knowledge (TPK):** knowledge about the use of information and communications technology (ICT) to implement instructional practices, principles and strategies (Howard *et al*., 2020).

**Technological Pedagogical Content Knowledge (TPACK):** understanding of how technology can be used to represent content, pedagogical techniques to effectively use technology, and how technology can improve learning (Mishra and Koehler, 2006).

There is no perfect digital pedagogy model and there are always challenges and opportunities with the integration of technology in teaching. Some users of the TPACK model have criticized the model for lack of practical examples to explain knowledge required for the crossovers TCK and TPK and how technology fits into these crossovers (Reid, 2016). According to a blog post on TPACK (Rodriguez, 2015), a drawback of the model is that teachers who lack training and IT skills will not adopt the technology in their classroom and inadequate post-training support will discourage the use of technology. Interestingly, an experienced English teacher using the TPACK framework for teaching English found that technology integration in teaching was quite complicated, the teacher had to deal with challenges like IT literacy, internet connection, and lack of ideas to create meaningful tasks using technology (Taopan, Drajati and Sumardi, 2020). To circumvent this, Taopan and co-workers (2020) emphasize the need to support the teaching and learning process in the classroom with sufficient technology and ICT support. Similarly, challenges highlighted by teachers in a private higher institution in Malaysia with using ICT in teaching and learning environment were lack of TPACK teaching and learning skills and ICT support. These challenges were attributed to poor instructional design and 80% of the teachers not using ICT in their teaching and learning environment (Lye, 2013).

Constructivism is a learning theory central to transformative pedagogy. According to Bada (2015) central to the philosophy of constructivism is that learning is an active process. Hence, from a constructivist perspective, the primary responsibility of the teacher is to create and
maintain a collaborative problem-solving environment, where students are allowed to construct their own knowledge, and the teacher acts as a facilitator and guide. Furthermore, Hamlin (2015) adds another dimension that learning environments that are based on social constructivist learning principles can enhance transformative pedagogy. Donnelly (2008) implemented a constructivist learning approach in a blended problem-based learning module. Findings of the study indicate that some aspects of constructivist learning may be directly stimulated by using technology, the findings noted an increased level of collaboration and that involvement with content is often reinforced by technology use. Interesting observations were made by van Leeuwen et al. (2014) in a study aimed at examining the way teachers guide collaborating groups of students in a digital learning environment. Teachers used supporting tools that present summaries and visualizations and allows analyses of student participation. When presented with the supporting tools, the researchers observed that teachers and student teachers were better able to spot the problems regarding participation, intervened more often in problematic groups as time progressed, and displayed more specific explanations of their actions.

2.2.3 Harnessing Technology in Pedagogy

Universities, through properly designed learning spaces and technology will be in a better position to support pedagogies of collaboration, active learning environment, students’ engagement, flipped instruction and problem-based learning (PBL), which are all student-centred. According to Lee and Im (2014), integrating educational technology can maximize educational outcomes through innovative teaching and learning methodology. The main emphasis is on how technology can be included in various stages of curriculum delivery. It is perceived that the blending of online materials with in-class delivery can assist both classroom and laboratory teaching. Examples of the use of technology in student-centred pedagogies are detailed below.

2.2.3.1 Flipped learning

The flipped classroom fosters student ownership of learning through the completion of preparatory work and being more interactive during actual class time (O’Flaherty and Phillips, 2015). The authors affirms that this pedagogical approach is advantageous because it allows students to learn at their own pace and that they may have flexibility of when they engage with electronic resources. Furthermore, it frees up actual class time for robust discussion and
associated problem solving activities related to the aforementioned resources, and that these discussions could be initiated by the students, not the teacher.

Lee and Im (2014) present the “e-education 3.0” flipped instruction model proposed by the Ulsan National Institute of Science and Technology (UNIST) in Korea, which they argue is possible with established infrastructure and course redesign. The flipped instruction model for the Physics I module consist of three stages: pre-class, in-class, and after-class and is depicted in Figure 2.2.

![Figure 2.2: Class activities in the flipped instruction for the Physics I module (adapted from “Innovation of Higher Education in the Globalized Era” Lee and Im, 2014)](image)

In a paper presented at the International Conference on Initiatives in Chemistry Teacher Training, Seery (2013b) asserts that technology has the potential to assist teachers. However, he warns that an overwhelming amount of technology can make it difficult for new practitioners to know where to begin in the process of selecting fit-for-purpose technologies. The paper highlights some teaching scenarios that can be effectively addressed by incorporating technology into the Chemistry curriculum delivery. These include the following:

- **Pre-class activities** to present some information in advance of classes, and allow learners to check their understanding of this material;
- **Wikis** for facilitating group work and providing a mechanism for tracing each group member’s contribution;
- **Worked examples** to demonstrate problem solving approaches for basic problems;
- **Podcasting and screencasting** for providing supplemental revision material for all learners.

Figure 2.3 illustrates a typical flipped instruction framework where technology can be incorporated to supporting teaching at various stages of curriculum delivery.

Figure 2.3: Incorporation of technology to support teaching at various stages of curriculum delivery (adapted from “Harnessing Technology in Chemistry Education” Seery, 2013a)

### 2.2.3.2 Problem Based Learning

Donnelly (2008) defines problem-based learning (PBL) as an educational strategy that involves the presentation of significant, complex and “real-world” problems to students that are structured in such a way that there is not one specific correct answer or predetermined outcome. The author further describes the blended learning approach in their study as a form of complex blending in that it combines face-to-face and online PBL. The blended PBL model was originally developed by Oliver (1999). Figure 2.4 shows the implementation of a typical blended PBL module.
A higher-level Environmental Analytical Chemistry module, which included inquiry-based approaches, case methodology and PBL concepts was designed by Ramstedt and co-workers (2016). Technology was adopted to support students in their inquiry based learning processes by using online logs, group wikis and quizzes and with sections of laboratory work. From the feedback, students expressed that the adopted social-interactive technology enhanced their learning, made their learning more visible to them, guided them to solve learning problems in new ways (e.g., by summarising knowledge in the individual log and group wiki) and led them further to develop skills such as reflection and source criticism (Ramstedt et al., 2016).

2.2.4 Technology Tools for Learning

There are many software applications that offer a blend of synchronous and asynchronous technology, which can enhance collaborative learning. The list is not exhaustive but provides the most commonly used technology, supported by learning management systems (LMS):
Online discussions: Blackboard Collaborate allows teachers and students to interact with each other synchronously and asynchronously. This tool can be used to support online learning via live lectures, question and answer sessions, conference calls, webinars, virtual office hours, and much more. Teachers and students can present a PowerPoint, video, etc. while students/teachers ask/answer questions via the chat or by responding with a microphone (Blackboard.com, 2020).

Podcasting and Screencasting: A podcast (audio only) and screencast (audio with video or screen capture) allows students to recover material in their own time at their own pace (Seery, 2013b). By augmenting material given in classes, podcasting allows students to recover material (substitutional podcasts), to address material in a more active way (supplemental podcasting), or to hear feedback on work completed incorporating the richness of the tone of voice that written text lacks (Seery, 2012).

Wikis: Wikis are web applications that allow groups to add, delete and edit content on a web page in collaborative development efforts. The most famous wiki is Wikipedia, which is considered the bane of their existence by many faculty members but at the same time considered a treasure by students worldwide. Wikis have been used in a multitude of ways and lately schools at several levels have been experimenting with assignments that require student groups to work together in creating a wiki on some topic. Obviously, the collaboration aspect of wikis addresses social learning elements in situated learning as well as the transformative learning design process (Hamlin, 2015).

Gamification: Educaplay make it easy to create groups for dissemination of activities. Educaplay provides a wide range of activities that can be created, such as dictation, interactive maps and quizzes. It allows the exchange of pedagogical content among teachers and the collection of tips and tricks from their fellow teachers in order to improve and update the content and learning activities (Moreno, Heidelmann and Correia, 2018).

Video: TED-Ed is an online software available at http://ed.ted.com. The software is very malleable in that any video that is currently listed on YouTube or in the TED Talks directory can be used and questions can easily be created to follow along with the video. Within the TEDEd software, there are options to allow for open-ended or multiple-choice questions that students can answer and receive feedback on. In addition, the instructor is able to add supplementary commentary and links after the video to help students find additional information (Roach, 2014).
**Augmented Reality:** Using the combination of virtual and reality methods can increase understanding in learning. Augmented Reality (AR) offers a mixed reality, which incorporates the digital environment in the real world (Jamali, Shiratuddin and Wong, 2014). AR is an emerging technology, which is anticipated to begin to play a key role in the workplace too, so engaging students with this type of technology will set them up with lifelong skills (Ramirez, 2015).

**Simulation:** PhET is a set of interactive, research-based science and mathematics online simulations. The simulations open source code allows for modifications and re-designs by teachers and students (Moreno, Heidelmann and Correia, 2018).
3. Methodology

3.1 Introduction

The research approach adopted for this study is action research and quantitative analysis of the data. Bryman and Bell (2011: 712) define action research as “an approach in which the action researcher and a client collaborate in the diagnosis of the problem and in the development of a solution based on the diagnosis”. Action research is applied in order to improve specific personal or organizational practices and can be used to collect both quantitative and qualitative data (Bryman and Bell, 2011: 415). The process of action research, illustrated in Figure 3.1, consists of the following key steps, which may overlap at any given point of the study.

- Planning in order to initiate change
- Implementing the change (acting) and observing the process of implementation and consequences
- Reflecting on processes of change and re-planning
- Acting and observing
- Reflecting

Figure 3.1: Action research process (adapted from “Action Research” Dudovskiy, 2020)
The most important reasons, cited by Bauer and co-workers (2017), for engaging in action research in the field of education are: (1) the improvement of teaching skills, (2) improving the quality of teaching and learning (3) the development of schools as learning organizations. According to Apuke (2017), quantitative research deals with quantifying and analysing variables using specific statistical techniques to answer questions like who, how much, what, where, when, how many, and how. Preliminary data from the development project “MyTUTor usage for learning and teaching in the Department of Chemistry” conducted in December 2019 as part of Module 3 of the Haaga-Helia Education Management Programme for TUT Directors and Supervisors, indicated that teachers in the Department of Chemistry’s engagement with the MyTUTor, a Blackboard-based learning management system and virtual learning environment did not support student-centred learning. The chosen research model, necessitated reflection on the preliminary data that was collected in the development project conducted in 2019, before planning the project for this thesis. A framework based, on TPACK model, for implementing digitized pedagogy in the Department of Chemistry to bring transformative change in teaching and learning was then developed, against this backdrop.

This action research study was carried out in four phases as follows:

**Phase 1: Planning** included sharing the preliminary findings, reflection on previous information, identifying and limiting the research topic, developing research outcomes and research questions, reviewing literature and developing a research plan.

**Phase 2: Acting and Data Collecting** included implementing the research plan and collecting data.

**Phase 3: Data Analysis** using a rubric, statistics and historical data.

**Phase 4: Reflecting and Disseminating** included reflecting on the research process and learning process. Finally, the research findings and recommendations will be shared and communicated through this thesis, information seminars and publications.

### 3.2 Experimental Design

On Monday 23 March 2020, a national lockdown in response to the Covid-19 pandemic was announced in South Africa. Tshwane University of Technology implemented a remote multimodal teaching and learning strategy from 1 June 2020. This required an unprecedented rapid transition from face-to-face teaching to online teaching and learning. This necessitated the
initial proposed training schedule to be amended and shortened from 4 months (1 March 2020-31 July 2020) to two weeks (14-17 April 2020 and 11-15 May 2020) to ensure that teachers have the necessary technological skills and competencies to teach remotely.

Given the short timeframe to transition to online teaching and learning, there was limited time for teachers in the Department of Chemistry to upskill and prepare for implementation of the university’s remote multi-modal teaching and learning strategy. The Arena, Blended and Connected (ABC) learning design approach was used for training teachers to develop online modules. The ABC curriculum design, according to Young and Perović (2018) is a quick way to (re)design programmes and modules through a hands-on workshop where academic teams discuss and create storyboards of students’ activities. A minimal version of the ABC learning design adapted from Young (2020) was followed and consisted of the following elements:

- **Pre-workshop**: resources provided for teachers to engage with before each session
- **Live session**: daily using Bb Collaborate for about 1 hour 30 minutes
- **Post-workshop**: consisted of support provided through a community of practice WhatsApp chat group

### 3.2.1 Developing a framework for improving teaching and learning in the Department of Chemistry using digitalization pedagogy

To develop a successful framework that will improve teaching and learning using digitalization pedagogy and TPACK principles, it was important to first reflect on the findings of preliminary study, which was conducted in 2019 in order to develop a plan that will improve the teaching and learning practices. From the findings it was evident that a systematic approach was required for training of teachers to ensure that they possesses skills, values and attributes central to transformative pedagogies that are student-centred, engage higher order thinking skills and include a variety of interactions between students, content and teachers. A teacher development framework and a framework for designing online modules were developed and implemented. Thereafter, to evaluate the quality of the designed online modules, a rubric was developed. Finally, a quantitative study of the engagement of students with the learning content was done using data of modules taught during the first semester of 2020.
3.2.1.1 Teacher Development Framework

The experimental methods used were designed in such a way that the research questions will be answered and the outcomes of the study achieved.

| Outcome 1 | Improved competencies in the use of technology and digital tools by the teachers in the Department of Chemistry |
| RQ 1 | Can a training framework successfully upskill and improve the competencies that the teachers in the Department of Chemistry require to teach effectively using MyTUTor? |

A teacher-training framework was developed to upskill teachers in the Department of Chemistry with technological skills and TPACK pedagogical approaches to teaching online modules. The framework was designed and developed with the assistance of a Senior Instructional Designer in the Faculty of Science. The training framework consisted of 10 learning units with learning outcomes (see Table 3.1 for the Framework for remote training of teachers). Due to the national lockdown, training was conducted online, using Blackboard Collaborate tool of the LMS, MyTUTor. A MyTUTor online module 64911e named “Emergency Remote Support” was created and all 25 teachers were registered as students in the module. Training took place twice daily (morning and afternoon) for 2 hours over two weeks (14-17 April 2020 and 11-15 May 2020), a link to the live session was sent daily to teachers using the announcement tool of the LMS and also using a WhatsApp chat group that was established for the teachers to stay connected during the lockdown. A flipped learning approach was used. Teachers had access to the learning content and activities on myTUTor before the online session and could also engage the learning content at their own time and pace. Training was hands-on, teachers were provided with step-by-step instructions of how to design and develop modules, how to choose the relevant technology and tools for their subject matter and how to integrate technology in teaching online modules. All training sessions were recorded, to monitor attendance and so that the teachers can revisit any session that they need to, at their own time. At the end of the training, an “online teaching tool box” was developed and shared via email with all teachers to ensure that they engage with the training material at their own pace. The toolbox contained links to all the recorded training webinars, standard operating procedures of how to develop an online module using the standardized template, how to record audio over PowerPoint presentations, how to create online assessments and rubrics and how to use different technology tools, which are compatible with the MyTUTor LMS and VLE and many other useful resources for online teaching and learning.
### Table 3.1: Framework for remote training of teachers

<table>
<thead>
<tr>
<th>Unit</th>
<th>Learning Unit and Learning Outcomes</th>
<th>Duration</th>
<th>Date</th>
<th>Time in Session</th>
</tr>
</thead>
</table>
| 1    | Transition from traditional to remote teaching: Introduction to interactive remote module development  
Outcomes: 
- Prepare online teaching and learning material using a storyboard/course map/module descriptor | 2 h      | 14/04/2020 | 09:00-11:00          |
|      |                                     |          | 11/05/2020 |                       |
| 2    | Exploring Tools on myTUTor         | 2 h      | 14/04/2020 | 12:30-14:30          |
|      | Outcomes: Understand the different functionalities of MyTUTor  
- Content tools 
  - myTUTor server  
  - Folder  
  - Items  
  - File  
- Test 
  - myTUTor Test  
  - Microsoft form  
  - Respondus  
- Assignment 
  - Rubric  
  - Plagiarism  
- Collaboration 
  - Discussion Forum  
  - Journal  
  - Wiki  
  - Blog  
- Communication 
  - Announcement  
  - Email  
  - Calendar  
- Live teaching/Webinar 
  - Collaborate |          | 11/05/2020 |               |
- Creating Groups
- MyTUTor Management tools
  - Reports
  - Grade Centre (Marking)
  - Monitoring and Tracking students (Retention Centre)
- Enterprise Survey (Student lecturer evaluation)

| 3 | Design and developing online modules using the myTUTor structured template | 2 h | 15/04/2020 | 09:00-11:00 |
|   | Outcomes:                                                                 |     |            |             |
|   | • Create a Welcome Page                                                    |     |            |             |
|   |   - Insert the Department banner in the module landing page               |     |            |             |
|   |   - Create a text welcome statement                                       |     |            |             |
|   |   - Record a short welcome video using your smartphone and upload it on MyTUTor |     |            |             |
|   |   - Upload a headshot picture, add lecturer details and consultation time |     |            |             |
|   | • Write a module overview with module purpose statement, module outline and assessment plan |
|   | • Populate Learning Content on myTUTor server                             |     |            |             |
|   |   - Create Folders                                                        |     |            |             |
|   |   - Upload files in relevant folders                                       |     |            |             |

| 4 | Design Learning Activities: As indicated in the module descriptor          | 2 h | 15/04/2020 | 12:30-14:30 |
|   | Outcomes                                                                 |     |            |             |
|   | • Use ABC learning activities                                              |     |            |             |
|   | • Create short quizzes and exercises                                       |     |            |             |
|   |   - Microsoft forms                                                       |     |            |             |
|   |   - Respondus                                                              |     |            |             |
|   |   - myTUTor quiz tool                                                     |     |            |             |

| 5 | Design Assignments and Assessments                                        | 2 h | 16/04/2020 | 09:00-11:00 |
|   | Outcomes:                                                                 |     |            |             |
|   | • Design, load, release and time assignments and assessments               |     |            |             |
|   | • Design formative and summative assessments                               |     |            |             |
|   | • Use SafeAssign for plagiarism check                                      |     |            |             |
- Create a Rubric for online assessments

<table>
<thead>
<tr>
<th></th>
<th>Design Communication and Collaboration</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td><strong>Outcomes</strong></td>
<td>2 h</td>
<td>16/04/2020</td>
</tr>
<tr>
<td></td>
<td>• Communicating with students using MyTUTor</td>
<td></td>
<td>13/05/2020</td>
</tr>
<tr>
<td></td>
<td>o Create an announcement</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Send Emails to students and different class groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Create a calendar for the module</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Collaboration with and by students</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Create and manage a discussion forum</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Use a MyTUTor journal for reflection</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Remote teaching with Bb Collaborate</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td><strong>Outcomes</strong></td>
<td>2 h</td>
<td>17/05/2020</td>
</tr>
<tr>
<td></td>
<td>• Create a Bb Collaborate/webinar session</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Setting time and date and releasing the link using MyTUTor announcements or TUT email</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Functions of Bb Collaborate (recording the session, mute participants, video, chat, raise hands, etc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Creating breakaway sessions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Dry run before the session</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Saving and uploading the screencast of the webinar on the LMS</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Creating Groups on myTUTor</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>8</td>
<td><strong>Outcomes:</strong></td>
<td>2 h</td>
<td>17/04/2020</td>
</tr>
<tr>
<td></td>
<td>• Use create interactive tools</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Social Media tools: Facebook, WhatsApp, Twitter, YouTube Videos</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Create Social media groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Link social media tools on LMS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Scaffolding learning content</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td><strong>Outcomes:</strong></td>
<td>2 h</td>
<td>18/04/2020</td>
</tr>
<tr>
<td></td>
<td>• Design and develop online learning units</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- Create a learning unit folder
- Write learning unit outcomes and assessment criteria
- Develop a PowerPoint presentation with audio narration, add links to web resources, audio and video
- Upload learning material (Notes, Videos, PPT/Video PPT, Audio files, PDF, etc.) using links tool

<table>
<thead>
<tr>
<th></th>
<th>Monitor, track and discover students at-risk</th>
<th>2 h</th>
<th>14/04/2020</th>
<th>12:30-14:30</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Outcomes</td>
<td></td>
<td></td>
<td>15/05/2020</td>
</tr>
<tr>
<td></td>
<td>Activate Retention centre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Downloading module reports</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.2.1.2 Framework for MyTUTor online modules in the Blackboard Virtual Learning Environment

| Outcome 2 | Development of MyTUTor online modules that engage students for effective learning |
| RQ 2      | Can the chemistry curriculum be successfully converted into digital interactive modules that engage students and encourage effective learning? |

A template was developed as a framework for MyTUTor modules. The template provides a standardised structure that ensures that all modules have the same look and feel. The Senior Instructional Designer assisted with the design of the template, implementation and quality assurance of the template. The framework of the template is detailed in Table 3.2.
Table 3.2: Design template of MyTUTor modules

<table>
<thead>
<tr>
<th>Module name and code</th>
<th>Department of Chemistry Banner</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module Overview</strong></td>
<td></td>
</tr>
<tr>
<td>Welcome message</td>
<td>Short video clip introducing the module</td>
</tr>
<tr>
<td>Module teacher and contact details</td>
<td>Headshot photo of teacher</td>
</tr>
<tr>
<td></td>
<td>Name, Title</td>
</tr>
<tr>
<td></td>
<td>Office number</td>
</tr>
<tr>
<td></td>
<td>Consulting hours</td>
</tr>
<tr>
<td></td>
<td>Email</td>
</tr>
<tr>
<td></td>
<td>Telephone number</td>
</tr>
<tr>
<td>Module overview</td>
<td>Module purpose statement</td>
</tr>
<tr>
<td></td>
<td>Module outline with assessment plan</td>
</tr>
<tr>
<td>MyTUTor tips</td>
<td>MyTUTor support contact details</td>
</tr>
<tr>
<td></td>
<td>TUT Wi-Fi support contact details</td>
</tr>
<tr>
<td></td>
<td>How to activate a TUT email</td>
</tr>
<tr>
<td></td>
<td>How to submit and assignment</td>
</tr>
<tr>
<td></td>
<td>How to complete an online assessment</td>
</tr>
<tr>
<td></td>
<td>How to download Office 365 to a computer</td>
</tr>
<tr>
<td>Announcements</td>
<td></td>
</tr>
<tr>
<td><strong>Course Content</strong></td>
<td><strong>Study Guide and Practical Guide</strong></td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td><strong>Timetable</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Learning Content</strong></td>
<td>Learning units with credits and hours</td>
</tr>
<tr>
<td></td>
<td>Learning units outcomes</td>
</tr>
<tr>
<td></td>
<td>Learning activities</td>
</tr>
<tr>
<td></td>
<td>Link to webinar/Bb Collaborate</td>
</tr>
<tr>
<td><strong>Prescribed and Recommended Resources</strong></td>
<td>Prescribed textbook</td>
</tr>
<tr>
<td></td>
<td>Recommended textbooks</td>
</tr>
<tr>
<td></td>
<td>Supplementary reading material, eResources and videos</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td>Tests</td>
</tr>
<tr>
<td></td>
<td>Assignments</td>
</tr>
<tr>
<td></td>
<td>Tutorials</td>
</tr>
<tr>
<td><strong>Discussion Board</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Reflection</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Student Results</strong></td>
<td></td>
</tr>
<tr>
<td>Outcome 3</td>
<td>Implementation of student-centred teaching and learning using MyTUTor VLE</td>
</tr>
<tr>
<td>----------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RQ 3</td>
<td>Can MyTUTor online modules encourage students to engage with learning content actively and collaborative?</td>
</tr>
</tbody>
</table>

The ensure that the online module is easy to use and to encourage student engagement with learning content, the template’s design is based on scaffolding of learning content model that breaks up the learning content into smaller chunks (Alber, 2014). The developed template (Table 3.2) is customized in such a manner that the curriculum is presented in small chunks of work called learning units, which are arranged, in separate folders. Inside each learning unit folder, the learning unit outcomes, link to Bb Collaborate live session, learning content, learning activities, assessments and assignments can be easily located.

<table>
<thead>
<tr>
<th>Outcome 4</th>
<th>Improved engagement with MyTUTor online modules by students</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ 4</td>
<td>Can the digitalized student-centred curriculum improve the usage of MyTUTor by students?</td>
</tr>
</tbody>
</table>

Activity overview reports were generated from MyTUTor “Course Reports” tool for each module. The reports were downloaded in PDF format and saved on the researcher’s laptop. The only filters applied were the first day of the report (1 June 2020) and the last day of the report (30 November 2020). Only the first page of the report “Course Activity Overview” was saved to protect the identity of students enrolled in the module. Reports were not generated for individual students but a report detailing an average of the activity of all students enrolled in the module was generated. The report comprised the following data:

- Course Name
- Course ID
- Number of Students
- Number of Active Students
- Date Range
- Student Activity By Day
- Total Time in Course
- Average Time Per Active Student
3.3 Instruments and Data Collection

Historical data of 39 modules offered by the Department of Chemistry from 1 June 2020 to 31 November 2020 was retrieved from MyTUTor LMS on 3 December 2020. A list of the modules is provided in Appendix 2. A course activity overview report displaying the number of students, the number of active students and average time spent on the module per active student was generated for each module that was offered between 1 June 2020 to 31 November 2020. An example of the report is illustrated in Figure 3.1.

![Course Activity Overview](image)

Figure 3.1: A module activity report downloaded from MyTUTor LMS

A rubric (Figure 3.2) listing the criteria used in assessing module design was developed using Microsoft Excel (2016). A quality rating using a descriptor **Yes** or **No** was applied to evaluate the module design.
3.4 Data Analysis

Microsoft Excel, a spreadsheet software was used to capture the MyTUTor usage statistics and module design rubric results. MyTUTor usage statistics and module design quality results from the 2019 development project were compared to those obtained in 2020 after implementation of the digitalization pedagogy framework in the Department of Chemistry. Data was arranged using pie charts and bar graphs for interpretation and comparison purposes.
4. **Implementation and Outcomes**

This chapter provides a discussion of the implementation of the framework of digitization pedagogy in the Department of Chemistry and the findings of the study.

4.1 **MyTUTor online module template**

A standardised template for MyTUTor modules was developed taking into consideration that online teaching and learning at the Department of Chemistry is a blend of synchronous (live lectures online) or asynchronous (work at own pace). In synchronous teaching and learning, the lecturer and students have instantaneous or “real-time” interaction (Shank, 2020). The class met at a set time online via Blackboard Collaborate, a tool used on myTUTor for this purpose. MyTUTor also allows asynchronous teaching and learning, where students are self-paced, and can interact with the learning content and materials, such as online audio, video and discussion forums, at the time and place suitable to them (Shank, 2020).

The developed MyTUTor online module template is intended for students to interact with learning content in both asynchronous and synchronous learning activities, and use asynchronous activities provided by the teachers in the VLE, to further engage with the content at a student’s own pace. Figure 4.1 indicates examples of synchronous and asynchronous components in the MyTUTor online module. This blended approach often leads to deeper processing and retention of knowledge (Dalto, 2020). According to Dalto (2020), people do not learn from interacting with content only, however, they learn from processing that content and through social interactions. Therefore, blending content interactions (asynchronous learning) and social interaction (synchronous learning) leads to effective learning.
To support asynchronous teaching and learning, the template was then developed to present learning content in chunks to make it easy and simple for the students to know what is expected of them in each learning unit. Breaking complex learning content into smaller chunks reduces cognitive load in online learning, allows the learner to control the speed of learning and to process the information more effectively (Guyan, 2013).

Learning content in MyTUTor modules were structured to maximize retention and promote student success. Figure 4.2 illustrates an example of a MyTUTor module (Analytical Chemistry I) structured using the scaffolding and chunking design approach.
The design of the module is very simple and can be copied to design any online module in the Blackboard LMS. The module design has three main sections: **Module Overview**, **Module Content** and **Student Results**, that are scaffolded on the left hand side of the module-landing page. Each section is broken down in easy to follow chunks of information that can be accessed using links. For instance, clicking the “Learning Content” link will open up learning units which are arranged in scaffolding folders. Inside each learning unit folder, the learning content is arranged as follows:

- Learning outcomes
- Assessment criteria
- Learning Material (which can be a blend of the following):
  - PowerPoint presentation
  - Lecture Notes
  - Videos or YouTube video
  - Podcast
  - Live teaching or webinar
  - Relevant website & Additional reading
- Interactive Learning Activities (which can be a blend of the following):
  - **Collaboration** (Chats, WhatsApp, Facebook etc.) module related questions not marked
- **Discussion** (group activities, discussion forum, video conferencing synchronous [at the same time] and asynchronous [on your own time] etc.)
- **Investigation** (digital tools to collect and analyze data e.g. Respondus Survey, Microsoft Forms, Google forms, Student lecturer survey, search engine [Google Scholar, Electronic Resource TUT online Library] etc.)
- **Practice** (Simulations, Augmented Reality, Virtual labs, Virtual reality etc.)
- **Producing** (Assignments, ePortfolio, slides presentation, models etc.)
- **Assessments**
  - Short quizzes
  - Self-assessment
  - Formal tests
- **Reflection** (Journal)

### 4.2 Remote training of teachers

Department of Chemistry teachers were provided training to acquire skills and competencies required to teach using a blended online approach. All the 39 modules on MyTUTor had the same design framework and teachers were trained to develop their modules using the MyTUTor module template. The intended learning outcome for the remote training of teachers webinars was that all teachers in the Department of Chemistry, upon completion of the two weeks training, should possess relevant and appropriate ICT knowledge, skills, values and attributes to be able to develop interactive teaching and learning material which will be integrated into MyTUTor VLE to engage students and for students to engage with learning content synchronously and asynchronously.

The South African Department of Education’s Teacher Development Framework detailed in “The Guidelines for Teacher Training and Professional Development in ICT” (Department of Education, 2007) presented in Figure 2.1 was used to benchmark the level and skills at which the Department of Chemistry teachers are expected to engage and use technology in teaching and learning. The framework has three competency levels: **Basic**, **Intermediate** (Integrate ICT into teaching and learning) and **Advanced** (Specialization and Innovation in ICT in education). It was assumed that all teachers have basic ICT knowledge and skills to use ICT at a basic level, and correspond to the entry and adoption levels of the framework. The training was then intended to upskill the teachers to the level of adaptation and appropriation which focus on the knowledge, skills and values to integrate ICT into teaching and learning.
To evaluate if the developed training framework, presented in Section 3.2.1.2, achieved the intended learning outcomes and that Department of Chemistry teachers possessed intermediate ICT skills and competencies that allowed them engage MyTUTor at the level of adaptation and appropriation of technology, the different aspects of the module design and usage for teaching and learning were evaluated using the developed rubric (Figure 3.1) and reported using pie charts below.

4.2.1 Module homepage with a Department of Chemistry banner

All modules complied with this basic requirement. An example of a MyTUTor online module with the standardized Department of Chemistry banner is illustrated in Figure 4.3 below.

![Module homepage with a Department of Chemistry banner](image)

Figure 4.3: A MyTUTor online module homepage with a Department of Chemistry banner

4.2.2 Module Overview

The module overview (Table 4.1) which is designed using scaffolding and chunking of information must contain the following basic components, which are in the developed MyTUTor online module template (Figure 4.2):

![Module Overview](image)
Table 4.1: Components of the module overview in the MyTUTor online module

<table>
<thead>
<tr>
<th>Module Overview</th>
<th>Welcome message</th>
<th>Short video clip introducing the module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module teacher and contact details</td>
<td>Headshot photo of teacher</td>
<td>Name, Title</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Office number</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Consulting hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Email</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Telephone number</td>
</tr>
<tr>
<td>Module overview</td>
<td>Module purpose statement</td>
<td>Module outline with assessment plan</td>
</tr>
<tr>
<td>MyTUTor tips</td>
<td>MyTUTor support contact details</td>
<td>TUT Wi-Fi support contact details</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How to activate a TUT email</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How to submit and assignment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How to complete an online assessment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How to download Office 365 to a computer</td>
</tr>
<tr>
<td>Announcements</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An assessment of the module overview (Figure 4.4) indicated that 63% of online modules had a welcome message in the form of text and a short video clip, 68% of the modules included contact details of the module teacher in the module overview and 89% of the teachers were sending announcements to communicate with students using MyTUTor function of the module design. Only 47% of the MyTUTor online modules had a module outline with purpose statement and assessment plan. This could be attributed to the fact that this is a new feature that was included in the design of the MyTUTor online modules, even though this information is already available in the module descriptors, which were used in “Learning Unit 1: Transition from traditional to remote teaching” of the teacher training webinars. All modules had a MyTUTor tips, with links to contact details for support on using MyTUTor and videos illustrating how to complete tasks, as they were standard in the module design template (See Appendix 3 for an example of a MyTUTor tips).

According to Chen et al. (2015), a welcome message to students before the course begins is an important step aimed to establish a teacher’s online persona and to create a comfortable class environment. The message in the form of a statement or a short video and should include
vital information and protocols for the course and not the entire syllabus. There has been a significant improvement in the number of online modules that had a welcome statement and lecturer details in the module overview, after training of teachers (66%) compared to 11% of the online modules in 2019 before a structured training framework was developed (Figure 4.5). Announcements are an ideal way to communicate time-sensitive information critical to student success in a module. In a YouTube video, Graves (2018) affirms that announcements support quality course design and are a great way to create the connection that keeps students engaged with the teacher and on track with their module. The use of MyTUTor to communicate information to students timely improved from 56% in 2019 to 89% in 2020 after training the teachers and implementing remote multimodal teaching and learning (Figure 4.5).

Figure 4.4: Percentage number of online modules with a customized welcome message, lecturer details and communicating with students through MyTUTor announcements
4.2.3 Module Content

The module or course content outline in Table 4.2 provides the basic components in the MyTUTor online module template (Figure 4.2) with scaffolding and chunking of information principles of module design.

Table 4.2: Components of the module content in the MyTUTor online module

<table>
<thead>
<tr>
<th>Module/Course Content</th>
<th>Study Guide and Practical Guide</th>
<th>Timetable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Content</td>
<td>Learning units with credits and hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Learning units outcomes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Learning activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Link to webinar/Bb Collaborate</td>
<td></td>
</tr>
<tr>
<td>Prescribed and Recommended Resources</td>
<td>Prescribed textbook</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recommended textbooks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supplementary reading material, eResources and videos</td>
<td></td>
</tr>
<tr>
<td>Assessment</td>
<td>Tests</td>
<td></td>
</tr>
</tbody>
</table>
Learning content in the MyTUTor modules is organized in such a way that allows students to engage content synchronously or asynchronously as depicted in Figure 4.1. Gibson and Blackwell (2005) validates the objectives of this study, that the responsibility is on the teacher to organize the online module so that students know exactly what to do and when to do it and they recommend modularizing the learning content so that there is a discrete amount of work to be done in each online week. The MyTUTor online modules were evaluated using the rubric to ascertain the extent to which teachers have designed their online modules to present learning content in scaffolds of smaller chunks of learning units and the results are presented in Figure 4.6. All the online modules had the latest study guide and timetable uploaded in the module content. Learning content was arranged in learning unit folders in 79% of the online modules. The learning material included PowerPoint presentations, videos and links to recorded Bb Collaborate webinars. The lists of the prescribed textbook, recommended textbooks as well as links to supplementary reading material and eResources were provided in 61% of the modules. Online formative and summative assessments were used in 55% of the modules while 50% of the modules provided students with asynchronous activities and assessments in the form of assignments and tutorials.

A significant improvement in the design and usage of the functionalities of MyTUTor was observed after teachers in the Department of Chemistry were upskilled and gained relevant competencies to integrate technology in teaching. Figure 4.7 compares the statistics of the module design in 2019 to 2020. In 2020, 100% of the online modules had the latest study guide and timetable uploaded on the VLE, compared to 54% in 2019. The learning content was arranged in smaller easy to follow learning units in 79% of the modules in 2020 compared to 53% in 2019. The use of online assessments increased tenfold from 5% in 2019 to 55% in 2020. Similarly, asynchronous activities such as assignments and tutorials increased from 16% in 2019 to 50% in 2020.
Figure 4.6: Percentage number of online modules with the latest study guide and timetable, learning content arranged in learning units, list of prescribed and recommended resources, online assessments, tutorials and assignments.
4.3 MyTUTor Usage Statistics

The engagement of students with MyTUTor online modules, in Figure 4.8, was evaluated as a function of the total number of students registered per module, the number of active students and the average time spent per active student engaged with the module (in hours). The MyTUTor usage statistics of all the modules in all levels of study (from 1st year to 4th year) are reported. According to the statistics, an average of 93% of the students registered for a particular module spent an average of 8 hours engaged in different activities of the MyTUTor online module (weighted average of engagement with different aspects of module overview and module content).

A significant improvement was observed in the number of students who engaged with learning content in MyTUTor online modules in 2020 compared to 2019 (Figure 4.9). Student engagement with the MyTUTor online module content increased from 1.8 h in 2019 to 8 h in 2020. This significant improvement can, to a large extent, be attributed to the remote multimodal teaching due to the national lockdown brought about by the corona virus pandemic which necessitated all classes to be conducted 100% online for at least two and a half months (1 June - 20 September 2020) of the first semester which commenced on 1 June 2020 and ended on 30 November 2020. From 21 September to 30 November 2020, classes were a blend of online and face-to-face teaching.
Figure 4.8: Engagement of students with MyTUTor online modules as a function of the total number of students registered, the number of active students and the average time spent per active student engaged with the module (in hours)

Figure 4.9: Comparison of the number of students who engaged with learning content in MyTUTor online modules in 2020 compared to 2019

Lisha and Zhang (2003) made an interesting remark that during online learning environment, the lack of face-to-face interaction between students and teachers and some uncontrollable factors such as learning environment, information interference and learning time, teachers cannot grasp the degree of student engagement, especially the degree of emotional engagement. The same observation was made in this study where an average of 93% of the
registered students in a module actively engaged in online learning. No information is available about the 7% inactive students. According to Hu and Li (2017), no matter how good the learning content is but if student engagement is not there, it equals to zero. The authors maintain that it is necessary to analyse and study student engagement in the online learning environment. This will assist teachers identify inactive students in time, intervene in time, help students reflect on their learning behaviour and promote their deep participation in the learning process.
5. Conclusion

This chapter provides an overview of the study, summary of the research findings in the form of answers to the research questions, which are defined at the beginning of this thesis, the outcomes of the implementation of the project and finally conclusions and recommendations for further development.

5.1 Summary of research findings

The main objective of this study was to improve teaching and learning in the Department of Chemistry through digitalization pedagogy. There were 4 research questions (RQ) needed to be answered to achieve this objective and to create and effective framework for training of teachers and development of a standardized MyTUTor online template that engages students in synchronous and asynchronous modes of teaching. The summary of findings per research question are detailed below:

<table>
<thead>
<tr>
<th><strong>Outcome 1</strong></th>
<th>Improved competencies in the use of technology and digital tools by the teachers in the Department of Chemistry</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RQ 1</strong></td>
<td>Can a training framework successfully upskill and improve the competencies that the teachers in the Department of Chemistry require to teach effectively using MyTUTor?</td>
</tr>
<tr>
<td><strong>Summary</strong></td>
<td>A framework for the remote training of teachers was developed and consisted of 10 learning units with learning outcomes. All teachers attended the hands-on training for two weeks through webinars. At the end of the training, an &quot;online teaching tool box&quot; was developed and shared via email with all teachers to ensure that they engage with the training material at their own pace. The outcome was achieved because after training, the Department of Chemistry teachers possessed intermediate ICT skills and competencies that allowed them to engage with MyTUTor at the level of adaptation and appropriation of technology. All modules offered in the first semester (1 June - 30 November 2020) were offered online synchronously and asynchronously. To answer RQ1, yes, the teachers in the Department of Chemistry were able to gain competencies that allowed them to improve the online module design and use MyTUTor effectively for teaching and learning.</td>
</tr>
<tr>
<td><strong>Outcome 2</strong></td>
<td>Development of MyTUTor online modules that engage students for effective learning</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>RQ 2</strong></td>
<td>Can the chemistry curriculum be successfully converted into digital interactive modules that engage students and encourage effective learning?</td>
</tr>
<tr>
<td><strong>Summary</strong></td>
<td>To answer RQ 2 and to achieve outcome 2, a MyTUTor online module template was designed as a framework for converting the curriculum to digitized interactive learning content. The online module template was standardized so that all modules have a uniform look and feel and consistency that makes students feel connected to all their teachers. All modules had a similar Department of Chemistry homepage banner and 66% of the modules had a welcome message in the form of text or a short video-clip as well as a photo of the module teacher and their contact details in the module homepage. Outcome 2 was achieved and RQ 2 was successfully answered.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Outcome 3</strong></th>
<th>Implementation of student-centred teaching and learning using MyTUTor VLE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RQ 3</strong></td>
<td>Can MyTUTor online modules encourage students to engage with learning content actively and collaborative?</td>
</tr>
<tr>
<td><strong>Summary</strong></td>
<td>The template for the MyTUTor online modules was designed in such a way that the learning content is arranged in a scaffolding manner. Furthermore, to ensure ease of access and engagement with learning content, the curriculum was presented in small chunks of work called learning units, which are arranged, in separate folders. Inside each learning unit folder, the learning unit outcomes, link to Bb Collaborate live session, learning content, learning activities, assessments and assignments. Outcome 3 was achieved and RQ3 answered as findings indicate that an impressive 79% of the online modules are designed with learning content that allows the student to engage with the learning content live or at their own pace. Teachers in 89% of the online modules used the MyTUTor announcements function to communicate important information critical for the success of the module timeously to their students.</td>
</tr>
</tbody>
</table>

| **Outcome 4** | Improved engagement with MyTUTor online modules by students |
**RQ 4**

Can the digitalized student-centred curriculum improve the usage of MyTUTor by students?

**Summary**

As a measure to determine if outcome 4 was achieved, the MyTUTor online first semester modules usage statistics for the period 1 June to 30 November 2020 were downloaded from the MyTUTor Course Reports menu. The activity overview report was generated for each module displaying the overall activity within a single module, sorted by student and date. Data includes the total and average time spent per active student and the total amount and type of activity each student had in the module. Outcome 4 was achieved and RQ 4 answered as an average of 93% of registered students were actively engaged in each online module. The average time spent by a student actively engaged in MyTUTor improved from 1.28 h in 2019 to 8 h in 2020.

### 5.2 Conclusions

The national lockdown due to the corona virus pandemic accelerated the transition to fully online teaching, affecting the original plan of the upskilling of teachers planned for three months. The training of teachers was shortened to two weeks, however, was a resounding success as all the curriculum was digitized in time to commence online teaching on 1 June 2020. It can be concluded that the implementation of digitalized pedagogy in the Department of Chemistry was successful. Teaching and learning using MyTUTor VLE was improved through upskilling of teachers with competencies required for them to integrate technology in teaching. The design of online modules was significantly improved after training with a corresponding increase in the amount of time that students engaged the learning content online.

### 5.3 Recommendations

Many researchers agree that teaching online requires technological skills and a different pedagogical approach to face-to-face teaching. Even though all teachers in the Department of Chemistry were upskilled with competencies required for designing online modules and engaging students in a blend of synchronous and asynchronous teaching, there are still online modules that are lagging behind and need further intervention. From the findings of this study, it is recommended that online teaching self-efficacy be considered, as a key component of...
teachers’ readiness to teach online (Hung, 2016) and for continuous training of teachers, through the lens of the Technological Pedagogical and Content Knowledge (TPACK) framework. According to Howard et al. (2020), the use of the TPACK framework can provide a focus on learning and pedagogy that is typically missing from conceptions of online learning. This could benefit teachers to contextualize and articulate their pedagogical approach to online teaching.

This study acknowledges that student engagement with learning content is a multidimensional concept, involving student behaviour, cognition and emotion, including both explicit behaviour and emotional and psychological reflection (Hu and Li, 2017). This study was limited to quantitative analysis of MyTUTor activity logs of students and the assessment of the quality of the online module design and usage of the online module for synchronous and asynchronous teaching.

It is therefore, recommended that a mix of quantitative and qualitative methods should be combined to analyse students’ learning process from different dimensions of student engagement with the VLE. This will enable teachers and students to reflect on their practices, interventions put in place in different dimensions of student engagement to ensure that online learning outcomes are met and students are successful in the module.

5.4 Personal reflection on the learning from the project

The aim of this study was to develop a framework and implementation of digital pedagogy in the Department of Chemistry. This was motivated by a development project that I completed as part of Module 3 of this MBA programme. In addition, I undertook this study in a quest to deepen my theoretical knowledge regarding digital pedagogy and applying it in a practical context. This study has allowed me to gain insights into digital pedagogy, that it is not only about using digital tools for teaching and learning but approaching the tools from a critical pedagogical perspective and paying attention to the impact of digital tools on learning.

I have gained valuable skills and competencies such as developing and successfully implementing a training framework for teachers and developing a template for online modules underpinned by TPACK, ABC learning design and scaffolding of learning content principles, using different functionalities of the MyTUTor LMS to optimise teaching and choosing relevant digital tools for teaching. The national lockdown due to the corona virus pandemic required an extraordinarily rapid transition from face-to-face teaching to online teaching and learning.
Execution of this project was just in time and I was able to collaboratively work with teachers in the Department of Chemistry to ensure that they were equipped with skills and competencies required to implement the remote multimodal teaching plan of the university. I have gained confidence in digital pedagogy and as a leader. The project was a success, the outcomes of the study have been achieved and the university’s mandate to deliver 100% fully online modules during the national lockdown was also achieved.
References


Tshwane University of Technology Institutional Strategic Plan (2020 - 2025). Available at:


Appendices

Appendix 1: The E-Chemistry teacher-training module on MyTUTor

Learning Content

Presentations

- E-learning in the department of chemistry
  Attached Files: E-Learning in the Department of Chemistry at TUT.pdf  (1.12 MB)

- Teaching method and content
  Attached Files: Teaching method and content.doc  (64.5 KB)

- Technology in HE Chemistry
  Attached Files: eChemistry_Inst410.ppt  (3.738 MB)
  Presentation by N. Brouwer

- Learning objectives: Bloom
  Attached Files: eChemistry_Bloom.ppt  (1.605 MB)

- Introduction to Blackboard 9
  Attached Files: INT Black 42.ppt  (1.22 MB)

Discussion Forum

Forum: Stoichiometry forum
Forums are made up of individual discussion threads that can be organized around a particular subject. A thread is a conversation within a forum that includes the initial post and all replies to it. When you access a forum, a list of threads appears. More Help.

- [Thread: Stoichiometry]
  Author: Geoffrey Nkweku
  Status: Published
  Unread Posts: 2
  Unread Replies To Me: 2
  Total Posts: 2

- [Thread: sulfuric acid]
  Author: Nkobeng Mokgokola
  Status: Published
  Unread Posts: 3
  Unread Replies To Me: 0
  Total Posts: 3

Assessment

Begin: Stoichiometry Test

INSTRUCTIONS

- Timer Test: This test has a time limit of 1 hour and 30 minutes.
- Force Completion: Once started, this test must be completed in one sitting. Do not leave the test before clicking Save and Submit.

Click Begin to start Stoichiometry Test. Click Cancel to go back. You will be previewing this assessment and your results will not be recorded.

Click Begin to start. Click Cancel to quit.
Pre-lab activity/assignment

Stoichiometry

**Synthesis of aspirin**
1. Find the method currently used for the synthesis of aspirin.
2. Answer the following questions about the synthesis of aspirin:
   - What is the chemical reaction that describes the process?
   - What are the by-products of the synthesis of aspirin?
   - What conditions favour optimum yield of aspirin?
3. If the amount of acetic anhydride reactant used in the synthesis of aspirin is in excess over the amount needed to react with all of the salicylic acid.
   - How many grams of aspirin would you expect to get?
4. If the process gives 2.96 g of aspirin, what would be the percentage yield?
5. How can you estimate the purity of aspirin?
6. What safety concerns are associated with the synthesis of aspirin?

Announcement/schedule

**Programme October 21**
Posted on: Friday, 21 October 2011 09:31:11 o'clock GST

1. Wrap up day 2 and planning of day 3
2. Developing learning modules: learning outcome - learning activity - assessment
3. LUNCH
4. EChemText
5. Presentations and discussion
   - Content (learning objective): Pedagogy (activity): Technology (MyStern+)...
   - Think of:
   - How to motivate learners to really do the activity (stick or carrot?)
6. Conclusions and next steps

**Test Posted**
Posted on: Thursday, 20 October 2011 19:28:00 o'clock GST

The following Test has been made available in Content Test!.
Appendix 2: List of Modules offered by the Department of Chemistry from 1 June to 30 November 2020

The Department of Chemistry offers the following undergraduate programmes, in which these modules are taught: National Diploma in Analytical Chemistry, Bachelor of Technology in Chemistry, Diploma in Analytical Chemistry, Advanced Diploma in Analytical Chemistry, Bachelor of Science in Industrial Chemistry. In addition to these in-house modules, the department offers Chemistry modules as a service to other departments within the Faculty of Science (FoS) and in the Faculty of Engineering and the Built Environment (FEBE). The modules are listed as first, second, third and fourth year modules.

<table>
<thead>
<tr>
<th>First Year Modules</th>
<th>Module name</th>
<th>Module code</th>
<th>Offered in-house</th>
<th>Offered as service within the FoS</th>
<th>Offered as a service at the FEBE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Analytical Chemistry I</td>
<td>AYC105D</td>
<td>✓</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Chemistry I</td>
<td>CHE105P</td>
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<tr>
<td></td>
<td>Chemistry I</td>
<td>CHE141B</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Chemistry I</td>
<td>CHE141C</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chemistry I</td>
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<td>CHS115P</td>
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</tr>
<tr>
<td></td>
<td>Chemistry I</td>
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<td></td>
<td></td>
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<td>SCI100T</td>
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<td></td>
<td>Science for Occupational</td>
<td>SOR105D</td>
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<td></td>
<td>✓</td>
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<td>Purpose</td>
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<td>Second Year Modules</td>
<td>Analytical Chemistry II:</td>
<td>AHP201T</td>
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<td>Practical</td>
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<tr>
<td></td>
<td>Analytical Chemistry II</td>
<td>ANC251T</td>
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<tr>
<td></td>
<td>Bioanalytical Chemistry II</td>
<td>BAC216D</td>
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<tr>
<td>Module name</td>
<td>Module code</td>
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<td>Offered as service within the FoS</td>
<td>Offered as a service at the FEBE</td>
<td></td>
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<tr>
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<td>Environmental Chemistry II</td>
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<td>Fire Chemistry II</td>
<td>FBC211T</td>
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<tr>
<td>Inorganic Chemistry II</td>
<td>ICH231T</td>
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**Third Year Modules**

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Appendix 3: Example of MyTUTor tips and support in a module

MyTUTor Tips

MYTUTOR SUPPORT
Contact the myTUTOR service desk for assistance or download the self-help electronic help guide by clicking here.

Contact details:
Telephone number: 011 392 4417
eMail: mytutor@tut.ac.za
Office hours: week days only 08:00 - 10:00

EDURAM (TUT Wi-Fi) SUPPORT
You can find out more information about Eduran TUT Wi-Fi, by clicking on the link here.

1. Fill out your user name, you need to activate your password to access Eduran.
2. Enter your student number to access Eduran.
3. You can also access myTUTOR, TUT campuses, & Office 365 with the same password.

HOW TO ACTIVATE YOUR TUT EMAIL
Click here to activate TUT email
Your email address is: student number@tut.ac.za

HOW TO SUBMIT THE ASSIGNMENT
1. Open the Assignments Tab in the left menu.
2. Click on Assignment name to open the assignment
3. Click on the attachment to download the assignment
4. Complete the Assignment as instructed
5. Click on the Browse button and attach your Assignment.
6. You can write a message to the lecturer in the text box. This is optional.
7. Click on the blue Submit button.

MYTUTOR HOW TO COMPLETE A TEST
To complete a test:
1. Click on the Tests tab in the left menu.
2. Click on the text link.
3. Click on Begin.
4. Answer the questions as indicated.
5. On completion, click the Submit button.

HOW TO DOWNLOAD OFFICE 365 TO YOUR COMPUTER
As TUT registered students you have access to Office 365. Click here to access Office 365.