Developing guidelines for bridging the gap between IT theory and IT practice

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DECLARATION: AUTHENTIC SUBMISSION

I, J.T. Janse van Rensburg, declare that

Developing guidelines for bridging the gap between IT theory and IT practice

is my own work and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references, and that this dissertation has not previously been submitted by me for a degree at any other university.

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DECLARATION: LANGUAGE PRACTITIONER

To whom it may concern

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25 November 2019

Dear Mr / Ms

Re: Language editing of thesis (Developing guidelines for bridging the gap between IT theory and IT practice)

I hereby declare that I language edited sections of the above-mentioned thesis by Ms JT Janse van Rensburg (student number: 20398999). These sections are: All content prior to Chapter 1 (i.e. Abstract, Preface, etc.), Chapter 1, Chapter 2, Chapter 3 and Chapter 9, as well as the guideline contribution sections found in the respective articles' chapters.

Please feel free to contact me should you have any enquiries.

Kind regards



Cecile van Zyl
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- To all my friends and family for their continued support.

- And to you, my husband, and pillar of strength, Chris Janse van Rensburg, for all your love, encouragement, and never-ending research support – you are loved and appreciated.

Dedicated to the ones I've loved and lost



Dadio ♥

James Terblanche

2 April 1960 to 6 April 2019

Boetie ♥

JP Terblanche

9 February 1993 to 30 May 2014

PREFACE

This thesis is presented in article format, in accordance with the General Academic Rules (rule 5.10.5), as well as the Manual for Master's and Doctoral Studies (Section 6.9) of the North-West University.

The following five articles are included in this thesis:

- Janse van Rensburg J.T. & Goede R. 2019. A model for improving knowledge generation in design science research through reflective practice. *Electronic Journal of Business Research Methods*, 17(4):192-211.
- Janse van Rensburg J.T. & Goede R. 2019. A reflective practice approach for supporting IT skills required by industry through project-based learning. *Communications in Computer and Information Science*, 963:253-266.
- Janse van Rensburg J.T. & Goede R. 2019. Reflecting on the use of project-based learning for 21st century competencies in an IT extended programme. In: proceedings of the *10th Annual UNISA ISTE conference on mathematics, science and technology education*. pp.75-83.
- Janse van Rensburg J.T. & Goede R. 2019. Promoting career awareness among IT students in a South African context. *Higher Education, Skills and Work-based Learning*. (in press)
- Janse van Rensburg J.T. 2019. Guidelines for project-based learning in IT higher education. (submission pending)

The co-author of the articles in this thesis, Prof R Goede (promoter), hereby gives permission to the candidate, JT Janse van Rensburg, to include the articles as part of her PhD thesis. The contribution of the co-author was kept within reasonable limits, similar in nature to the supervision of a traditional thesis format (guidance, advice, and support), enabling the student to submit this thesis for examination purposes.

This thesis therefore serves as fulfilment of the requirements for the degree Doctor of Philosophy in Information Technology, within the School of Computer Science and Information Systems in the Faculty of Natural and Agricultural Sciences at the North-West University.

ABSTRACT

The primary research objective of this study is to develop guidelines for bridging the gap between IT theory (standard IT teaching practices at university) and IT practice (the required industry-related skills). The skills gap between higher education and industry is an ongoing problem, experienced in all fields of study. There is a need to understand what causes employers to be displeased with a graduate's ability to make an effective contribution to the workplace. During 2019, a study conducted by the South African professional bodies, Jo'burg Centre for Software Engineering and the Institute of Information Technology Professionals South Africa, highlighted that the information and communications technology skills gap is growing in South Africa, suggesting that we may need as many as 50 000 ICT practitioners in the near future. This statistic is concerning, as it is not feasible for South African tertiary institutions to collectively deliver 50 000 skilled ICT practitioners any time soon. The problem is exacerbated by the fact that South African employers feel that IT graduates are not work-ready.

This raises the concern that IT graduates lack certain skills expected by industry when they enter the workforce in South Africa. It is implied that the specific skills required by industry are not developed during the course of an IT degree. Suggestions towards bridging the skills gap include on-the-job-experience such as internships, intense training through apprenticeships, early exposure to IT careers, recognised certifications, and improved instructional approaches to assess the skill levels of IT students. Early career advice, and contact with industry through recent alumni, or presentations by industry, would also support IT students in making informed career choices. The use of authentic 'real' problems in the curriculum is recommended to encourage the development of relevant problem-solving skills.

The instructional approach that is consistently used to bridge the theory-practice gap in computer science-related curricula is project-based learning (PBL). The use of PBL is popular in engineering, computer science, and information technology degrees due to the expected artefact creation that is typical of these project-based working environments. Project-based learning is a practical approach to skills development in any field and can be used to evaluate the skill levels of students in a collaborative environment that simulates the setup of industry. Project-based learning is suggested as a suitable pedagogy that can be used to address the South African IT skills gap, but the approach needs to be refined. Due to the various implementation methods used for PBL, as well as different approaches towards IT skills development and promoting IT career awareness, it is recommended to construct a single source of guidelines that can address the IT theory-practice gap within a South African context.

Developing guidelines falls within the research paradigm of design science research (DSR), as artefact creation. The focus of this study is on the development of the guidelines, and not on the emancipation of the user group that the guidelines are intended for. Reflective practice is considered the theoretical framework that informs the research methodology in this study, and serves a dual purpose. Firstly, it is incorporated into project-based learning for IT skills development towards improving the professional practice of the student, as well as the facilitator. Secondly, reflective practice is also embedded in the methodology of this research.

The central participants of the study include entry-level and exit-level IT students enrolled for a BSc undergraduate degree in Information Technology at a university in South Africa. Other role players of the study include members from the IT industry in South Africa. The problem experienced started with exit-level IT students, when a skills gap was noticed between IT theory and IT practice during 2017. Industry members were subsequently asked, in a pilot study, to provide feedback on the skills that IT graduates typically lack. The feedback was used to improve the curriculum at entry-level and exit-level of an IT degree. Students at both levels were asked to comment on the strategies that were implemented towards improving the curriculum, with the aim of bridging the gap between IT theory and IT practice.

Qualitative methods were used to gather data from participants, including written interviews, reflective sheets, and interpretive questionnaires. Interpretive content analysis in the form of open coding was used to analyse the qualitative data. Themes identified in the data highlighted aspects such as South African IT graduate skills that were found lacking, teaching and learning approaches that improved skills development, and intervention strategies that promoted career awareness. Findings from literature and the identified themes were used to develop guidelines towards bridging the IT theory-practice gap.

This thesis is submitted in article format, with five articles included in the research. The study concludes with a set of consolidated guidelines for bridging the IT theory-practice gap, which is a result of the research findings of the respective articles. The guidelines include themes for formulating an intervention strategy, identifying crucial IT skills, best practice for general IT pedagogy, effective project-based learning for IT higher education, and involving industry in higher education.

Keywords: Information technology, higher education, guidelines, IT skills development, project-based learning, reflective practice, and design science research

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1.1 Introduction

In this study, the focus of the research is on the skills gap of South African information technology (IT) students that exists between higher education and the IT industry. The skills gap between higher education and industry is an ongoing problem, experienced in all fields of study. Previous research on the topic originated from a need to understand what caused employers to be displeased with a graduate's ability to make an effective contribution to the workplace (Sarkar, Overton, Thompson, & Rayner, 2016:31). Moreover, graduates are critiqued by employers if they exit university with underdeveloped skills, and are not employable (Cavanagh, Burston, Southcombe, & Bartram, 2015:278).

In a study conducted by AlMunifi and Aleryani (2019:98) in Yemen, the knowledge and skill levels of graduate civil engineers were compared to employers' perceptions. The results of

the study indicated that employers were satisfied with the potential of the graduates' practical skills, but found that their interpersonal skills were lacking, specifically teamwork, problem-solving, and critical thinking. Employers further recommended that curricula should be revised to reflect the current requirements of the labour market. In another study conducted in Scotland, the perceptions of chemical engineering students and alumni were used to develop employability skills (Fletcher, Sharif, & Haw, 2017:24). Through survey data, they suggested that transferable skills (typically soft skills that can be used in any form of employment) were deemed most important for employment, and as a result, they have added induction classes that address the development of these skills.

Similar employability skills were found lacking nearly a decade ago. In a study by Wickramasinghe and Perera (2010:20) conducted in Sri Lanka, the perceptions of computer science graduates, university lecturers and employers were compared with regard to employability skills. Survey findings indicated that self-confidence, problem-solving and teamwork were the most important employability skills to all stakeholders. A study by Rasul, Rauf, Mansor, Yasin, and Mahamod (2013:249) highlighted that manufacturing employers in Malaysia placed high value on teamwork, communication, and problem-solving skills. Employers indicated that these skills, if addressed more thoroughly in higher education, would provide a positive impact in the industry. Employers also indicated that the development of technical skills is crucial as students will be exposed to a variety of technologies in the industry.

A number of studies recommend the development of effective learning strategies in higher education to address the skills gap, and suggest that higher education should do more to ensure industry alignment in their curriculum (Cavanagh *et al.*, 2015:278; Rasul *et al.*, 2013:249; Sarkar *et al.*, 2016:44). Worldwide, the higher education sector is aware of the skills gap, and studies in multiple fields have aimed to identify suitable courses of action. A number of instructional approaches to support graduate employability in higher education have been adopted. These instructional approaches range from variations of teacher-centred to learner-centred approaches, all with the common goal of aligning the skills that students develop during their studies with the skills that the industry needs (Mistry, Awasekar, & Halkude, 2017:181).

For example, a study conducted by Du Plessis (2019:22) pointed out that work-integrated learning (WIL) could be used as an appropriate training approach for radiography students in South Africa. The study concluded that a WIL curriculum provided opportunities to integrate theory and practice while developing the required skills, and that the implementation of WIL should be a continuous and reflective process to improve teaching and learning practices. In

a study by Taylor-Smith, Smith, Fabian, Berg, Meharg, and Varey (2019:128), it was suggested that degree apprenticeships may be the answer to bridge the skills gap. They explain that Scotland's first degree apprenticeships in computing-related degrees started in 2017, in which students were employed full-time while completing degree credits. They highlighted the potential of the apprenticeships to address the skills shortage, with employers supporting their current staff to complete degrees and improve their skills, rather than needing to increase their skills base with additional employees. Early indications of the approach seemed positive, with the biggest limitation indicated as continuous funding for the initiative.

Project-based learning has also been widely adopted to develop employability skills. A study by Du Toit, Havenga, and Van Der Walt (2016:66) recommended the use of project-based learning as a preferred teaching and learning strategy for the preparation of educators in the field of consumer studies in South Africa. They highlighted that a project-based learning approach is active, self-directed, and life-relevant, which encourages an environment of learning and enjoyment. They recommended that specific skills such as collaboration and time management be developed through project-based learning to increase employment opportunities. Wood (2016:105) demonstrated the suitability of project-based learning to develop the employability skills of archaeological students in England. Among others, he highlighted the importance of skills development and reflection through project-based learning, stating that it is just as important to realise which skills one possesses, and not only to focus on acquiring new skills. He went on to suggest the development of project-based learning exercises as a suitable alternative for excavation and fieldwork. In a study by Hart (2019:63), a literature review of interdisciplinary project-based learning as an instructional method for a variety of undergraduate science degrees was presented. Data included in the research was largely from the disciplines of engineering and computer science, with most of the data representative of American case studies. Her findings highlighted the need for collaboration with industry for skills development, embedding employability skills in curriculum planning, and developing effective methods to assess employability skills. Additionally, she indicated that discipline content need not be sacrificed for the development of employability skills when project-based learning is used effectively.

At its core, project-based learning is a *reflective practice* approach to solving a project-based problem. A characteristic of project-based learning, according to Helle, Tynjälä, and Olkinuora (2006), is that students have to create artefacts and that, during the development process, they become aware of gaps in their knowledge. Students then need to research the problem, apply possible solutions by trial and error and, through a reflective approach, find a solution. Reflective practice is a philosophical term coined by Donald Schön and is described as the

process of immediate reflection during the process of fulfilling a task, and also the reflection that takes place after the activity was completed in order to improve future similar scenarios (Schön, 1983:50). Reflective practice is central to professional development, and is considered as a method to transform implicit knowledge into explicit knowledge through experience (Finlay, 2008:3). For this reason, the researcher considers reflective practice as central to the success of a project-based learning strategy towards cultivating professional development in students.

Within the context of this research, the focus is on the skills gap in the information technology (IT) sector. A discussion on the IT skills gap will be provided in Section 1.2.1, as well as in the problem statement in Section 1.3.1. The research suggests the use of project-based learning as an instructional method to support IT skills development. Reflective practice is recommended for the effective use of project-based learning towards IT skills development. The researcher also engages in reflective practice to improve the implementation of project-based learning, as well as research approaches followed to conduct the research. Towards this purpose, it is suggested that guidelines be developed that provide structure to the results of the study. These guidelines are considered part of a strategy to bridge the gap between IT theory and IT practice.

The proposed guidelines can be seen as an artefact. The creation of artefacts (be they models, frameworks, guidelines, documents, instantiations, or actual IT tools) falls within the research paradigm of design science research (Gregor & Hevner, 2013:341; March & Smith, 1995:256). The paradigm of design science research is used to guide the process of knowledge generation through artefact creation. Vaishnavi, Kuechler, and Petter (2004/2019:9) describe design science research as a process for “knowing through making”. There is an implicit assumption that reflection takes place during all phases of development in design science research. In the design science research process model, however, as depicted by Vaishnavi *et al.* (2004/2019:11), reflection and abstraction only take place during the conclusion phase. Abstraction is considered as an explicit process for theory building. It is, however, recommended that the use of reflective practice is applied in all phases of the design science research process model. The outcome will result in explicit knowledge generation that contributes to the prescriptive knowledge of design science research.

Section 1.2 provides literature context to the central theoretical concepts that form part of this research, IT skills development, project-based learning, reflective practice, and design science research. The problem statement, research questions and objectives are provided in Section 1.3. Section 1.4 highlights the research elements and perceived contribution of the study

according to the FMA model by Checkland and Holwell (1998:13). The research methodology is discussed in Section 1.5, and provides an overview of the participants, data collection and analysis methods, and the ethical considerations for the research. Section 1.6 provides the chapter layout of the thesis, structured according to the phases of the design science research process model. A conclusion to the chapter is presented in Section 1.7. This thesis is submitted in article format, with five articles presented as separate chapters in the research. For this reason, all chapters contain their own reference sections.

1.2 Theoretical concepts

Section 1.2 is presented to create a shared understanding of the central concepts that form part of this research, IT skills development, project-based learning, reflective practice, and design science research.

1.2.1 IT skills development

An IT skills gap is experienced globally, and the focus is more often on the lack of technical skills in an ever-changing industry. A survey conducted by the American non-profit professional body, Computing Technology Industry Association (CompTIA), highlighted the widening IT skills gap in 2017 (CompTIA, 2017). A total of 600 American IT professionals completed the survey. Top IT skills gaps were identified in the fields of emerging technology such as artificial intelligence (AI) and automation, platform integration where different applications and devices are used, cloud infrastructure, cyber security, software development, and the management of big data. Their suggestions towards bridging the skills gap included on-the-job-experience such as internships, intense training through apprenticeships, early exposure to IT careers, recognised certifications, and improved evaluation methods to assess the skill levels of candidates. They emphasised that the cyber security skills gap was especially problematic as the importance of data was growing across all sectors of the industry. In a critical analysis of the cyber security skills shortage, it was estimated that the threat against information systems exceeded more than one million unfilled positions globally (Cobb, 2016:6). Larson (2018:27) commented on the survey results of the CompTIA report, supporting the claim that universities are not preparing students for current IT jobs, which include critical roles for the field of cyber security. He went on to say that university degrees may no longer be the solution, as motivated students can learn the underpinnings of information technology through freely available resources, and that students are focusing on certifications and industry training instead.

The concept of industry training is supported by Jaradat (2017:114), who explored student satisfaction levels after internship training was implemented as part of a computer science

degree in Jordan. The aim of the industry training was focused on employability for the job market, towards improving their personal and professional skills, as well as their work readiness. The results of the study highlighted that internships at undergraduate level provided work exposure for the students, bridging the concepts learned in class with workplace practice. Factors that influenced satisfaction were positive working environments, new skills learned, improved communication skills, and improved opportunities for employment. Taylor-Smith *et al.* (2019:131) also support the concept of industry training in Scotland through computing degree apprenticeships, but emphasise the fact that the intensity of this type of training is more suitable for people who have some experience in the IT profession, rather than learners from secondary education who may not be set on their career paths. Sarkar *et al.* (2016:45) highlighted that opportunities for job placements in a computer science degree would promote skills development. They also indicated that early career advice, and contact with industry through recent alumni, or presentations by industry, would support students in making informed career choices. Australian employer participants in this study also recommended the use of authentic 'real' problems in the curriculum to encourage the development of relevant problem-solving skills.

A study by Moore and Morton (2017:603) highlights that even though the skills gap concept in recent academic debate is focused on bridging the gap between the learning and application setting, universities should not surrender too much authority of curriculum development to industry expertise. They maintain that if education is tailored too narrowly for specific jobs, the skills can become inflexible, making it difficult to apply in new settings. This suggests that the curriculum should include generic teaching and learning strategies that can be adapted so that both transferable skills and industry-specific skills can be trained in a flexible manner. Arguably, computing and software engineering educators' preferred teaching and learning method, which is consistently used to bridge the theory-practice gap, is project-based learning (Isomöttönen, Daniels, Cajander, Pears, & Mcdermott, 2019:22).

1.2.2 Project-based learning

For the purpose of this research, project-based learning is abbreviated as 'PBL', as indicated by respected author Thomas (2000:1), and not as 'PjBL' – an abbreviation sometimes used within the context of project-based learning in literature to distinguish it from problem-based learning. Project-based learning (PBL) is a student-driven learning approach that is structured around the completion of projects. PBL typically results in artefact creation for an authentic problem in which rich inquiry from students is encouraged. Project-based learning has been implemented as a teaching and learning approach to support skills development in various

learning environments over the past two decades (Bell, 2010:39; Condliffe, Quint, Visher, Bangser, Drohojowska, Saco, & Nelson, 2017:2; Thomas, 2000:8).

The use of PBL is popular in engineering, computer science and information technology degrees due to the expected artefact creation that is typical of these project-based environments. In a study by Viswambaran and Shafeek (2019:8), a model for project-based learning was implemented in two engineering subjects. 70 student participants provided feedback on the impact of the PBL strategy taken. The study concluded that team-based PBL is a suitable pedagogy for improving student engagement, and supports skills such as problem-solving, report writing, and critical thinking. A study by Renz and Meinel (2019:580) demonstrates the use of an agile methodology to manage teams in PBL for computer science education. The study highlights a gap between academic education and the role of the university. The authors were surprised by the fact that excellent programmers failed the degree due to poor perceived academic performance, while students who struggled with coding passed the degree based on good academic performance. This issue emphasises the need for more practical-based curricula in university degrees, considering that the field of information technology is constantly evolving.

Project-based learning is a practical approach to skills development in any field and can be used to evaluate the skill levels of students in a collaborative environment that simulates the setup of industry. This idea is supported by McManus and Costello (2019:43), who indicate that a PBL approach in computer science provides an environment to practise and develop workplace skills that are challenging to simulate in traditional lecture settings. Additionally, they suggest that PBL promotes professional skills, discipline, and time management skills, in a similar manner as the professional world would demand. Project-based learning does have challenges in its implementation, as highlighted in a study by Fowler and Su (2018:316). Their study reports on the manner in which tasks are divided among teams in a project, indicating that there is a perceived dissatisfaction in teams where two or more women are present. Male students tend to take on the role of programmer, while female students are tasked with the role of documenter. They indicate that men are more likely to gain technical experience through PBL activities, while women more often build on project management and communication skills. While the acquisition of any new skill is a step in the right direction, the structure of PBL activities should ensure that technically skilled students are also produced from the historically underrepresented groups in computer science and engineering.

As emphasised in a report by Sindre, Giannakos, Krogstie, Munkvold, and Aalberg (2018), research on the benefits and challenges of project-based learning in IT education needs

further development. They indicate that the use of projects in IT education is expected because the IT industry is comprised of project environments. The authors suggest that a project-based learning environment not only trains technical IT skills, but also contributes to a robust understanding of entrepreneurship, data analysis, computational thinking, critical thinking, creativity and other 21st century skills. Project-based learning is a suitable pedagogy to address the IT skills gap, supporting the IT graduate's development through real-life experiences (Sindre *et al.*, 2018). For best practice, a project-based learning environment should encourage continuous reflective practice for professional development (Condliffe *et al.*, 2017:11; Larmer & Mergendoller, 2010:3; Lee, Blackwell, Drake, & Moran, 2014:29).

1.2.3 Reflective practice

"Modes of thought, of observation and reflection, enter as forms of skill and of desire into the habits that make a man an engineer, an architect, a physician, or a merchant" (Dewey, 1916:32). John Dewey wrote that learning only takes place through problem-solving or applying a reflective process with the aim of solving the problem (Dewey, 1896:369). Dewey argued that reflective thinking transforms traditional thinking into reflective action that involves critical consideration. Habermas (1971:12) further defined reflection as a means to develop diverse forms of knowledge. Argyris and Schon (1974) redefined reflection within the context of organisational learning. They encouraged reflection for professional effectiveness by stating that individuals react to effective behaviour based on their ability to review a situation.

Even in scientific professions, when practitioners address unique problems, it is an artistic process in which reflective practice takes place (Schön, 1983:68). Reflective practice is a professional learning and development strategy focused on improved practices, based on assumptions that cause-effect relationships shape behaviour (Osterman, 1998:2). Reflective practice is rooted in experiential learning, where the process of learning is most effective when it starts with a problematic experience. The four stages of learning according to Kolb (1984:21) give experiential learning as a cyclical process that starts with an experience, continues with reflective observation, leads to an abstract conceptualisation of the problem, and results in active experimentation to address the problem. The last stage may result in a different experience which prompts the continuation of reflective observation and so on (Figure 1.1).

During the abstract conceptualisation phase, the practitioner is motivated to search for new and unique theories, techniques, processes, or ideas to solve the problem (Osterman & Kottkamp, 1993:7). This stage of the experiential learning cycle deals with the abstraction of new concepts and provides a known strategy for knowledge generation. The principle of

abstraction and generalisation, given by Klein and Myers (1999:75), provides an explicit reasoning to knowledge generation for this reflective practice process. They explain that theoretical abstractions should be carefully conveyed by the researcher as it was experienced and collected, so that the reader can understand how the theoretical insights were reached. The validity of drawn inferences and conclusions should not depend on the ability to present the information statistically, but rather on the credibility and impact of the logical reasoning used to describe the results.

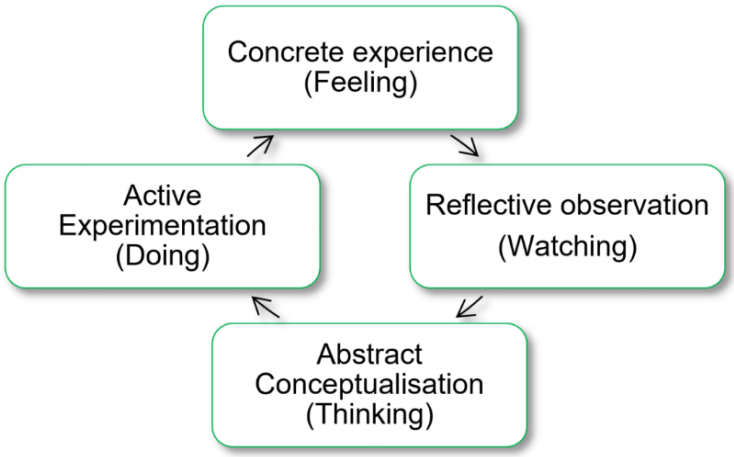


Figure 1.1: The experiential learning cycle (Kolb, 1984:21)

In this study, reflective practice serves a dual purpose. Firstly, it is incorporated into project-based learning for IT skills development towards improving the professional practice of the student, as well as the facilitator. Secondly, reflective practice is also embedded in the methodology of this research. As suggested, the study will propose guidelines for bridging the gap between IT theory and IT practice as a result of structuring the findings from literature, and the findings from the empirical research. Developing guidelines falls within the research paradigm of design science research, as artefact creation.

Herbert Simon (1996:137) first suggested that design could be an interdisciplinary field across the sciences, art and technology in his book *The sciences of the artificial* (originally printed in 1969). Simon suggested to link natural science with design practice through a 'science of design', but his view of design was strongly positivistic as he believed that all design could be addressed with rational problem-solving (Schön, 1983:47). Schön (1983:49) argues that design falls within the context of intuitive, artistic processes and that it cannot be boxed within well-formed solutions. Schön maintains that design practice more often deals with disordered, challenging situations, and for this reason, falls within the context of reflective practice.

1.2.4 Design science research

Design science research (DSR) is a research paradigm where new knowledge is created by designing innovative artefacts as a solution to a relevant human problem (Hevner & Chatterjee, 2010:5). Vaishnavi *et al.* (2004/2019:4) support this definition by stating that design science includes knowledge in the form of theories, techniques, methods, models, and constructs. The epistemological assumption of DSR is "knowing through making" (Adebesin, Kotzé, & Gelderblom, 2011:310). According to Vaishnavi *et al.* (2004/2019:1), DSR artefacts include two activities towards an improved understanding of the behaviour of information systems. The first activity includes creation of knowledge through the design of innovative artefacts such as 'things' or processes. The second activity includes artefact performance analysis through reflection and abstraction. The set of guidelines that are presented in this study are representative of both activities, as the guidelines in itself are an artefact in the form of a process that can be followed, and the contribution of the guidelines will be subject to evaluation through reflection and abstraction.

To guide design science research studies, the DSR process model (Vaishnavi *et al.*, 2004/2019:11) iterates through five phases to facilitate the creation of new artefacts (Figure 1.2). These phases are 1) awareness of a problem; 2) suggestion; 3) development; 4) evaluation; and 5) conclusion. These phases are described in more detail in Chapter 3.

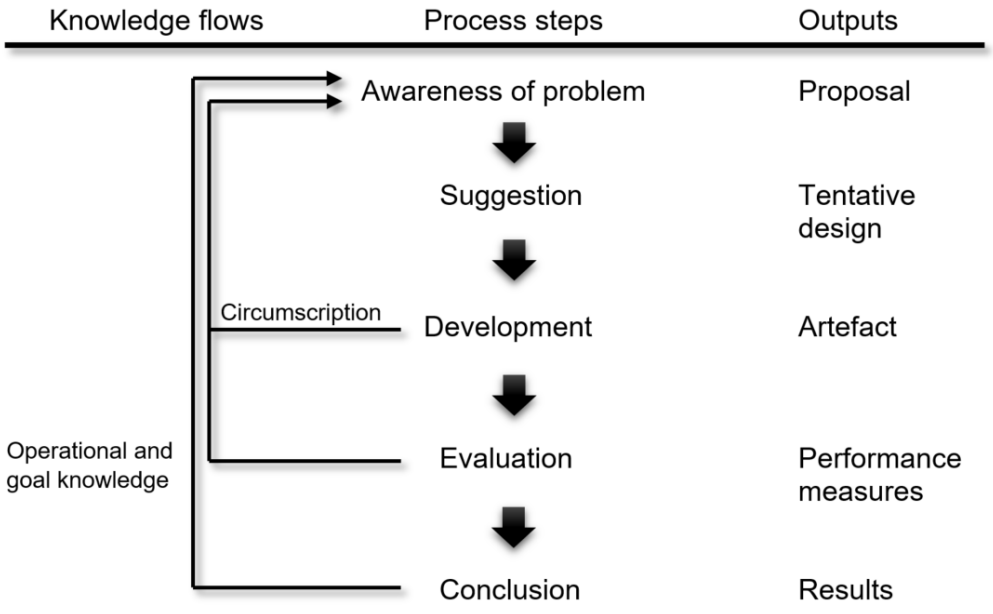


Figure 1.2: The DSR process model (Vaishnavi *et al.*, 2004/2019:11)

In their article, Peffers, Tuunanen, Rothenberger, and Chatterjee (2008) describe methods used in the evaluation phase of DSR. The case studies presented in this article include

positivistic methods such as quantitative performance measures, as well as interpretive methods such as interviews to obtain client feedback. They posit that the evaluation of DSR artefacts can include any appropriate method that results in empirical evidence (Peffers *et al.*, 2008:56). To this end, the study will also include characteristics of the interpretive research paradigm when qualitative data collection techniques are used for evaluation purposes.

It is important to note that an individual may become aware of a new problem during any phase of the DSR framework, and that the process iterates back through each stage as necessary. As this study is structured in the design science research paradigm to support the development of the guidelines, the research chapters are organised according to the phases of the DSR process model (see Section 1.6).

In order to provide context on the need for this artefact (guidelines for bridging the IT theory-practice gap), the following section provides an overview of the problem statement for this study.

1.3 Problem statement, research questions, and research objectives

In this section, a discussion is provided on the IT skills gap experienced in South Africa (Section 1.3.1), the use of project-based learning to develop IT skills (Section 1.3.2), and why guidelines towards bridging the IT theory-practice gap are suggested (Section 1.3.3). This section is concluded with the research questions and objectives relevant to the study (Sections 1.3.4-1.3.5).

1.3.1 The IT skills gap in South Africa

The IT skills gap is also experienced in South Africa. Continuous skills shortages are a result of a misalignment between the traditional skills a graduate possesses and the skills an employer requires (Van Broekhuizen, 2016:27). A lack of the required skills is often the reason why South African graduates are unsuccessful in the recruitment stage, highlighting that employers do not find university-based skills adequate (Oluwajodu, Greyling, Blaauw, & Kleynhans, 2015:3). Calitz, Cullen, and Greyling (2015:11) urge South African universities to take note of future skill requirements in the ICT sector in order to address the skills gap.

A survey conducted by professional bodies, Jo'burg Centre for Software Engineering (JCSE) and IITPSA (Institute of Information Technology Professionals South Africa), highlighted the current state of ICT skills in South Africa during 2019 (Schofield & Dwolatzky, 2019). The report was the 10th edition of the survey, the first of which was conducted during 2008. The

report did not specify the number of respondents who took part in the survey, but did indicate that the sample sizes were sufficient to draw valid conclusions from the data. The results indicated 'hard to fill vacancies' in the South African ICT industry, such as software developers, computer network and system engineers, system analysts, security specialists, business analysts, and database administrators. Future trends that impact the South African skills gap were highlighted as cloud computing, Internet of Things (IoT), virtual and augmented reality, big data analytics, and information security – technologies that are all associated with the 4th industrial revolution. There is an alignment with international findings, in that information security/cyber security is the top priority in demand during 2019. The survey results indicated that the most used programming languages in South Africa were Java, Python and C#.

In the closing remarks of the report (Schofield & Dwolatzky, 2019:45), the authors highlight the fact that the ICT skills gap is growing in South Africa, indicating that we may need as many as 50 000 ICT practitioners in the short- to medium term. The survey results indicate that employment opportunities in the IT sector of South Africa are not necessarily sparse, but rather that employers have difficulty in filling their positions with skilled candidates. This raises the concern that IT graduates lack certain skills expected by industry when they enter the workforce in South Africa. It is implied that specific skills required by industry are not developed during the course of an IT degree.

Another factor that influences work-readiness of IT graduates is the ability of students to make informed career choices. Academics are tasked with being well informed about current developments in the IT industry, to ensure that graduates are aware of current IT career opportunities. Using industry professionals for guest lectures is recommended, as they provide richer context through real-world examples (Calitz, Greyling, & Cullen, 2011:8; Taylor, 2017:34).

Within the context of this study, the IT skills gap is addressed by reviewing which soft and technical skills an IT student needs and typically lacks, which 21st century competencies are important for the professional development of an IT student, and which approaches for career awareness promote self-reflection on IT skills development.

1.3.2 Project-based learning for IT skills development

The IT industry comprises project teams that operate in project-based environments. It can be suggested that the gap between IT theory (standard IT teaching practices at university) and IT practice (the required industry-related skills) can be addressed by using project-based learning for skills development in an IT degree. Examples of PBL used within a South African

context provide evidence of its success towards skills development. In a study by Havenga (2015:154), 89 computer science and information technology students worked in teams of two on a programming project as part of a PBL activity. The results of the study indicated that project-based learning contributed to a range of skills such as teamwork, self-directedness, solving complex problems and creating innovative artefacts. A study by Taylor and Goede (2015:19) provides benefits and challenges of using project-based learning in data warehouse education. Findings from interview feedback indicated that students felt that the PBL activity had improved their technical skills needed for industry, as well as related soft skills such as time management, problem-solving, teamwork, communication, and research skills. Challenges experienced with the PBL activity included time constraints, dependencies on team members, and assessment practices. The authors recommended careful construction of rubrics to provide improved feedback when using project-based learning activities.

Project-based learning is suggested as a suitable pedagogy that can be used to address the South African IT skills gap, but the approach needs to be refined. Due to the various implementation methods used for PBL, as well as different approaches towards IT skills development and promoting IT career awareness, it is recommended to construct a single source of guidelines that can address the IT theory-practice gap within a South African context.

1.3.3 Guidelines for bridging the IT theory-practice gap

For the purpose of this study, it is recommended to develop guidelines for bridging the gap between IT theory and IT practice. This could be supported through project-based learning for IT skills development. Developing the guidelines will require a suitable research methodology, such as design science research for artefact creation. The contribution of the guidelines can be improved upon by engaging in reflective practice in the development process; and also encouraging reflective practice for professional development throughout the research.

The central concepts of this research are identified as IT skills development, project-based learning, reflective practice, and design science research. Towards understanding how each concept contributes to the study, the following section poses the required research questions.

1.3.4 Research questions

The following research questions are identified to guide the research in this study:

- Which industry-related skills does an IT graduate need and typically lack?
- Is project-based learning a suitable instructional method for IT skills development, and how can it be implemented in an IT degree to introduce industry-related IT skills?

- How can a set of guidelines be developed for bridging the IT theory-practice gap in order to improve the skills of IT graduates required by industry?
- How can reflective practice support the development of these guidelines (a design science research artefact) by generating explicit knowledge?

Based on the research questions identified, the following section provides an overview of the research objectives of the study.

1.3.5 Research objectives

The primary research objective of this study is to develop guidelines for bridging the gap between IT theory (standard IT teaching practices at university) and IT practice (the required industry-related skills).

To support the primary objective, secondary research objectives are presented in Table 1.1 divided between theoretical and empirical objectives. The secondary objectives are structured according to the phases of the design science research process model; to illustrate the natural process the research follows within the specified research methodology.

Table 1.1: Secondary objectives of the study

DSR phase	Secondary objectives
Awareness of problem	**Theoretical** • To define the research problem • To describe the literature concepts that are significant for further investigation • To motivate the suitability of the research methods proposed to conduct the research **Knowledge required to *make a suggestion*:** • To provide a shared understanding of design science research as a paradigm for artefact creation • To provide a shared understanding of the relationship between design science research and reflective practice • To provide a shared understanding of reflective practice for professional development
Suggestion	**Theoretical** • To provide a shared understanding of reflective practice as a method to improve explicit knowledge generation in design science research • To provide a shared understanding of project-based learning as an instructional method that supports the development of 21st century competencies, soft skills, and technical skills • To understand which industry-related skills IT graduates typically lack • To understand how project-based learning can be implemented in an IT degree to improve the industry-related skills of future IT graduates
Development	**Empirical** • To develop guidelines for bridging the gap between IT theory and IT practice

Evaluation	**Empirical** • To identify which aspects of the guidelines should be evaluated by specific role players • To conduct interpretive data gathering methods with relevant role players in order to understand the problem experienced, and the value of implemented approaches, from their respective perspectives • To use interpretive data analysis methods on the qualitative data gathered in order to identify themes in the data • To evaluate and improve the effectiveness of the developed guidelines by demonstrating them in an IT degree and reflecting on the analysed data
Conclusion	**Theoretical** • To communicate a set of guidelines for bridging the gap between IT theory and IT practice • To communicate recommendations within the context of a reflection on the research • To communicate the limitations of the study • To suggest possibilities for future research that can supplement the guidelines for bridging the gap between IT theory and IT practice

1.4 Research contribution

The study will aim to make a contribution in the fields of reflective practice, DSR, PBL, and IT skills development in the three areas of the FMA model of Checkland and Holwell (1998:13). The FMA model showcases three important elements of research, namely the framework of ideas (F), the methodology (M), and the area of concern (A). During the research process, it is important that learning takes place for each element as depicted in Figure 1.3.

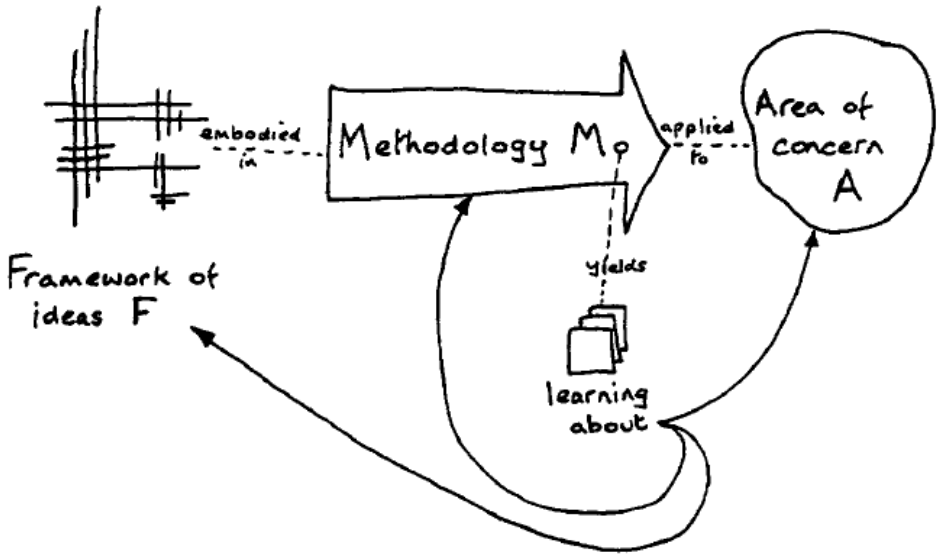


Figure 1.3: The elements of research according to Checkland and Holwell (1998:13)

Within the context of this research, Figure 1.4 depicts a richer picture of the study using the FMA model to indicate the contribution of the research in the field of information technology.

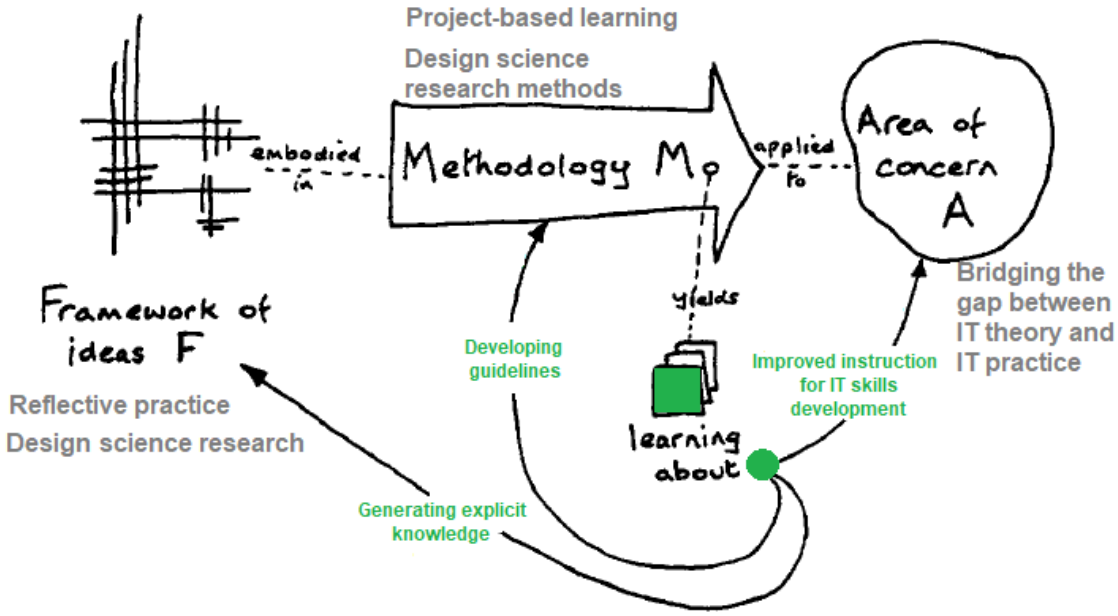


Figure 1.4: FMA research elements of this study

The contribution of this study, according to the FMA model, is:

- Framework of ideas (F):
  - To enrich the field of design science research by using reflective practice to generate explicit knowledge within its process (level 2 contribution to the DSR knowledge base as a *model*, refer to Chapter 3, Section 3.3.2).
  - To enrich the field of reflective practice by *reflecting* on its explicit and implicit application in the research methodology applied, research approaches followed, and research results obtained, in this study.
- Methodology (M)
  - To enrich the field of design science research through the development of guidelines as an artefact (level 2 contribution to the DSR knowledge base as a *method*, refer to Chapter 3, Section 3.3.2).
  - To enrich the field of project-based learning as an instructional approach towards bridging the IT theory-practice gap.
- Area of concern (A)
  - To bridge the gap between IT theory and IT practice through improved instructional approaches that support IT skills development.
  - To demonstrate a collection of guidelines built using a DSR approach towards bridging the gap between IT theory and IT practice (level 1 contribution to the DSR knowledge base as an *instantiation* which is an example of a developed artefact using DSR rules, refer to Chapter 3, Section 3.3.2).

1.5 Research paradigm, design, and methodology

This section provides a discussion on the reasoning behind using design science research, as well as a brief overview of the participants, data collection and analysis methods, ethical considerations, and delimitations of the study.

1.5.1 Justification for using design science research

As a response to the secondary objective, *To motivate the suitability of the research methods proposed for conducting the research*, this section provides context for the chosen paradigm, i.e. design science research.

Research is conducted based on a fundamental research paradigm (Oates, 2006:13). A research paradigm can be seen as the worldview of a person regarding the nature of truth and the development of research (Fraenkel & Wallen, 2008:559). Vaishnavi *et al.* (2004/2019:9) define three research paradigms with their philosophical beliefs, namely the positivistic, interpretive, and design science research paradigms. Oates (2006:296) includes a fourth paradigm for research conducted in information systems and computing, named critical research. All paradigms have ontological, epistemological and axiological assumptions (Myers, 2009:37; Vaishnavi *et al.*, 2004/2019:9).

In this study, guidelines for bridging the gap between IT theory and IT practice are developed. The focus of this study is on the development of the guidelines, and not on the emancipation of the user group that the guidelines are intended for. Only after a final set of guidelines has been proposed can it be implemented in its entirety with the goal of emancipating future IT graduates. The research paradigm most suitable for the objective of this study is design science research (discussed in Section 1.2.4), as the focus is on the development of the guidelines, and not on the emancipation of IT students by implementing the guidelines (critical research).

1.5.2 Participants

The central participants of the study include entry-level and exit-level IT students enrolled for a BSc undergraduate degree in Information Technology at a university in South Africa. Other role players of the study include members from the IT industry in South Africa. The problem experienced started with exit-level IT students when a skills gap was noticed between IT theory and IT practice during 2017. Industry members were subsequently asked, in a pilot study, to provide feedback on the skills IT graduates typically lack. The feedback was used to improve the curriculum at entry-level and exit-level of an IT degree. Students at both levels were asked to comment on the strategies that were implemented towards improving the

curriculum, with the aim of bridging the gap between IT theory and IT practice. Participant detail is discussed in more detail in Section 3.5.3.

1.5.3 Data gathering and analysis

As part of the evaluation phase of the DSR process model, qualitative methods were used to gather data from participants. The qualitative methods included written interviews, reflective sheets, and interpretive questionnaires. Interpretive content analysis in the form of open coding was used to analyse the qualitative data. Themes identified in the data highlighted aspects such as South African IT graduate skills that were found lacking, teaching and learning approaches that improved skills development, and intervention strategies that promoted career awareness. Findings from literature and the identified themes were used to build guidelines towards bridging the IT theory-practice gap. The literature context of the data collection and analysis methods are discussed in greater detail in Sections 3.5.1-3.5.2.

1.5.4 Ethical considerations

The researcher signed the code of conduct as prescribed by the North-West University (Appendix A). This document commits to four principles of research integrity, namely honesty, accountability, professional courtesy and good stewardship.

Ethical clearance was obtained from the North-West University to conduct the research. The process followed was via an ethical clearance application submitted to the ethics sub-committee of the faculty. The committee reviewed the application for risk. The study was approved and an ethical clearance number was awarded – ECONIT-2017-074 (Appendix B).

As the study includes interpretive qualitative methods with participants, where valuable input can be obtained, it is important to remind participants of the intellectual property clause of the university. Any information or ideas gathered during the data collection methods will remain the property of the university according to Paragraph 2.1 and 2.2 in the rules and guidelines for management of intellectual property at the North-West University (North-West University, 2010:12).

The researcher commits to the ethical responsibilities as set out by Oates (2006:60):

- To respect the confidentiality and anonymity expected by participants;
- To obtain informed consent appropriate to the method of data collection;
- To behave with integrity by accurately recording data; and
- To give credit where it is due, by accurately referencing sources used in the research.

Ethical principles to be followed for design science research studies (Myers & Venable, 2014:806) include identifying the public interest, providing informed consent, privacy, honesty and accuracy, declaring ownership of intellectual property, and the delivery of quality artefacts. These DSR ethical principles will be discussed, within the context of this study, in greater detail in Chapter 3.

1.5.5 Delimitations of the research

The following delimitations of the research were identified:

- The model for generating explicit knowledge in design science research through reflective practice proposed in Chapter 4 (Article 1) was used to identify the central role players that formed part of this research as participants.
- The development of the artefact was based on the feedback from student participants that took part in modules that the researcher facilitated at the time of this research. These included extended IT students as well as IT students in their final year.

1.6 Chapter layout

Figure 1.5 illustrates the chapter layout of this study, structured according to the phases of the design science research process model. As reflective practice is a central framework of the research, it is important to note that reflective practice takes place across all chapters and content. When reflective practice is embedded in a research approach from the onset, the researcher can more clearly determine what knowledge will be required in order to *make a suggestion*. For this reason, the DSR phases are adapted for this study, to also indicate the knowledge requirement that informs the suggestion, development, and evaluation phases.

Chapter 1: Introduction

This chapter provides an overview of the study by providing background literature of the research environment and problem statement. Research objectives are presented, and the research methodology that guides the study is discussed.

Chapter 2: Literature review outline

Chapter 2 provides an outline of where all literature regarding key concepts of the research can be found in this thesis (in table format).

Chapter 3: Research methodology

The chapter starts with a broad discussion on research methodologies in order to position the study within the context of design science research. An in-depth

discussion on the concepts that form part of the central theoretical framework of the research is provided (design science research and reflective practice). The chapter also provides literature context to data collection and analysis methods used in this study.

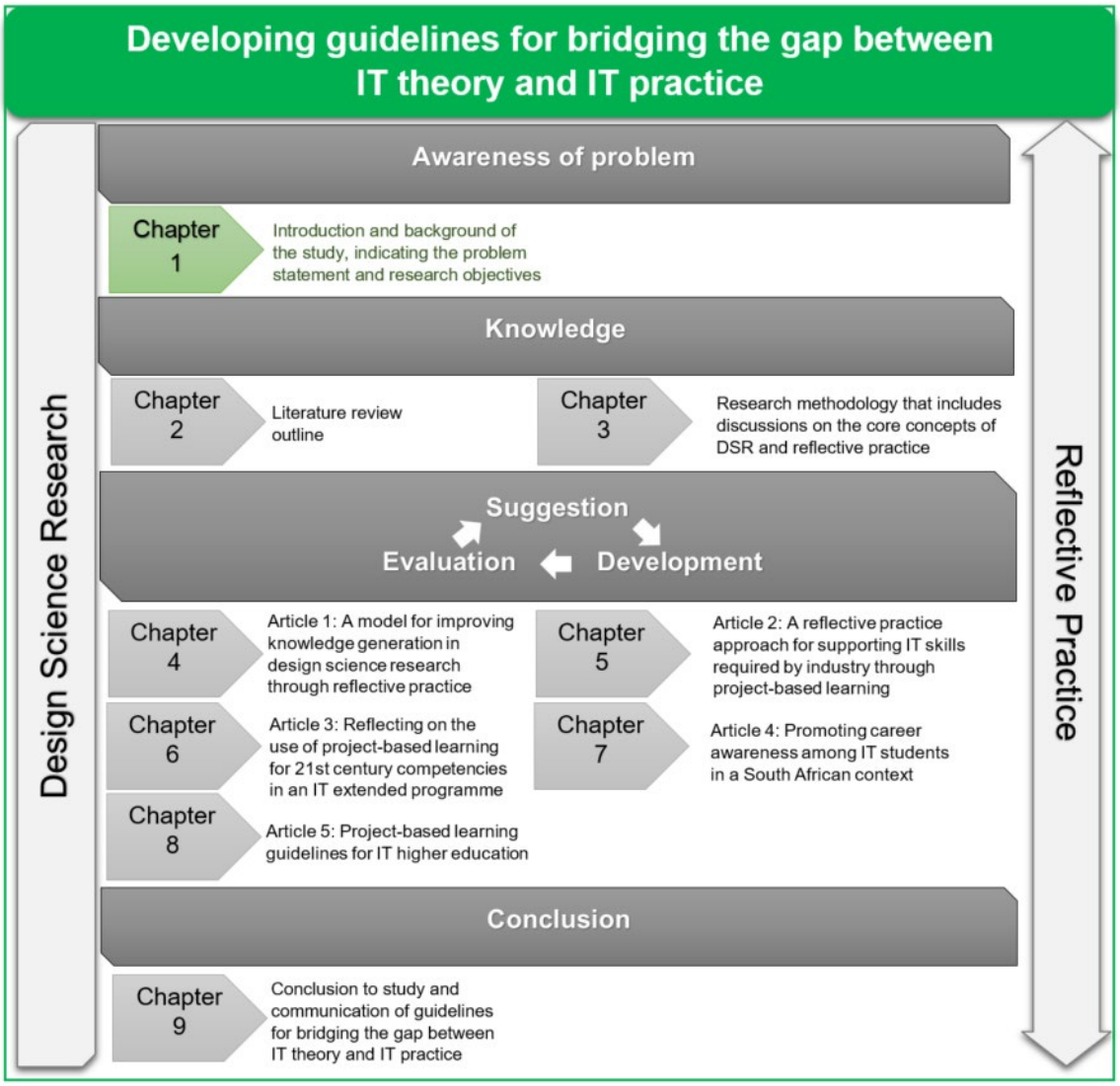


Figure 1.5: Chapter layout of study according to the phases of the DSR process model

Chapter 4: Article1 – *A model for improving knowledge generation in design science research through reflective practice*

Article 1 provides a contribution to the theoretical framework of this research by presenting a model to improve knowledge generation in design science research through reflective practice. A demonstration is provided that offers the foundational context of this research by explaining how DSR and reflective practice were used to develop guidelines for bridging the gap between IT theory and IT practice.

Chapter 5: Article 2 – *A reflective practice approach for supporting IT skills required by industry through project-based learning*

Article 2 serves as the pilot study of this research, where members from the IT industry highlighted the skills that they found lacking in IT graduates. The article also demonstrates how project-based learning can be used to facilitate the execution of industry project briefs in higher education.

Chapter 6: Article 3 – *Reflecting on the use of project-based learning for 21st century competencies in an IT extended programme*

Article 3 is presented in response to comments made in Article 2 – where it is suggested that interventions should take place earlier in an IT degree. The paper demonstrates that project-based learning can be implemented in an IT extended degree towards skills development. The paper also highlights guidelines towards bridging the IT theory-practice gap.

Chapter 7: Article 4 – *Promoting career awareness among IT students in a South African context*

Article 4 presents an intervention strategy to raise career awareness among IT students. The article is written in response to previous articles and literature that highlighted the need for career awareness to make informed career decisions. The implications of the research resulted in a comprehensive list of guidelines to raise career awareness towards bridging the IT theory-practice gap.

Chapter 8: Article 5 – *Project-based learning guidelines for IT higher education*

Chapter 8 presents a literature-based article on project-based learning. The article provides a set of guidelines for the specific use of project-based learning in IT higher education. The article contains novel contributions within the context of project-based learning that is currently relevant to IT industry training. The article provides a demonstration of how to implement the guidelines by using three exit-level IT projects as examples.

Chapter 9: Conclusion

The final chapter in this research provides a conclusion to the study, by reflecting on how the research objectives were met and how the process of design science research was followed for research rigour. Limitations and future research opportunities are provided. Finally, Chapter 9 communicates

how the primary objective of this research was met, by providing a consolidated set of developed guidelines for bridging the gap between IT theory and IT practice.

1.7 Conclusion

In this chapter, background research for the research problem was presented, and research objectives were formulated. The primary objective of this study is to develop guidelines for bridging the gap between IT theory and IT practice. To achieve this goal, the research paradigm of design science research, and the theoretical framework of reflective practice, guide the development of the guidelines. Project-based learning is implemented as an instructional approach to support IT skills development in entry-level and exit-level modules of an IT degree. Feedback from participants on skills shortages and the implemented instructional approaches is used to identify themes in the data, towards the development of the proposed guidelines.

The chapter layout is provided within the context of the DSR process model (Figure 1.5) to demonstrate the logical flow that the study follows based on the chosen research methodology. Contributions of the research are highlighted within the context of the FMA model (Figure 1.4).

Limitations and future research opportunities of the study will be discussed in the final chapter of the thesis to provide context to the research results. The following chapter contains an outline of literature sources used in this study, to guide the reader through the research.

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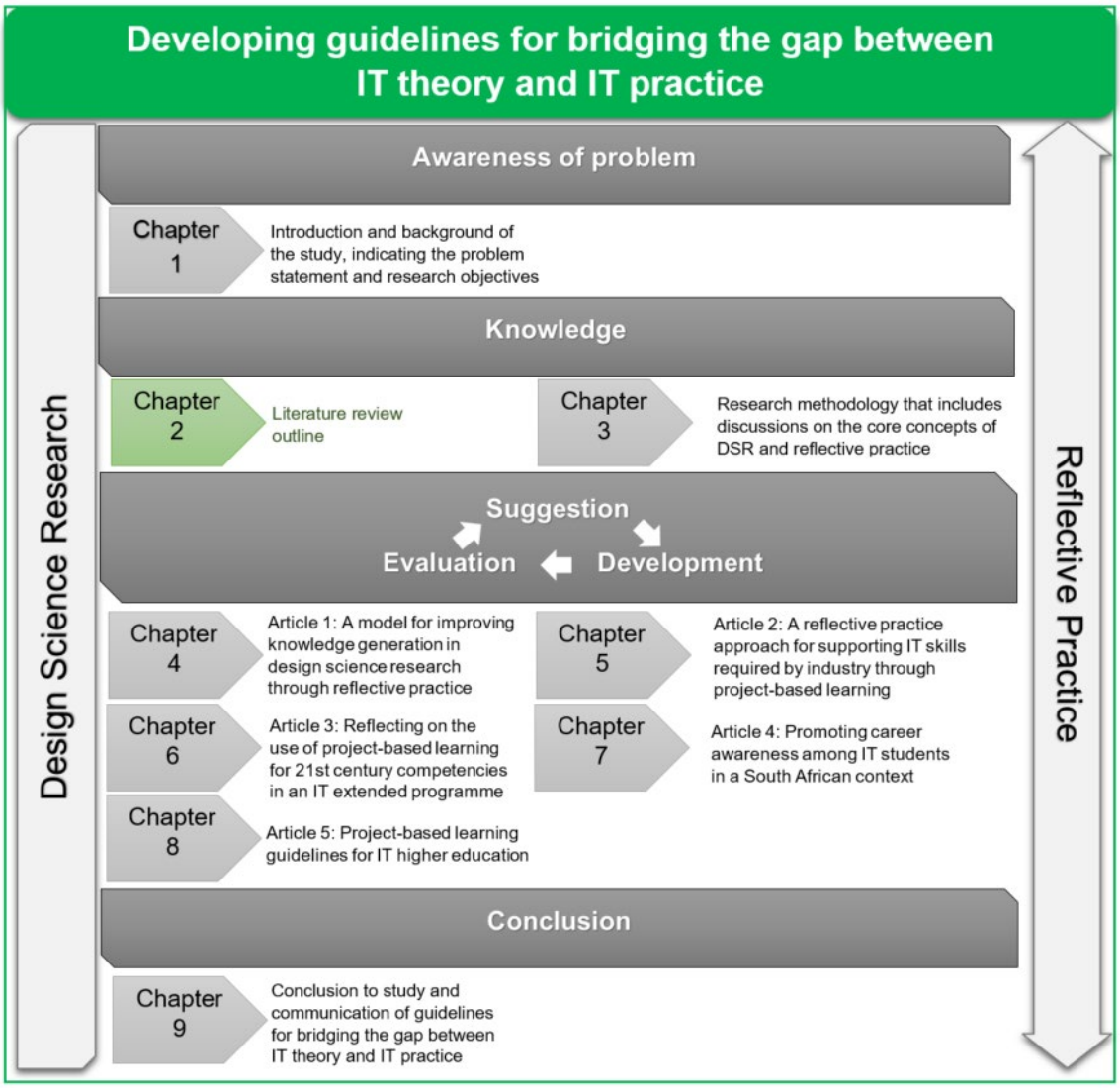
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CHAPTER 2: LITERATURE REVIEW OUTLINE



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2.1 Introduction

The primary objective of this study is to develop guidelines for bridging the gap between IT theory (standard IT teaching practices at university) and IT practice (the required industry-related skills). Design science research and reflective practice are used for artefact creation within the context of project-based learning implemented during an IT degree. This research results in the development of a set of guidelines that can be followed to improve the alignment between higher education and industry in the IT sector.

Design science research is a research paradigm with related approaches commonly used for the development of IT artefacts. The cyclical nature of the phases of design science research is intuitively similar to that of reflective practice. Reflective practice, however, provides deeper insight through experiential learning and can improve the knowledge generated through design science research practices. For this reason, a combined approach is adopted using design science research to guide the development of the guidelines as an IT artefact, and reflective practice to improve the contribution and value of the guidelines.

As the study results in a set of guidelines for bridging the IT theory-practice gap, the central literature required should also include concepts that are related to an information technology environment. The IT industry consists of project development and project teams, and for this reason higher education should mimic its project-based nature. Project-based learning is researched and applied within the context of entry-level and exit-level IT modules. Academic literature indicates the usefulness of project-based learning to improve the 21st century competencies, soft skills, and technical skills of students. In order to use project-based learning effectively for IT higher education, research is required to understand which IT practices should be integrated for optimal learning that is both current and relevant.

The purpose of this chapter is to provide a brief overview of the literature reviews included throughout this study. Due to the nature of this research, which does not follow the traditional thesis format, sections of literature reviews are distributed across Chapter 3 as well as the respective articles included in the research (Chapter 4 to Chapter 8). This chapter provides guidance to the reader, in order to locate the background research per key concept.

Section 2.2 contains a table overview of where the literature reviews can be found in this study, and a conclusion to the chapter is provided in Section 2.3.

2.2 Outline of literature reviews found in study

Concepts for discussion in this study include research methodology, design science research, reflective practice, and project-based learning within the context of IT skills development. The literature reviews for these concepts are distributed across multiple articles in the research.

The concepts are addressed in response to the theoretical secondary objectives highlighted in Chapter 1:

- To describe the literature concepts that are significant for further investigation
- To motivate the suitability of the research methods proposed to conduct the research
- To provide a shared understanding of design science research as a paradigm for artefact creation
- To provide a shared understanding of the relationship between design science research and reflective practice
- To provide a shared understanding of reflective practice for professional development
- To provide a shared understanding of reflective practice as a method to improve explicit knowledge generation in design science research
- To provide a shared understanding of project-based learning as an instructional method that supports the development of 21st century competencies, soft skills and technical skills
- To understand which industry-related skills IT graduates typically lack
- To understand how project-based learning can be implemented in an IT degree to improve the industry-related skills of IT graduates

Table 2.1 serves as an outline of literature reviews that can be found in this study.

Table 2.1: Outline of literature reviews per theoretical concept

Research methodology	
Background	Chapter 3: Section 3.2 contains an overview of the different research paradigms with their epistemological and ontological assumptions, indicating the appropriateness of each paradigm toward solving the research problem.
Design science research	Chapter 1: Section 1.2.4 provides an overview of design science research within the context of the study. Section 1.5.1 motivates the selection of design science research as a suitable paradigm for the research.
	Chapter 3: Section 3.3 contains a general overview of design science research, focusing on the research process, appropriate approaches and guidelines when using this paradigm.
	Chapter 4, Article 1: Section 1, Section 2, and Section 4 contain reflections on the epistemological assumptions of design science research, as well as methods to improve explicit knowledge generation.
Research plan	Chapter 1: Section 1.3.4 and Section 1.3.5 provide an overview of the research questions and objectives of the study. Section 1.5 provides an overview of the methodology used in the study. The research is structured according to the phases of design science research to illustrate the developmental nature of guideline building. To that end, Section 1.6 provides a chapter layout of the thesis according to the phases of the DSR process model.
	Chapter 3: Section 3.4.1 provides an overview of the research process followed in this study.
	Chapter 3: Section 3.5 contains an overview of the data collection methods and their related analysis methods used in the study.

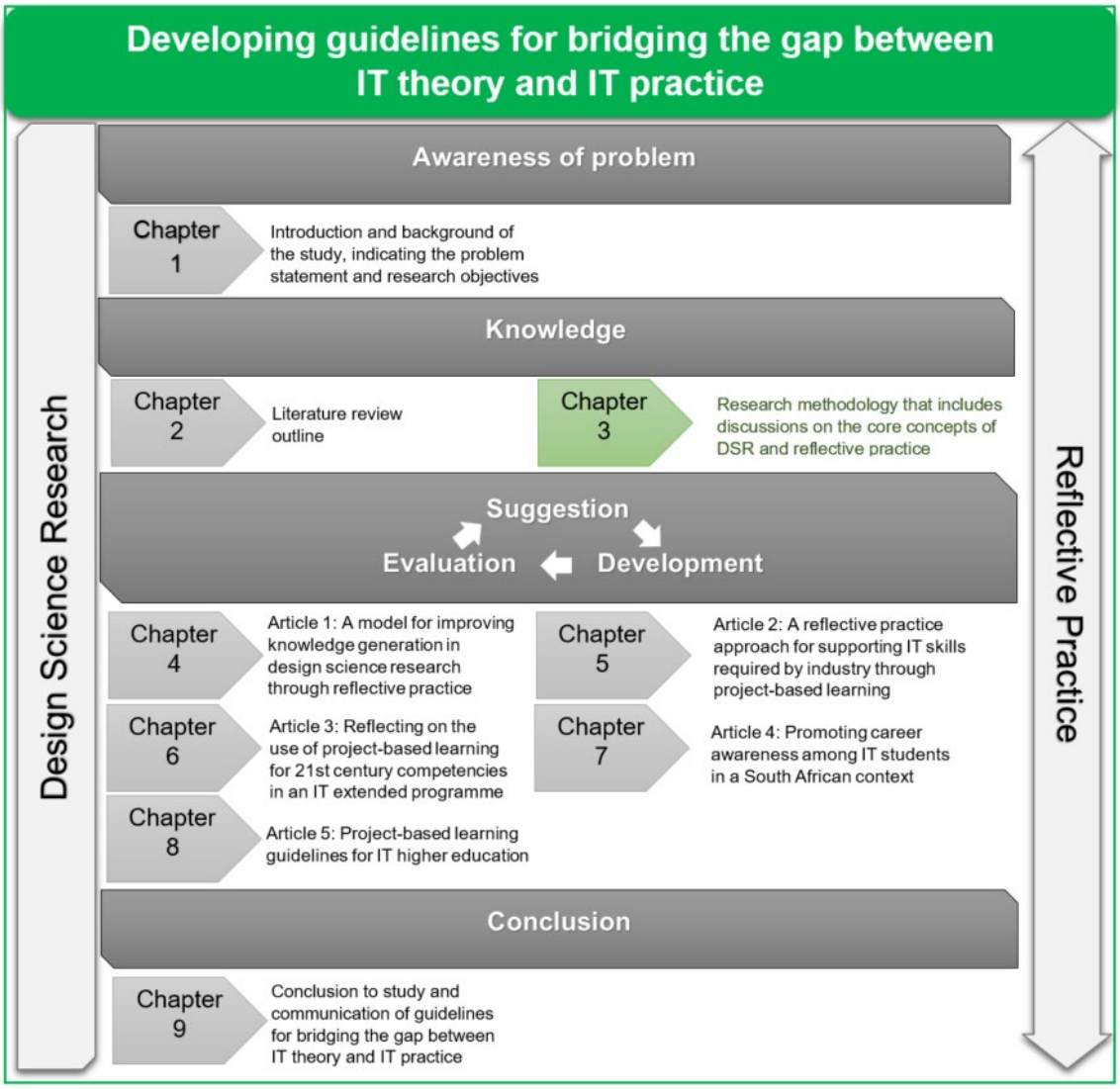
Qualitative research methods	Chapter 4, Article 1: Table 1 contains references to qualitative methods that can be used within the context of a study that makes use of design science research and reflective practice for explicit knowledge generation.
	Chapter 5, Article 2: Section 4 contains references to the data collection (written interviews with members of industry) and analysis methods (undirected approach to open coding) used in the article.
	Chapter 6, Article 3: The sections for the research approach and results contain an overview of the research approach (interpretive), the data collection method (student reflections of entry-level IT students), and the data analysis method (directed approach to open coding).
	Chapter 7, Article 4: Section 3.1 and Section 4.3 contain an overview of the research approach (interpretive), the data collection method (interpretive online questionnaire completed by exit-level IT students), and the data analysis method (directed approach to open coding).
Reflective practice	
Overview and experiential learning	Chapter 1: Section 1.2.3 provides context for the use of reflective practice in the research. Reflective practice is central to the research methodology adopted for the research, as well as the professional development of IT students through project-based learning. The researcher also engages in reflective practice towards improved practice through instruction, research, and personal development.
	Chapter 3: Section 3.3.5 contains an overview of reflective practice, its history and context to the DSR study.
	Chapter 4, Article 1: Section 3 and Section 4 contain an overview of how knowledge is explicitly generated with methods for reflective practice and experiential learning, as well as how reflective practice can be used in design science research to improve explicit knowledge generation.
	Chapter 5, Article 2: Section 2.2 provides an overview of how reflective practice supports the nature of project-based learning. The section also highlights that practising reflection is important for the student, as well as the researcher to improve best practices.
	Chapter 6, Article 3: The section on promoting reflective practice in project-based learning highlights the need to embed reflection of learning approaches taken for long-term impact.
	Chapter 7, Article 4: Section 2.1 provides a discussion on the application of reflective practice within the context of organisational learning.
	Chapter 8, Article 5: Section IV provides an overview of how reflective practice is embedded in project-based learning for professional development.
Project-based learning	
Overview and guidelines	Chapter 1: Section 1.2.2 and Section 1.3.2 respectively provide examples of studies where project-based learning was used in IT-related instruction internationally, as well as locally.
	Chapter 5, Article 2: Section 2.1 provides an overview of the characteristics of project-based learning.
	Chapter 6, Article 3: The section on project-based learning contains a discussion on the need and usefulness of PBL to address 21st century competencies.
	Chapter 8, Article 5: This article in its entirety is a literature review on the background and application of project-based learning. A novel contribution is made in the form of guidelines for effectively using project-based learning specifically in IT higher education - towards bridging the IT theory-practice gap.

IT skills development	
Background	Chapter 1: Section 1.2.1 and Section 1.3.1 respectively provide an overview of the IT skills gap experienced internationally, as well as locally, by referring to related studies conducted.
IT soft and technical skills	Chapter 5, Article 2: Section 1 and Section 4 provide context to typical soft skills, technical skills, and additional required learning expected of a South African IT student.
	Chapter 7, Article 4: The section on the typical career path of an IT student in South Africa contains a brief overview of graduate soft and technical skills expected by the South African IT industry.
	Chapter 8, Article 5: Section III provides an overview of how project-based learning is used in IT higher education, in order to address IT soft and technical skills.
21st century competencies	Chapter 6, Article 3: The section on project-based learning provides an overview of which skills are identified as 21st century competencies.
	Chapter 8, Article 5: Section II contains reference to the importance of 21st century skills development through project-based learning in order to create a stronger alignment of skills development between university and industry.
Career awareness	Chapter 7, Article 4: Section 2.2 and Section 2.3 provide an overview of approaches to promote career awareness in order to make explicit connections between required skills and employability, as well as context as to why collaboration between IT higher education and the IT industry is important in South Africa for IT skills development.

2.3 Conclusion

The chapter provided a brief overview of the manner in which literature reviews per key concept were addressed. The following chapter provides detailed literature reviews on research methodology approaches, design science research, and reflective practice within the context of the development of guidelines for bridging the IT theory-practice gap.

CHAPTER 3: RESEARCH METHODOLOGY



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3.1 Introduction

The primary objective of this study is to develop guidelines for bridging the gap between IT theory (standard IT teaching practices at university) and IT practice (the required industry-related skills). In this chapter, the process followed to conduct the research is reflected on. The research process should be sensibly articulated to ensure that other scholars accept the

outcome of the study (Oates, 2006:32). Hofstee (2006:107) indicates that readers validate the content of a study based on the chapter or section that explains the approach that was followed to conduct the research.

As discussed in Chapter 1, Checkland and Holwell (1998:13) provide the FMA model that depicts the relevant elements of any research (Figure 3.1). The three important elements of research are the framework of ideas (F), the methodology (M), and the area of concern (A). During the research process, it is important that learning takes place for each element.

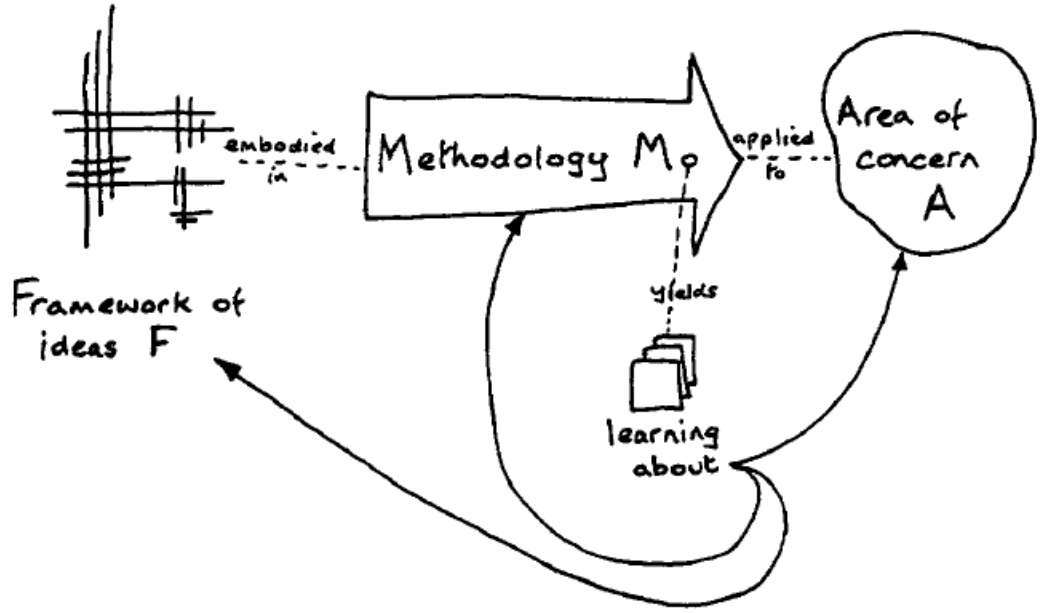


Figure 3.1: The FMA model depicting key elements of research (Checkland & Holwell, 1998:13)

The framework of ideas ("F" in Figure 3.1) represents the ontological and epistemological assumptions of the available research paradigms. After the research paradigms are evaluated for their relevance within the context of a specific study, an informed decision is made regarding which paradigm to use for the research. The framework of ideas is the foundation of the methodology and guides the specific approaches and guidelines appropriate for the research ("M" in Figure 3.1). The methodology is then applied to the context of the area of concern ("A" in Figure 3.1), which represents examples that highlight the need for the primary objective of the research.

Section 3.2 provides an overview of the different research paradigms available ("F" in Figure 3.1). Section 3.3 provides a general overview of the chosen research paradigm for this study and its research process, knowledge base, approaches, and guidelines. Section 3.4 explains how this research paradigm and its research methods are adopted within the context of this

study (“M” in Figure 3.1). Section 3.5 provides an overview of the areas of application of the research by reflecting on the samples, data collection and data analysis methods, and ethical principles considered for this research (“A” in Figure 3.1). Section 3.6 summarises the chapter by indicating the contributions made to the FMA model.

3.2 Research paradigms

Research is conducted based on a fundamental research paradigm (Oates, 2006:13). A research paradigm can be seen as the worldview of a person regarding the nature of truth and the development of research (Fraenkel *et al.*, 2012:559). A paradigm is a recurring depiction of coherent conceptual theories (Kuhn, 1970:43), and the understanding thereof is a sign of maturity for any researcher in any given scientific field (Kuhn, 1970:11). Researchers should understand the available research paradigms and also the manner in which readers will review their research based on their respective worldviews (Oates, 2006:282). Paradigms are defined as the basic beliefs of a person and embody the nature of the world and a person’s relationship to it (Guba & Lincoln, 1994:107). Vaishnavi *et al.* (2004/2019:9) define three research paradigms with their philosophical beliefs, namely the positivistic, interpretive and design science research paradigms. Oates (2006:296) and Myers (2009:36) discuss a fourth paradigm called critical research. All paradigms have ontological and epistemological assumptions that guide the research process (Myers, 2009:37; Oates, 2006:303; Scotland, 2012:9). Table 3.1 provides an overview of the four research paradigms and their underlying ontological and epistemological assumptions (Adebesin *et al.*, 2011:310; Vaishnavi *et al.*, 2004/2019:9).

Table 3.1: Research paradigms with their philosophical worldviews (first three columns adopted from Vaishnavi *et al.* (2004/2019:9) and last column adopted from Adebesin *et al.* (2011:310))

Basic belief	Positivist	Interpretive	Design science research	Critical social theory
Ontology	Single reality; knowable; probabilistic	Multiple realities; socially constructed	Multiple; contextually situated alternative world-states. Socio-technologically enabled	Socially constructed reality; power; discourse
Epistemology	Objective; dispassionate; detached observer of truth	Subjective; i.e. values and knowledge emerge from the researcher-participant interaction	Knowing through making: Objectively constrained construction within a context. Iterative circumscription reveals meaning	Suspicious; political; observer constructing versions

Methodology	Observation; quantitative; statistical	Participation; qualitative; hermeneutical; dialectical	Developmental. Measure artefactual impacts on the composite system.	Textual analysis; discourse analysis; deconstruction
Axiology	Truth; universal and beautiful; prediction	Understanding: situated and description	Control; creation; progress (i.e. improvement); understanding	Contextual understanding; inquiry is value-bound; researcher's values affect the study

Ontology can be defined as the study of being (Scotland, 2012:9), and investigates the question of existence or reality (Crotty, 1998:10). An ontological assumption is concerned with defining the construction of meaning and what individuals observe as reality, i.e. what is tangible, what is important and what is unoriginal. Researchers make a decision regarding their perception of how things work and how things are (Scotland, 2012:9). Crotty (1998:10) gives five categories of ontology, namely conceptualism, nominalism, rationalism, empiricism, and realism, and state that these are not restricted to a specific epistemology.

Epistemology refers to the theory of knowledge and is concerned with understanding the limitations, the validity and the scope of knowledge (Myers, 2009:35). An epistemological assumption is concerned with exploring the creation of knowledge and the manner in which individuals learn about their supposed reality, i.e. what does knowledge depend on, how can we be sure that what we know is real? Epistemology explains how knowledge is created, how knowledge is attained, how knowledge is articulated and how knowledge is communicated (Scotland, 2012:9).

In order to determine which research paradigm is most suitable for this study, a discussion on the epistemological and ontological assumptions of the different research paradigms follows.

3.2.1 Positivist paradigm

The positivistic paradigm suggests that there is an order to all things (Adebesin *et al.*, 2011:310). It is viewed as a single reality that is typically measured by quantitative research approaches to prove or reject a hypothesis (Myers, 2009:37). These quantitative research approaches include methods such as questionnaires and surveys, and are subject to statistical analysis.

Francis Bacon is one of the first well-known positivistic philosophers of the 16th century, whose worldview was that of anthropocentric bias – a false idea that allows individuals to view all things in relation to themselves (Bhaskar, 1975:123). Bhaskar (1975:99) also indicated that

René Descartes was the catalyst for new physics, influenced by philosophers such as Aristotle and Aquinas, and as such he is known as the father of modern philosophy. According to Louth (2011:69), Auguste Comte is considered the father of positivism and aimed to find the scientific underpinnings in all historic laws. Comte (1868:25) referred to positivism as the *positive philosophy* and explained that the positive (scientific) state of the human mind can only be reached after it has progressed respectively through the theological (fictitious) state and the metaphysical (abstract) state. Comte (1868:26) explained that in the final positive (scientific) state, the human mind has rejected the vain search for absolute concepts and the origins of a phenomenon, and instead focuses its efforts on studying the laws of the phenomenon. Comte (1868:26) indicated that this knowledge was acquired by reason and observation. From Comte's work, we can gather that the goal of positivism is to determine (measure) the impact that diverse variables have on a phenomenon.

3.2.1.1 Positivistic assumptions

The ontological assumption of positivism stems from the notion of realism (Scotland, 2012:10). According to Myers (2009:214), realism is concerned with authoritative common-sense, descriptive accounts of reality; where reality is objectively given and is measured by the properties of natural phenomena that are independent of the researcher or his mechanisms (Myers, 1997:242; Scotland, 2012:10). Positivists make the assumption that reality exists independent of the researcher and that reality is not arbitrated by an individual's senses (House, 1991:3). The positivist paradigm is also referred to as the scientific paradigm and its objectives are established on data and facts (House, 1991:2).

The epistemological position of positivism is objectivism and is considered as knowledge to be discovered (Scotland, 2012:10). Positivists are unbiased in nature and ascertain absolute facts about an objective reality (Crotty, 1998:8). Crotty (1998:8) further gives the example that a tree in a forest is still a tree, regardless of the possibility that no person may know that it exists. When a person eventually realises that it is a tree, they merely discover a fact that has been true before they knew of the tree's existence. This discoverable knowledge is thought of as true and is not positioned in a political or historical background (House, 1991:2). Positivistic studies typically formulate a hypothesis and test whether it is true.

3.2.1.2 Suitability of the positivistic paradigm

The primary objective of this study is to develop guidelines for bridging the gap between IT theory (standard IT teaching practices at university) and IT practice (the required industry-related skills). The objectives provided in Chapter 1 offer an overview of the research activities that form part of this study. Among these, the qualitative data collection methods are of an

open-ended nature, and will be conducted to obtain rich feedback regarding the participants' experiences. The research objectives of the study also include the design and development of an artefact (guidelines). There is are no hypothesis to prove or reject through quantitative measurements, and as such the positivistic paradigm is not suitable for this study.

3.2.2 Interpretive paradigm

The interpretive paradigm assumes that there are multiple realities, and individuals' understanding thereof depends on aspects such as different languages, culture and the meaning they give to specific phenomena (Myers, 2009:38). Interpretive research includes knowledge that is only gained through social constructions and puts emphasis on the intricacy of human sense making (Klein & Myers, 1999:69). Qualitative research approaches are generally used in interpretive research as the researcher aims to gain a richer understanding of the subject (Oates, 2006:292); however, depending on the researcher's philosophical assumptions, not all qualitative research can be seen as interpretive (Klein & Myers, 1999:69). Interpretive research methods typically used include case studies, ethnographies and interviews.

According to Brown (1976:208), Wilhelm Dilthey meaningfully influenced research in the social sciences by introducing the concept of interpretivism as a result of his pursuit to understand other human beings. Dilthey's research was fundamentally influenced by the work of philosopher Friedrich Schleiermacher whose life work was that of hermeneutics. Dilthey's essay *The rise of hermeneutics*, a 1900 German publication translated by Frederic Jameson in 1972 (Dilthey & Jameson, 1972:230), poses the question that: If scientific knowledge is indeed the principal form of singular existence, is this knowledge probable and what resources do we have available to attain it? Dilthey goes on to say that the concern with this type of knowledge is that it assumes our knowledge of other individuals, when the central issue with human studies is that we encounter problems that are specific to each individual and cannot be generalised. Human studies cannot be investigated within the constraints of natural studies as it is not a reflection of reality within consciousness. Dilthey states that human studies are concerned with "inner reality, a coherence experienced from within" and that it is only through the process of understanding "by which an inside is conferred on a complex of external sensory signs" (Dilthey & Jameson, 1972:231).

The goal of hermeneutics is to understand the individual better than he originally understood himself (Dilthey & Jameson, 1972:244). Hermeneutics can be seen as the theory of interpretation that reports on all human manifestations – that is, not only the physical attributes that we can easily perceive, but also visual expressions, unintended gestures and discernible

actions. The philosophical perspective of interpretive research is founded on hermeneutics and its central principle, the hermeneutic circle (Klein & Myers, 1999:72). The “hermeneutic circle suggests that we come to understand a complex whole from preconceptions about the meanings of its part and their interrelationships” (Klein & Myers, 1999:71).

3.2.2.1 Interpretive assumptions

Relativism is seen as the ontological stance of interpretivism (Scotland, 2012:11). According to Guba and Lincoln (1994:110), relativism is the opinion that reality is subjective and that it depends on the individual person. Orlikowski and Baroudi (1991:5) state that interpretive studies differ from positivistic studies in that interpretive research discards the likelihood of factual or objective accounts of phenomena. They conclude that interpretive research seeks the relativistic and collective understanding of the phenomena. Interpretive research places an emphasis on the meaning of phenomena within the context of the phenomena, and seeks to understand the significance of the phenomena relative to the individual who perceived it (Myers, 2009:39).

Orlikowski and Baroudi (1991:14) suggest that the epistemological stance of interpretive research is that researchers build motives that account for the manner in which subjective connotations are shaped and sustained in a specific situation. A researcher cannot detach himself from the scenario that is under investigation and for this reason needs to understand the significant factors that affect the interpretations made by diverse societies (Myers, 2009:40). Klein and Myers (1999:69) indicate that interpretive field studies include methods such as ethnographies and case studies, if the aim is to gain knowledge of reality solely through social constructs. An interpretive researcher may use coding methodologies such as grounded theory as it allows the researcher to develop a theory that is grounded in data that was systematically gathered and thoroughly analysed (Myers, 2009:106). Grounded theory provides interpretive researchers with a sense of vision so that they are able to discover what is truly happening, determine whether the theory is relevant, and understand the complexity and inconsistency of human action and phenomena (Strauss & Corbin, 1990:8).

3.2.2.2 Suitability of the interpretive paradigm

The primary objective of this study is to develop guidelines for bridging the gap between IT theory (standard IT teaching practices at university) and IT practice (the required industry-related skills). This objective of the study is dependent on the design and development of an artefact (guidelines). The guidelines are considered an artefact, similar to the paper from Gregor and Hevner (2013:342) in which they stated that they used a design science research approach to develop guidelines that formed part of their publication. During the development

of the artefact, interpretive methods will be used for evaluation purposes, but it is not the foundational paradigm that the research is built on. The research takes on “a pragmatic viewpoint which prioritises using any approach that allows research questions to be answered regardless of its supposed philosophical presuppositions” (Bryman, 2006:124). Design science research draws from the philosophical assumptions of pragmatism (Goldkuhl, 2012:93), and is discussed in greater detail in Section 3.3.5.2.

3.2.3 Critical social theory paradigm

Critical social theory assumes that reality is socially assembled, i.e. it aims to deconstruct a problem in order to understand it better and through this process make corrections where necessary and reconstruct a better instance of the original situation (Harvey, 1990:19). Critical social theory research aims to emancipate the oppressed by focusing on factors such as contradiction and conflict in present-day culture (Myers, 1997). Action research is most often used in conjunction with critical social theory research as its goal is intervention by understanding problems within social context (Baskerville, 1999:11).

Sudersan (1998:254) claims that critical theory was born when the Frankfurt theorists’ declared mission was to “interpret the scenario which unfolded as a result of the World Wars in which Germany was the key aggressor”. Sudersan (1998:254) indicated that they were shocked by the rise of Nazism and Fascism after the workers’ movement – when a new day in which the oppressed people were to participate in a meaningful way had failed. According to Horkheimer (1972:230), the founders of the Frankfurt School initiated their investigation into critical theory with the notion that “the power of nature and the weakness of society – are interconnected and are based on the experienced effort of man to emancipate himself from coercion by nature and from those forms of social life and of juridical, political, and cultural orders which have become a straightjacket for him”. They suggested that dated theories failed to determine the categories in the consciousness of man and the manner in which these categories influence man’s perceptions of what he thought possible (Horkheimer, 1972:230). It was Jürgen Habermas, a learned disciple from the Frankfurt School, who made the largest contribution towards critical theory. Habermas developed his theory on the supposition that man is driven by his interest to acquire knowledge and that emancipation is essential to man (Sudersan, 1998:262). He gave critical theory a new perspective with his worldview of “‘language which was free from subjective bias of the consciousness” (Sudersan, 1998:264).

As critical theory evolved, critical realism found middle ground between the dated notion of positivism and the unhindered notions of hermeneutic analysis under the guidance of Roy

Bhaskar (Harvey, 2002:163). “Roy Bhaskar has provided a philosophical vindication of the experimental method, effectively critiqued postmodernism, and showed how notions concerning agency might be integrated into naturalistic modes of social scientific explanation” (Harvey, 2002:163). Bhaskar formulated the concepts of transcendental realism and critical naturalism, which formed the abridgment of the concept of critical realism (Harvey, 2002:164). Mingers (2014:209) compared the work of Habermas and Bhaskar. He states that both philosophers express similar opinions regarding the nature of a perfect society towards which man should strive. He postulates that these philosophers differ in their opinions of where the society originated and how it is to become an ideal social order. Habermas was concerned with “how, in today’s globalized society, conflicting collectives, be they based on religion, culture or ethnicity, can reconcile their differences in a way that is satisfactory for all” (Mingers, 2014:211). Bhaskar mostly saw the concern as the oppressive authoritative relations of prevailing societies and the action needed to eliminate these restrictions (Mingers, 2014:211).

3.2.3.1 Critical social theory assumptions

Harvey (1990:2) indicates that the fundamental ontological perspective of critical social research is that there is constantly a set of social relations among two individuals or groups of people where one is oppressive of the other. According to Wynn and Williams (2012:789), the ontological stance of critical social research is critical realism. Wynn and Williams (2012:789) indicate that critical realism is a specific subcategory of realism that recognises that the world and entities that constitute reality exist regardless of whether humankind has the ability to perceive it. Delanty (2011:75) states that “critical realism seeks to promote a transformational as opposed to an affirmative account of the social world”. Bhaskar initiated the concepts of transcendental realism and critical naturalism, which respectively are, the fundamental reality of the world that exists autonomously of our knowledge of it, and the essential union of processes among the social and natural sciences (Bhaskar, 1975:100; Bhaskar, 2005:3).

Harvey (1990:3) indicates that the epistemological perspective of critical social theory is that critique and knowledge are entwined. He states that “for the critical methodologist, *knowledge is critique*”. What Harvey meant by this was that the process of critical social research rejects the impartial status of knowledge and turns its attention to the procedural nature of knowledge. Critical social research aims to analyse social procedures, while investigating beneath the apparent and central conceptual settings, in order to disclose the fundamental practices, their historical specificity and organisational manifestations (Harvey, 1990:3). According to Wynn and Williams (2012:793), the epistemological assumption of critical realism is that of mediated knowledge, where it is assumed that “our knowledge of the intransitive entities that comprise an independent reality is formed in the transitive dimension, mediated by the social structure

to which we belong". Wynn and Williams (2012:793) support Harvey's view of the epistemological stance of critical social research by stating that all knowledge "is value-aware and theoretically informed, derived from multiple value-aware perceptions of a single independent reality". According to Delanty (2011:75), critical realists are more concerned with the characteristics of the ontological influences in critical social research, over the epistemological influences, as these are required to understand the construction of social reality.

3.2.3.2 Suitability of the critical social theory paradigm

The primary objective of this study is to develop guidelines for bridging the gap between IT theory (standard IT teaching practices at university) and IT practice (the required industry-related skills). In the scope of this study, the research does not intend to uplift an oppressed society (yet). The focus of this research is on the design and development of an artefact (guidelines). During the process of development, the artefact will be implemented within the context of oppressed societies, and *may* result in a limited form of emancipation. The relevance of the emancipation, however, is only within the context of *evaluation methods used to improve the artefact*. The focus of the research is on the development of the artefact, and iterative improvement thereof, so that a complete set of guidelines can be presented at the end of the study. In future research, the final artefact will *have the potential* to be used as part of an action research study in critical research to emancipate the oppressed. The critical social theory paradigm is therefore not suitable for the scope of this study.

3.2.4 Design science research

Design science research is a research paradigm where new knowledge is created by designing innovative artefacts as a solution to a relevant human problem (Hevner & Chatterjee, 2010:5). Vaishnavi *et al.* (2004/2019) support this definition by stating that DSR alters the world through the creation of innovative artefacts. Two schools of thought exist on the applicability of DSR as a paradigm. Some researchers view DSR as a method or methodology to use when conducting design research, for example, "we adhere to the view that DSR does not represent a separate academic discipline but rather a way to conduct research" (Baskerville & Pries-Heje, 2019:55). This is a conflicting view to an earlier paper also written by Baskerville, where he states that "design science seems to be more of a research paradigm than a research methodology" (Baskerville, 2008:442). Other researchers view DSR as an approach situated in a paradigm of pragmatism:

> "Design research is an emergent research approach within information systems. There exist demands to clarify the meta-scientific foundations for this approach.

> Different responses to these demands are made. There exist attempts to position design research within interpretivism and critical realism. Some scholars have suggested pragmatism as an appropriate paradigm base for design research." (Goldkuhl, 2012:84)

For the most part, leading authors in the field of design science research, view it as a separate paradigm:

> "Over the past decade, design science research (DSR) has re-emerged as an important research paradigm in the field of information systems." (Myers & Venable, 2014:801)

> "Design science research (DSR) has been an important paradigm of Information Systems (IS) research since the inception of the field, and its general acceptance as a legitimate approach to IS research is increasing." (Gregor & Hevner, 2013:337)

> "Design science research is a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artifacts, thereby contributing new knowledge to the body of scientific evidence." (Hevner & Chatterjee, 2010:5)

> "In recent years, several researchers succeeded in bringing design research into the IS research community, successfully making the case for the validity and value of design science (DS) as an IS research paradigm." (Peffers *et al.*, 2008:47)

For the purpose of this study, design science research is viewed as its own paradigm, rooted in a worldview of pragmatism.

It was Richard Buckminster Fuller who first coined the term design science when he developed a university course in *Comprehensive Anticipatory Design Science* in the 1950s, which was a theory he worked on since 1927. Fuller was a systems theorist, philosopher, designer, inventor, architect and author of several publications. Fuller is renowned for his proposal of the "World Game" in the 1960s, which he envisioned to be an instrument to assist with the problems of the world by using his comprehensive anticipatory design science method. His instructions were simply "make the world work, for 100% of humanity, in the shortest possible

time, through spontaneous cooperation, without ecological offence or the disadvantage of anyone". Fuller's intention was to create artefacts to solve the world's problems. In his own words, Fuller described the function of design science as follows: "to solve problems by introducing into the environment new artefacts, the availability of which will induce their spontaneous employment by humans and thus, cause humans to abandon their previous problem-producing behaviours and devices" (Fuller & Kuromiya, 1992).

Fuller called for a *design science revolution* during the 1960s and, as such, 1965 to 1975 was known as the design science decade (Fuller, 1969:305). Fuller gives Leonardo da Vinci as an exemplary instance of a comprehensively anticipatory design scientist as he designed weaponry and defensive systems for military powers (Fuller, 1983:6). Cross (2001:51) states that it was conceivably Fuller who first used the term design science, but that it was adopted by Gregory into the 1965 conferences on design methods (Gregory, 1966). Cross (2007:42) further stated that the 1960s concluded with the appeal of Herbert Simon for a science of design in tertiary institutions.

Herbert Simon first addressed the research topic of design science in his 1969 book *The sciences of the artificial*. Simon initially referred to the topic as a science of design that, in his words, was the appropriate study of mankind, not solely in its professional capacity of technical instruction, but as a central subject area for every accomplished individual (Simon, 1996:138). Simon (1996:113) wanted "a body of intellectually tough, analytic, partly formalizable, partly empirical, teachable doctrine about the design process". Simon (1996:137) suggested design could be an interdisciplinary field across the sciences, art and technology. He proposed to link natural science with design practice through the science of design, but his view of design was strongly positivistic as he believed that all design issues could be addressed with rational problem-solving (Schön, 1983:47). Donald Schön (1983:49) argued that design falls within the context of intuitive, artistic processes and that it cannot be boxed within well-formed solutions. Schön maintains that design practice more often deals with disordered, challenging situations and for this reason falls within the context of pragmatism, and requires methods of reflective practice for experiential learning.

3.2.4.1 Design science research assumptions

Bunge (1984:177) called for a distinctive ontology for the creation of technological artefacts, which differed from that of the natural and social sciences. The appeal for a separate ontology for design was "because artefacts are under intelligent control or are endowed with control mechanisms which have not emerged spontaneously in a process of natural evolution, they constitute a distinct ontic level characterised by properties and laws of its own". The appeal

was supported by Orlikowski and Lacono (2000:358), who expressed that the “truth is not out there” when it comes to developmental fields such as design science, implying that the reality connected to artefact design only exists because of humans who create them. This theme is also central to the work of Hevner and Chatterjee (2010:190), who say that “an artefact comes into being through application of the research process”, implying that there were no preconceived ideas of reality as with other paradigms. Vaishnavi *et al.* (2004/2019:9) elaborate on this concept by stating that design science research “changes the state-of-the-world through the introduction of novel artefacts” and its “researchers are comfortable with alternative world-states”. More specifically, the ontological stance of DSR is both evolutionary, as it includes shifting ontological assumptions in its process, and complementary, as it considers the phenomenon surrounding the artefact (Iivari, 2007:12). The ontological assumptions of design science research are reflected in the work of Habermas (1984) and Popper (1986), in their theories regarding the three different world states.

New knowledge is created by designing innovative artefacts as a solution to relevant human problems (Hevner & Chatterjee, 2010:2; Vaishnavi *et al.*, 2004/2019:1). An artefact can include, but is not limited to constructs, models, methods and instantiations (March & Smith, 1995:255), as well as frameworks, architectures, design principles and design theories (Gregor & Hevner, 2013:342; Gregor & Jones, 2007:312; March & Smith, 1995:256; Purao, 2013:51). In DSR, a piece of information is factual and the meaning of the information is made clear through circumscription. An artefact is developed, and the interaction between its components results in its behaviour. Descriptions of these interactions become information, and the level to which the behaviour is predictable makes the information factual. DSR is dependent on an artefact that functions in a predictable manner. The functionality that the artefact delivers comprises what the meaning of the artefact is – which supports the epistemological stance of ‘knowing through making’ (Vaishnavi *et al.*, 2004/2019:9). The theoretical standpoint of DSR may change as it iterates through phases of artefact development, changing from a positivist, while recording behaviour, to an action researcher, when interpreting the observations and planning subsequent interventions. DSR practitioners have more success when they move between pragmatic and critical realist standpoints, directed by a pragmatic evaluation of development in the DSR cycle (Bunge, 1984:176).

3.2.4.2 Suitability of the design science research paradigm

The primary objective of this study is to develop guidelines for bridging the gap between IT theory (standard IT teaching practices at university) and IT practice (the required industry-related skills). The focus of this research is on the design and development of an artefact which is in the form of guidelines. The research paradigm most suitable for this objective is

design science research as it is focused on designing artefacts to solve human problems (for an example of guidelines built following a DSR approach see Gregor and Hevner (2013:342)). DSR examines the usability of artefacts and may include other methods used by positivistic or interpretive paradigms. Apart from DSR, this study will also include characteristics of the interpretive research paradigm (as mentioned in Section 3.2.2.2), when qualitative data collection techniques are used for evaluation purposes of the artefact. From a pragmatic stance, the quality criteria of a specific data gathering technique is used to ensure research rigour (Bryman, 2006:122), and for this reason, principles for interpretive studies are reflected on for the interpretive data collected in this DSR study (Section 3.5.2.3).

3.3 DSR explained

As DSR is the appropriate research paradigm for this study, it is important to understand the research process of DSR, the contribution the study makes to the DSR knowledge base, the different approaches in DSR research, guidelines to conduct DSR research and the role that reflective practice plays in DSR.

3.3.1 The research process

The creation of new knowledge by following a specific process can be seen as research (Oates, 2006:7). A research process needs to be mapped cautiously to guarantee that other researchers accept the findings (Oates, 2006:32). The key objective of a research process is to offer a road map for the project (Myers, 2009:19). A clearly defined research process will also guide the researcher in following a structured approach to conduct the study. Gregor and Hevner (2013:35) provide a design science research process where they define sections of a publication scheme that could guide the logical flow of a research study (Table 3.2).

Table 3.2: DSR study publication schema (Gregor & Hevner, 2013:350)

Section	Contents
1. Introduction	Problem definition, problem significance/motivation, introduction to key concepts, research questions/ objectives, scope of study, overview of methods and findings, theoretical and practical significance, structure of remainder of paper. For DSR, the contents are similar, but the problem definition and research objectives should specify the goals that are required of the artefact to be developed.
2. Literature review	Prior work that is relevant to the study, including theories, empirical research studies and findings/reports from practice. For DSR work, the prior literature surveyed should include any prior design theory/knowledge relating to the class of problems to be addressed, including artefacts that have already been developed to solve similar problems.
3. Method	The research approach that was employed. For DSR work, the specific DSR approach adopted should be explained with reference to existing authorities.

4. Artefact description	A concise description of the artefact at the appropriate level of abstraction to make a new contribution to the knowledge base. This section (or sections) should occupy the major part of the paper. The format is likely to be variable, but should include at least the description of the designed artefact and, perhaps, the design search process.
5. Evaluation	Evidence that the artefact is useful. The artefact is evaluated to demonstrate its worth with evidence addressing criteria such as validity, utility, quality, and efficacy.
6. Discussion	Interpretation of the results: what the results mean and how they relate back to the objectives stated in the *Introduction* section. Can include: summary of what was learned, comparison with prior work, limitations, theoretical significance, practical significance, and areas requiring further work. Research contributions are highlighted and the broad implications of the paper's results to research and practice are discussed.
7. Conclusions	Concluding paragraphs that restate the important findings of the work. Restate the main ideas in the contribution and why they are important.

Once the researcher has established a research process that can be followed within the context of design science research, further investigation needs to take place into defining the knowledge base of DSR.

3.3.2 Defining the knowledge base

Gregor and Hevner (2013:342) provide different types of contributions that can be made to the knowledge base of design science research (Table 3.3). They explain levels of abstraction where contributions to DSR can start with the creation of artefacts, evolve into design principles for the creation of artefacts, and further be defined into design theories.

Table 3.3: DSR contribution types quoted from Gregor and Hevner (2013:342)

	Contribution types	**Example artefacts**
More abstract, complete, and mature knowledge	Level 3: Well-developed design theory about embedded phenomena	Design theories (mid-range and grand theories)
↕	Level 2: Nascent design theory – knowledge as operational principles/architecture	Constructs, methods, models, design principles, technological rules
More specific, limited, and less mature knowledge	Level 1: Situated implementation of artefact	Instantiations (software products or implemented processes)

Design science research is categorised into two groups of knowledge, i.e. descriptive and prescriptive knowledge. According to Gregor and Hevner (2013:343), descriptive knowledge is concerned with the 'what' and prescriptive knowledge is concerned with the 'how' knowledge of created artefacts. Figure 3.2 provides a high-level overview of descriptive and prescriptive knowledge within DSR.

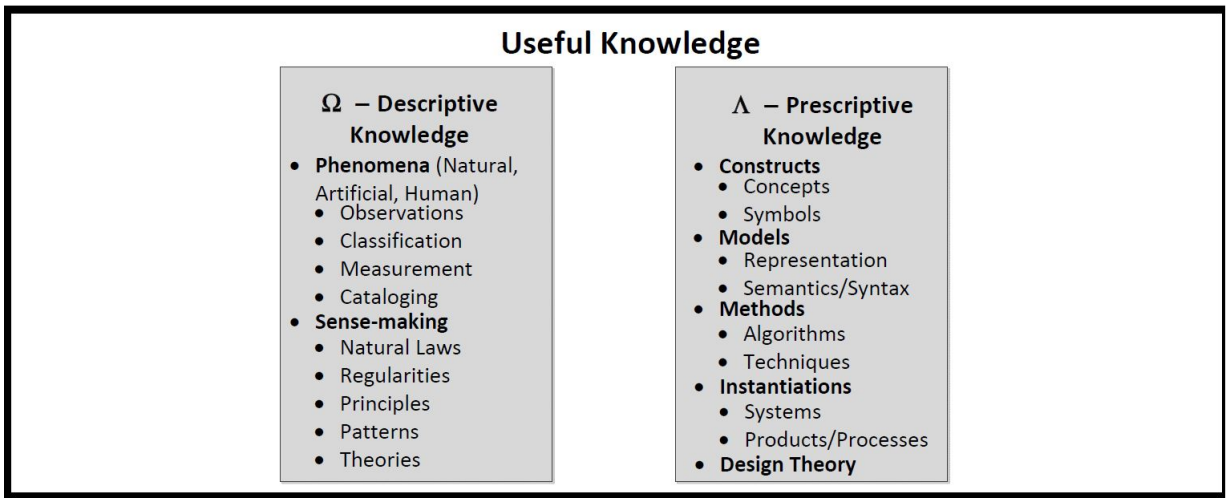


Figure 3.2: The knowledge base of DSR: Descriptive and prescriptive knowledge – quoted from Gregor and Hevner (2013:344)

3.3.3 Approaches in DSR

Within the context of DSR, there are different research approaches available. Vaishnavi *et al.* (2004/2019) established an original process model for design science research in 2004, which was later adopted by Hevner and Chatterjee (2010:27) (Figure 3.3). The DSR framework iterates through five phases. The researcher first becomes aware of a problem, suggests a possible solution to the problem, the suggested solution is then developed and evaluated repeatedly until the research process can naturally conclude.

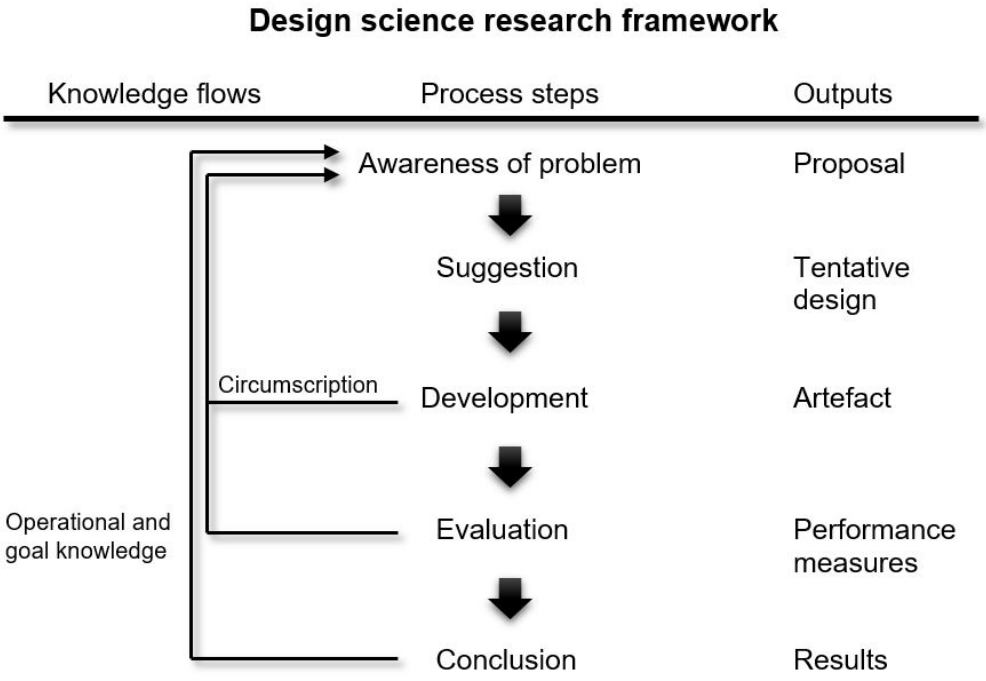


Figure 3.3: The DSR process model by Vaishnavi *et al.* (2004/2019:11)

Peffers *et al.* (2008:54) also created a model for DSR called the DSRM (design science research methodology) model (Figure 3.4). Peffers *et al.* (2008:54) present this model as an extended version of the DSR process model by iterating through six clearly defined phases that follow the same logical flow of events.

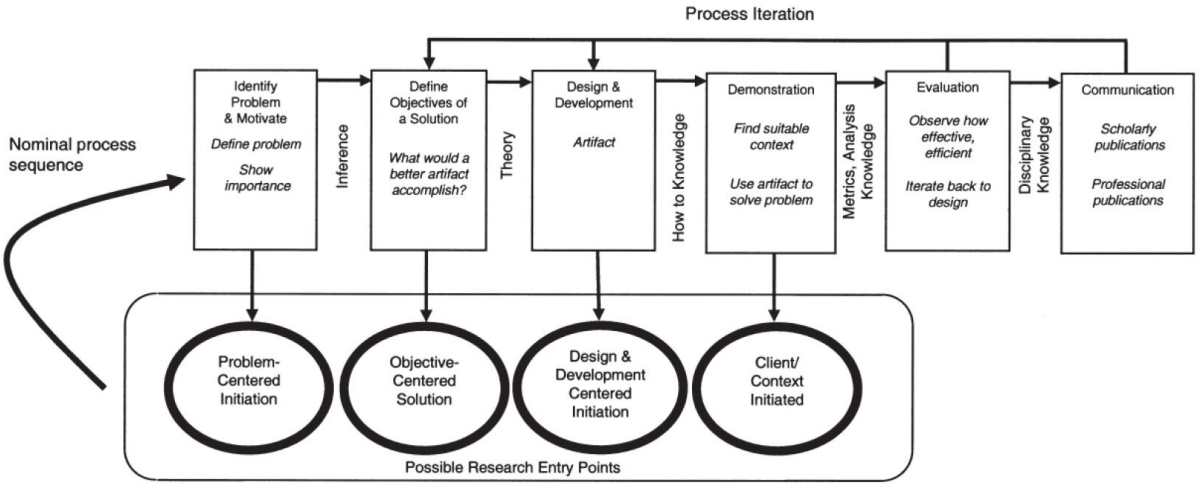


Figure 3.4: The DSRM model by Peffers *et al.* (2008:54)

3.3.4 Guidelines for DSR

Guidelines have been developed to direct the researcher's approach to design science research. Hevner *et al.* (2004:83) provide a set of guidelines that can be used to monitor the progress of the research and also to evaluate the outcomes against the initial research objectives (Table 3.4).

Table 3.4: Guidelines for DSR by Hevner *et al.* (2004:83)

DSR guidelines	Description
Guideline 1: Design as an artefact	Design science research must produce a viable artefact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem relevance	The objective of design science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design evaluation	The utility, quality, and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research contributions	Effective design science research must provide clear and verifiable contributions in the areas of the design artefact, design foundations, and/or design methodologies.
Guideline 5: Research rigor	Design science research relies upon the application of rigorous methods in both the construction and evaluation of the design artefact.
Guideline 6: Design as a search process	The search for an effective artefact requires utilising available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of research	Design science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Hevner and Chatterjee (2010:20) further provide a checklist for a design science research project (Table 3.5). The checklist can be used at the end of a project to ensure that each aspect was addressed. The success of the DSR project can be evaluated by answering each of the questions in the checklist honestly.

Table 3.5: The DSR checklist quoted from Hevner and Chatterjee (2010:20)

Question	
1	What is the research question (design requirements)?
2	What is the artefact? How is the artefact represented?
3	What design processes (search heuristics) will be used to build the artefact?
4	How are the artefact and the design processes grounded by the knowledge base? What, if any, theories support the artefact design and the design process?
5	What evaluations are performed during the internal design cycles? What design improvements are identified during each design cycle?
6	How is the artefact introduced into the application environment and how is it field-tested? What metrics are used to demonstrate artefact utility and improvement over previous artefacts?
7	What new knowledge is added to the knowledge base and in what form (e.g. peer-reviewed literature, meta-artefacts, new theory, a new method)?
8	Has the research question been satisfactorily addressed?

The following section discusses the relevance of reflective practice within the context of design science research, by reflecting on pragmatism, inquiry, and experiential learning.

3.3.5 Reflective practice in this design science research study

In this section, the relationship between reflective practice and the methodology is explored, by providing discussions on reflective practice for professional development and its impact on design science research.

3.3.5.1 Reflective practice for professional development

“External monotony and internal routine are the worst enemies of wonder” (Dewey, 1986:154). In response, Dewey suggested *reflection* in educational practice as “the active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends” (Dewey, 1986:118). Boud *et al.* (1985:19) extended his definition of reflection as “a generic term for those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to a new understanding and appreciation”. In another description, Moon (1999:23) defines reflection as “a form of mental processing with a purpose and/or anticipated outcome that is applied to relatively complex or unstructured ideas for which there is not an obvious solution.”

For Dewey, reflection meant learning from experience through inquiry and investigation (Dewey, 1916:92). In some thoughts on reflection (Dewey, 1933; Hatton & Smith, 1995; Mezirow, 1991; Moon, 1999), reflection is indicated as an activity that happens after an experience i.e. *reflecting on experience*. This is similar to the notion of reflection-on-action as proposed by Schön (1983:276).

In his seminal work, *The reflective practitioner, how professionals think in action,* Donald Schön (1983) proposed reflective practice for professional development. He extends Dewey's concept of reflecting on experience, stating that reflection should be a dual process, in that it should not only happen after an experience, but during the experience as well. He terms this respectively as reflection-on-action and reflection-in-action. He explains that reflection is prompted during an experience (in-action), where the practitioner needs to creatively solve the problem in that moment, as well as after the experience (on-action), where the practitioner thinks about the action that was taken, and how the problem could be better solved in future. Boud *et al.* (1985) have a similar view of reflection, exploring its objective as having the potential to develop improved understanding that leads to suitable actions in similar scenarios.

Dewey's interpretation of reflection was specifically targeted at education, with the goal of developing knowledge and expertise in teaching practices (Sellars, 2013:4). Argyris and Schon (1974) redefined reflection within the context of organisational learning. They encouraged reflection for professional effectiveness by stating that individuals react to effective behaviour based on their ability to review a situation. They pioneered the idea of single-loop learning that focuses on the gradual improvement of an established method, and double-loop learning that questions the frame of reference that the method was built on. The difference between these models of reflection is illustrated through *when* learning takes place through reflection. According to the models of Dewey (1997) and Kolb (1984), a full cycle of planning, acting, reflecting, and experimenting needs to take place for learning to happen through experience. With double-loop learning, reflection can take place at any given point, enriching the learning experience (Argyris & Schon, 1974:81).

Schön (1983:viii) proposed his concept of reflective practice "as an epistemology of practice based on the close examination of what some practitioners….actually do", to place "technical problem solving in a broader context of reflective inquiry" (Schön, 1983:69). Schön extended his work on reflective practice within an educational context, to include an overview of how the gap between university and practice could be bridged (Schön, 1987:305). Schön questioned Herbert Simon's view of how professional schools should be designed according to his book *The Sciences of the artificial*. Simon (1969:354) indicated that a solution to the organisational

problem of professional schools was dependent on “developing an explicit, abstract, intellectual theory… that can be taught in the same way that the laws of chemistry, physiology, and economics can be analysed and taught”. Simon suggested to link natural science with design practice through a ‘science of design’, but his view of design was strongly positivistic as he believed that all design could be addressed with rational problem-solving (Schön, 1983:47). Schön (1983:49) argued that design falls within the context of intuitive, artistic processes and that it cannot be boxed within well-formed solutions. Schön maintained that design practice more often deals with disordered and challenging situations, and when educating a reflective practitioner, one needs “a coherent professional school [that] places a reflective practicum at the center, as a bridge between the worlds of university and practice” (Schön, 1987:309).

3.3.5.2 The relationship between DSR and reflective practice

According to Goldkuhl (2012:93), design science research draws from the philosophical assumptions of pragmatism (a meta-paradigm), which separates it from interpretivist and positivistic research. This idea is supported by Confrey (2006:135), who states that design research has a stronger relation to pragmatism than to experimental research, in that design research uses its theory actively in real-world scenarios, and not only to guide ‘pristine experimentalism’. Pragmatic research is conducted in social, historical, political, and other disciplines, driven by the expected outcome of the inquiry, and includes both quantitative and qualitative research methods – with the primary goal of finding the most suitable manner of solving the problem (Creswell, 2007:23). Bunge (1984:176) suggests that design research practitioners are more effective when shifting between a pragmatic and critical realist perspective that is directed by pragmatic evaluation of progress in the DSR cycle. Pragmatism allows for the use of several methods, diverse worldviews and assumptions, and different types of data gathering and analysis methods (Creswell, 2014:12). Purao (2002:15) proposes that this type of ‘epistemological chaos’ can be better understood through methods of reflection.

An educational pragmatic approach dates back to the work of Dewey. He indicated that his pragmatic stance did not relate to that of idealism or realism (Dewey, 1916:213). Dewey’s pragmatic view of reflection was that situations that caused confusion, or a sense of wonder, were to be addressed by analytical thinking directed towards reaching the goal (Sellars, 2013:4). Reflection for Dewey meant that learning takes place by actively attempting to solve the problem (Atkinson & Irving, 2013:1). The concept of reflection is also apparent in the work of philosophical pragmatist Simon (1977a:23), who says “we are accustomed to think of the

scientist as observing the state of the world, but not of his observing as part of the state of the world".

According to Avenier (2010:10), human experience is placed at the core of knowledge development in Simon's sciences of the artificial. Simon (1977b:2) states that "when man describes [vague methods], he depicts not some external reality, but himself". His words imply that 'best practice' is derived through honest accounts of human experience, and that learning can only be improved through additional experience. The role of experiential learning has been explored by theorists such as Dewey, Lewin, and Piaget, and inspired the work of theorists such as Kolb, Boud and Schön (Dybå *et al.*, 2014:33).

Dewey's pragmatic worldview meant that he saw scientific knowledge as a means to improve human practices (Zaphiris & Ang, 2009:2072). This is closely associated with the purpose of design science research, which is to create innovative artefacts to solve human problems (Vaishnavi *et al.*, 2004/2019:1). For philosophical pragmatists, the ontological stance is depicted by what works in practice (March & Smith, 1995:225). This is supported by Hevner and Chatterjee (2010:181), who specify that the utility of the artefact is the reason to develop the artefact, indicating that "for a pragmatist, truth and utility are indistinguishable – truth lies in utility". According to March and Smith (1995:255), "IT research should be concerned both with utility, as a design science, and with theory, as a natural science". This is supported by Markus *et al.* (2002:180), who state that design research must pass both tests of science and practice.

In design science research, artefact creation iterates through invention phases. These invention phases are subject to implicit reflection. The relationship between the need for *explicit reflection* and design science research is perhaps best interpreted from Gregor and Hevner (2013:345), who describe reflective practice in DSR, without actually mentioning reflection explicitly:

> "The invention process can be described as an exploratory search over a complex problem space that requires cognitive skills of curiosity, imagination, creativity, insight, and knowledge of multiple realms of inquiry to find a feasible solution. While this process of invention is perhaps ill-defined, invention activities can still be considered DSR when the result is an artefact that can be applied and evaluated in a real-world context and when new knowledge is contributed to the [descriptive and prescriptive] knowledge bases."

Explicitly stated by Hevner and Chatterjee (2010:190), a limitation of design research is that it lacks “a clear stage for reflection to specify learning”, stating that the need for reflection is to understand how the outcomes of the artefact have addressed the problem experienced, and why the artefact is successful or unsuccessful when implemented in its organisational setting. Their view of when reflection takes place is similar to that of Dewey, where reflection takes place after the experience. This is also illustrated in the DSR process model, where Vaishnavi *et al.* (2004/2019:14) demonstrate that abstraction and reflection take place in the conclusion phase (Figure 3.5).

This is a questionable approach to reflection, as understood from the view of Schön, in that reflection should take place *during* the development of the artefact, and not only after the artefact has been completed. Article 1 in Chapter 4 provides a deeper discussion on this topic, illustrating the usefulness of embedding reflection in each phase of the DSR process model to generate explicit knowledge. The model discussed in the article is also used as a baseline to structure the research process of this DSR study, and is elaborated on in Section 3.4.5.

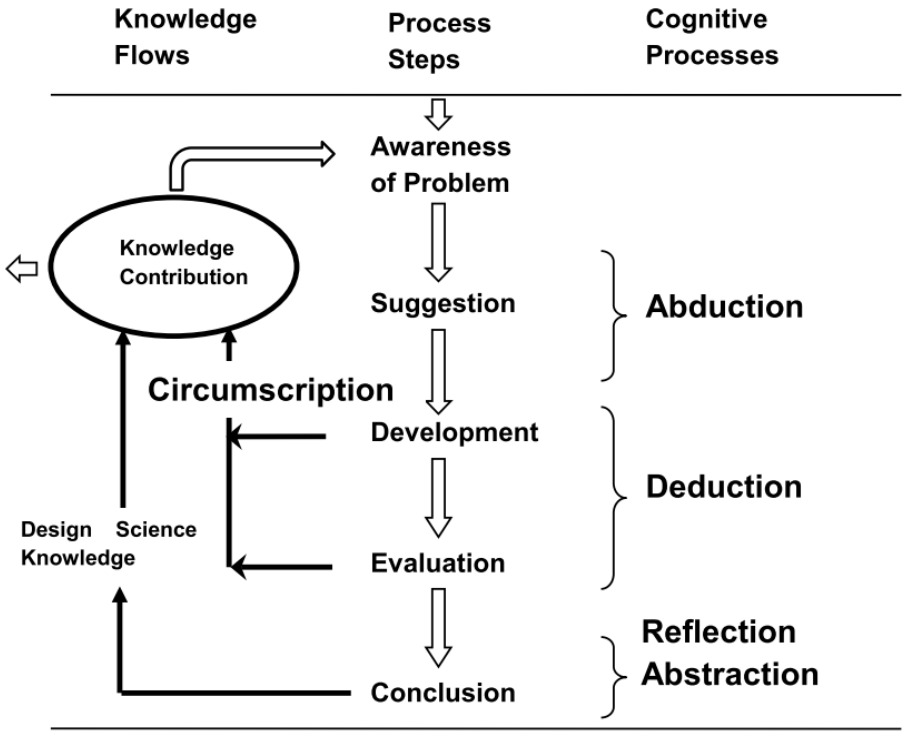


Figure 3.5: Cognition in the DSR cycle (Vaishnavi *et al.*, 2004/2019:14)

3.4 Research design in this study

In this section, the methodology discussed in the previous section is explained within the context of its application in this research study.

3.4.1 The research process

An overview of the publication schema for design science research (Gregor & Hevner, 2013:350) was provided in Section 3.3.1. In Table 3.6, this study is outlined using the proposed publication schema to illustrate the manner in which the research naturally follows the process of design science research.

Table 3.6: The DSR publication schema of this research

Section	Contents
1. Introduction	Chapter 1 provided an overview of the problem statement, central concepts, research questions, methodology, and structure of the research using the DSR process model to illustrate how chapters are organised (Figure 1.5). In design science research, special attention is placed on how the problem statement and objectives specify the goals towards developing the artefact. To this end, the secondary research objectives were structured according to the phases of the DSR process model, showcasing the design goals of the artefact in each stage of the research (Table 1.1, and also discussed in Section 3.4.3).
2. Literature review	For DSR research, prior artefacts that have been developed for similar purposes should be discussed from a literature context. Chapter 1 provides a rigorous overview of empirical studies that have been published on similar research. The review highlights studies that have focused on skills development and instructional approaches towards bridging the theory-practice gap and employability. The research gap for the artefact is motivated through the diverse approaches that were taken – highlighting the need for a single source of guidelines to bridge the IT theory-practice gap. Chapter 2 provides an outline of where literature reviews for the central concepts can be found. As this thesis is submitted in article format, the central concepts are discussed over multiple chapters and articles. Chapter 3 provides literature context to the theoretical framework and methodology employed in the research.
3. Method	Chapter 3 provides a discussion on the research approach taken, highlighting the specific DSR approaches and guidelines used to inform the research. Chapter 4 contains the first article in this thesis. It is a theoretical paper that proposes a model for improving knowledge generation in design science research through reflective practice. The paper discusses a method to improve the methodology of this paper by explicitly embedding the theoretical framework in its cyclical process. A demonstration of how this model was used in this research is provided in Section 5 of the paper. All articles contain discussions on the methods used in that specific paper for research rigour.
4. Artefact description	As the thesis is presented in article format, there is combined information of the artefact, its evaluation, and discussions on the findings found in all papers. Chapter 5 (Article 2) is the pilot study of the research, highlighting the need for improved IT skills development, and stressing the need for project-based learning in IT higher education. Chapter 6 (Article 3) provides a discussion on the use of PBL earlier in an IT degree, and produces guidelines for inclusion in the artefact.
5. Evaluation	

6. Discussion	Chapter 7 (Article 4) discusses the importance of career awareness, resulting in important guidelines for inclusion in the artefact. Chapter 8 (Article 5) presents guidelines for using PBL specifically in IT higher education, by demonstrating how they are applied in context of two examples.
7. Conclusions	Chapter 9 communicates the findings of the research, restating the objectives and how they were met. The chapter highlights the contribution of the artefact – providing a single source of guidelines towards bridging the IT theory-practice gap.

3.4.2 The knowledge base

As depicted in Figure 3.2, DSR has two types of knowledge contribution – descriptive and prescriptive. In design science research, all artefacts are considered as prescriptive knowledge (e.g. constructs, models, methods, and instantiations). Even design theory is considered as *prescriptive* knowledge because "abstract knowledge contributions that are created in DSR can also be treated as an artefact" (Gregor & Hevner, 2013:341). Design theory can also contain other forms of artefacts, such as models and methods, resulting in a consolidated DSR artefact. Design theory labelled as prescriptive knowledge causes confusion, as 'theory' is generally included in *descriptive* knowledge. The reasoning behind this separation is that design theory is man-made; it is not a theory that exists outside of human existence. Design theory is dependent on human contribution, whereas general theory results from phenomena.

Within the context of design science research, prescriptive knowledge can be seen as the methods or approaches that inform the research, and the associated descriptive knowledge is determined by the researcher's philosophical standpoint. For example, prescriptive knowledge in DSR contains rules that **all** researchers can use, but the manner in which the rules are implemented depends on the theoretical framework of the **individual researcher** (i.e. the descriptive knowledge the researcher will use to implement the prescriptive knowledge). This explains why researchers following the same design rules may end up with completely different artefacts. Table 3.7 provides a summary of the prescriptive and descriptive knowledge in this research.

Table 3.7: Descriptive and prescriptive knowledge applicable to this study

Prescriptive knowledge		**Descriptive knowledge**
Design science research assumptions	→ **is rooted in** →	Pragmatism
DSR methodology		Reflective practice
Interpretive research guidelines		Inquiry
Project-based learning characteristics		Experiential learning

The assumptions, methods, and guidelines used for design science research, interpretive data methods and project-based learning are considered prescriptive knowledge. These are rooted in the descriptive knowledge of the research, which includes pragmatism, reflective practice, inquiry, and experiential learning. IT skills development is not added to the descriptive and prescriptive knowledge of DSR in this research, as the need for specific types of IT skills is dynamic, and requires continuous research to ensure that the approaches used are *current*. To summarise, IT skills development is the area of application in this research that is improved on, through the use of prescriptive and descriptive knowledge, as presented in Table 3.7.

This research aims to contribute to descriptive knowledge in the following ways (based on the DSR contribution types – Table 3.3):

- To enrich the field of design science research by using reflective practice to generate explicit knowledge within its process (level 2 contribution to the DSR knowledge base as a *model* – presented in Chapter 4).
- To enrich the field of design science research through the development of guidelines as an artefact *(*level 2 contribution to the DSR knowledge base as a *method* – presented in Chapter 9).
- To demonstrate a collection of guidelines built using a DSR approach towards bridging the gap between IT theory and IT practice (level 1 contribution to the DSR knowledge base as an *instantiation* which is an example of a developed artefact using DSR rules – presented through the DSR approach followed throughout the research).

3.4.3 The DSR approach

In this study, the DSR process model of Vaishnavi *et al.* (2004/2019:11) is the approach followed to conduct the research. This is showcased through the chapter layout of the thesis, which is structured according to the phases of the DSR process model (Figure 1.5). It is more apparent in the organisation of the secondary objectives (Table 1.1), which were planned according to the phases of the DSR process model. This approach to the DSR study illustrates the intended actions for each phase of the model, demonstrating the use of design science research to inform the research process. A discussion on how each secondary objective was met within the context of the DSR process model is provided in Chapter 9.

3.4.4 DSR guidelines followed

The seven guidelines provided by Hevner *et al.* (2004:83) are used to guide the research process, which leads to artefact creation in this research. The artefact in this research is a set of guidelines towards bridging the IT theory-practice gap. This type of artefact is seen as an

instantiation (guideline 1), as it is a process that can be implemented in other studies to determine whether similar value can be obtained. The artefact is a proposed solution to a relevant problem experienced in information technology education (guideline 2). The usefulness and effectiveness of the artefact are demonstrated in several articles (guideline 3). Research contributions were made in scholarly publications, as well as to the DSR knowledge base as discussed in Section 3.4.2 (guideline 4). The artefact is evaluated in several articles through interpretive methods that follow scientific principles (Klein & Myers, 1999:72) (guideline 5). The artefact is constructed through trial and error, over several articles, demonstrating that the design occurs through a search process (guideline 6). The results of the research are communicated in the respective articles, as well as in the conclusion of this thesis. These are both forms of peer-review that indicate the acceptance of the artefact and approach followed (guideline 7).

The DSR checklist created by Hevner and Chatterjee (2010:20) provides eight questions that need to be answered to evaluate the acceptance of a DSR study. These questions will not be addressed here, but will be answered instead in Chapter 9, to demonstrate the research rigour of this research.

3.4.5 Generating explicit knowledge in DSR through reflective practice

Chapter 4 presents the first article in this research. The theoretical paper provides a discussion on design science research and reflective practice. The paper posits that reflection is implicit in the phases of design science research, and is only explicitly indicated in the conclusion phase of the DSR process model. The paper proposes a model to generate explicit knowledge in design science research through the use of reflective practice. The phases of experiential learning are mapped to each phase of the DSR process model. The implication of this approach is that reflective practice takes place in each phase of the DSR process model *explicitly*. Table 1, in Section 4 of the article, provides an in-depth overview of how reflective practice can generate explicit knowledge in each DSR phase. A demonstration of how this model is used in this research is subsequently provided in Section 5 of the paper. A representation of the model is depicted in Figure 3.6. An explanation of this concept is detailed in Chapter 4.

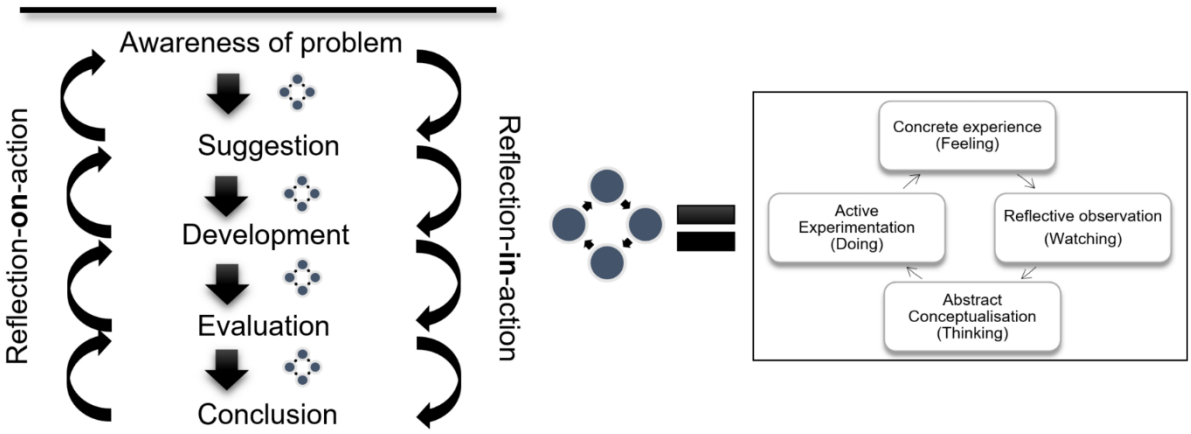


Figure 3.6: A model for generating explicit knowledge in DSR through reflective practice

The sections that follow detail the data gathering and analysis methods used in this research, highlight the ethical principles considered, and indicate contributions the research makes in terms of the FMA model.

3.5 Data gathering and analysis

In this section, the data gathering and analysis methods used in this research are discussed. As indicated in Section 3.2.2.2 and Section 3.2.4.2, the study includes interpretive qualitative methods for data gathering as part of the evaluation phase of the DSR process model.

3.5.1 Qualitative sampling and data gathering techniques

Qualitative sampling usually involves smaller sample sizes than quantitative sampling, as participants are selected based on specific characteristics that "make(s) them the holders of the data needed for the study" (Maree, 2007:79). Even though there are guidelines for qualitative sample sizes from different literature sources (Mason, 2010:3), specific rules for sample sizes in qualitative studies do not exist (Patton, 2002:244). Qualitative studies make use of purposive sampling, which indicates that sampling decisions depend on how and when the research questions can be answered with rich information (Maree, 2007:79; Patton, 2002:244). Information is typically collected until resources are exhausted, or redundant data indicates saturation (Lincoln & Guba, 1985:265). Saturation refers to the point where no new information is generated during the data analysis, indicating that no additional data collection is necessary (Chenail, 2011:260; Marshall, 1996:523).

Two approaches to saturation as a guide for sufficient sample sizes in qualitative research are suggested, i.e. code saturation and meaning saturation (Hennink *et al.*, 2017:604).

Approximately nine interviews are needed for code saturation (an understanding of the concrete codes), and between 16 and 24 interviews are needed for meaning saturation (adding additional meaning to subtle conceptual issues missed in concrete codes). These are only provided as a guideline and may vary from one study to the next. Code saturation is not expected in pilot studies, as they are small-scale studies used to test the feasibility of a main study (Kim, 2011:191). Pilot studies are conducted at the start of a research project in order to highlight which aspects of the research are important to focus on, and as an opportunity to correct any possible elements that may have been overlooked (Lazar *et al.*, 2010:60). In qualitative research, pilot studies can be used to develop an understanding of the concepts held by knowledgeable participants (Maxwell, 2012:67). Data obtained from qualitative pilot studies is often used as part of the main study (Van Teijlingen & Hundley, 2001:3). Required sample sizes for pilot studies are generally not specified in qualitative research, and will depend on what the objective of the pilot study is.

Patton (2002:230) provides an overview of 16 methods of purposive sampling in qualitative research. From these, the most common sampling techniques used in qualitative research include:

- *Convenience sampling*, which refers to participants who were selected because they are easily accessible, reducing constraints such as effort, money and time. This approach to sampling is considered as the least rigorous technique (Marshall, 1996:523). An example of this sampling technique is when a researcher makes use of colleagues as participants in a study.

- *Snowball or chain sampling*, which occurs when a researcher interacts with a suitable participant for the research objective, and then asks the participant to suggest other people who would be suitable for the research, and so on (Oates, 2006:98). An example of this sampling technique is when a sports manager interviews a known participant who plays a specific sport, and requests the participant to ask his team mates to consider taking part in the research.

- *Stratified purposive sampling* is used when participants are selected as part of a subgroup of interest and fulfil the relevant criteria of the research (Maree, 2007:79). An example of this sampling technique is when educators use specific learners, in a specific grade, and in a specific region, as participants in their research.

Marshall (1996:523) highlights that most qualitative studies do tend to have an element of convenience sampling, but that the selection of a sample can be justified by circumscribing a thoughtful approach as to why the participants were relevant to the research. For the purpose of this research, a stratified purposive sampling method was used. The researcher included students, at entry- and exit-level of an information technology degree of a university in central South Africa, as participants in the research. A pilot study with members from the IT industry as participants was also included in the research. The researcher did have direct access to the student groups and members from the IT industry at the time of the research, which may also include characteristics of convenience sampling.

All participants in the research took part in qualitative data gathering methods. A limited amount of quantitative data was collected during the qualitative methods, and provided demographic and required background information. Table 3.8 provides a literature summary of the data gathering methods used in this research, which include written interviews, interpretive questionnaires, and reflective sheets. Maree (2007:113) stresses the importance of using more than one data source in qualitative research to ensure reliability, stating that findings from different data sources can be compared to determine whether the key aspects of the research lead to similar conclusions.

Table 3.8: A summary of the data gathering methods used in this research

Data gathering method	Description
Written interviews	An interview is a type of recorded communication about specific subject matter (Anderson, 1990:222). It is a conversation between participant and researcher, where questions are asked relating to the objectives of a study (Maree, 2007:87). Interviews can typically be unstructured (open-ended conversation with no script), structured (a prepared list of questions that follow a specific script), or semi-structured (prepared questions guide the conversation but allow for improvisation of the script) (Chu & Ke, 2017:289; Fontana & Frey, 2000:363). Interviews may be recorded, or the researcher can take notes (Hoepfl, 1997:52). Transcribing recorded interviews is a time-consuming activity (Silverman, 2006:297). Researchers can use alternative methods such as email, or instant messaging for written formats of interviews. The benefit of a written format is that the data is already in text format and does not need to be transcribed.
Interpretive questionnaire	A questionnaire is sometimes referred to as a survey, and can be used to collect quantitative and qualitative data (Walliman, 2011:97). Data is collected through a list of predefined questions (Chu & Ke, 2017:290). A questionnaire can be paper-based or in electronic format, and can contain closed- and open-ended questions (Lazar *et al.*, 2010:100). The benefit of questionnaires is that they can be distributed to large samples in a short period of time (Rabianski, 2003:45). Open-ended questionnaires allow for rich information. Interpreting and coding open-ended questionnaire responses can be a daunting task for the researcher (Chu & Ke, 2017:290). An interpretive questionnaire is similar to an open-ended survey, where the purpose is to receive rich qualitative information regarding a specific topic.

Reflective sheets (documents)	Documents are public and private information contained in minutes of meetings, newspapers, reports, letters, or journals (Creswell, 2014:190; Saunders *et al.*, 2009:146). Documents can be published or unpublished work (Maree, 2007:82). Documents are analysed systematically and provide contextual background information, supplementary data, or verification of findings (Bowen, 2009:30). Documents are an invaluable source of information to compare findings and provide details relating to events (Myers, 2009:161). Personal journals and diaries are considered as examples of documents (Creswell, 2014:190; Myers, 2009:155; Saunders *et al.*, 2009:146). Reflective sheets are considered as a type of document, similar in nature to a reflective journal (George, 2001), but make use of structured questions to guide the reflection (Dunlap, 2006:24).

3.5.2 Qualitative data analysis

In this section, qualitative coding techniques are discussed, as well as how to prepare the data for coding, and guidelines that can be followed for interpretive research.

3.5.2.1 Coding qualitative data

According to Hsieh and Shannon (2005:1278), qualitative content analysis is "a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns". Patton (2002:453) describes qualitative content analysis as "any qualitative data reduction and sense-making effort that takes a volume of qualitative material and attempts to identify core consistencies and meanings". Coding involves reviewing transcribed data in a sequential manner to divide it into chunks of information that have a specific meaning (Maree, 2007:105). Unique identifiers are given to the chunks of information – such as symbols and descriptive names (Maree, 2007:105). Prior related research and theories can be used to inform the coding categories (Zhang & Wildemuth, 2009:311).

There are three phases to coding, which are open, axial and selective (Hoepfl, 1997:55; Oates, 2006:275; Priest *et al.*, 2002:33; Strauss & Corbin, 1990:57). These phases were developed by Strauss and Corbin (1990) when they refined grounded theory methods. Open coding is the initial phase where units of data are labelled using concepts and terms that were identified in the data, and not from existing theories or literature. Axial coding happens next when the researcher starts looking for relationships in the codes, merging codes under a broader heading, or isolating codes that are perceived as more important than other codes. Selective coding is the final phase where the researcher focuses on the central codes that are essential in explaining a theory or phenomenon that occurs in the research.

When starting the open coding phase, Hsieh and Shannon (2005:1286) provide an overview of three approaches to content analysis, namely, conventional (undirected), directed, and summative. Table 3.9 provides a high-level overview of the differences in these approaches.

Table 3.9: Characteristics of qualitative content analysis approaches quoted from Hsieh and Shannon (2005:1286)

Type of content analysis	Study starts with	Timing of defining codes or keywords	Source of codes or keywords
Conventional content analysis	Observation	Codes are defined during data analysis	Codes are derived from data
Directed content analysis	Theory	Codes are defined before and during data analysis	Codes are derived from theory or relevant research findings
Summative content analysis	Keywords	Keywords are identified before and during data analysis	Keywords are derived from interest of researchers or review of literature

According to Hsieh and Shannon (2005:1279), conventional content analysis is used to describe a phenomenon, is appropriate to use when there is limited existing theory, and is often used as the initial analysis approach in qualitative research. Kondracki *et al.* (2002:224) indicate that researchers avoid using predetermined categories in conventional content analysis, allowing themes to flow naturally from the data. The process starts with reviewing all data repeatedly to improve an 'understanding of the whole' through immersion (Tesch, 1990:60). Codes emerge from the data by reading the content word for word (Miles & Huberman, 1994:57). The researcher makes notes on first impressions, labelling data with codes that reflect multiple thoughts, creating an initial coding scheme produced directly from the data (Hsieh & Shannon, 2005:1279).

Directed content analysis can be used when prior research or existing theory about a phenomenon could use further explanation. The objective of a directed approach is to authenticate or extend a theoretical framework conceptually (Hsieh & Shannon, 2005:1281). Existing research can provide context to important aspects or relationships between concepts, which, in turn, will assist with producing an initial coding scheme (Potter & Levine-Donnerstein, 1999:262). Directed content analysis follows a more organised approach to coding than conventional coding (Hickey & Kipping, 1996:81).

Summative content analysis typically starts with identifying words in the research that need to be understood within the context of the number of times they appear in the content (Hsieh & Shannon, 2005:1283). Quantifying the use of words or phrases is an attempt to explore usage, and not to derive meaning. This form of content analysis is initially quantitative in nature, when counting the frequency of words or specific content that occurs in the data (Kondracki *et al.*, 2002:226). Patterns are identified in the data to contextualise the codes based on frequency (Morgan, 1993:112).

In this research, both conventional and directed content analysis is used within the context of an open coding approach. The data included in the study does have limited elements of quantitative data that cannot be coded using content analysis. For this, descriptive statistics are used to depict summaries of the sample characteristics, such as gender, race and demographic data (Babbie, 2016:451).

3.5.2.2 Preparing qualitative data

Defining a code unit for qualitative content analysis is the most important decision (Weber, 1990:21). This statement is supported by De Wever *et al.* (2006:19), who indicate that the content needs to be unitised before coding can commence, as differences in unit interpretation can affect the comparability of the results with other studies.

Coding themes in data refer to finding related expressions that offer similar examples of a specific idea (Zhang & Wildemuth, 2009:310). Due to the nature of qualitative content analysis, units of text can be assigned to multiple themes in the data (Tesch, 1990:296). While coding the content, it is necessary to repeatedly review the naming conventions of themes for consistency (Schilling, 2006:33). According to Zhang and Wildemuth (2009:312), a balance between the description and interpretation of themes and codes used in qualitative data analysis is essential. Table 3.10 provides a summary of the eight steps provided by Zhang and Wildemuth (2009:310) to analyse qualitative content.

Table 3.10: A summary of the steps for analysing qualitative content, quoted from Zhang and Wildemuth (2009:310)

Step	Description
1. Prepare the data	Qualitative content analysis can be used to analyse various types of data, but the data needs to be transformed into written text before analysis can start. When transcribing qualitative data, the following questions arise: • Should all the questions or only the main questions be transcribed? • Should the verbalisations be transcribed literally or only in a summary? • Should observations during the interview be transcribed or not? Your answers to these questions should be based on your research questions.
2. Define the unit of analysis	The unit of analysis refers to the basic unit of text to be classified during content analysis. Qualitative content analysis uses individual themes as the unit for analysis. An instance of a theme might be expressed in a single word, a phrase, a sentence, a paragraph, or an entire document.
3. Develop categories and a coding scheme	Categories and a coding scheme can be derived from three sources: the data, previous related studies, and theories.
4. Test your coding on a sample of text	The best test of the clarity and consistency of your category definitions is to code a sample of your data. After the sample is coded, the coding consistency needs to be checked, in most cases through an assessment of inter-coder agreement.
5. Code all the text	When sufficient consistency has been achieved, the coding rules can be applied to the entire corpus of text. Because coding will proceed while new data

	continues to be collected, it is possible that new themes and concepts will emerge and will need to be added.
6. Assess your coding consistency	After coding the entire dataset, you need to recheck the consistency of your coding. It is not safe to assume that, if a sample was coded in a consistent and reliable manner, the coding of the whole corpus of text is also consistent.
7. Draw conclusions from the coded data	At this stage, you will make inferences and present your reconstructions of meanings derived from the data. Your activities may involve exploring the properties and dimensions of categories, identifying relationships between categories, uncovering patterns, and testing categories against the full range of data
8. Report your method and findings	For the study to be replicable, you need to monitor and report your analytical procedures and processes as completely and truthfully as possible. In the case of qualitative content analysis, you need to report your decisions and practices concerning the coding process, as well as the methods you used to establish the trustworthiness of your study.

Qualitative content analysis cannot be judged in a similar nature to positivistic research studies (Berg, 2001:242). For this reason, Guba (1981:80) highlighted four criteria that can be used to evaluate the trustworthiness and rigour of interpretive research:

- *Credibility* refers to the accurate representation of the environment being researched.
- *Transferability* refers to the extent to which the framework of ideas can be applied within a different context.
- *Dependability* refers to the logic and consistency with which the researcher reports on changes made in the research approach.
- *Confirmability* refers to the extent to which other researchers can confirm the characteristics of the data.

Patton (2002:434) indicates that the final expectation of qualitative research is to report on the findings, and the extent thereof depends on the objectives of the research. In qualitative content analysis, it is typical to use direct quotations from participants to strengthen and support the research findings (Schilling, 2006:34). A typical software tool used for qualitative content analysis is Atlas.ti.

3.5.2.3 Guidelines for qualitative data analysis

Depending on the underlying philosophical assumptions of the qualitative research conducted, qualitative research may or may not be interpretive (Myers, 1997). Within the context of this research, the researcher takes a subjective stance when engaging in data gathering, gaining knowledge through social interaction while using qualitative data gathering and analysis methods. As mentioned in Section 3.2.2.2 and 3.2.4.2, this design science research study is rooted in pragmatism, which “prioritises using any approach that allows research questions to be answered regardless of its supposed philosophical presuppositions” (Bryman, 2006:124). As such, the qualitative methods discussed above is performed from an interpretive stance

and, to ensure method validity and quality, are subject to principles for interpretive research. Klein and Myers (1999:72) provide a set of principles that can be followed for interpretive research (Table 3.11).

Table 3.11: Interpretive field research principles quoted from Klein and Myers (1999:72)

Principle	Description
The fundamental principle of the hermeneutic circle	This principle suggests that all human understanding is achieved by iterating between considering the interdependent meaning of parts and the whole that they form. This principle of human understanding is fundamental to all the other principles.
The principle of contextualisation	Requires critical reflection of the social and historical background of the research setting, so that the intended audience can see how the current situation under investigation emerged.
The principle of interaction between the researchers and the subjects	Requires critical reflection on how the research materials (or 'data') were socially constructed through the interaction between the researchers and participants.
The principle of abstraction and generalisation	Requires relating the idiographic details revealed by the data interpretation through the application of principles one and two to theoretical, general concepts that describe the nature of human understanding and social action.
The principle of dialogical reasoning	Requires sensitivity to possible contradictions between the theoretical preconceptions guiding the research design and actual findings ('the story that the data tells') with subsequent cycles of revision.
The principle of multiple interpretations	Requires sensitivity to possible differences in interpretations among the participants as are typically expressed in multiple narratives or stories of the same sequence of events under study. Similar to multiple witness accounts, even if all tell it as they saw it.
The principle of suspicion	Requires sensitivity to possible 'biases' and systematic 'distortions' in the narratives collected from the participants.

Within the context of this research, two principles are emphasised, although all principles are considered for research rigour. The fundamental principle of the hermeneutic circle is applied throughout the qualitative data analysis to ensure that an understanding of the complex whole is attained by understanding the meaning of its subsequent parts and the relationships between those parts. This is achieved by identifying a unit of analysis, developing a coding scheme, coding all the text and assessing the coding consistency, as suggested by Zhang and Wildemuth (2009:310).

The principle of abstraction and generalisation provides an explicit reasoning to knowledge generation within the context of reflective practice in the design science research process model. Theoretical abstractions should be carefully conveyed by the researcher as it was experienced and collected, so that the reader can understand how the theoretical insights were reached. Building on the work of Walsham (1993), the validity of drawn inferences and conclusions should not depend on the ability to present the information statistically, but rather on the credibility and impact of the logical reasoning used to describe the results.

3.5.3 Sample context per article

As this thesis is written in article format, data gathering and analysis methods vary per article. The manner in which participants were identified in the research is highlighted in Article 1 (Chapter 4), Section 5.

3.5.3.1 Article 1 (Chapter 4)

Chapter 4 contains a research methodology paper that structures the context of the research process followed in this study. It is a theoretical paper and does not contain any data obtained from participants. It does, however, outline this study in a demonstration, using the model depicted in Figure 3.6.

3.5.3.2 Article 2 (Chapter 5)

A pilot study was conducted using a convenience sample of three participants. These participants represented all companies that provided industry project scopes for the capstone projects of IT exit-level students during 2017. Participants were contacted via email correspondence and asked to provide a written summary of typical skills they found lacking in IT graduates. The email correspondence received was considered as the data gathering technique referred to as unstructured written interviews. Table 3.12 provides the participant detail for Article 2. The qualitative data was analysed using open coding to find themes in the data. A conventional undirected approach was used in the open coding phase. Four themes were identified in the data, namely, expected soft skills, expected understanding of technical skills, expected knowledge of advanced technical skills, and recommendations for additional learning.

Table 3.12: Pilot study participants 'P', with 'YoE' = Years of Experience, 'Co' = Company

P	Job title	YoE	Co	Location
P1	Information security consultant (involved in graduate training)	3	A	Johannesburg
P2	Consultant (involved in graduate training)	30+	B	Johannesburg
P3	Systems developer (involved in graduate training)	10+	C	Meyerton

3.5.3.3 Article 3 (Chapter 6)

The research was conducted at a university in central South Africa as part of an entry-level module in an IT extended degree. The researcher only became aware of reflective journaling towards the conclusion of the module. The approach could not realistically be applied at this point as it would lack the reflective nature that is central to the process. As a pilot study to determine whether value can be derived from this approach for future iterations, students were asked to complete a structured, reflective set of questions on an A4 page after the completion

of the module. The instructions comprised taking a moment to reflect on the activities that had formed part of the module, structured questions to indicate preferred teaching- and learning methods, and self-reflections on the skills they thought they had improved on. Students were asked to provide their reflections voluntarily and anonymously. Out of 49 students who were enrolled for the module, 34 students returned their filled-in copies. After reviewing the feedback rate, four copies were removed as they stopped providing reflections after the second question/ lost interest in completing the sheet. The reflections provided on these four sheets were reviewed for value, and the decision to discard these responses was based on the fundamental principle of the hermeneutic circle (Klein & Myers, 1999:71). Quantitative and qualitative data was received due to the reflective nature of writing about personal experiences. A final set of 30 completed reflective sheets was included for analysis.

Basic descriptive statistics were used to analyse quantitative data in the form of gender information, preferences between specific methods, and improvements in skill levels. Atlas.ti 8.4 was utilised as a scientific software tool to analyse qualitative data by identifying codes and groups. A directed approach to open coding was used to perform content analysis on the qualitative data that related to their personal experiences within the context of 21st century competencies. The qualitative data analysis process followed in this paper to ensure traceability and rigour, with the aim of satisfying the fundamental principle of the hermeneutic circle, comprised the following:

- A directed approach to coding focusing specifically on questions and answers that were related to 21st century competencies.
- Each individual question was coded based on the identified codes from the previous question. Each question made use of existing codes and produced additional codes.
- When the final question was coded, the process was restarted at the first question to check whether codes that had been produced in subsequent questions were not overlooked when the process was started.
- The codes for all questions were re-evaluated for coding consistency. Similar codes were merged, renamed, or deleted if redundant, which resulted in a final set of 26 unique code names across the qualitative data.

Interpretive content analysis is used to prepare and process qualitative data for traceability (Zhang & Wildemuth, 2009:310). It is important to note that when using interpretive methods that the analysed data is not weighted. The purpose of interpretive data analysis is to ensure that all voices are heard through identified themes in the data.

3.5.3.4 Article 4 (Chapter 7)

The research was undertaken at a university in South Africa as part of an exit-level IT module. In an attempt to understand the students' experiences of the intervention, they were asked to participate in an interpretive data gathering method to obtain feedback. An interpretive questionnaire was created using Google Forms, and the link was made available to the students after the conclusion of the module. The nature of the questionnaire was interpretive with the aim of understanding student background and opinions relating to their experiences. Completion of the interpretive questionnaire was voluntary. The interpretive questionnaire did not request identifiable data and could be completed in their own time ensuring a level of anonymity. The interpretive questionnaire consisted of mostly open-ended questions (qualitative data) to obtain richer feedback on the approaches taken during the course of the module. A limited amount of the data was quantitative in nature to provide demographic and required background information. Open coding was used to analyse the qualitative data, and descriptive statistics were used to present the quantitative data. From 86 students who completed the module, 32 students completed the voluntary interpretive questionnaire. Due to the qualitative format of the interpretive questionnaire, and the rich feedback received, this method produced similar qualitative data volumes to that of traditional transcribed interviews. For the purpose of this study, 32 responses were considered sufficient for the substantial volume of feedback received, considering that code saturation and meaning saturation occur between nine and 24 interviews as discussed (Hennink *et al.*, 2017:604).

Quantitative data was analysed in Microsoft Excel using its basic descriptive statistic features. Atlas.ti version 8.4 was used as scientific software tool to create codes and groups for the qualitative data. In order to review the data according to the fundamental principle of the hermeneutic circle, the following data analysis process was followed for traceability and rigour:

- A directed approach was taken, coding the data specifically within the context of answers provided that related to an experience of career awareness.
- Each individual question with its 32 answers was coded based on the codes identified from the previous questions. Each question made use of existing codes and produced additional codes.
- When the final question was coded, the process was restarted at the first question to validate whether codes that had been produced in subsequent questions were not overlooked when the process was started.
- The codes for all questions were re-evaluated three times to validate the coding consistency. Similar codes were merged, renamed, or removed if redundant, which resulted in a final set of 26 unique code names across all qualitative data.

3.5.3.5 Article 5 (Chapter 8)

Chapter 8 contains a literature review paper on project-based learning, and proposes guidelines for the application thereof in IT higher education. The paper does not include data gathering methods as part of an empirical study, but does demonstrate the application of the guidelines using three project-based learning examples. These examples do provide brief discussions of the students who participated in the PBL activities, merely to provide context on how the application of the guidelines is relevant to IT higher education.

3.5.4 Ethical considerations for DSR

In their article, Myers and Venable (2014:806) propose ethical principles for design science research in information systems. These ethical principles were constructed based on four parameters, namely:

1. The potential of information technology to improve or destroy human self-worth (Mason, 1986:5). The authors reviewed, and built on, the four ethical issues highlighted by Mason – privacy, accuracy, property, and accessibility.
2. Ethics education in business schools – the hub of IT artefact creation. The importance hereof is emphasised in research that ranks business schools according to their ethical code of conduct (Gloeckler, 2013).
3. The ethical requirements of institutional review boards for research projects. An example of this can be seen in the institution's required ethical process where this research was conducted (North-West University, 2019).
4. Design science researchers have different ethical priorities than behavioural researchers in information systems. In behavioural research, priority is given to the participants of the study, while in DSR research, priority is given to the public interest (Myers & Venable, 2014:802). The reason for this is that with DSR research, the developed artefact is still being used after the research was conducted, by stakeholders who were not involved in the research. Public interest is specified as the top priority in the British Computer Society Code of Conduct (2015:2), and the Association for Computing Machinery (ACM) Code of Ethics (ACM Code 2018 Task Force, 2018).

Myers and Venable (2014:805) went on to use prior research from Venable (2009:103) to identify stakeholders in design science research. It is important to determine who the relevant stakeholders are in order to specify which ethical procedures should be put in place. Venable used the boundary questions of critical systems heuristics by Ulrich (1987:280) to identify the role of the client, the decision-maker, the professional, and the witness in design science

research. Once the researchers understood the expected ethical considerations from literature and professional bodies, and were able to determine who the relevant stakeholders are, they proposed six ethical principles for design science research (Table 3.13).

Table 3.13: Six ethical principles for DSR quoted from Myers and Venable (2014:806)

Ethical principle	Description
1. The public interest	Design science researchers should explicitly identify all stakeholders who may be affected by the artefacts once placed into use, and critically consider what benefit or harm may result for/to such stakeholders. Generally, principles of safety, health, democracy, empowerment, and emancipation for all, particularly for the public, should predominate in choices of features and capabilities that an artefact should or should not have.
2. Informed consent	All design science researchers in IS should obtain informed consent from any person who is in some way involved with the research project.
3. Privacy	All design science researchers in IS should ensure that there are adequate safeguards in place to protect privacy, not just of those people directly involved with the current project (as with any behavioural research project), but those who might use or be affected by any developed software, IS, or IS development method artefact in the future.
4. Honesty and accuracy	Design science researchers should not plagiarise ideas, but should acknowledge inspiration from other sources. They should also honestly report their research findings about the new artefact.
5. Property	All design science researchers in IS should ensure that there is an agreement about ownership of the IP at the beginning of the project. There should also be an agreement about the ownership of any information that is collected during the project and what rights the researcher has to publish findings.
6. Quality of the artefact	Every attempt should be made to ensure the quality of the artefact(s). Where risks are potentially high, for example in safety-critical situations, design should account for and address such risks and evaluation, and testing should be sufficiently rigorous to ensure safety in use.

To provide an overview of the ethical approaches adopted in this research, the ethical considerations of this study are discussed within the context of the six ethical principles for design science research (Table 3.14).

Table 3.14: Ethical considerations of this DSR study

Ethical principle	Description in context of this study
1. The public interest	The relevant stakeholders in this research were initially identified as IT students, IT educators, and members of the IT industry. All stakeholders were informally approached to understand the context of the problem experienced from their perspectives during the *awareness of problem* phase in the DSR process model. The researcher later became aware that IT educators were not required for participation in this research – they did not provide valuable feedback on areas for improvement. The reasoning behind this decision was that there was a notable gap between industry expectations and the curriculum that was being taught. Some information was outdated, and some educators had very little interest in doing market research or collaborating with their colleagues or industry. Context to this discussion is provided in Article 1 (Chapter 4), Section 5. The ethical concerns within the context of the public interest are addressed through the ethical clearance application required by the institution where the research took

	place. An ethics committee reviewed the application, with specific reference to the type of participants required for the study, as well as the possible impact of the study within the larger context. Ethical clearance for the study was approved on 16 September 2017 (Appendix B).
2. Informed consent	In this research, members from the IT industry took part in written interviews, and IT students at entry-level and exit-level of the degree took part in evaluation methods of the improved curriculum. Members from IT industry were asked, via email, to provide an overview of skills they found lacking in IT graduates. The communication explained that the responses would be used as part of publishable doctoral research, and that their names and employers would not be identifiable in the research. Receiving a response to the email was considered as informed consent to use the information for research purposes based on the parameters specified. Within the context of the IT entry-level student participants, an A4 reflective sheet was made available at the end of a module. The sheets were not distributed;, students who were willing to take part in the research could collect a sheet from a box at their own discretion. In the introductory part of the reflective sheet, it is explained that students could participate voluntarily, anonymously (no names were collected), withdraw at any time, and gave permission to use the research for publication (Appendix G). The research conducted using exit-level IT student participants, required the completion of an online interpretive questionnaire. A link to the interpretive questionnaire was made available, and participants who were willing to take part in the research could complete it in their own time and at their own discretion. The form did not collect any identifiable data, and the introductory section of the online interpretive questionnaire requested that the participant select an option to indicate whether they understood the purpose of the research and agreed to take part in the study (Appendix I).
3. Privacy	The ethical principle of privacy, refers to artefacts that are used outside of the research context that may cause privacy concerns. An example of this type of artefact would be an email application that is used by multiple users and requires registration with personal data. The use of the application after implementation is outside of the boundaries of the research project. There are, however, still privacy concerns for the users of the application. The artefact in this research is a set of guidelines to bridge the IT theory-practice gap. The manner in which the guidelines are implemented in this research can be controlled by the researcher. The artefact can be used by other researchers and academics in future, but does not require any personal data for the effective use thereof. For this reason, there are no additional privacy concerns apart from informed consent in this study.
4. Honesty and accuracy	A requirement of the ethical process of the institution where the research took place is to read, understand and sign the code of conduct for researchers (Appendix A). The values highlighted in this document are those of honesty, accountability, professional courtesy, and good stewardship. The undersigned 14 ethical responsibilities of the researcher include ensuring the trustworthiness of the research, following required laws within the context of the research, using appropriate research methods, and keeping accurate records, among others. Literature resources are accurately referenced in this research, and findings are accurately presented according to the data received.
5. Property	This research document was submitted as part of the requirements for the degree Doctor of Philosophy in Information Technology, within the School of Computer Science and Information Systems in the Faculty of Natural and Agricultural Sciences at the North-West University. According to the rules and guidelines for management of intellectual property at the North-West University, Paragraph 2.1 and 2.2, any information or ideas submitted as part of the evaluation of a degree will remain the property of the University (North-West University, 2010:12). This thesis is, however,

	submitted in article format, which means that one or more articles may be published in scholarly journals (North-West University, 2016:20). The intellectual property of the articles may then be transferred to the journal, depending on the conditions for publication.
6. Quality of the artefact	The ethical principle of quality refers to the risk associated with the design of some artefacts that may cause harm to the user. This is more often associated with physical artefacts. The set of guidelines proposed in this research cannot cause physical harm to its users. The guidelines were conceived over multiple articles through different qualitative research methods, confirming rigour in the design process. The researcher can control the risks associated with quality issues within the context of this study, but cannot control the quality of the artefact if misused by other researchers or academics.

3.6 Chapter summary: Contributions to the FMA model

In this chapter, the research design of this study was articulated. The suitability of research paradigms was considered, which led to an overview of design science research as the selected paradigm. Relevant processes, methods, and guidelines of DSR were discussed within the context of this study. The relevance of reflective practice in the research design is provided by referring to the theoretical foundation that it shares with pragmatism and inquiry. Data gathering and analysis methods used in this research are also outlined in this chapter, providing an overview of methods used per article, and discussing the ethical principles that were considered in this DSR study.

The research contribution of the study according to the FMA model (Checkland & Holwell, 1998) was highlighted in Chapter 1, Section 1.4. This chapter provided discussions on the framework of ideas (F) and methodology (M). To provide a research design within the context of the chapters found in this study, by referring to F, M and A, Figure 3.7 illustrates an overview of how each chapter fits into the research. Chapter 1 and Chapter 2 provide introductory information to the research, and are not referred to within the context of the FMA research elements in Figure 3.7.

The framework of ideas (F) was addressed in this chapter, through a discussion of DSR as the suitable paradigm for this research, as well as how reflective practice is implicit in DSR. The next chapter, Chapter 4, contains Article 1, which provides a model to illustrate how reflective practice can generate explicit knowledge in DSR. The methodology (M) was also addressed in this chapter, through discussions on the research approaches, guidelines, and qualitative data methods used in this DSR study. Article 5 in Chapter 8 provides a discussion on project-based learning, the instructional methodology used for IT skills development.

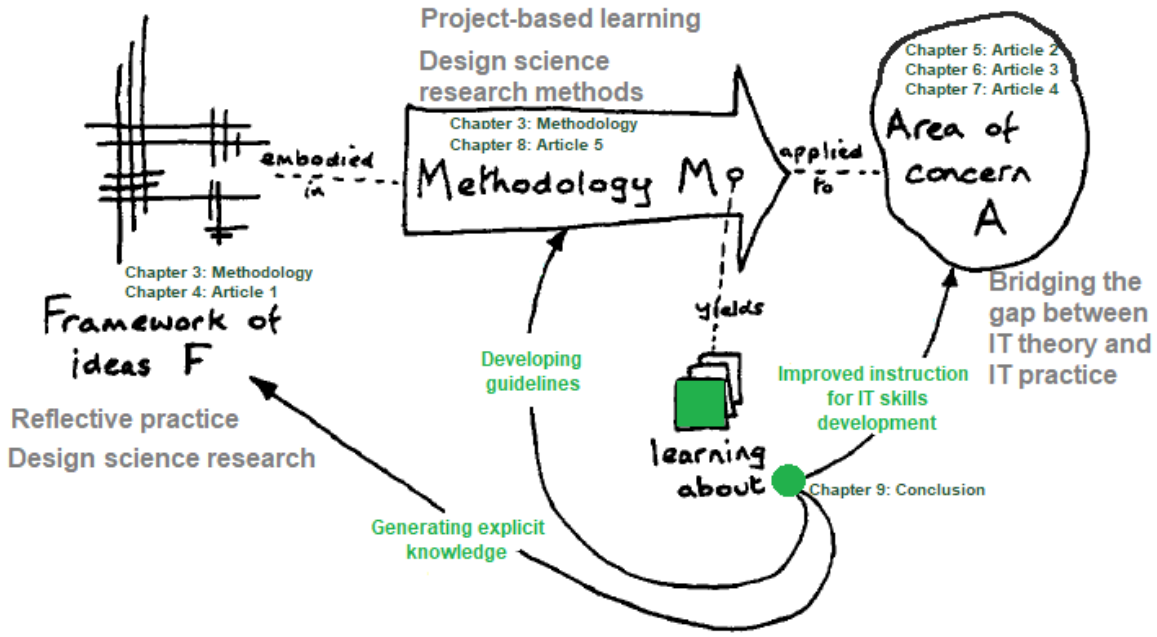


Figure 3.7: Chapters in the FMA elements of this research

The area of concern (A) is addressed in forthcoming chapters. Chapter 5 (Article 2) provides context to the IT skills that graduates lack, and project-based learning used in IT capstone projects. Chapter 6 (Article 3) discusses benefits and improvements of a PBL strategy adopted for IT entry-level students to improve 21st century competencies. Chapter 7 (Article 4) highlights the importance of career awareness, indicating benefits of and suggestions for industry involvement in IT higher education.

As learning takes place for all elements of the research, illustrated in the FMA model, brief discussions of the context of all FMA research elements are inherent to all articles, showcasing the importance of an integrated research design.

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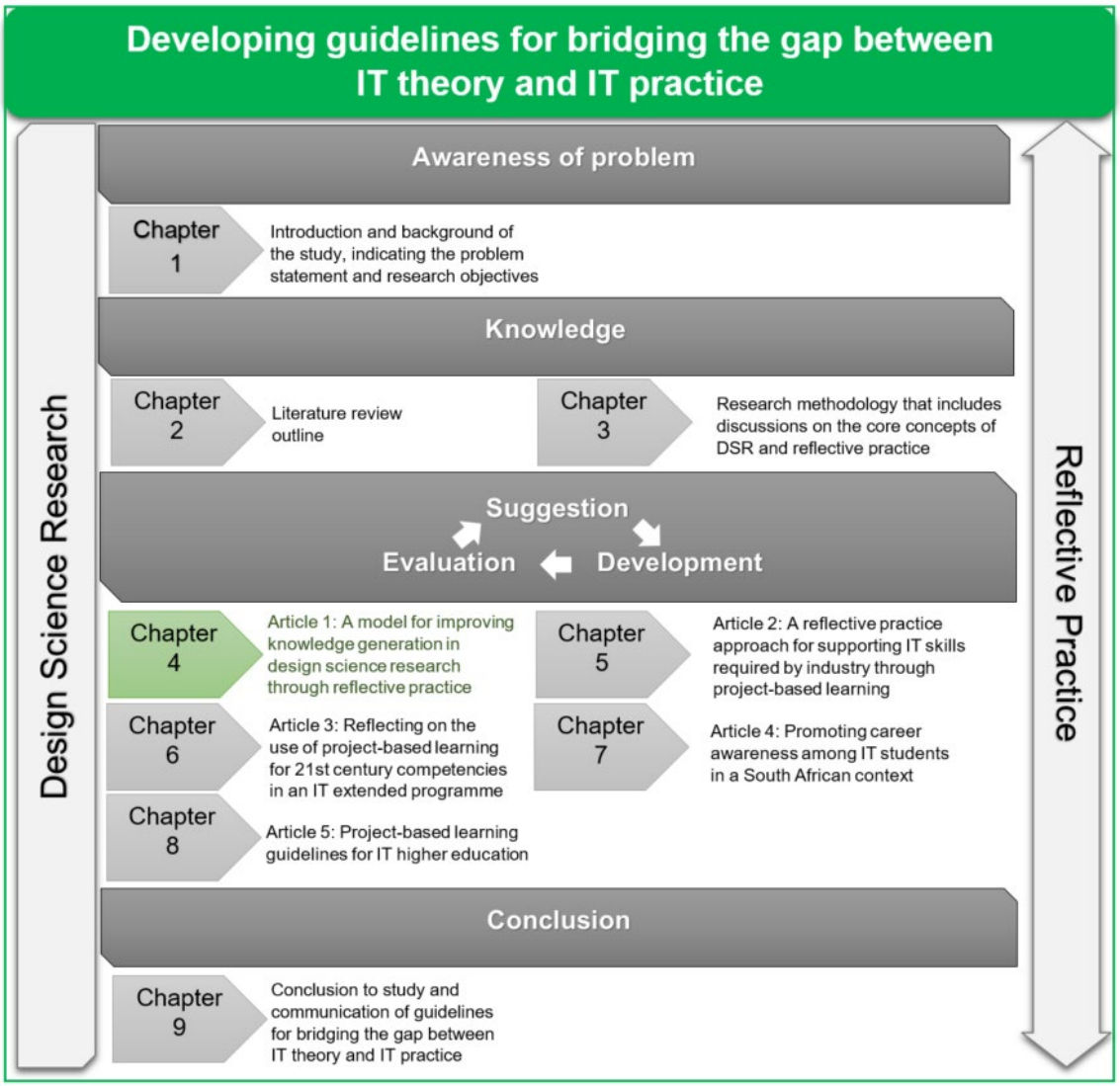
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CHAPTER 4: A MODEL FOR IMPROVING KNOWLEDGE GENERATION IN DESIGN SCIENCE RESEARCH THROUGH REFLECTIVE PRACTICE



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Preamble to Article 1

The article presented in this chapter is entitled *A Model for Improving Knowledge Generation in Design Science Research through Reflective Practice*. An initial version of this article was presented at the 18th European Conference on Research Methodology for Business and Management Studies (ECRM19), hosted by the University of Witwatersrand (Wits) Business School, in Johannesburg, South Africa on the 20th and 21st of June 2019. The conference paper was subject to double-blind peer review.

The conference paper was invited for further development for the Electronic Journal of Business Research Methods, which is an accredited journal listed by the Department of Higher Education and Training South Africa. The extended journal article was accepted for publication after an additional round of blind peer review. The article was published online in volume 17, issue 4 – the December 2019 issue of the Electronic Journal of Business Research Methods (see Appendix D).

Article 1 is the first of five articles included in this research. The article describes how the generation of explicit knowledge in design science research can be improved through the use of reflective practice. The article contributes to the research methodology followed in this research. The novelty of this article lies in the overview of how reflective practice can generate explicit knowledge in the DSR framework as presented in Table 1, as well as a demonstration of its application in Table 2. The demonstration provided in Table 2 offers the foundational context of this research by explaining how DSR and reflective practice was used to develop guidelines for bridging the gap between IT theory and IT practice.

The Harvard referencing style was required for this journal publication. Information regarding author guidelines can be found in Appendix C.

A Model for Improving Knowledge Generation in Design Science Research through Reflective Practice

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Abstract: Epistemology refers to the philosophy of knowledge and aims to address central questions of how we create new knowledge. All research paradigms can be distinguished in terms of epistemological assumptions, that is, assumptions of how knowledge is produced in the respective paradigms. Design science research (DSR) is a research paradigm often used in technical disciplines for the creation of artefacts. DSR has roots in pragmatism, where beliefs and theories are evaluated based on the success of its practical application. New knowledge is produced in DSR when original artefacts are created to solve a problem. The epistemological assumption of DSR can then shortly be defined as 'knowledge through making'. At its core, DSR is goal-orientated and its practical approaches are focused on delivering the product according to straight-forward processes - without being affected by human factors. This process of acquiring new knowledge is efficient but not necessarily effective in terms of capturing all aspects of the experience of the practitioner. Frameworks exist for the creation of artefacts in DSR, but the process of knowledge generation is not explicit. The aim of the paper is to guide explicit knowledge generation in DSR. The research question is "How can we make the process of obtaining knowledge in DSR more explicit?" DSR Frameworks are iterative in nature and focus on the creation and evaluation of artefacts. There is an implicit assumption that reflection takes place in these iterations. Schön, author of The Reflective Practitioner, writes that new knowledge is produced through reflection during and after an event has occurred. He also states that you can only have a complete understanding of a problem through the dual process of reflection-in-action and reflection-on-action. We argue that this also holds true for artefact design and development in DSR. A reflective DSR practitioner can explicitly indicate how knowledge is produced in the design science research cycle. The effective use of reflective practice changes each individual phase of a DSR framework from goal-orientated to problem-orientated. Epistemologically, knowledge is then produced through 'learning by doing', which gives DSR a worldview that supports reflective practice. The paper promotes the incorporation of reflective practice in DSR and provides a demonstration thereof in an example on the preparation of IT students for their chosen career.

Keywords: Design science research, reflective practice, epistemology, knowledge generation

1. An introduction to the epistemological assumptions of design science research

All paradigms have ontological, epistemological and axial assumptions which guide the research process (Vaishnavi & Kuechler, 2004; Oates, 2006; Scotland, 2012). Even though these terms motivate assumptions about reality, knowledge and value for any intellectual effort, they are implicit for most people, including researchers (Vaishnavi, Kuechler & Petter, 2017). Researchers may conduct investigations for the duration of their professional careers without realising the philosophical implications of their research approaches (Kuhn, 1996). One of these terms, epistemology, refers to the theory of knowledge and is concerned with understanding the limitations, the validity and the scope of knowledge (Myers, 2009). An epistemological assumption is concerned with exploring the creation of knowledge and the manner in which individuals learn about their supposed reality i.e. what does knowledge depend on, how can we be sure that what we know is correct. Epistemology explains how knowledge is created, how knowledge is attained, how knowledge is articulated and how knowledge is communicated (Scotland, 2012).

In design science research (DSR), new knowledge is created by designing innovative artefacts as a solution to a relevant human problem (Hevner & Chatterjee, 2010). Vaishnavi and Kuechler (2004) support this definition by stating that DSR alters the world through the creation of innovative artefacts. An artefact can include, but is not limited to, constructs, models, methods, and instantiations (March & Smith, 1995), as well as frameworks, architectures, design principles and design theories (Purao, 2002; March & Smith, 1995; Gregor & Jones, 2007; Gregor & Hevner, 2013).

In DSR, a piece of information is factual and the meaning of the information is made clear through circumscription. An artefact is developed, and the interaction between its components results in its behaviour.

Descriptions of these interactions become information, and the level to which the behaviour is predictable makes the information factual. DSR is dependent on an artefact that functions in a predictable manner. The functionality the artefact delivers comprises of what the meaning of the artefact is – which supports the epistemological stance of 'knowing through making' (Vaishnavi et al, 2017). The theoretical standpoint of DSR may change as it iterates through phases of artefact development, changing from a positivist whilst recording behaviour, to an action researcher when interpreting the observations and planning subsequent interventions.

DSR practitioners have more success when they move between pragmatic and critical realist standpoints, directed by a pragmatic evaluation of development in the DSR cycle (Bunge, 1984). "The design science researcher arrives at an interpretation (understanding) of the phenomenon and the design of the artefact simultaneously" (Purao, 2013).

The aim of design science research then is to contribute new design science knowledge that is "a body of intellectually tough, analytic, partly formalizable, partly empirical teachable doctrine about the design process" (Simon, 1996). The design science researcher can then be seen as a pragmatist (Peirce, 1931).

2. Design science research process

This section provides an overview on the role of knowledge in DSR and how knowledge is generated.

2.1 Role of knowledge

"Knowledge is generated and accumulated through action. Doing something and judging the results is the general model… the process is shown as a cycle in which knowledge is used to construct works, and works are evaluated to build knowledge" (Owen, 1997). A graphical representation of this can be seen in Figure 1. The process to build knowledge through creation is not unstructured, although sometimes thought to lack rigour (Vaishnavi et al, 2017). The channels in the diagram below are the "systems of conventions and rules under which the discipline operates. They embody the measures and values that have been empirically developed as "ways of knowing" as the discipline has matured. They may borrow from or emulate aspects of other disciplines' channels, but, in the end, they are special to the discipline and are products of its evolution" (Owen, 1997). In short, the creation of artefacts produces new knowledge as part of the knowledge building process. Researchers then delve into the knowledge base to inform designs of new artefacts. This then becomes an iterative process where knowledge is added to the knowledge base through creation, and improved artefacts are created due to the existing knowledge base.

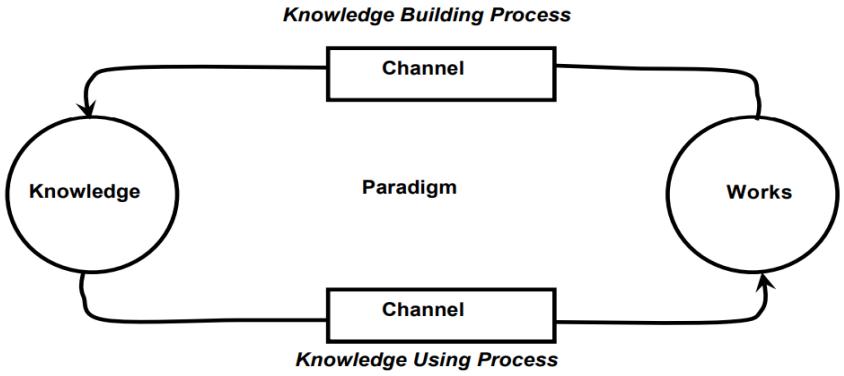


Figure 1: A general model for generating and accumulating knowledge (Owen, 1997)

Different types of contributions can be made to the knowledge base of design science research. Levels of abstraction are explained where contributions to DSR can start with the creation of artefacts, evolve into design principles for artefacts and further be defined into design theories (Purao, 2002).

Design science research is categorised into two groups of knowledge, descriptive and prescriptive knowledge. Descriptive knowledge (omega knowledge) is concerned with the 'what' and prescriptive knowledge (lambda knowledge) is concerned with the 'how' knowledge of created artefacts (Gregor & Hevner, 2013). Examples of descriptive knowledge include phenomena (such as observations, measurements and classifications) and sense-making (principles, theories, patterns etc.) Examples of prescriptive knowledge include artefact creation such as constructs, models, methods, instantiations and design theory.

2.2 Knowledge generation

Within the context of DSR there are different research approaches available. Vaishnavi and Kuechler (2017) established an original framework for design science research in 2004, which was later adopted by Hevner and Chatterjee (2010) (Figure 2). The framework was an adaptation of the model for a computable design process (Takeda, 1990). The phases in the design process and the design science research are similar, but the activities that take place in each phase are significantly different. The biggest difference is that the DSR process requires that the contribution of new knowledge be a key focus of its approach. This framework is still applicable in their latest research. The DSR framework iterates through five phases. The researcher first becomes aware of a problem, suggests a possible solution to the problem, the suggested solution is then developed and evaluated until the research process can naturally conclude. The DSR framework is goal-orientated. Knowledge is generated through circumscription of the process followed to reach the conclusion. This contribution of knowledge is known as Design Science Knowledge. Notably, Peffers, Tuunanen, Rothenberger, and Chatterjee (2008) also created a model for DSR called the DSRM (design science research methodology) model. Peffers et al (2008) appear to present this model as an evolved version of the DSR framework by Vaishnavi and Kuechler (2004) by iterating through six clearly defined phases that follow the same logical flow of events. When comparing the DSR framework and the DSRM model, both approaches suggest that reflection and abstraction take place in their final phases only.

Knowledge is explicitly generated during the last phase of the DSRM model, by suggesting that the results should be communicated through scholarly and professional publications.

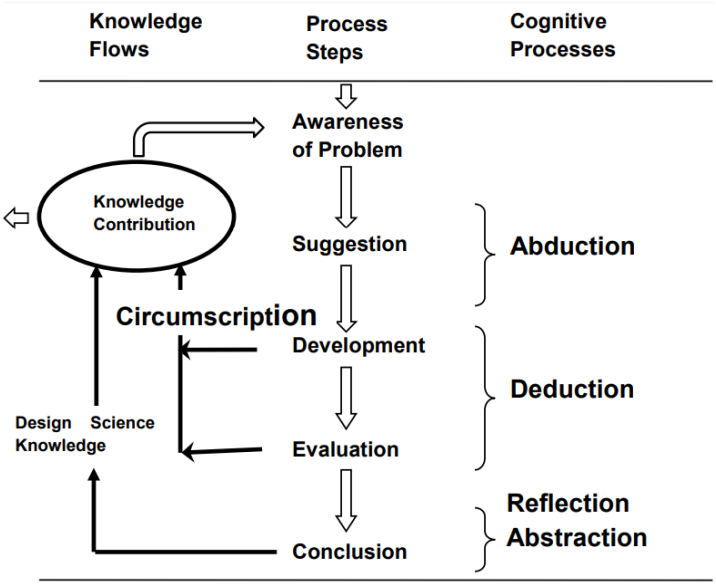


Figure 2: Cognition in the DSR framework (Vaishnavi et al, 2017)

There is an implicit assumption that reflection takes place in both approaches. The presentation of the models however, only explicitly suggests that reflection takes place in the last phases when the project is concluded and communicated. The cycle for cognition in DSR (Figure 2) illustrates the cognitive process followed by indicating the type of knowledge that is produced in each phase of the DSR framework. The DSR framework goes through cycles of abduction, deduction, abstraction and reflection. The creative intellectual process of reflection is used in the conclusion phase to contribute to design science knowledge. In the DSR framework, the overall contribution to advance knowledge needs to be argued at the conclusion of the project (Vaishnavi et al, 2017).

2.3 Limitations in DSR knowledge generation

The aim of the paper is to report on how the process of knowledge generation could be made more explicit if reflective practice is applied throughout the framework, and not only when concluding a project as suggested in Figure 2. The premise of the research implies that there are limitations in the knowledge generation process of the design science research framework.

Knowledge generation in DSR is not explicit. DSR frameworks are iterative in nature and focus on the creation and evaluation of artefacts. Knowledge generation is a result of circumscription of the process followed. The contribution of the knowledge then adds to the knowledge base of design science knowledge. There is an implicit assumption that reflection takes place in these iterations but it is only explicitly stated as part of the conclusion phases of the approaches.

A body of knowledge already exists on the foundation of learning by doing. The epistemological assumption of DSR which is "knowing through making" is limited when compared to the epistemological assumption of reflective practice which is "learning by doing". Even in scientific professions, when practitioners address unique problems, it is an artistic process in which reflective practice takes place (Schön, 1983). Reflective practice is a professional learning and development strategy focused on improved practices, based on assumptions that cause-effect relationships shape behaviour (Osterman, 1998).

Reflective practice is a continuous process. Building on the first limitation listed, the DSR framework only explicitly states that reflection/ abstraction takes place when the cycle has concluded. Reflective practice is intuitively similar to DSR but incorporates known scientific methods for explicitly stating how knowledge is generated. Using reflective practice should be a continuous process throughout the phases of the DSR framework and should not be limited to the conclusion of the artefact.

A model formulated for the use of explicit knowledge generation in design science research would thus require continuous integration of reflective practice approaches embedded in its iterative phases.

3. Explicit knowledge generation in reflective practice

This section provides a shared understanding of reflective practice, and the known scientific methods for knowledge generation within its process.

Reflection is an action of self-deliberation that involves using prior experience and contextual awareness. It is an essential skill that enables one to formulate a philosophy of sharing knowledge and can be used as a standard to observe and measure other professionals' practices (Atkinson & Irving, 2013). Reflective practice comprises carefully considering our personal experiences when knowledge is applied to practice (Schön, 1983).

A reflective practitioner should continuously reflect on his or her experiences and draw knowledge from these practices. Reflective practice is the dual process of immediate reflection during a situation (reflection-in-action) and also reflecting on the situation after it has been resolved in order to better resolve similar scenarios in the future (reflection-on-action) (Schön, 1983). Reflective practice has been defined by numerous academics as the process of learning from and through one's experiences with the aim of acquiring a new understanding of practice ((Boud et al, 1985; Boyd & Fales, 1983; Mezirow, 1981, Jarvis, 1992)). The academic evolution of reflective practice has produced a number of explicitly stated processes for knowledge generation.

Reflective practice is rooted in experiential learning, where the process of learning is most effective when it starts with a problematic experience. The four stages of learning according to Kolb (1984) gives experiential learning as a cyclical process that starts with an experience, continues with reflective observation, leads to an abstract conceptualisation of the problem and results in active experimentation to address the problem. The last stage may result in a different experience which prompts the continuation of reflective observation and so on (Figure 3).

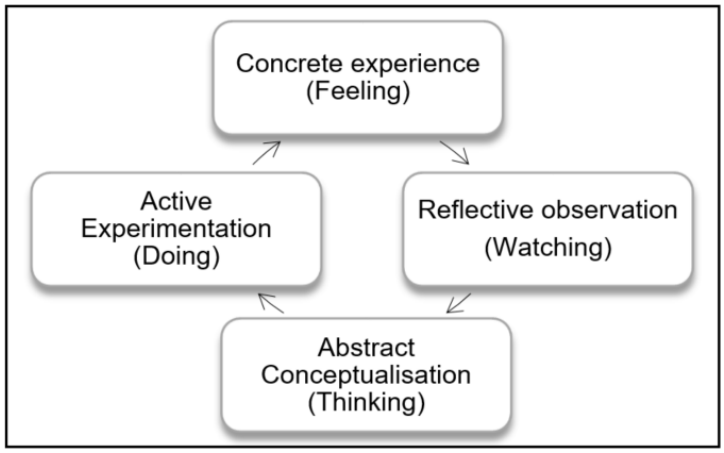


Figure 3: The four stages of learning (Kolb, 1984)

Osterman and Kottkamp (1993) explain that while the experiential learning cycle is a process for using experience as the foundation of learning, that learning cannot take place without reflection, and reflection should be integral to the process of action-taking. Reflective practice, summarised, is the "dialog of thinking and doing through which I become more skilful" (Schön, 1987). Figure 4 provides a summary of what is expected in each phase of the cycle.

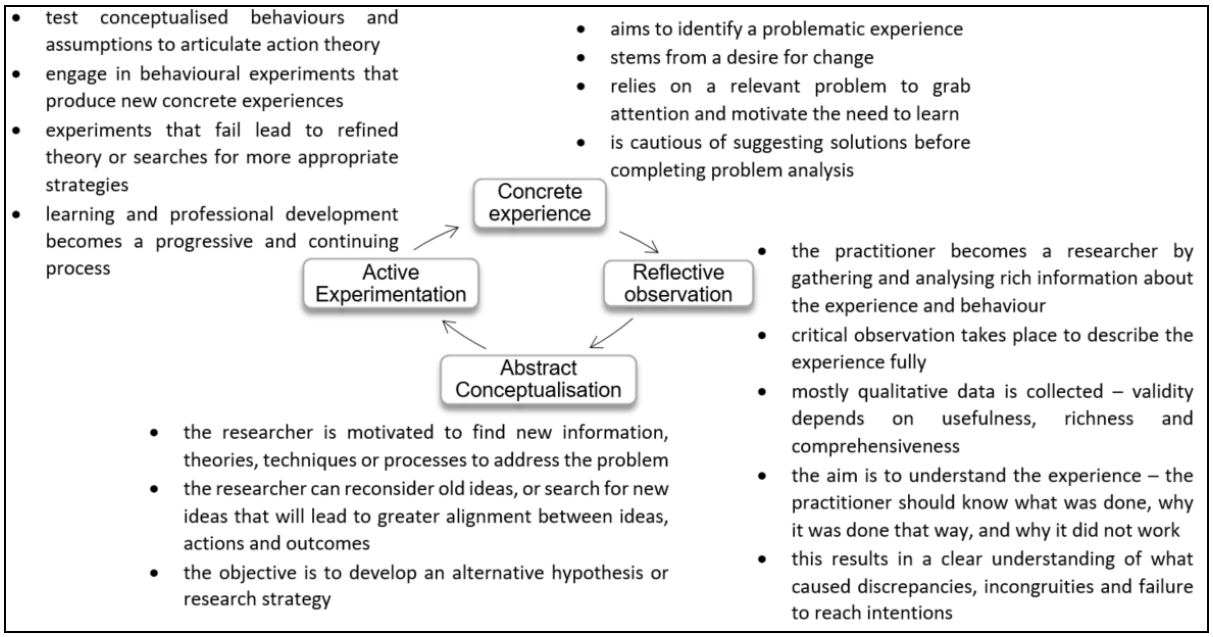


Figure 4: An adaptation of experiential learning explained (Osterman & Kottkamp, 1993)

During the abstract conceptualisation phase, the practitioner is motivated to search for new and unique theories, techniques, processes or ideas to solve the problem (Osterman & Kottkamp, 1993). This stage of the experiential learning cycle deals with abstraction of new concepts and provides a known strategy for knowledge generation. The principle of abstraction and generalization given by Klein and Myers (1999), provides an explicit reasoning to knowledge generation for this reflective practice process. They explain that theoretical abstractions should be carefully conveyed by the researcher as it was experienced and collected, so that the reader can understand how the theoretical insights were reached. Building on the work of Walsham (1993), the validity of drawn inferences and conclusions should not depend on the ability to present the information statistically, but rather on the credibility and impact of the logical reasoning used to describe the results.

When reviewing the DSR framework, it is notable that ideas and recommendations are given in the *Suggestion* phase. The knowledge generated from this phase cannot be assumed to be abstraction, as it relies more often on a plan that is driven by instinct or intuition, and not on explicit methods. Abstraction is an explicit process

for theory building and through the use of reflective practice the knowledge generated could contribute to the prescriptive knowledge of DSR.

To summarise, the following advantages of using reflective practice for improved knowledge generation in design science research are noted:

- Knowledge generation in reflective practice is explicit.
- Knowledge generation in reflective practice fits into known scientific methods.
- Knowledge generation in reflective practice is intuitively similar to that of design science research when following a cyclical model for creating ideas.
- Knowledge generation through reflective practice puts a stronger focus on the creation of prescriptive knowledge in design science research.

From the perspective of reflective practice, a model for explicit knowledge generation in DSR should include:

- Engaging in reflective practice to gain a deeper understanding of the problem experienced.
- Reflection that takes place during each phase of the DSR framework while iterating through the phases.
- Reflection that takes place after each phase of the DSR framework has been completed to better improve future similar scenarios.
- Reflection that takes place in context of observation and abstraction during each phase of the framework with the aim of understanding which type of knowledge was generated.
- Embedding continuous reflection to deliver explicit DSR knowledge during active experimentation of suggestions made towards addressing the problem experienced.

The next section provides an overview of how these advantages, and suggested elements for a DSR model that produces explicit knowledge generation, motivate the use of reflective practice to enrich design science research knowledge generation.

4. Improving knowledge generation in DSR through reflective practice

New knowledge in DSR is produced through the process of creation. The creation of artefacts is a practical approach to knowledge building. The practical nature of DSR has roots in pragmatism, where approaches and theories are evaluated based on their practical application. DSR and pragmatism both lend towards goal-orientated approaches, which is why knowledge generation through reflection typically only takes place when the project has concluded. This process of acquiring new knowledge is efficient but not necessarily effective in terms of capturing all aspects of the experience of the practitioner.

For example, the DSR framework iterates through five phases, the first of which is becoming aware of a problem. An individual wishing to do research on a specific problem area has already employed some form of reflective practice by researching a phenomenon that cannot be addressed by tacit knowledge or knowing-in-action. During the suggestion phase the researcher could offer a solution from his existing knowledge but it would be better practice to include other researchers to jointly reflect on possible solutions for the problem. During the development phase the research will reflect on the initial design of the artefact and choose to conduct evaluation methods to better understand the context of the artefact. During the evaluation phase the researcher will include users or experts to assess the artefact. This is a deeply reflective practice as the feedback obtained creates a richer picture of the solution than the researcher could have suggested on his own. During the conclusion phase the researcher reflects on the methods he used and determines whether the artefact is an appropriate solution to the original problem. He also determines whether new problems may arise which may need suggested solutions and so on. This also is a deeply reflective practice as the researcher cannot conclude the study if he believes that other researchers will not accept the results. The DSR framework in its entirety can then be seen as following a process of reflective practice, even though researchers only propose reflection in its conclusion phase (Vaishnavi et al, 2017).

A reflective DSR practitioner has the ability to explicitly indicate how knowledge is produced in the design science research cycle. The effective use of reflective practice changes each individual phase of a DSR framework from goal-orientated to problem-orientated. Epistemologically, knowledge is then produced through ‘learning by doing’, which gives DSR a worldview that supports reflective practice. Reflective practice

focuses on the user's ability to reflect on situations as they occur but also after they have occurred to improve future practices.

Within the context of design science research, reflective practice is a valuable approach for knowledge generation in a project. The reflective practice process of experiential learning can be used in the DSR framework for improved knowledge generation. The DSR framework is iterative in nature and can move forwards or backwards in any of its phases. It can then be suggested that the cycle of experiential learning should take place during phases to promote abstraction and explicit knowledge generation. Furthermore, the process of moving forward in the DSR framework is typically when reflection-in-action takes place e.g. 'What do I currently need to move forward to the next phase?' The process of moving backwards in the DSR framework is when reflection-on-action takes place e.g. 'How can I improve future iterations under similar circumstances?' Figure 5 provides a graphical representation of a DSR framework enriched with reflective practice for improved knowledge generation.

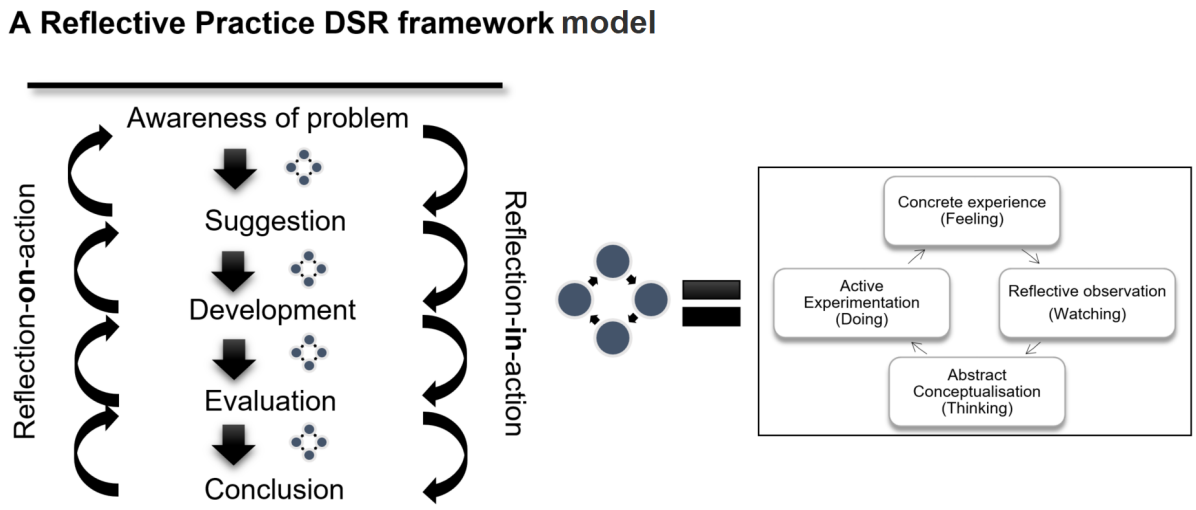


Figure 5: A reflective practice DSR framework model

The use of the DSR framework enriched with reflective practice can be used to explicitly indicate knowledge generated for all types of artefacts. As depicted in Figure 5, the reflective practice cycle is incorporated in each phase of the DSR framework, allowing a reflective process of abstraction to take place for knowledge generation before continuing to the next phase. This method of reflective practice provides a scientific approach for knowledge generation throughout the DSR framework, and not only when concluding a developed artefact as depicted in Figure 2. To further explain the process of embedding reflective practice in the DSR framework, Table 1 provides an in-depth overview of how experiential learning can generate explicit DSR knowledge.

Table 1: An overview of how reflective practice can generate explicit knowledge in the DSR framework.

DSR phase	RP cycle	Addressing a problem experienced in related fields to higher education, information technology and engineering	Explicit knowledge generation
Awareness of problem	Concrete experience	A specific problem is experienced in a specific context, for example, information technology, engineering or higher education (amongst others). There is a desire for change to improve the problem experienced. The problem experienced is *currently* relevant, and when researched indicate existing gaps in the literature that require further development. A critical reflection and analysis of the problem in context is required ***before*** attempting to suggest solutions.	Strategies are researched and evaluated for its appropriateness in addressing the problem. Explicit knowledge is generated in the

DSR phase	RP cycle	Addressing a problem experienced in related fields to higher education, information technology and engineering	Explicit knowledge generation
	Reflective observation	The aim of reflective observation in the DSR *awareness of problem* phase is to fully *understand* the problem experienced by reflecting on what worked, what did not work, why the problem was addressed in a specific manner, to determine inconsistencies, incompatibilities and actions that lead to failure. For this reason, it is necessary to gather and understand as much information that is available on the problem experienced as possible. At this stage, formal research methods are not recommended as the objective is first to fully understand the problem experienced. When formal research methods are employed such as recorded interviews or questionnaires – participants may be reluctant to share sensitive or profound details of the problem experienced. Initially, informal contact will deliver more honest responses that will improve the direction of the research. Reaching an understanding of the problem experienced can be achieved by: • Conducting academic literature reviews through journal articles, conference papers or books. The research can be supplemented by information found from informal platforms such as websites, word of mouth or media outlets. • From initial research, stakeholders or central role players should be identified. Stakeholders can also be determined through strategies such as stakeholder theory (Donaldson & Preston, 1995) or using the boundary questions for critical systems heuristics (Ulrich, 1983). • Initial interaction with stakeholders or role players should be conducted via informal contact methods to increase the honesty of responses. Obtaining honest responses at the start of a research process is crucial, as this will guide the direction and duration of the research. • The information received from stakeholders should provide rich usable data. As informal research methods are adopted that do not provide a back-up of data collected, recommended methods that the researcher can employ to retain the qualitative feedback include autoethnography (Ellis, Adams & Bochner, 2011) or reflective journaling (Dunlap, 2006).	form of proposed strategies that could suit a specific problem.
	Abstract conceptualisation	Abstract conceptualisation can commence on the condition that the researcher has a clear understanding of the problem experienced. If there is any uncertainty whether the problem was completely understood the research process should circle back to reflective observation. The objective of this phase is to evaluate all existing information gathered and to find new techniques or processes that can address the problem. Old theories can be reconsidered and applied in a different context. New theories from other disciplines can be considered for implementation in the problem context. The aim is to conceptualise a new research strategy that is suitable for the problem. Typical research strategies could include: • Self-directed learning (Garrison, 1997), project-based learning (Thomas, 2000), or computational thinking strategies (Wing, 2008) – for higher education • TOGAF (The Open Group Architectural Framework) (Buckl, Ernst, Matthes, Ramacher & Schweda, 2009), DoDAF (Department of Defense Architecture Framework)(Zeigler & Mittal, 2005), or foundational architectures (Goertzel & Wang, 2007) – for IT and engineering projects	
	Active experimentation	The identified research strategies should be informally discussed with the stakeholders. Suggesting suitable research strategies that are accepted by the stakeholders indicate that the researcher has a clear understanding of the problem. Reactions and behaviours should be observed when the research strategies are suggested. If all stakeholders do not agree with the suggested research strategies, it implies that the problem was not completely understood and this will lead to refined theories and approaches.	
Suggestion	Concrete experience	The *suggestion* phase of the DSR framework can only commence when suggested research strategies resulted in a positive experience for the stakeholders. A negative experience indicates that the problem was not completely understood and that the research process should circle back to the *awareness of problem* DSR phase. Identified research strategies can then be further researched for their possible effectiveness in solving the problem. The suggested research strategies should explicitly bring about change to the problem experienced.	Gaps in literature are identified. New information is added to the knowledge base in order to address the gap.

DSR phase	RP cycle	Addressing a problem experienced in related fields to higher education, information technology and engineering	Explicit knowledge generation
	Reflective observation	The objective of reflective observation in the *suggestion* phase is to promote a deeper understanding through research of the strategies or approaches that were well received by the stakeholders. Once the researcher has achieved a deeper understanding, the stakeholders are informally updated on new information regarding suitable strategies and approaches that were suggested. Stakeholders should actively be informed of new developments to ensure that the identified research is still addressing the problem experienced and does not stray from the initial issue.	
	Abstract conceptualisation	Abstract conceptualisation in the suggestion DSR phase aims to consolidate information gathered from academic research with informal discussions or conversations held with stakeholders. This action should lead to identifiable gaps in the research that emphasise the possibility of new suitable approaches towards addressing the problem experienced. When identifying appropriate strategies or approaches to address that gap in research, it is important to reflect on how, and which type of, knowledge will be generated when these methods are implemented.	
	Active experimentation	During active experimentation in the *suggestion* DSR phase, new strategies and approaches identified to address the gap should be presented to the stakeholders during informal discussions. The suitability of the new approaches will rely largely on acceptance from the stakeholders. Strategies or approaches that are questionable need further research and development, and the research process may need to circle back to reflective observation for refinement.	
Development	Concrete experience	A concrete positive experience results from the suggested new strategies and approaches. A feasible suggestion is agreed upon by all stakeholders for implementation towards solving the problem experienced. A needs analysis or requirements analysis (Potts, Takahashi & Anton, 1994) may be required before development of the strategy can commence in order to fully comprehend how the suggested strategy will address the problem experienced. The development phase can be guided by methods used for implementation which can be extended to suit the context of a problem experienced in higher education, IT or engineering such as design thinking (Brown & Wyatt, 2010), prototyping (Zalzal, Gava, Kelouwani & Cohen, 2009), or agile methodologies (Maruping, Venkatesh & Agarwal, 2009).	Specific strategies are adopted for the problem experienced based on research and feedback. Formal research methods are employed that deliver scientific findings which add value to the knowledge base. Limitations to chosen strategies are identified. Suggestions to address the limitations are presented.
	Reflective observation	The development of the strategy in context of the problem experienced has commenced. Continuous feedback is required from stakeholders to ensure that the development of the suggested strategy remains relevant to the problem experienced. At this stage of the research it is recommended to start using formal research methods for data gathering and analysis such as interviews and questionnaires (Zhang, Kuchinke, Woud, Velten, & Margraf, 2017), or participatory design (Bratteteig & Wagner, 2016). The qualitative feedback received from stakeholders should provide rich usable data. Scientific guidelines for data analysis can be followed to improve the integrity of the findings. Example approaches for data validation include the principles for conducting and evaluating interpretive field studies in information systems (Klein & Myers, 1999) and the qualitative analysis of content (Zhang & Wildemuth, 2009). Tools for qualitative data analysis may include traditional spreadsheets or advanced software such as Atlas.ti.	
	Abstract conceptualisation	Formal qualitative data analysis methods will deliver scientific findings that can inform the development of the strategy at an academic level. Research remains a continuous process, and as the data analysis provides insights into the development of the strategy, new knowledge is generated and added to the knowledge base. Formal research is produced, and can be consolidated with existing strategies to further refine the research process and suggested approaches.	
	Active experimentation	During the development of the strategy, challenges will occur. Stakeholders may react differently than expected, and behaviours should be observed to understand the context of the concerns identified. Challenges result in new experiences that guide the research process and determines which actions should be taken. Iterative development is emphasised for improved outcomes as learning is a continuous process. If the initial strategy fails, the feedback from stakeholders leads to refined theory. If the developed strategy is considered acceptable, the research process continues to evaluation.	

DSR phase	RP cycle	Addressing a problem experienced in related fields to higher education, information technology and engineering	Explicit knowledge generation
Evaluation	Concrete experience	Depending on the type of experience that resulted from the previous DSR phase, the developed strategy is subject to evaluation. Evaluation will highlight additional shortcomings not identified through data analysis. In context of higher education, IT or engineering, evaluation may include formal research methods such as TAM (Technology Acceptance Model) (Legir, Ingham & Collerette, 2003), UX (user experience) evaluation (Law & Abrahão, 2014), or extending traditional data gathering methods that include stakeholder feedback.	Different evaluation methods are researched that will deliver the best possible feedback for the strategy developed. Evaluation of the strategy contributes knowledge on successful and unsuccessful approaches. Academic literature is added to the knowledge base.
	Reflective observation	In the *evaluation* phase, reflective observation refers to the researcher's ability to identify suitable methods to assess the progress of the developed strategy. As there are numerous methods of evaluation, it is crucial that a suitable option is used in context of the problem experienced in order to produce the best possible feedback. When an optimal evaluation method is applied, the findings will result in a clear understanding of which development processes lead to discrepancies, incongruities or failure to reach the intended outcome.	
	Abstract conceptualisation	When a clear understanding can be achieved of which specific parts of the collective whole were successful and unsuccessful the research process naturally becomes easier to guide. Targeted research can be conducted to find information that addresses the discrepancies. All research previously undertaken can be reconsidered if there is evidence that it can address the problem. The objective is to refine specific elements of the developed strategy that were identified as substandard, in order to improve the general success of the strategy as a whole.	
	Active experimentation	The refined strategy can be evaluated by stakeholders using formal data gathering methods to test their behaviours and observe the assumptions made. Explicit knowledge is generated and should be shared with other researchers via publications to encourage peer-review of the suggested strategy. Findings from the data collection methods with stakeholders should be included in the publications to encourage other researchers to also critically reflect on the problem experienced as a whole. Consolidating feedback from stakeholders and peers lead to refined theories and may guide the research process back to reflective observation in any of the DSR phases.	
Conclusion	Concrete experience	After a number of iterations the developed strategy may or may not be final. Feedback received from peers and stakeholders will determine the level of completeness. The problem experienced was current and relevant and the final artefact should be shared for academic reflective practice.	Successes and failures of the overall artefact can be documented to contribute to the related fields, as well as the knowledge base of reflective practice and design science research.
	Reflective observation	Academic findings should also be shared with stakeholders for improved feedback and may highlight significant elements that were overlooked. A final round of formal data collection methods with stakeholders are recommended to ensure that the findings were valid and rigorous.	
	Abstract conceptualisation	The research process followed a DSR framework enriched with reflective practice to encourage explicit knowledge generation. The research gap, development and evaluation processes of the artefact should be highlighted in academic publications. Suitable methods for reporting on DSR studies include developmental research for curriculum design (Mckenny & Van Den Akker, 2005), the DSR framework (Vaishnavi et al., 2017), the DSR process model (Peffers et al., 2008), and the DSR checklist for rigourous artefact development (Hevner & Chatterjee, 2010). The objective is to determine whether the explicit knowledge generated is accepted by other academics and researchers pending peer-review.	
	Active experimentation	Feedback received from peers may lead to refined theory building for the problem experienced. Depending on the experiences of different stakeholders, additional research may be required that could circle back to any of the phases of the DSR framework. Failed strategies also result in research outputs that highlight methods or approaches that were not suitable for addressing the problem experienced. Active experimentation in the *conclusion* phase of the DSR framework includes applying generated theory to similar problems experienced in other disciplines. Engaging in reflective practice for professional development is encouraged and research findings should be shared continuously to highlight successes and failures.	

A demonstration of the application of embedding reflective practice in the DSR framework is explained in the next section.

5. Demonstration

The paper aims to improve knowledge generation in DSR through reflective practice. An example thereof is provided in context of the preparation of IT students for their chosen career.

There is an increasing concern that information technology (IT) graduates lack certain skills expected by industry when they enter the workforce.

Reflecting from a traditional DSR perspective, the researchers became *aware of the problem* and *suggested* a possible solution. An artefact in the form of guidelines for bridging the gap between IT theory at university level, and IT practice at industry level, could provide insight on improved practices. The process naturally lent itself to the phases of the DSR framework for artefact creation, and limitations in its knowledge generation process for the guidelines were identified. Following the original DSR framework resulted in guidelines that were only truly reflected on towards the end of the project. When the guidelines went through another iteration of application in context, more gaps were noted than guidelines originally produced. This led the researchers to believe that the DSR framework is a well-structured process for developing a prototype version of an artefact, but it lacks a scientific approach to knowledge management. The DSR framework is intended for experimental creation but does not explicitly indicate how to generate knowledge and how to retain and improve the knowledge generated before a project is concluded.

In order to provide some context for the demonstration, the following sections provide an overview of the research questions and objective, participants and data analysis methods used for the problem experienced.

5.1 Research questions and objective

In Table 2, during the first reflective practice cycle of the *awareness of problem* DSR phase, the initial problem experienced is described. From this experience, the following research questions were identified:

- Which industry-related skills does an IT graduate need and typically lack?
- Can project-based learning be implemented in an IT degree to introduce industry-related IT skills?
- Can a set of guidelines be derived for bridging the IT theory-practice gap in order to improve the skills of IT graduates required by industry?
- How can reflective practice support the development of these guidelines (a design science research artefact) by generating explicit knowledge?

The primary objective of the research used in this demonstration was then to develop guidelines for bridging the gap between IT theory (standard IT teaching practices at university) and IT practice (the required industry-related skills).

5.2 Participants

The central participants of the study were entry-level and exit-level students in their undergraduate IT degree. Other role players of the study included members from the IT industry and IT educators. The problem experienced started with exit-level IT students during 2017 when a skills gap was noticed between IT theory and IT practice. Industry was subsequently asked to provide feedback on skills IT graduates typically lack (Janse van Rensburg & Goede, 2019). The research described in this demonstration is still ongoing at the time of this publication.

5.3 Data analysis

Qualitative methods were used to gather data from participants. Interpretive content analysis was used to analyse qualitative data in order to identify themes in the data. Findings from literature and identified themes were used to build guidelines for bridging the IT theory-practice gap.

Research conducted provided evidence on the validity of experiential learning through reflective practice with the focus on abstraction for improved knowledge generation. Following the process for reflective practice in the phases of the DSR framework added value to the knowledge generation process and resulted in guidelines for how to reflect-in-action, and reflect-on-action. Using the guidelines provided in Table 1 (and building on the model presented in Figure 5), Table 2 provides an overview of how reflective practice was embedded in

the DSR framework in context of the problem experienced, resulting in guidelines for bridging the IT theory-practice gap.

Table 2: A demonstration of reflective practice embedded in DSR to address a problem experienced.

DSR phase	RP cycle	Problem in context
Awareness of problem	Concrete experience	A gap between IT theory (higher education) and IT practice (industry) was noted. Recent IT graduates lacked certain skills expected by industry when they entered the workforce. There was a need to better prepare IT students during higher education to bridge the gap between university and industry. This raised the question of what higher education can improve on or do additionally to better prepare IT students for industry. Before solutions towards bridging the identified gap could be proposed, it was necessary to complete a comprehensive problem analysis to ensure that the problem was fully understood.
	Reflective observation	In order to understand the context of the problem experienced through analysis, it was necessary to first do informal research to determine whether similar problems have been experienced by other academics. The objective of the informal research was to understand the context of the problem, who was involved, and which approaches were recommended towards solving the problem. From this research, stakeholders could be identified that were central to the current problem experienced. In context of the problem experienced, the stakeholders identified were IT students, members of the IT industry and IT educators. From an initial perspective, feedback from all stakeholders was required to fully comprehend the problem experienced. Informal discussions were held with IT students, educators and members from the IT industry to understand the problem experienced from their different perspectives. As the aim of an informal conversation is first to understand the problem from these different perspectives, no formal method of data gathering and analysis was adopted. The conversations however did lead to qualitative feedback that needed to be retained in some manner. The researcher opted for autoethnography, where all important ideas and issues raised during informal conversations were noted on an available medium, for example, a note book, a research journal or the 'notes' application on a mobile phone. Interactions took place during informal settings, such as coffee with colleagues (IT educators), conversations with IT industry members while attending hackathons or discussing possibilities for collaboration, and casual feedback sessions with IT students on their experiences and expectations. The action of autoethnography lead to a clearer understanding of the problem experienced. During this process, the researcher was able to explain the experiences relative to the individual perspectives of all stakeholders. A deeper understanding of the problem was achieved through this process of reflective practice during which the researcher identified areas for improvement. In short, IT students wanted more industry exposure, and members of IT industry highlighted specific skills that needed to be better developed in IT graduates. From the perspective of the researcher, it was assessed that IT educators did not provide valuable feedback on areas for improvement. The reasoning behind this decision was that there was a notable gap between industry expectations and curriculum that was being taught. Some information was outdated, and some educators had very little interest in doing market research or collaborating with their colleagues or industry. For this reason, IT educators were not considered a central stakeholder in providing feedback on what needs to change – they were solely considered as the vehicle for providing updated and *current* education that should adjust their approaches accordingly.
	Abstract conceptualisation	Having had a better understanding of the problem, the researcher was motivated to start looking for information, theories or methods that could assist in addressing the problem experienced. Existing strategies being used were reflected on, and notes were made regarding their effectiveness towards supporting the feedback obtained (still via autoethnography). For example, projects are often included in the assessments of IT students, but are most often compiled by the IT educator. Through reflection and research, this approach could be improved on by managing the scope of the project through the use of industry projects (rather than *thumb-sucking* the scope), or topics that provide value and meaning to the student (i.e. community projects). Before identifying any specific methods that could deliver a positive experience, new strategies were also researched, reflecting on their appropriateness for the problem experienced and the feedback obtained. Some of the strategies researched and reviewed in context of IT higher education, for example, included problem-based learning, self-directed learning, blended learning, computational thinking and project-based learning.

DSR phase	RP cycle	Problem in context
	Active experimentation	By identifying possible strategies from literature, the researcher could use these examples for discussion with the relevant stakeholders. Informal discussions with IT students and members from the IT industry were held to suggest the strategies and their expectations thereof. Perceptions and opinions were still noted via autoethnography methods. Not all possible strategies were equally welcomed, but a general approval of project-based learning (PBL) instruction was voiced. The reasoning behind this was that IT industry comprises of project-based environments and research indicates that PBL settings promote the early acquisition of diverse 21st century competencies. Project-based learning also has the ability to address the other approaches – as it can include methods for problem-based learning, self-directed learning, blended learning, and improving computational thinking. PBL was initially introduced in an exit-level IT module using industry scopes to understand whether this approach would address the problem experienced. The researcher wanted to understand why some methods were preferred as other proposed approaches also had relevant advantages for the problem experienced. After additional research was conducted, it was noted that the different approaches could still be used to achieve the same goal. This highlighted that the various teaching and learning approaches were not necessarily the concern but rather how they were implemented.
Suggestion	Concrete experience	A lack of generic rules for the manner in which these approaches are implemented highlighted the need for guidelines that indicate how these teaching and learning strategies, including PBL, could be used to address skills shortages in IT students. Guidelines were required that facilitate the manner in which these approaches should be implemented so that they are industry focused and share the same goal – improving 21st century competencies. Additional research was required before suggestions could be made to understand what the contribution of the guidelines needed to be.
	Reflective observation	Research was conducted to find existing guidelines that can address the problem experienced. The existing literature was critically reviewed to determine whether all suggested strategies, including PBL instruction, were addressed by all existing guidelines. The researcher continued to make notes on the qualitative data through autoethnography, reviewing guidelines that were repeated, understanding why and how they were formulated, and understanding the value and context of their application. Appropriate guidelines found in existing literature were presented to students and industry during informal discussions, and their perceptions and ideas were noted.
	Abstract conceptualisation	During the process of research and informal discussions, gaps in the existing guidelines were identified. Guidelines that were partially applicable were reconsidered and adjusted to better address the problem experienced. New techniques and processes in the form of guidelines needed to be developed to address the missing information not covered in existing literature. The objective was to consolidate existing guidelines with new suggested guidelines in order to provide a single set of guidelines that can be followed to address the skills shortages and improve 21st century competencies of IT students.
	Active experimentation	In order for the guidelines to be considered, they needed to be refined based on their acceptance by the relevant stakeholders and their successful application in an IT curriculum. Existing and suggested additional guidelines were proposed during informal discussions with students and industry to determine whether they saturate the current need for skills development to address 21st century competencies. Guidelines that were questioned were further refined, and an initial set of guidelines were confirmed for implementation in a first instance of IT higher education.
		The problem experienced started with exit-level IT students, and the initial set of guidelines were applied in context of their education. The aim of applying the guidelines was to understand whether a positive experience in terms of their career awareness and skills development could be achieved.

DSR phase	RP cycle	Problem in context
Development	Concrete experience	The guidelines were applied in context of relevant teaching and learning strategies such as PBL to simulate an IT working environment which motivated their desire to learn. While following the proposed guidelines it was noted that some guidelines did not have the expected outcomes. Additional research was required to understand why these guidelines did not have the intended impact.
	Reflective observation	The researcher became aware that addressing these guidelines at exit-level of a curriculum is too late in some instances to successfully prepare the soon to be IT graduate. As the first research cycle where the guidelines were applied had started, it was necessary to establish formal research methods for data gathering and analysis to address the problem experienced. The researcher asked IT students that formed part of an exit-level IT module in which the guidelines were applied to complete an interpretive questionnaire. The feedback included their perceptions of the strategy taken and provided suggestions to further improve the approaches taken that did not meet their expectations. The feedback was analysed in Atlas.ti using open coding to identify themes in the data. The themes identified indicated advantages of the strategy taken, highlighted approaches that raised career awareness and improved their 21st century competencies, and provided additional suggestions that they would find beneficial. From the additional suggestions, it was realised that certain guidelines would have a greater impact if they were applied earlier in the IT degree and not only at exit-level.
	Abstract conceptualisation	A conceptual framework was formed that following the guidelines at an earlier stage of the curriculum can prepare the future IT graduate in a systematic manner. Guidelines that were suitable to follow earlier in the IT degree needed to be identified. For example, PBL instruction could also be implemented at IT extended level. Additional guidelines were required that would suit the needs of the IT extended students. The objective was to reflect on the initial set of guidelines and suggest improvements that would assist the future IT graduates earlier in their degrees.
	Active experimentation	Guidelines that could be followed in an IT extended degree were identified and implemented at entry-level of the curriculum. The impact of the guidelines was informally observed and noted. Certain guidelines were challenging to implement at entry-level and additional research was required.
Evaluation	Concrete experience	A problem was experienced when following the guidelines at entry-level of the curriculum. It was noted that the guidelines cannot be applied in the exact same manner for entry- and exit-level IT students. For example, it is noted that the student groups require different motivation for completing projects. Exit-level students were more focused on their careers and wanted to participate in industry scope projects. Entry-level students were more focused on their studies, and engaged better in projects that were relevant to their current context. The researcher was cautious of adjusting guidelines without additional research and feedback to better understand the problem experienced.
	Reflective observation	In order to understand the challenges experienced while implementing guidelines at entry-level of the curriculum, IT extended students were asked to reflect on their experiences. The data was gathered using guided reflective sheets that contained questions relating to their experiences, preferred teaching and learning methods and self-reflection on improved 21st century competencies. The feedback was analysed using a combination of basic descriptive statistics for the quantitative data, as well as open coding for the qualitative data. The aim was to understand why only certain approaches were successful following the initial set of guidelines. From the data analysis an understanding was achieved as to which approaches were valuable and which approaches required further research and development.

DSR phase	RP cycle	Problem in context
	Abstract conceptualisation	The approaches contained in guidelines that were found lacking needed further research for possible solutions as to how they could be applied at different year levels. The existing guidelines were evaluated to understand the extent of adjustments required so that they would address the problem experienced. The objective was to find strategies for applying similar guidelines at different year levels with the common goal of improving the 21st century skills of IT students.
	Active experimentation	The appropriate guidelines were applied at entry-level and exit-level, but the scope was adjusted to suit the context of the student. When a new approach was implemented within a guideline, students were informed of how this would improve their 21st century competencies. While the identified guidelines seemed to support the problem experienced, the scope was continuously reevaluated and adjusted as necessary. The learning process was continuous for entry-level and exit-level students, as well as the researcher, who articulated her ideas noted through autoethnography via research publications to share explicit knowledge on best practices using formal methods of data analysis.
Conclusion	Concrete experience	The set of guidelines were not finalised after a limited number of iterations had been concluded. This implied that the guidelines should continuously be evaluated and reflected on for relevance and applicability. Where it was experienced that guidelines were not sufficient, more research was required in order to attempt to saturate the information.
	Reflective observation	In order to understand whether the guidelines were sufficient, feedback was required from members of the IT industry that had recently employed IT students that had been subject to the guidelines. Formal interviews were held with members from the IT industry, and the qualitative data was analysed in Atlas.ti using open coding to identify themes in the data. The objective of the data analysis was to determine whether members of industry could notice improvements in the 21st century competencies of IT students based on the initial feedback received during informal conversations at the start of the research process. Guidelines were discussed, and where additional concerns were voiced, supplementary research was suggested to further understand the problem experienced. At this stage of the research, it was important to publish research papers on the study to assist with providing clarity on the problem experienced and addressing the gaps in literature.
	Abstract conceptualisation	In the conclusion phase of the DSR framework, it is not only important to provide research contributions on the literature gap identified, but also to report on the DSR process followed to conduct the research. The objective of this type of research publication is to provide explicit knowledge generated when following a DSR framework or approach. As the set of guidelines is also considered as an artefact that was created by following a DSR approach, it was necessary to use a formal DSR reporting method such as the DSR checklist of Hevner and Chatterjee (2010).
	Active experimentation	Preparing future IT graduates is an iterative and reflective process. As change occurs, guidelines should be updated to remain current and relevant. Guidelines should continuously be applied at all levels, contextual to the environment of the student, to ensure a well-rounded work-ready student. Reflective practice is central to the learning process of the student and the researcher, and should continuously be implemented as part of the development process. The DSR framework was enriched with reflective practice for explicit knowledge generation, and in this example, resulted in the formulation of guidelines for bridging the IT theory-practice gap. This method of explicit knowledge generation can also be applied in context of other disciplines to structure the research in a professional and academic manner.

In the context of this example, explicit knowledge was generated in the following ways:

- Suitable strategies towards addressing the problem experienced was identified and highlighted in research publications.
- A gap in academic literature was identified for the creation of guidelines towards bridging the IT theory-practice gap.
- Through formal research of data gathering and analysis, specific strategies could be identified that would address the problem experienced and was highlighted in research publications.
- Through the process of development and iteration, shortcomings were identified in the strategies that could be refined for further research.
- Targeted evaluation methods that suited the development process of the problem experienced were highlighted in research publications.
- Results and findings from evaluation methods employed contributed to the academic knowledge base.
- Contributions to the knowledge base of design science research and reflective practice resulted in explicit discussions that address the problem experienced, while highlighting the elements of the research processes that were successful and unsuccessful.

6. Summary

The DSR framework is an excellent tool for prototyping artefact creation, but it is limited in its explicit methods for knowledge generation. When following the DSR framework, the researcher will iterate through the phases and produce an artefact that concluded as a *prototype* that addresses the *current* requirements of the problem. DSR more often results in outstanding artefacts, which can be implement and used for the specified problem, but that is not easily adaptable to a changing environment. In DSR, when the problem changes, a new artefact needs to be created and the DSR framework has to restart in the first phase. The goal-orientated nature of DSR is effective for immediate results, but not efficient in anticipating problems in a holistic manner. Abstraction for tried and tested approaches is only reflected on in the concluding phase, which provides limited knowledge generation for the knowledge base of DSR. It is notable that following a DSR framework enriched with reflective practice results in a more rounded artefact, due to the reflective cycle that takes place between phases. The cyclical process of reflection allows the practitioner to address the current problem as well as anticipate and prepare for future variations of the problem. This allows the practitioner to holistically apply the DSR framework, and conclude the artefact without having to restart at phase one when problems are identified. This process of reflection results in improved knowledge generation for design science research.

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Article 1: Guideline development

Through the iterative nature of the design science research approach followed in this study, this article adds explicit guidelines towards bridging the gap between IT theory and IT practice.

Article 1 is a research methodology paper which presents a model for generating explicit knowledge in design science research through reflective practice. In the demonstration of the model, this study's process is described by going through the phases of design science research, and looping though a cycle of experiential learning in each phase to add reflective practice throughout the design. Following this model as a guide for this study, the researcher *implicitly* became aware of guidelines that an IT educator could use to formulate an intervention strategy. Figure 4.1 provides a high-level overview of these guidelines.

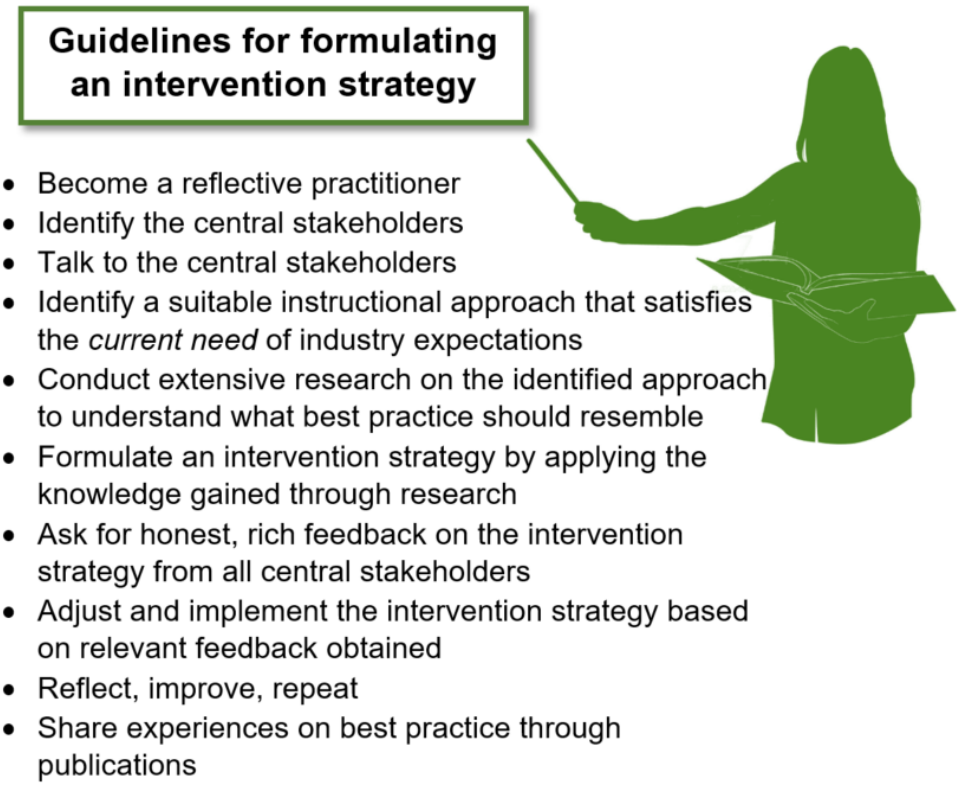


Figure 4.1: Guidelines for formulating an intervention strategy

Table 4.1 provides a discussion and context on each guideline that forms part of formulating an intervention strategy.

Table 4.1: Description of guidelines for formulating an intervention strategy

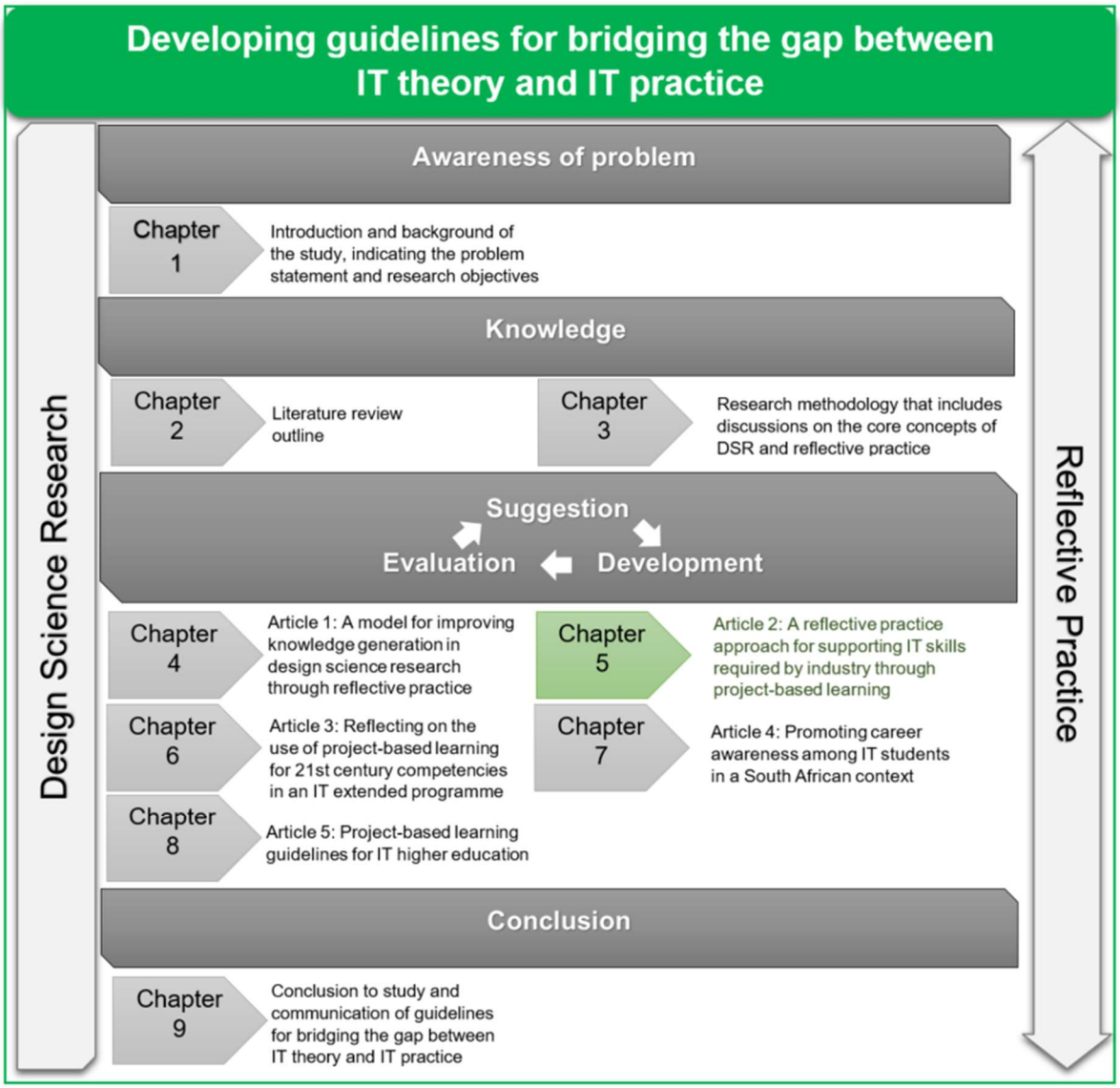
Guideline	Description
Become a reflective practitioner	To advance your own professional development, continuously engage in reflective practice. Reflection is central to any intervention strategy. Reflect-in-action on what needs to happen next, reflect-on-action to keep improving your approach. *Learn from your experiences* – both success and failure shape the impact of your strategies, as well as your professional development.
Identify the central stakeholders	The starting point is to determine who *really* matters. Initially identify all stakeholders who are connected to the problem experienced. Through reflection, informal contact, and research, you should be able to identify whether all stakeholders are *central* to the problem experienced. It may occur that an identified stakeholder does not provide immediate value to the problem you are trying to solve. Explain this, and move on. Your approach to an intervention strategy should be pragmatic; ask yourself, "does this stakeholder have information that I need right now to solve the problem?" If the answer is no, revisit the conversation at a later stage.
Talk to the central stakeholders	The next step is to talk to the central stakeholders (or samples from the stakeholder groups). A reflective practitioner attempts to understand the problem experienced fully, before starting with formal research methods. Do not underestimate the value of informal conversation. The information you receive at the start of your strategy will guide the direction that your approach takes. Talking to the wrong people, or too few people, might mean that you find flawed perceptions too late in your strategy. Talking to too many people might be time consuming, but it will give you a good idea of who is giving you valuable information and who is not.
Identify a suitable instructional approach that satisfies the *current need* of industry expectations	When you understand the problem experienced fully, look for methods or approaches that will best solve the problem. There are many successful instructional approaches available. Choosing one depends on which approach will best work for the current need highlighted while talking to stakeholders. Ask yourself, "which instructional approach will best resemble the industry environment, and can be used to train related skills?"
Conduct extensive research on the identified approach to understand what best practice should resemble	Once you have identified an approach, find scholarly publications that outline successes and failures of its implementation. Research should be focused on (but not limited to) studies where the approach was implemented in the discipline you want to use it for. Pay special attention to *suggestions for improvement* and *recommendation* sections – researchers/academics hide the elements they wished they had implemented/known from the start in these sections. *Learn from their experiences.*
Formulate an intervention strategy by applying the knowledge gained through research	You have talked to the central stakeholders, and you have conducted extensive research on best practice for the chosen instructional approach. Use the knowledge you have gained from other people's experiences (stakeholders and researchers) to formulate an intervention strategy that addresses the problem experienced.
Ask for honest, rich feedback on the intervention strategy from all central	Do not leap into the intervention strategy blindly. Outline your intervention strategy, present it to stakeholders, and ask for critical feedback. If you are truly a reflective practitioner, you will ask the *difficult-to-hear-the-answer* questions such as, "did I interpret your

stakeholders	feedback correctly?", "do you think this can/ will work?", "can you suggest a better way?", and "what can I improve on?"
Adjust and implement the intervention strategy based on relevant feedback obtained	First attempts are hardly ever perfect; use the critical feedback that you received on your intervention strategy to make amendments to improve your approach. Then, implement your intervention strategy in practice.
Reflect, improve, repeat	Do not forget to take time to reflect once you have started implementing your intervention strategy within a real-world context. Refection is a dual process. Reflect on what is working well and what needs refinement during the intervention strategy, and change your approach mid-strategy if you need to. After all, experience is the best learning tool to understand what works in practice. Once you have reached the end of your intervention strategy, reflect on the entire approach taken, make notes on the issues that you experienced along the way, and make self-recommendations for improvement. Adjust the intervention strategy for future use, present it to stakeholders for feedback, and ask for advice from the practitioners for hard-to-solve problems. Rinse, and repeat.
Share experiences on best practice through publications	Depending on your target audience, share the information with other people who might be interested to know the answers you have uncovered. This might be in the form of a weekly blog, social media updates, meetings for an educational society, or academic publications. If it is the latter, formal data gathering methods should be deployed at some point in your intervention strategy, but not at the start. To receive rich honest feedback, it is best to have informal conversations. If the informal conversations highlighted essential information that should form part of a publication, you can perhaps summarise the conversation via email and ask the potential participant to confirm whether you have understood the information correctly. If the intervention strategy worked well, share the lessons learned with other educators, researchers and academics. If it worked partially, or not at all, outline the mistakes and make suggestions for improvement. A reflective practitioner gives honest accounts of what really happened – *partial* truths will only lead to intervention strategies that are *partially* successful.

It is important to note that these guidelines are expressed in a generic manner, which imply that they can be used by any individual who wants to formulate an intervention strategy for their discipline.

The next chapter contains the article for the research that piloted this investigation.

CHAPTER 5: A REFLECTIVE PRACTICE APPROACH FOR SUPPORTING IT SKILLS REQUIRED BY INDUSTRY THROUGH PROJECT-BASED LEARNING



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Preamble to Article 2

The title of this article is *A Reflective Practice Approach for Supporting IT Skills Required by Industry Through Project-Based Learning*. The article was presented at the 47th Annual Conference of the Southern African Computer Lecturers' Association, hosted by the University of Cape Town (UCT), in Gordan's bay, South Africa from the 18th to 20th of June 2018. The conference paper was subject to three blind peer reviews.

The conference paper was invited for further development as a book chapter for the Springer series Communications in Computer and Information Science. Improvements were made to the paper based on reviewer feedback, and feedback received during the conference presentation. The book chapter was published online during December 2018. A refereed chapter in this Springer series is considered equal to an accredited journal publication in South Africa.

Article 2 is the first article that forms part of the empirical research that includes qualitative data analysis. A skills gap was noticed in the competencies of exit-level IT students. To address the skills gap, project-based learning was implemented as an appropriate instructional approach for IT higher education that mimics the project-based nature of the IT industry (as discussed in Chapter 1). Three IT companies were asked to provide project scopes as part of an IT capstone module. The goal of using industry project scopes was to make students aware of the type of projects they could expect when entering the workforce. As a pilot study, representatives from the three companies were asked (via written communication) for feedback regarding the typical skills IT graduates lack. The qualitative responses received were open coded to identify skills that were most relevant to IT employers. The novelty of this article lies in the identified soft skills, technical skills and recommendations for additional learning that is a *currently relevant* in the IT industry. Additionally, the article also demonstrates how project-based learning can be used to facilitate the execution of industry project briefs – towards preparing IT students for the project-based nature of the IT industry.

For this edition of the Springer book series, submission was required in LaTeX format, using BibTeX for the reference list along with their personalised MathPhySci referencing style. Author guidelines are available in Appendix E.

A Reflective Practice Approach for Supporting IT Skills Required by Industry Through Project-Based Learning

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Abstract. This paper reflects on the concerns that IT graduates lack specific skills required in industry and how project-based learning (PBL) can support these skills. An overview of the instructional design of a course module containing only IT capstone projects received from industry is provided. Feedback regarding the IT skills required of graduates are identified in a pilot study using the industry partners that provided the project scopes. The qualitative data is analysed using open coding. Through reflection on the data analysis, recommendations are made towards supporting required IT skills through PBL in a capstone module in an IT degree.

Keywords: Reflective practice · Project-based learning · IT skills
Capstone projects · Industry requirements

1 Introduction

There is an increasing concern that information technology (IT) graduates lack certain skills expected by industry when they enter the workforce. A large number of reports have appeared in the media as it is an industry issue. An article claimed that 52% of 635 employers (419 of which were specifically responsible for recruiting graduates) indicated that graduates lacked basic attributes such as communication, team work, the ability to cope under pressure and punctuality [12]. 17% of employers stated that none of the recruits were work-ready. Students have also started to notice the gap between theory and practice and are demanding an improved curriculum. In the year 2014, students from as many as 19 countries formed 41 protest groups to object the fact that the curriculum focus in a specific subject is too narrow and the examples are not based on real-world problems [8].

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The issue also exists as a gap (already often mentioned in the literature) between IT graduate skills and expectations from industry. These industry-related skills include both soft and hard skills. Soft skills refer to attributes of emotional intelligence, while hard skills refer to the technical skills required to perform specific work-related tasks. Many of these issues suggest that IT graduates need more exposure to project-based assessments, where they can take on different roles in a team environment and exercise different types of skills in the process.

Even in most companies in industry, a project-based learning environment was expected from as early as nearly two decades ago [9]. Especially in IT occupations, job-related tasks are presented in project-based form with employees assigned to specific roles. These roles can include, but are not limited to, the role of a project manager, software developer, database administrator, user-interface specialist, consultant, or administrator who documents the progress of the project. The success of IT projects are frequently measured by the manner in which project management is included, applied and improved upon [10].

Project-based learning (PBL) has also been applied to many different forms of educational instruction. The main idea is that real-world problems are used as part of a student-centered learning process. Furthermore, students take ownership of their learning process if they are intrinsically motivated, and this can be achieved by managing the scope of the project [7]. It can be suggested that a project-based learning exercise that is of personal relevance to students will encourage them to put further effort into the learning process.

At its core, PBL is a reflective practice approach to solving a project-based problem. Reflective practice (RP) is a philosophical term coined by Donald Schön and is described as the process of immediate reflection during the process of fulfilling a task, and also the reflection that takes place after the activity was completed in order to improve a future approach to similar tasks [14].

The remainder of this paper, which continuates our work of [6], is organised as follows. Section 2 provides a short literature review on key concepts of our study. Section 3 provides an overview of the instructional design of a module for IT capstone projects. Section 4 presents the data collection technique and method of data analysis. Section 5 provides recommendations for supporting IT skills required by industry through project-based learning. Conclusion and outlook to future work are given in Sect. 6.

2 Central Concepts (Related Work)

A short section on related work is presented to create a shared understanding on the concepts that inform our study.

Project-Based Learning. Project-based learning (PBL) is the process of 'learning by doing' as well as 'doing with understanding' [2]. Many descriptions of project-based learning revolve around the idea of learning by completing realistic or real-world projects. Six characteristics of PBL are discussed [7]: The first

characteristic is referred to as problem-orientated learning, where the project scope encourages the learning activity of the student. Apt project scopes motivate learning amongst students [3]. The second characteristic involves the creation of an artefact by the students. A project scope with specific instructions is provided to the students. During the creation process of the artefact, the students regularly discover gaps in their knowledge. The students then have to do research to solve the problem and take control of their learning process. This is seen as the third characteristic of project-based learning [7]. Project-based learning places the student at the heart of the learning process [5]. Contextualisation of the project where students are exposed to the implementation of the artefact is the fourth characteristic of PBL. The fifth characteristic claims that students are exposed to various types of knowledge representation with respect to resources. They need to develop skills to integrate knowledge from several forms of sources such as text, video and graphs. The last characteristic addresses the reason or motivation for learning of the students. Students are more intrinsically driven and take ownership of their learning experience with project-based learning, more so than in traditional teaching methods [7]. Projects are often the 'flagships' of a syllabus, and students should work collaboratively on real-world activities to solve problems that are important to them [4].

Reflective Practice in Project-Based Learning. Donald Schön argued that design falls within the context of intuitive, artistic processes and that it cannot be boxed within well-formed solutions [14]. Schön maintains that design practice more often deals with disordered and challenging situations. Reflective practice is the dual process of immediate reflection during the situation (reflection-in-action) and reflecting on the situation after it has been resolved in order to better handle future scenarios (reflection-on-action). A characteristic of PBL is that students have to create artefacts and that during the development process, they become aware of gaps in their knowledge [7]. Students then need to research the problem, apply possible solutions by trial and error and, through a reflective approach, find a solution. Reflective practice is an iterative sequence that usually starts with a case study where challenging concerns arise, after which a reflection on possible solutions is conceptualised, leading to a new approach towards solving the problem [11]. Furthermore, the reflective skills of a student is advanced through project-based learning [1].

In this paper, 'reflective practice' not only refers to the iterative process of learning that students go through, but also to the reflective practice approach of the academics to evaluate best practices for reinforcing IT skills through project-based learning.

3 Instructional Design of IT Capstone Projects

As part of the Information Technology degree offered at our university, where this study was conducted, one course module is presented in the last semester of the degree that consists exclusively out of projects (i.e. no tests, assignments,

nor written exams). The purpose of this module is to test the combination of knowledge of all previous modules presented at different levels in the degree. An additional outcome of this module is also to immerse students in a project-based environment that would simulate their future working-environment. This module can be seen as the capstone of the IT degree offered.

During the course of this module, students are required to complete 3 projects for marks towards access to the exam project. A fourth project is given as the exam project. As indicated through the use of PBL, students are more intrinsically motivated to take ownership of their learning experience. This idea is further encouraged by the first characteristic given by Helle et al. which indicates that the project scope heartens the participation of the student. As the goal of exit-level students is to obtain employment, it can be reassured that industry-related projects would motivate the learning experience of the student. In the academic year 2017, the four project scopes given to the students were:

Project 1—Internal project scope provided by the university's *robotics* team. The duration of the project was six weeks. Students received a weekly class on topics relating to the robotics project. Students participated in teams of four, divided into groups by the presenter. Project documentation was not expected.
Project 2—Industry project scope provided by 'Company *A*' on *cyber security*. The duration of the project was six weeks. The project was given after project *A*. A guest lecture on cyber security was presented by Company *A* at the beginning of the project. Students participated in teams of two to four students. Students divided themselves into groups. Project documentation was expected, and a detailed rubric was provided.
Project 3—Industry project scope provided by 'Company *B*' on a comprehensive multifaceted project brief relating to bookings and tracking of courier packages. The project was an individual project and was given at the beginning of the semester along with project 1. The duration of the project was 13 weeks and ran concurrently with project 1 and project 2. A guest lecture on the project facets was presented by Company *B* three weeks after the scope was released, so that students could compile a list of questions for the presenter. Students could choose between three problems, i.e., solve the problem of the driver (e.g. via mobile application), solve the problem of the scheduler (e.g. via desktop application), or solve the problem of the customer (e.g. via mobile and/or desktop application). Project documentation was expected, and a detailed rubric was provided.
Project 4—Industry project scope provided by 'Company *C*' on a comprehensive project brief relating to internal event bookings. The project was an individual project and was given after project 3 was completed. The duration of the exam project was five weeks for the 1st examination opportunity. Students who failed the 1st examination opportunity could improve their projects for the 2nd examination opportunity, providing them with an additional two weeks. Students could also elect to miss the 1st opportunity, use seven weeks for the project and present at the 2nd opportunity (with no chance of an

During scheduled class time	PROJECT 1 Team work Robotics	PROJECT 2 Team work Cyber Security	PROJECT 3 Individual work Multifaceted project	EXAM PROJECT Individual work Exam project
Week 1	Commence project 1		Commence project 3 (Company B)	
Week 4			Guest lecture: Company B	
Week 6		Guest lecture: Company A		
Week 7	Submit & Present Project	Commence project 2 (Company A)		
Week 13		Submit & Present Project		
Week 14			Submit & Present Project	Commence exam project (Company C)
Exam Opportunity 1				
Week 19				Submit & Present Project
Exam Opportunity 2				
Week 21				Submit & Present Project

Fig. 1. Schedule of our capstone projects

additional examination opportunity). No guest lecture was provided, and students were encouraged to research the topics related to the project. No project documentation was expected, and a detailed rubric was provided. The company that provided the exam scope also acted as external moderator during the exam presentations.

Figure 1 provides an overview of the schedule followed for the capstone projects. Students had a weekly three hour session during which they had access to the facilitator of the module. Students were encouraged to find the answers on their own as far as possible, but could ask for assistance from the facilitator if proof of unsuccessful research was presented. Students were not forced to attend these sessions, it merely provided a set period for access to the computer laboratories and facilitator. Students could also contact the facilitator during consultation hours or via email correspondence.

4 Industry Perspectives on Lack of Skills of IT Graduates

During unstructured interviews with the partner companies that provided the industry-related project scopes, we engaged in topics related to the perceptions of IT graduates and the expectations of industry. Issues were highlighted that were previously experienced with IT graduates when entering the workforce at Companies A, B, C. As part of our reflective practice approach, in order to improve

Table 1. Pilot study participants, with 'YoE' = Years of Experience, 'Co' = Company

P	Job title	YoE	Co	Location	Project scope
P1	Information Security Consultant (involved in graduate training)	3	*A*	Johannesburg (RSA)	Project 2: Cyber Security (Web site only)
P2	Consultant (involved in graduate training)	30+	*B*	Johannesburg (RSA)	Project 3: Multifaceted (Web site, mobile application, and/or desktop application)
P3	Systems developer (involved in graduate training)	10+	*C*	Meyerton (RSA)	Project 4: Internal event bookings application (mobile application only)

the future iterations of the capstone projects, a pilot study was conducted to identify skills that IT graduates typically lack. Any initial issues identified during this study could possibly be addressed during the 2018 round of student capstone project-based learning experiences with the aim of improving the lack in skills of IT graduates.[1]

Research Method. A pilot study was conducted using a convenience sample of three participants. These participants represented all companies that provided industry project scopes for the capstone projects of 2017. The pilot study was conducted as a first iteration, and baseline, of a reflective practice approach to identifying skills that IT graduates lack. Once initial data has been collected and analysed, a starting point for future research on the same subject can be established. Table 1 contains an overview of participant details.

Data Analysis. Participants were again contacted via email correspondence and asked to provide a written summary of typical skills they found lacking in IT graduates. The email correspondence received was considered as the data collection technique referred to as unstructured written interviews. The data was qualitative in nature. For this reason a data analysis method referred to as open coding was used to find themes in the data. Table 2 provides a summary of the findings from the data analysis.

Additionally, the participating companies also indicated *when* those skills should be addressed or obtained:

Category 1: Skills expected prior to employment (i.e., to be reinforced during undergraduate training *at university*):

Soft skills: Verbal and written communication, presentation skills, interview skills, research skills, willingness to learn.[2]

[1] For comparison see Part III: *Educational Cooperation with the ICT Industry*, pp. 146–205 of SACLA'2017 Revised Selected Papers, CCIS **730**, Springer 2017.

[2] For comparison see [13].

Table 2. Codes assigned to data analysis

Code	Example answers
Communication Skills: Verbal (2 occur.)	*"Lack of clear, concise, communication skills"* (P2). *"Graduates cannot convey their ideas in a clear and concise manner orally, and there is much use of 'uhm', 'ah', and 'like"'* (P2). *"They cannot explain anything on a board"* (P3)
Communication Skills: Written (1 occur.)	*"It is thus very important to us that graduates have the ability to write formal reports in a clear, concise and professional manner"* (P2)
Presentation Skills (2 occur.)	*"These are sometimes found to be lacking, as interns can become very nervous"* (P2). *"I see people are also afraid to write on a white board, everyone thinks presentations are only done in PowerPoint"* (P3)
Critical Thinking, Problem Solving and Attention to Detail (3 occur.)	*"I find the type of conceptual thinking ability, attention to detail and natural curiosity is more of a differentiator"* (P1). *"Graduates should also have a strong aptitude for problem solving, as the environments we work in often require that a non-standard approach be taken"* (P2). *"Most of the graduates with whom I have worked cannot do planning before coding"* (P3)
Professionality, Work Ethics (1 occur.)	*"This point is a non-negotiable one for us. Professionalism and awareness of the environment which you're in is critical in not exposing any information pertaining to our clients"* (P2)[a]
Time Management (2 occur.)	*"One of the big mind shift changes for new members is the reality of challenging deadlines"* (P1). *"It is often required that we familiarise ourselves with various technologies, which we may have not encountered before, in a short space of time"* (P2)
Willingness to Learn (3 occur.)	*"I find the type of conceptual thinking ability, attention to detail and natural curiosity is more of a differentiator"* (P1). *"A graduate's ability to think on their feet and approach problems with an enquiring mindset, where the answer to the problem is not necessarily well-defined, is something which is important to us"* (P2). *"I think one gets too comfortable with only one or two languages; they must see that the same thing can be done with any language"* (P3)
Interview Skills (2 occur.)	*"We often receive CVs and internship applications which appear as if minimal effort has been made to make the application and CV look professional and presentable. Further to this, sending an email with only attachments and no message body can be seen as unprofessional"* (P2). *"They do not have proper interview skills"* (P3)
Research Skills (2 occur.)	*"When one knows one is destined to be a rock'n'roll star, you tend to know your rock n roll heroes really well; I find many developers do not know their industry heroes. One of the core books I recommend every developer owns is* Code Complete, *which has an in depth discussion of the core practices of professional coding"* (P1). *"It is easy to differentiate a candidate who has a strong interest in information security from someone who has recently been intrigued by something in the news"* (P2)
Programming Languages (1 occur.)	*"Python: for applications that may run on Linux; C#: back-end apps.; HTML, Javascript"* (P3)
GUI Design (1 occur.)	*"C#: front-end apps.; CSS"* (P3)
Data Bases (1 occur.)	*"Entity framework—integration with other databases"* (P3)

(*continued*)

Table 2. (*continued*)

Code	Example answers
Reusable Code (1 occur.)	*"The difference between functional code and production quality code: I have seen project code that works functionally but would not survive any kind of negative or destruct testing. I want people to have a basic grasp of design patterns"* (P1)
Architectural Patterns (1 occur.)	*"Increasingly people are using MVVM to display tier stuff"* (P1)
Code Refactoring (1 occur.)	*"I want people to know how and what to refactor"* (P1)
Advanced Design Principles (1 occur.)	*"I want people to understand SOLID"* (P1)
Unit Testing (1 occur.)	*"All of the teams I work with use automated unit testing extensively"* (P1)
Source Control (1 occur.)	*"One of the hardest things for new members to grasp is source control, which becomes much harder to manage in a larger team with shared ownership of code. Merging conflicting code using a merging tool is an essential skill that is expensive to learn while fighting deadlines"* (P1)
Internships (1 occur.)	*"It is important to do as many internships as possible for a number of reasons. Firstly, it helps to determine the kind of field that you will enjoy working in most. Secondly, it allows you to pick up many of the aforementioned skills with relative ease"* (P2)
Certification (1 occur.)	*"I want people to know Scrum. The process is not hard to understand, and a formal training course is normally only a day or two, with a certification. I believe a scrum certification can be a career accelerator"* (P1)

[a]For comparison see the *Code of Conduct of the ICT Professional* at www.iitpsa.org.za.

Expected technical skills: Understanding of programming languages, understanding of GUI design, understanding of databases.

Category 2: Skills expected prior to (but specifically reinforced during) *internships*, graduate programmes, *employment*:

Soft skills: Critical thinking, problem solving, attention to detail, professionalism, work ethic, time management.

Advanced technical skills: Knowledge of reusable code, source control.

Category 3: Skills that would be beneficial prior to (but can be trained during) internships, graduate programmes, employment:

Advanced technical skills: Knowledge of architectural patterns, knowledge of code refactoring, knowledge of advanced design principles, knowledge of unit testing.

The skills of these categories are further discussed below.

5 Findings and Recommendations

Table 3 provides a summary of the IT skills required by industry and at which point in a student's career these issues should be exercised. Short code keys provided in the table are: 'S' for soft skills, 'T' for technical skills, and 'R' for

Table 3. Reflection on ways to reinforce skills through PBL

Category 1	Reinforcement method	Reflection on inclusion of recommendations in the IT capstone projects at our university
S1: Communication Skills: Verbal	Prompt students to explain their initial project ideas to smaller audiences via a traditional method (e.g. whiteboard)	For all projects, students should explain the initial manner in which they will solve the problem. This will be addressed in a one-on-one setting between facilitator and team. Feedback towards improving verbal communication will be provided
S2: Communication Skills: Written	Prompt students to compile technical project documentation	For each project, students will compile a technical report on the system analysis. Students will be evaluated on relevance of content as well as academic writing standards. Feedback on improving written communication skills will be provided
S3: Presentation Skills	Prompt students to explain their final project to larger audiences via technology-centered methods (e.g. PowerPoint)	Teams or individuals should present their final project outcomes via professional presentation to a panel. The panel could consist of other academics, members from industry and peers. Feedback on presentation skills should be provided
S4: Willingness to Learn	Manage the scope of the project as in [7]. Undergraduate students in their final year will be intrinsically motivated to complete projects that are received from industry (as a reference to what is expected from employment)	Project scopes should not be fictional, but should rather be received from industry. The project scopes should reflect the types of projects companies work on currently. In this manner, students are motivated to learn, as they are exposed to similar projects they will come across during employment
S5: Interview Skills	Additional training in the form of workshops: These can be short presentations offered during class time	A short workshop on interview skills will be presented. A good starting point for structuring the workshop will be to research the STAR method.[a] Furthermore, an informal roleplay activity in which peers evaluate each others' responses to interview questions could pinpoint additional problems that need to be addressed
S6: Research Skills	Technical project documentation: restricting content to recent references on IT (and using the appropriate referencing methods)	In all projects a certain level of research is expected as students need to find methods of addressing the project scopes. A formal research project can also help to train this skill: see T6–T9 below. Students should receive guidance on the structure of a research project in the form of a short workshop

(*continued*)

Table 3. (*continued*)

T1: Programming Languages	Prompt students to complete different projects in different programming languages	Students have completed modules pertaining to different programming languages prior to the capstone projects. To further train different language programming skills, each capstone project will have instructions for a different language the problem needs to be solved in
T2: GUI Design	Provide clear expectations of user interfaces for projects; prompt students to refer to design principles followed in the technical documentation	Students will be made aware of literature on different design principles and prompted to discuss how they implemented these principles in their projects, via the technical report
T3: Data Bases	Prompt students to use a suitable database for each project	Students are required to integrate a database in all capstone projects. Students also receive instruction on database design in additional modules. To further reinforce the skill, a short workshop on database integration and SQL statements will be presented
Category 2	Reinforcement method	Reflection on inclusion of recommendations in the IT capstone projects at our university
S7: Critical thinking, problem solving, attention to detail	Reinforce skills through the planning stages of project development. Students should provide weekly updates on progress and recommendations on how they will address problems. Additionally make students aware of iterative frameworks used for project creation, and prompt them to explain their projects according to the phases of a specific framework (i.e. design science research)	Students will be required to present their capstone projects according to an iterative development framework such as design science research. Students will then be obligated to structure their thought processes in a logical but critical manner, which in turn will train their skills towards reflective practice
S8: Professionalism and work ethic	Additional training in the form of workshops	A short workshop on work ethics and professional conduct will be presented
S9: Time management	Deadline-driven project time-lines: should be feasible, but not overestimated. Create the need for students to work at an acceptable pace at all times	Specific deadlines will be given for each project. These deadlines will be carefully evaluated according to the scope and outcomes of the project. The deadlines will be feasible, but will require students to work continuously
T4: Reusable Code	Additional training in the form of workshops. Guest lectures from industry might be useful	Invite guest speakers

(*continued*)

Table 3. (*continued*)

T5: Source Control	Prompt students to use a version of source control for each project	Source control shall be mandatory for all capstone projects. Students will be asked to use Git for version control[b]
Category 3	Possible recommendations for supporting skill through PBL	Reflection on inclusion of recommendations in the IT capstone projects at our university
T6–T9: Architectural patterns, code refactoring, advanced design principles, unit testing	Difficult to reinforce advanced concepts during a single semester module. Possibly provide a research project to familiarise students with concepts	Students will be required to compile a professional research document with suitable examples on the topics of architectural patterns, code refactoring, advanced design principles and unit testing. In this manner students will become aware of advanced concepts prior to interviews, and reinforce their research skills (S6). This approach will need to be evaluated for effectiveness for future use
Additional learning	Possible recommendations for supporting skill through PBL	Reflection on inclusion of recommendations in the IT capstone projects at our university
R1: Internships	Replace one project with an expected internship at a local company	Facilitator needs to determine whether it will be viable to replace a project with a mandatory internship as part of future employment training. If not, students should be encouraged to attend internships for work exposure and experience. Additionally, students will be motivated to attend 'Hackathons' (short sprints of programming events usually hosted by companies to identify talented individuals). Not only is this a method of exposure for possible employment, but also allows the student to learn about technologies, deadlines and work environments expected in industry
R2: Certification	Suggest additional certifications as part of the B.Sc. degree as a whole	Certifications call for additional funding which does not form part of tuition fees: this will be a problematic issue to implement. In 2018, additional certifications at the students' expense will be suggested. The suggestion will also be discussed with management for including additional IT certifications in the degree as part of tuition fees

[a] https://www.vawizard.org/wiz-pdf/STAR_Method_Interviews.pdf.
[b] https://git-scm.com/.

Table 4. Overview of planned activities

Week	Activity	IT skill addressed via PBL
1	Introduction to module outcomes	Explanation of IT skills required for industry and how these will be addressed during the course of the module
	Workshop on interview skills	S5
	Replace Project 1 with internship at a local company (if feasible)	R1, S8
2	Workshop on professional conduct and work ethics	S8
3	Workshop on research processes	S6
	Commence research project pertaining to architectural patterns, code refactoring, advanced design principles, and unit testing	S2, S4, S6–S9, T6–T9
4	Workshop on reusable code and source control	T4–T5
5	Workshop on database integration and SQL statements	T3
	Students submit research project	S2, S4, S6–S9, T6–T9
	Commence Project 2 (industry scope)	S1–S4, S6–S9, T1–T5
11	Submit and present Project 2; Commence Project 3 (industry scope)	S1–S4, S6–S9, T1–T5
17	Submit and present Project 3; Commence Project 4 (industry scope)	S1–S4, S6–S9, T1–T5
21–22	Submit and present Project 4	S1–S4, S6–S9, T1–T5

recommendations. Furthermore the table provides a reflection on methods of reinforcing the required IT skills through project-based learning in the capstone projects of an IT degree. The last column in the table is a self-reflection on how these recommendation can be addressed in the capstone projects at our university.

6 Conclusion and Future Work

From Table 3 we can now, through reflective practice, suggest a *time line with activities* for supporting IT skills identified in this paper on project-based learning in the IT capstone projects of an IT degree. Table 4 provides a summary

towards this initiative. As seen in the table, a clear process for addressing required IT skills is presented through the use of PBL in a capstone module.

Other skills not addressed in Table 4, but that should form part of continuous learning during the course of the semester, are:

1. Project 1 should be a mandatory internship of at least one week that can be completed at any stage during the course of the semester, but needs to be finished before examination as part of the participation mark (R1: S8–S9).
2. Students should be recommended to complete additional internships in their own time to increase learning opportunities (R1).
3. Opportunities should be made available for attending 'Hackathons' hosted by industry (R1).
4. Students should be referred to additional certifications for career acceleration at own cost (R2).

This paper serves as a baseline to an iterative pilot study to determine the effectiveness of the recommendations made, if implemented in the IT capstone projects. On completion of the course module we will reflect on the effects of the changes made to the presentation of the module and suggest improvements. This process shall become a continuous reflective practice exercise, ensuring that best practice is always maintained when facilitating learning through PBL in IT capstone projects.

Many of these IT skills are expected from graduates when entering the workforce. Addressing the support of these IT skills required from industry in the IT capstone projects is a step in the right direction, but may also be too late to viably train the skills before employment. It can be suggested that these skills should be reinforced earlier in an IT degree.

As part of the iterative nature of this study, we will also attempt in future research to improve modules offered in the 'Extended IT Degree'[3] to include skills training through smaller activities of PBL. In this manner the long-term effects of reinforcing required IT skills earlier in an undergraduate degree can be assessed when these students reach their final study-year.

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[3] Explanation for readers from outside South Africa: in South Africa the 'extended' degree 'stretches' the contents of the regular curriculum into a longer study-duration, for the benefits of weak students who (for various reasons) enter into university rather under-prepared.

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Article 2: Guideline development

Through the iterative nature of the design science research approach followed in this study, this article adds explicit guidelines towards bridging the gap between IT theory and IT practice.

Article 2 is a pilot study that includes members from the IT industry as participants. Feedback regarding which skills an IT graduate typically lacks was requested from the participants. During the process of identifying the required soft skills, technical skills, and recommendations for additional learning, the researcher implicitly became aware of a process that was followed to identify crucial IT skills. This process is provided as guidelines for identifying crucial IT skills in Figure 5.1.

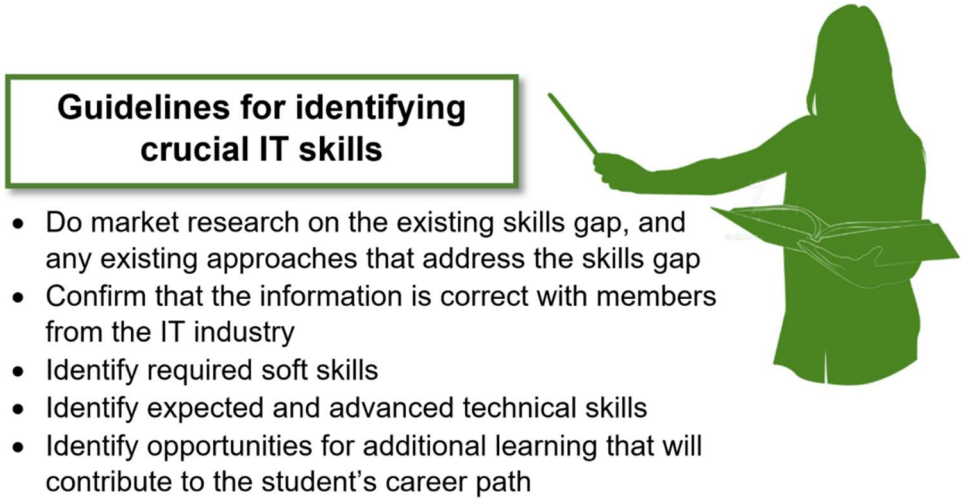


Figure 5.1: Guidelines for identifying crucial IT skills

Table 5.1 provides a discussion and context on each guideline that forms part of identifying crucial IT skills.

Table 5.1: Description of guidelines for identifying crucial IT skills

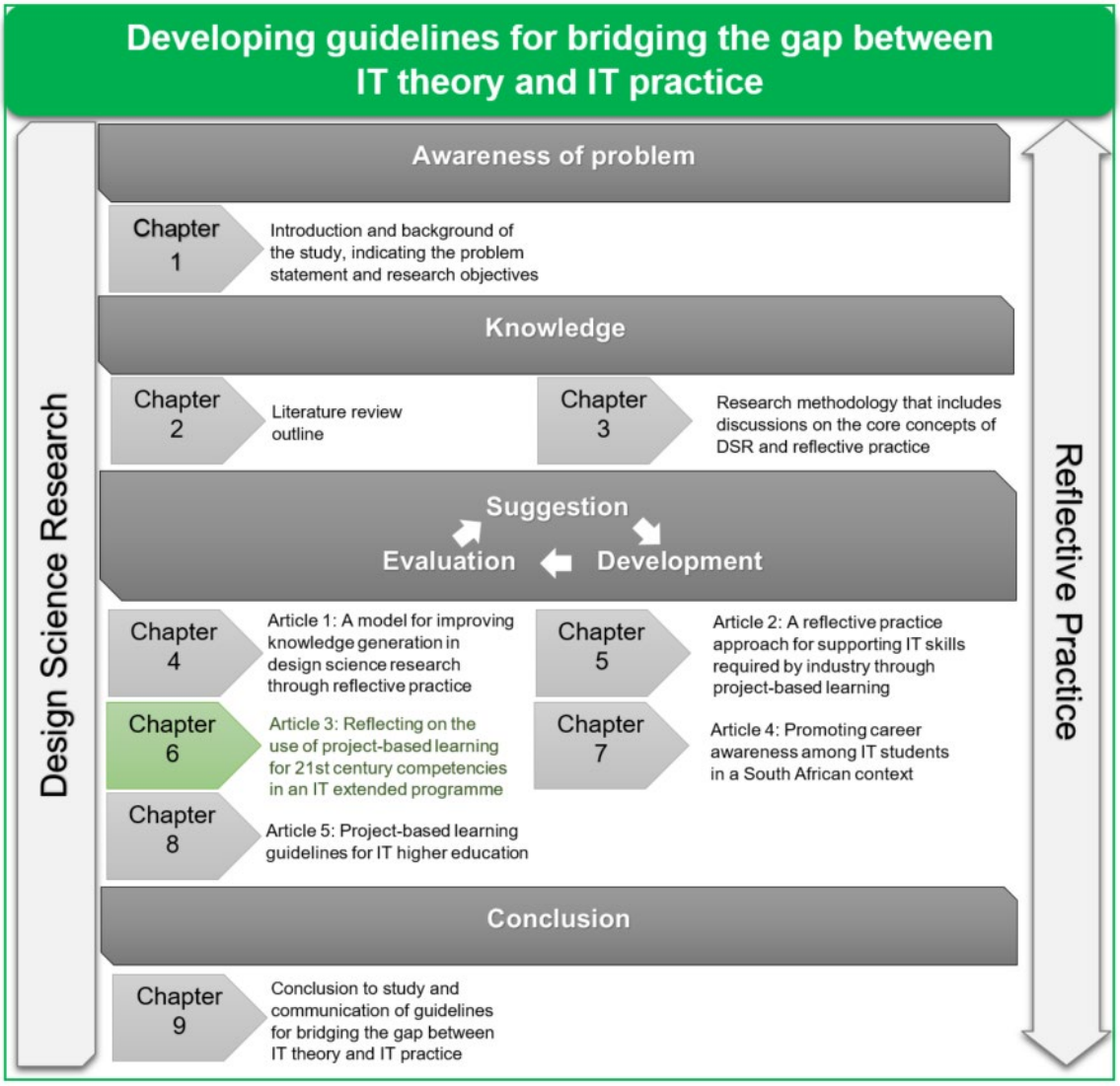
Guideline	Description
Do market research on the existing skills gap, and any existing approaches that address the skills gap	Research *current* information that is available on the skills gap online. This can be in the form of news articles or surveys conducted by professional bodies in your discipline that highlight the current skills gap, current and future trends, preferred organisational methodologies, and suggested approaches for advancing knowledge/ learning.
Confirm that the information is correct with members from the IT industry	Once you've done the market research, use the information to guide a conversation with members from the IT industry – and to determine whether the information is accurate according to practice. Ask industry members, "which technology stacks do you use most often?", "which types of projects do you work on?", "what is the current skills need in this sector?", and "what are the skills that IT graduates typically lack?"
Identify required soft skills	From the research and feedback obtained, identify which soft skills the IT industry values most. These will be the soft skills that are repeated by most of the people you have spoken to. Find creative ways to address the soft skills in your intervention strategy. For example, presentations and demonstrations of projects to exercise verbal communication, research reports to improve professional writing, research, written communication skills, team projects to strengthen teamwork, time management, and professionalism.

Identify expected and advanced technical skills	From the research and feedback obtained, identify the technical skills that are currently relevant, and that may/will be relevant in future. Especially in the IT industry where technology changes at a fast pace, it is necessary to understand where the skills gap is heading in order to train the most beneficial skills. For example, instruct students to develop a project in a specific technology stack, use agile methodologies to manage projects and teams, include specific design patterns in the development, and use projects that require both relational and non-relational databases.
Identify opportunities for additional learning that will contribute to the student's career path	Vacation work, internships, and certifications are extremely beneficial to have on a curriculum vitae (CV). Encourage students to start applying for vacation work or internships in the relevant discipline as soon as possible. Industry exposure in any form is beneficial for the student because it will allow the student to determine whether s/he is interested in the specific career path; the student will pick up on the required soft and technical skills with relative ease, and it provides a record of work experience. Additional learning (apart from a degree) is also advantageous to have on a CV, and sometimes even expected. Market research should be done on which certifications are currently relevant. Paid-for certifications such as the courses offered by Microsoft are a good place to start. Free courses on sites such as Udemy or Cybrary also provide certificates of completion that can be added to a CV.

It is important to note that these guidelines are expressed in a generic manner, which imply that they can be used by any individual who wants to identify the crucial skills required for their discipline. The second guideline which refers to 'the IT industry' can be substituted by any other discipline to generalise the guidelines within its context.

The next chapter contains an article where skills development for entry-level students take place through a project-based learning strategy.

CHAPTER 6: REFLECTING ON THE USE OF PROJECT-BASED LEARNING FOR 21ST CENTURY COMPETENCIES IN AN IT EXTENDED PROGRAMME



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Preamble to Article 3

REFLECTING ON THE USE OF PROJECT-BASED LEARNING FOR 21ST CENTURY COMPETENCIES IN AN IT EXTENDED PROGRAMME is a conference paper that was presented at the 10th Annual Conference on Mathematics, Science and Technology Education. The conference was hosted by the Institute for Science and Technology Education (ISTE), a department of the University of South Africa (UNISA). The conference was held in the Kruger National Park, South Africa, from the 20th to 24th of October 2019.

This paper was written in response to Article 2, in which it was highlighted that exit-level in an IT degree may be too late to address IT skills development for industry-readiness. In the conclusion section of Article 2 it is suggested that PBL should be implemented in an IT extended degree to reinforce the required IT skills earlier in the degree.

In this paper, a project-based learning strategy is presented as the instructional design of an IT extended module. PBL is implemented in context of the capabilities of IT extended students with the aim of improving their 21st century competencies. An outline is provided on how each competency is addressed in the PBL strategy. As part of the evaluation of the effectiveness of the PBL strategy, the IT extended students were asked to complete reflective sheets to capture their experiences and perspectives of the PBL activities. The qualitative data received was analysed using open coding, and provided themes relating to the benefits of the PBL strategy and suggested improvements for future iterations. The novelty of the paper lies in the resulting guidelines presented in the conclusion section of the paper, towards bridging the IT theory-practice gap. Additionally, the paper demonstrates that project-based learning can also be implemented in an IT extended degree towards skills development. Students accepted into an IT extended degree do not meet the minimum requirements of a three year undergraduate degree. These students need additional support and are subject to an additional year of

training. The paper demonstrates that project-based learning is also a suitable instructional method at entry-level of IT higher education, permitted that the scope of the project is drafted in context of the level of the student.

An American Psychological Association (APA) referencing style was required for this paper. Author guidelines can be found in Appendix F. An example of the reflective sheet can be found in Appendix G.

REFLECTING ON THE USE OF PROJECT-BASED LEARNING FOR 21ST CENTURY COMPETENCIES IN AN IT EXTENDED PROGRAMME

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ABSTRACT – Employment in the information technology (IT) industry will most often result in project-based environments or project-based objectives. Preparing IT students for this industry is recommended through project-based learning (PBL). PBL has become increasingly popular over the past two decades for skills development in IT-related curriculum. The use of traditional pedagogies should be critically reviewed due to the noticeable skills gap in IT graduates' lack of 21st century competencies. This suggests that PBL should be implemented earlier in an IT degree. Literature reviews are offered on PBL and promoting reflective practice in PBL. A PBL strategy followed in an IT extended programme is presented. 30 student participants completed a reflective sheet towards the end of a module to provide insights on their 21st century competencies developed via PBL instruction. An interpretive approach is taken towards data analysis with the aim of understanding their experiences.

Keywords: Project-based learning, reflective practice, 21st century competencies, IT students, extended programme

INTRODUCTION

The goal of this paper is to highlight the value of implementing project-based learning (PBL) earlier in an information technology (IT) degree. PBL is a teaching and learning strategy where learners are exposed to real-world challenges, gaining a deeper understanding of the specific problem domain. The research questions for this study are *'how do we understand the value of a PBL strategy taken in an IT extended degree?'* and *'how do we improve the value of a PBL strategy in an IT extended degree?.'* It is important to note that *value* is used as a qualitative expression of suitability or appropriateness in this paper, and not as a value to be measured.

The central objective of implementing a PBL strategy for IT extended students is to improve their 21st century competencies. It is suggested that increased learning takes place for the student, as well as the facilitator, through methods of reflection.

The paper provides literature reviews on PBL, and reflective practice in context of PBL. The PBL strategy followed in an IT extended degree module is presented. An overview of the research methodology, data collection and analysis is provided. A discussion relating to the benefits of, and suggestions for, a PBL strategy for IT extended students leads into the conclusion and overview of future research.

THEORETICAL BACKGROUND

PROJECT-BASED LEARNING

Project-based learning and other pedagogical strategies that accentuate the development of skills needed at university and when entering the work-force are becoming increasingly popular (Huberman et al., 2014; Scardamalia, 2012). The theoretical groundwork for project-based learning was introduced by Dewey's philosophy on experiential learning and the 'project method' by Kilpatrick (Ravitch, 2000). The value of a PBL strategy lies in student-directed inquiry, with the aim of promoting deeper learning and supporting 21st century competencies. An overview of 21st century competencies are provided in Table 1 (Partnership for 21st Century Skills, 2019). The competencies are numbered for further use in the paper.

Table 1: Overview of 21st century competencies.

A: Learning and innovation skills		B: Information, media and technology skills		C: Life and career skills	
A1	Creativity and innovation	B1	Information literacy	C1	Flexibility and adaptability
A2	Critical thinking and problem solving	B2	Media literacy	C2	Initiative and self-direction
A3	Communication	B3	ICT literacy	C3	Social and cross-cultural skills
A4	Collaboration			C4	Productivity and accountability
				C5	Leadership and responsibility

With a PBL strategy, 21st century competencies are developed via student-directed inquiry instead of traditional teacher-directed approaches. Another reason PBL has been widely adopted at university level is due to poor perceived outcomes from secondary education (Duncan & Murnane, 2011). Project-based learning is seen as a strategy that can bridge these gaps by enhancing student motivation, and improving their theoretical and practical knowledge (Darling-Hammond et al., 2008; Thomas, 2000; Blumenfeld et al., 1991). Even though PBL is focused on student-centered learning, it can also be supported by facilitator-centered approaches such as lectures and demonstrations (Veletsianos et al., 2016).

Artefact development is often cited as a suitable assessment for a PBL activity (Krajcik & Shin, 2014; Grant & Branch, 2005). These artefacts are typically performance-based assessments and can be used to measure difficult criteria such as 21st century competencies (Pellegrino & Hilton, 2012). A concern experienced with using PBL activities, however, is that facilitators do not have the capacity or time to provide constructive feedback, or to assist students with engaging in self-reflection (Krajcik & Shin, 2014; Grant & Branch, 2005).

PROMOTING REFLECTIVE PRACTICE IN PBL

Cohen et al. (2013) emphasise the importance of embedding reflection to improve the long-term impact of strategies taken. They indicate that students should have an opportunity to think deeply about what they have learned, and that activities that promote reflection include journaling, class discussions and responding to structured questions. Nikolou-Walker and Garnett (2004) made use of reflective journaling where students continuously answered the question ‘what did I learn?’ throughout the course of an academic year. They also incorporated structured sections to encourage reflective and learning practice. Dunlap (2006) similarly suggests providing computer science students with prompts and structured questions to assist with focusing their responses in reflective journals. Even though reflective journaling has a long history as a learning strategy in the humanities, it has only been documented over the past two decades in computer-related fields (George, 2001). Supporting PBL with reflective practice approaches can address the concern experienced where facilitators feel that they do not have the capacity to engage students in self-reflection. Even though reviewing student reflections can be labour intensive, recent efforts have been made with automated detection of reflection for analysing reflective texts (Ullmann, 2017).

When reviewing and improving curriculum content and its successfully reached outcomes, student reflection is not the only perspective to take into consideration. It is crucial that facilitators engage in reflective practice when evaluating learning approaches that were effective and ineffective. Using a PBL approach requires critical reflection to ensure that a coherent strategy is implemented, and reflected on upon completion to improve future iterations of the module.

METHODOLOGY

BACKGROUND OF INSTRUCTIONAL DESIGN

A practical module is presented in the second year of a four year IT extended degree. The content of the module centers around design processes for IT artefact creation. The theoretical component includes topics of human-computer interaction (HCI), while the practical component allows for animated artefact creation in Scratch. The curriculum development plan is built on traditional assessment methods in the form of assignments and tests, and a written examination for summative assessment. This style of teaching and learning may be considered as outdated, based on the increasing concern that South African graduates struggle to find employment. Projects are central to the IT workplace, and training future graduates in a project environment is recommended. Project-based instruction is more established in exit-level modules but adopting project-based learning earlier in a degree should be considered.

The project-based learning strategy implemented during the course of this module is presented in the next section. Factors not changed for the module include the number of study hours allocated, the assigned contact sessions during the semester and the position of the module in the degree.

PROJECT-BASED LEARNING STRATEGY

In an attempt to align module outcomes with industry expectations a decision was made to replace the written theoretical examination (summative assessment) with a project-based examination. This approach is overlooked in entry-level modules due to the manner in which Bloom's Taxonomy is integrated at each level in the university. Creation only takes place in the highest level of Bloom's Taxonomy, and is typically expected of exit-level students, but in an IT degree the creation of artefacts is already expected of first year students. Exposing an IT student to development and creation for the first time in his final year of study puts him at a disadvantage when entering the rapidly changing IT workforce.

For the summative assessment (examination *project*) of this module, students were required to create a serious game on a specific topic, along with supporting project documentation. In order for this approach to be successful, a number of supporting formative assessments needed to be implemented. Table 2 provides a summary of all the activities that supported the project-based learning strategy, their context to the summative assessment and how they contribute towards 21st century competencies. The project is detailed in the next section.

Table 2: Overview of supporting activities in the PBL strategy.

Activities supporting the PBL strategy	Context of activity	21st century competency addressed by activity
Theory and practical lectures with related class exercises	Theory lectures pertaining to the components of HCI, interaction basics and design rules in preparation of elements to be considered in the project. Practical lectures pertaining to available gaming features in Scratch for possible inclusion in the projects.	A1, A2, B1, B2, B3, C1, C2, C4
Marshmallow Challenge (Wujec, 2010)	A Design Thinking (Brown, 2008:3) activity in preparation of Assignment 1. The aim of the activity is to encourage teams (4 members) to collaborate, think about design rules they have come across in the module, and to understand time constraints that are associated with development in the real world.	A1, A2, A3, A4, B1, C1, C2, C3, C4, C5
Assignment 1: Conceptual game design activity	A paper-based, group (4 members), class activity where teams draw a random movie theme from a hat. They need to complete a game design worksheet and indicate elements of a conceptual game based on the theme, such as the appearance of the avatar, game-play mode, the storyline, how resources are collected and used during the	A1, A2, A3, A4, B1, C1, C2, C3, C4, C5

	game, and which design rules should be considered. This assessment supports the examination project in that it encourages the students to reflect on the game components they should consider in the design of their artefact.	
Short workshop on professional writing and research skills	From previous research conducted, it was explained to the students that industry members feel that students struggle with professional writing and research skills, and that Assignment 2 would contribute towards improving these skills. A short workshop was presented to demonstrate features in Microsoft Word that they may not be familiar with e.g. using Styles, proper alignment and academic language. Additionally, a demonstration of research approaches on Google Scholar, and where to find the university's local repository was provided. Referencing was also reviewed.	B1, B2, B3
Assignment 2: Research project on HCI design principles	An individual digital research report to evaluate any existing website according to design principles from theory. This assessment supports the documentation component of the exam project in that students need to write professional project documentation in which they need to indicate HCI design principles used in their exam projects.	A1, A2, A3, B1, B2, B3, C1, C2, C4, C5

THE PROJECT

One of the characteristics of PBL is that the scope of the project influences the motivation to complete the project (Helle et al., 2006). At entry-level, students cannot yet complete industry scope projects because they have not necessarily mastered the essential skills. In order to encourage the motivation of students to complete the project, they were asked to provide their preferred topics live in class using a Google Doc displayed through the projector. The ideas were narrowed down to 7 themes. Students could vote via poll for the theme they preferred to have as scope for their exam project. The student-proposed-and-chosen theme for the 2018 exam was '*what happens after graduation*'.

The traditional written examination was replaced with a practical project. Students had to create a serious game on the topic 'what happens after graduation'. Students completed the project in teams of two members. Game requirements included a start-up screen with relevant options, 3 levels of increasingly difficult game play, and a credit scene. Rubric criteria additionally focused on the level of coding difficulty and structure, HCI principles applied in the design, suitability of sprites and backgrounds to the theme, error handling, and presentation skills.

Project documentation included a general explanation of their game idea, the logical game play, and scoring system. Students had to report on the design process followed for their game by using the Design Thinking process model. Rubric criteria also included evaluation on formatting, referencing and professional writing.

All 21st century competencies as mentioned in Table 1 were addressed through this method of project-based learning.

The following sections focus on the research approach taken by reflecting on the methodology and data analysis that informs the results of the study.

RESEARCH APPROACH

An interpretive approach towards understanding the experiences and perceptions of IT extended students in context of the PBL strategy is taken. Orlikowski and Baroudi (1991) indicate that interpretive studies are preferred when a deeper understanding of data is required. Qualitative data gathering and analysis methods are used in context of interpretive research for increased understanding (Oates, 2006). Interpretive content analysis is used to prepare and process qualitative data for traceability (Zhang & Wildemuth, 2009). It is important to note that when using interpretive methods that the analysed data is not weighted. The

purpose of interpretive data analysis is to ensure that all voices are heard through identified themes in the data.

RESULTS

DATA COLLECTION

The research was conducted at a university in central South Africa as part of an entry-level module in an IT extended degree. The researcher only became aware of reflective journaling towards the conclusion of the module. The approach could not realistically be applied at this point as it would lack the reflective nature that is central to the process. As a pilot study to determine if value can be derived from this approach for future iterations, students were asked to complete a structured, reflective set of questions on an A4 page after the completion of the module. The instructions comprised of taking a moment to reflect on the activities that had formed part of the module, structured questions to indicate preferred teaching- and learning methods, and self-reflections on the skills they thought they had improved on. The reflective sheets were readily available during the first examination opportunity for the module, and students were asked to provide their reflections voluntarily and anonymously. Out of 49 students that were enrolled for the module, 34 students returned their filled-in copies. After reviewing the feedback rate, 4 copies were removed as they stopped providing reflections after the second question/ lost interest in completing the sheet. The reflections provided on these 4 sheets were reviewed for value, and the decision to discard these responses were based on the fundamental principle of the hermeneutic circle (Klein & Myers, 1999). Quantitative and qualitative data were received due to the reflective nature of writing about personal experiences. A final set of 30 completed reflective writings were included for analysis.

DATA ANALYSIS

Basic descriptive statistics were used to analyse quantitative data in the form of gender information, preferences between specific methods, and improvements in skill levels. Atlas.ti 8.4 was utilised as a scientific software tool for analysing qualitative data by identifying codes and groups. A directed approach to open coding was used to perform content analysis on the qualitative data that related to their personal experiences in context of 21st century competencies. The qualitative data analysis process followed in this paper to ensure traceability and rigour, with the aim of satisfying the fundamental principle of the hermeneutic circle, comprised of:

- A directed approach to coding focusing specifically on questions and answers that were related to 21st century competencies.
- Each individual question was coded based on the identified codes from the previous question. Each question made use of existing codes and produced additional codes.
- When the final question was coded, the process was restarted at the first question to check whether codes that had been produced in subsequent questions were not overlooked when the process was started.
- The codes for all questions were re-evaluated for coding consistency. Similar codes were merged, renamed, or deleted if redundant, which resulted in a final set of 26 unique code names across the qualitative data.

DATA REPRESENTATION

The participant gender information indicated that 63.3% female students and 36.7% male students completed the reflective sheets. Racial information was not collected.

96.7% of students indicated that they enjoyed programming in Scratch for this module. In context of the PBL strategy taken, 63.3% indicated that the marshmallow challenge was valuable, 80% benefitted from the game concept creation assignment, and 83.3% found the workshop on professional writing useful.

Qualitative findings related to the theme of 21st century competencies were included for the purpose of this paper. Structured questions (4) relating to their experiences of the formative assessments, and suggestions for improvement were analysed. Figure 1 (depicted in the next section) provides a summary of codes identified, as well as the number of times they occurred. It is important to note that the code was counted for every occurrence across all included questions. Some answers provided such as 'yes' or 'no' did not provide value to the qualitative analysis and was coded separately under a unique code *quantitative answer provides no insight (yes/no/etc.)*.

DISCUSSION OF RESULTS

As the reflective exercise produced largely qualitative data, the discussion on results is focused on the reflections, experiences and suggestions made by the student participants. Figure 1 also depicts the codes grouped according to 5 identified themes, namely 1.) 21st century competency/ skill needs further development (4 codes), 2.) Improved a 21st century competency/ skill (6 codes), 3.) Benefits of following a PBL strategy (5 codes), 4.) Suggestions for improving the PBL strategy (6 codes), and 5.) Not related to outcomes of PBL strategy (4 codes). 21st century competencies improved on during the PBL strategy included time management, team work, critical thinking, attention to detail, problem-solving, and professional writing. The two important themes to focus on in context of this paper are the benefits and suggestions in context of using a PBL strategy.

Name	Grounded	Groups
PBL strategy is challenging (negative view)~	2	
Problem-solving skill needs further development	3	[21st century competency/ skill needs further development]
Professional writing skill needs further development	1	[21st century competency/ skill needs further development]
Time management skills need further development	3	[21st century competency/ skill needs further development]
Resource management skills need further development	2	[21st century competency/ skill needs further development]
PBL strategy was enjoyed	18	[Benefits of following a PBL strategy]
PBL strategy informs future perspective of IT career	7	[Benefits of following a PBL strategy]
PBL strategy promotes a learning environment	5	[Benefits of following a PBL strategy]
PBL strategy is challeging (positive view)~	5	[Benefits of following a PBL strategy]
PBL strategy promotes self-awareness of skill levels	2	[Benefits of following a PBL strategy]
Improved time management skill	2	[Improved a 21st century competency/ skill]
Improved working in a team skill	3	[Improved a 21st century competency/ skill]
Improved problem-solving skill	7	[Improved a 21st century competency/ skill]
Improved critical thinking skill	4	[Improved a 21st century competency/ skill]
Improved attention to detail skill	2	[Improved a 21st century competency/ skill]
Improved professional writing skill	14	[Improved a 21st century competency/ skill]
Content with PBL strategy implemented	1	[Not related to outcomes of PBL strategy]
Absent for PBL activity	3	[Not related to outcomes of PBL strategy]
Lecturer: Personal praise	3	[Not related to outcomes of PBL strategy]
Quantitave answer provides no insight (yes/no/etc.)	10	[Not related to outcomes of PBL strategy]
Extended training on difficult concepts	1	[Suggestions for improving the PBL strategy]
Provide more homework and exercises	7	[Suggestions for improving the PBL strategy]
Provide more context-related examples	2	[Suggestions for improving the PBL strategy]
Add additional programming platforms for development	1	[Suggestions for improving the PBL strategy]
Provide additional training outside of class (student ass...	1	[Suggestions for improving the PBL strategy]
Keep PBL strategy up to date with current trends	2	[Suggestions for improving the PBL strategy]

Figure 1: Atlas.ti extract of all identified groups, codes and number of occurrences.

Benefits of following a PBL strategy in an IT extended programme can be summarised as:

- IT students generally enjoy the project-centered nature of a PBL approach. *"It was fun." (participant 3)*
- IT students feel that the activities that form part of a PBL strategy promotes an environment for learning. *"I learned to create ideas through animation or portray my idea." (participant 28)*

- IT students feel that a PBL strategy challenges them in a positive way. *"It is because programming in Scratch is interesting, challenging, and mind opening" (participant 18)*
- IT students become aware of their own skill levels through a PBL approach. *"It shows my way of thinking and how it can be improved." (participant 26)*
- IT students focus on their future IT careers when subjected to a PBL strategy. *"This will help me in the future." (participant 4)*

Student-suggested improvements for the implemented PBL strategy are summarised as:

- IT students want additional training on difficult concepts. *"Perhaps give the theory part a little bit more time and lecturing I found it hard to study because some topics were new." (participant 4)*
- IT students want more homework and exercises to better prepare them. *"Make the students do more assignments and challenge them more." (participant 21)*
- IT students want more context-related examples. *"More examples of different coding and methods." (participant 8)*
- IT students want to be trained in as many development platforms as possible. *"Combine scratch and another programme to allow students to get more knowledge." (participant 26)*
- IT students want additional support outside of the classroom. *"Try to have the SI [supplementary instructor] to assist students out of class." (participant 27)*
- IT students want to keep up with current trends. *"Put more time in doing external research." (participant 29)*

CONCLUSION AND FUTURE WORK

A PBL strategy was adopted in this module to improve the 21st century competencies of IT students in an extended degree. The aim of improving their 21st century competencies earlier in an IT degree is to prepare them for employment sooner. In this way, the gap between IT higher education and the IT industry can more easily be bridged.

The value of project-based learning as pedagogy for training IT students cannot be stressed enough. Even though PBL is most often used at exit-level, traditional teaching and learning methods at entry-level should also be reconsidered. This view is supported by the student participants who indicated that even though only 56.7% preferred a project-based examination to a written examination, 73.3% agreed that additional learning takes place through a project-based examination.

As part of the PBL strategy taken, a large number of the assessments were *class* activities and *class* assignments to promote increased facilitator support. A surprising finding however was that students still prefer to be overloaded with homework and specifically requested additional exercises for training (7 occurrences).

While an overall improvement in 21st century competencies of the IT extended students was clearly noticeable through the PBL strategy taken (32 occurrences total), further development of the approach needs to be refined. A strong focus of this paper is the reflection of the student as well as the facilitator. Through continuous reflection on the PBL strategy taken, it was noted that certain approaches can further be classified as guidelines for bridging the IT theory-practice gap. Some of these guidelines include:

Interventions for bridging the IT theory-practice gap should take place earlier in a degree to raise career awareness continuously. Interventions include adapting teaching and learning approaches to the context of the industry.

Project-based learning is a suitable instruction method for IT education at all levels but the scope of the project needs to be managed in the context/ level of the student. The motivation for entry-level students are different than that of exit-level students. Entry-level students are motivated by project scopes that are relevant to their current environment, while exit-level students are motivated by project scopes that are similar to what they can expect in industry.

IT students should be encouraged to engage in reflective practice on a continuous basis to highlight aspects that they need further development on. Reflective practice can take place through methods such as journaling, reflective sheets, and autoethnography. Keeping a reflective account of the successes and struggles during the course of a module will promote self-directed learning as the student identifies competencies that he/she has mastered and need additional assistance with.

Additional workshops on improving 21st century competencies are beneficial. More often, educators focus only on the content of the module that they are teaching, and not on the different skills needed to support the content. For example, IT students rarely receive training on professional writing methods, as the courses are more focused on technical skills. It is however expected in industry that reports need to be written or project documentation need to be compiled. Providing a short workshop on research and professional writing may be beneficial for an IT student to complete their projects successfully, and will contribute to the quality of their assessments throughout the degree.

The research can further be extended by making use of reflective practice to review all data received via the reflective sheets for guideline building as suggested. Other available data not included in the body of knowledge for this paper comprises of self-reflections on skill levels, the created games and project documentation. The artefacts can be reviewed based on the perceptions students had of what happens after graduation when they created a theme and storyline for their games. Additional valuable data contained in the project documentation of each game is the manner in which students attempted to explain their game development in the context of the design thinking process. The data received from participants not included in this paper (as it was not directly related to 21st century competencies) could also be included for analysis to improve the future PBL strategy.

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Article 3: Guideline development

Through the iterative nature of the design science research approach followed in this study, this article adds explicit guidelines towards bridging the gap between IT theory and IT practice.

Article 3 presented a project-based learning strategy for IT extended students. The PBL strategy aimed to develop 21st century competencies in entry-level students. After reflecting on the strategy adopted in the research, four explicit guidelines towards bridging the IT theory-practice gap were proposed in the conclusion section of the paper. These guidelines are adapted for this DSR study, to suggest guidelines that are important for best practice in general IT pedagogy. Figure 6.1 provides a high-level overview of guidelines formulated for general IT pedagogy.

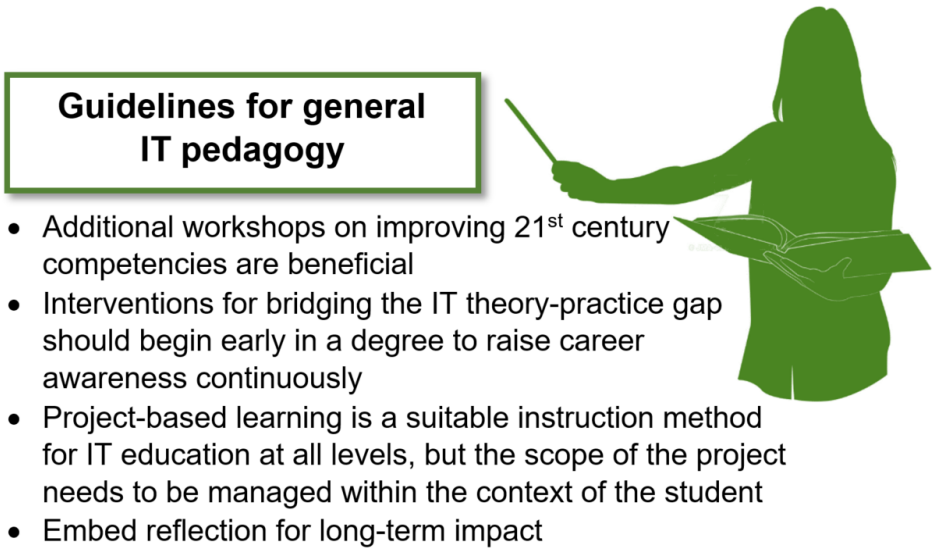


Figure 6.1: Guidelines for general IT pedagogy

Table 6.1 provides a discussion and context on each guideline that forms part of the suggested best practices for general IT pedagogy.

Table 6.1: Description of guidelines for identifying crucial IT skills

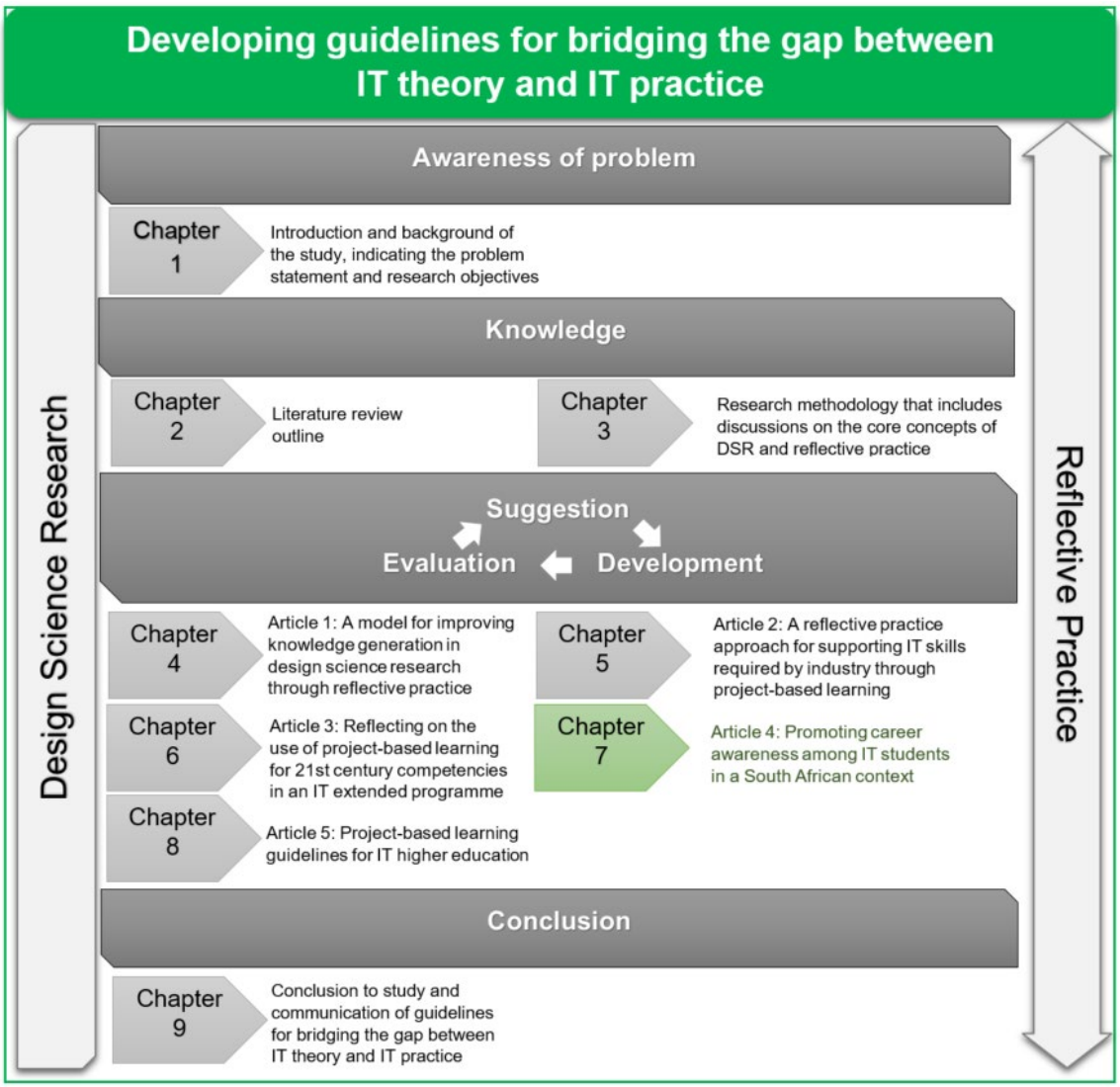
Guideline	Description
Additional workshops on improving 21st century competencies are beneficial	More often, IT educators focus only on the content of the module that they are teaching, and not on the different skills needed to support the content. For example, IT students rarely receive training on professional writing methods, as the courses are more focused on technical skills. It is, however, expected in industry that reports need to be written or project documentation needs to be compiled. Providing a short workshop on research and professional writing may be beneficial for IT students to complete their projects successfully, and will contribute to the quality of their assessments throughout the degree.

Interventions for bridging the IT theory-practice gap should begin early in a degree to raise career awareness continuously	Types of interventions include adapting teaching and learning approaches within the context of industry requirements. Other approaches include involving industry in higher education through guest lectures, seminars, or as part of advisory boards.
Project-based learning is a suitable instruction method for IT education at all levels, but the scope of the project needs to be managed within the context of the student	The motivation for completing projects is different for entry-level students than for exit-level students. Entry-level students are motivated by project scopes that are relevant to their current environment (e.g. #FeesMustFall), while exit-level students are motivated by project scopes that are similar to what they can expect in industry (e.g. solving a real-world client's problem).
Embed reflection for long-term impact	Embed reflective practice methods such as reflective journaling, reflective sheets, autoethnography, or feedback sessions that encourage deeper reflection in your module. Students tend to *understand* the value of approaches taken after they have critically reflected on the impact it had on their ability to deliver working artefacts. Keeping a reflective account of successes and struggles during the course of a module will promote self-directed learning as the student identifies competencies that s/he has mastered and needs additional assistance with.

It is important to note that these guidelines are expressed in a generic manner, which imply that they can be used by any individual who wants to improve pedagogy for best practice in their discipline. The guidelines that contain discipline specific context, can be replaced with keywords from other disciplines to generalise the guidelines within its context.

The next chapter contains an article that provides guidelines for promoting career awareness among IT students, towards bridging the IT theory-practice gap.

CHAPTER 7: PROMOTING CAREER AWARENESS AMONG IT STUDENTS IN A SOUTH AFRICAN CONTEXT



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Preamble to Article 4

The title of this article is *Promoting career awareness among IT students in a South African context*. The article was submitted to an accredited journal, entitled Higher Education, Skills and Work-based Learning on 8 September 2019. The article was double blind peer-reviewed and feedback was received on 7 October 2019. The article was revised and resubmitted for review on 27 October 2019. The article was accepted for publication on 10 January 2020 (see evidence of acceptance in Appendix J). The article was still in press at the time this thesis was published.

Article 4 is an evaluation of an intervention strategy for IT exit-level students. Taking previous research iterations into account, project-based learning was supplemented with industry contact opportunities. An improved intervention strategy was proposed that comprised of a combination of industry talks, capstone projects, and specific events. The exit-level IT students were asked to provide feedback regarding events that formed part of the intervention strategy by completing an interpretive questionnaire online. The qualitative data was open coded to find themes in the data. Benefits of industry contact sessions and suggestions for improvement of future iterations of the intervention strategy were highlighted. A central theme was identified during the analysis that laid the foundation for this article – the importance of *career awareness*. This central theme builds on the guideline proposed in Article 3, which states that interventions for bridging the IT theory-practice gap should take place earlier in a degree to raise career awareness continuously. The novelty of this paper can be found in Section 6, the implications of the research, which provides a comprehensive list of guidelines towards bridging the IT theory-practice gap.

The Harvard referencing style was required for this article. Author guidelines can be found in Appendix H. The interpretive questionnaire used for this article can be found in Appendix I.

Promoting career awareness among IT students in a South African context

Abstract

Purpose – The purpose of this paper is to present an intervention strategy for promoting career awareness among IT students in a South African context, followed by a reflection thereof based on qualitative data collected from students. Career awareness during study has shown to be a factor in the work-readiness of IT graduates.

Design/ methodology/ approach – The paper suggests an intervention strategy aimed at promoting IT students' career awareness. It provides context of the exit-level higher education (HE) module used to implement the intervention. Career awareness is achieved by industry talks, projects, and events. Interpretive data collection and content analysis are used to understand the impact of the intervention from the students' perspective.

Findings – Recommendations are made towards productive interventions for raising career awareness among IT students using industry participation in higher education. The proposed intervention comprises of a combination of industry talks, capstone projects, and specific events. Students had largely positive reactions and made suggestions for additional interventions they would find beneficial. A hackathon attended proved the most influential where 7 out of 8 involved students received job offers from one company. Other students became aware of their own employability, limitations and preferred career paths.

Originality/ value – Findings provide confirmation on existing feasible approaches and also introduces new interventions that may be generalised to other fields of study. The paper not only provides an instructional design for a module to raise career awareness but also reflects on the feedback of the students. The reflection provided by students act as a point of reference to ensure that the process followed for the intervention is practical within a South African context. The paper highlights the perceived benefits of involving industry in higher education to raise career awareness, factors that may prevent career awareness among IT students, and valuable suggestions made by students to further enhance the intervention strategy. An implication of the research is a set of guidelines identified towards bridging the IT theory-practice gap. These guidelines can be used by many educators in similar environments to justify their interventions.

Keywords – Career awareness, reflective practice, industry involvement, higher education, Information Technology, intervention strategy

Paper type – Research paper

1 Introduction

Research have indicated the importance of career awareness at all ages, and that it has been a central concern for more than half a century (Hashish, 2019, de Hollander et al., 2018, Cohen et al., 2013, Fouad et al., 2006, Kemple et al., 1999, Dorr & Lesser, 1980, Wise et al., 1976). Raising career awareness is an important element for improving degree completion (Department of Education and Training, 2017). Additionally, raising career awareness through methods of career education can reinforce the value of a chosen degree, especially if the degree was not the student's first choice (Yorke & Thomas, 2003). The role of higher education is continuously challenged as knowledge provider and authenticator of work-based instruction. It is necessary to provide additional opportunities to students where they can learn about different career paths that may emerge from their degrees. A common approach for raising career awareness is the participation of industry in higher education (de Hollander et al, 2018, Sarkar et al, 2016, Zegwaard & Coll, 2011).

While raising career awareness, students should become reflective practitioners when giving consideration to their career aspirations. Encouraging reflective practice in career awareness will promote a better understanding of the roles available in the workplace and incite questions about self-identity and the need for change (Mezirow, 1991). A reflective practitioner is aware of his limitations, and therefore knows how to improve the abilities he does possess, making him more employable in a career path that he is suited for and prefers. Students do however need knowledgeable educators to highlight connections between their interests, classroom lecturers and real-world applications (Cohen et al., 2013).

The purpose of this paper is to present an intervention strategy for promoting career awareness among information technology (IT) students in a South African context, followed by a reflection thereof based on qualitative data collected from students. A literature review on the key concepts is provided in Section 2, followed by an overview of the elements of the research in Section 3. The background information and an overview of the planned intervention strategy is provided in Section 4, along with the representation of the data collected. Section 5 provides a discussion on results, leading into Section 6 which indicates resulting guidelines for bridging the IT theory-practice gap. Section 7 concludes the research and indicates future work.

2 A discussion on key concepts

This section provides a short literature review on the central concepts of this study in order to achieve a shared understanding. Reflective practice is discussed as the foundation of experiential learning, which is significant for promoting long-term retention and reflection of the proposed intervention strategy. Raising career awareness through industry involvement in higher education is discussed as part of the possible approaches for the intervention strategy. The typical career path of a South African IT student is also discussed to provide further context of the need for industry involvement in higher education.

2.1 Reflective practice

John Dewey wrote that learning only takes place through problem solving or applying a reflective process with the aim of solving the problem (Dewey, 1896). Dewey argued that reflective thinking transforms traditional thinking into reflective action that involves critical consideration. Habermas (1971) further defined reflection as a means to develop diverse forms of knowledge. Schön and Argyris (1974) redefined reflection in context of organisational learning. They encouraged reflection for professional effectiveness by stating that individuals react to effective behaviour based on their ability to review a situation. They pioneered the idea of single loop learning that focuses on the gradual improvement of an established method, and double loop learning that questions the frame of reference that the method was built on. Schön (1983) went on to identify methods to promote awareness among professionals of their implicit knowledge by learning from their experiences. The central theme of his work was to facilitate a process to empower the reflective practitioner. Kolb (1984) defined his concept of experiential learning as a similar train of thought as that of reflective practice. He stated that learning should be a lifelong process and that ideas should be re-evaluated according to our experiences. Experience drives conceptual reflection and emphasises the process of learning by doing. The practitioner reflects on experiences that cause confusion, astonishment and bewilderment in a unique situation (Schön, 1983). He reviews his prior understanding, and in doing so creates a novel understanding of a phenomenon and introduces the possibility for change.

Schön (1983) further proposes that reflective practice is the dual process of immediate reflection during a situation (reflection-in-action) and also reflecting on the situation after it has been resolved (reflection-on-action) in order to better resolve similar scenarios in the future. Reflective practice encourages the habit of investigating one's own experiences and paying attention to thought processes and actions during a specific situation. Reflective practice is primarily focused on the process of continuous inquiry. In the context of this paper, reflective practice is fundamental to both the researcher's attempt to improve an Information Technology curriculum towards bridging the gap between theory and practice,

as well as to the students, who should mature into reflective practitioners by encouraging them to reflect on their future careers.

2.2 Career awareness: The need for industry involvement in higher education

The need for reflection in curriculum planning while motivating students to engage in reflective practice relating to their careers is a continuous process (Nikolou-Walker & Garnett, 2004). Students tend to base their qualification choice on their preferences and aptitude for specific subjects, with only a vague idea of the career opportunities that the qualification may offer (Zegwaard & Coll, 2011). It is well established that university students are unaware of career opportunities, career paths and career descriptors in the related fields of Information Technology (Calitz et al., 2011, Becerra-Fernandez, 2010, Jacobs & Sewry, 2010, Murphy, 2009, Ross, 2007). Even as early as the 1970's it was the role of educational programs to provide opportunities that encourage the best possible career development (Wise et al., 1976). This remains a continuous focus in higher education for all types of careers (Salonen et al., 2018, Ruggunan & Kanengoni, 2017, Cohen et al., 2013). The common sources of information for career awareness among students are: family, friends, career counsellors, career exhibits, media, the internet, fellow students and lecturers (Ruggunan & Kanengoni, 2017, Calitz et al., 2011).

Additionally, factors that influence career choice are:

- permanent residence that has an impact on the available opportunities in an area (Green and White, 2007),
- self-imposed limits based on gender (Direito et al., 2017, Gottfredson, 2005, Fouad, 1995),
- African and minority groups make distinctively different choices than Caucasians do (Hutchinson, 2011, Fouad, 1995),
- parents (Gorard & See, 2009),
- previous work experience, and talking to family and friends that are employed in a field of interest to the student (Millword, 2006).

Career awareness among students in all fields remains a current problem (Hashnish, 2019, Salonen et al., 2018, Sin & Amaral, 2017, Finch et al. 2016). Literature indicates a number of approaches to promote career awareness as provided in Table 1. Different approaches in this table are coded in column 1 for reference later in the paper.

Table 1: Literature review of approaches to promote career awareness

#	Approach	de Hollander et al., 2018	Direito et al. 2017	Sarkar et al., 2016	Cohen et al, 2013	Calitz et al., 2011	Zegwaard & Coll, 2011	Nikolou-Walker & Garnett, 2004	Boud & Solomon, 2001
A1	Integrating authentic tools used by practitioners in industry			x	x				
A2	Exposure to working environments	x					x	x	
A3	Career fairs and seminars				x	x			
A4	Formal and informal opportunities to connect with practitioners	x		x	x				
A5	Explicit connections between content and related careers		x	x	x	x			
A6	Conceptual links between the skills developed and employability		x	x	x		x	x	
A7	Context-based pedagogy		x	x	x				
A8	Incorporating real-world assignments into the curriculum		x	x	x				

A9	Work-integrated learning/ Work-based learning/ Work placements	x		x			x	x	x
A10	Embedding reflection of the approaches taken for long term impact	x		x	x			x	
A11	Partnerships between universities and industry organisations	x		x	x		x	x	x

To provide context of the need for industry involvement in higher education in South Africa, the following section provides an overview of the typical career path of a South African IT student.

2.3 South African IT students' typical career paths

In South Africa, an undergraduate degree in Information Technology or a related degree is typically three years in duration (University of Johannesburg, 2019, University of Cape Town, 2019). Many students elect to complete a fourth year of study as part of a relevant honours degree. Entry to honours programmes typically have higher academic requirements (North-West University, 2019), limiting the possible intake of full-time students. This implies that most IT students need to enter the workforce after completing their undergraduate degree. IT students typically apply to graduate programmes during their final year of study. Recent graduates are seldom directly appointed in junior positions, as the requirements usually specify at least one to two years of working experience (based on a review of junior IT job listings on South African job portals such as careerjunction.co.za, careers24.com, graduates24.com, and indeed.co.za). Graduates also run the risk of not finding employment, as specified in the quarterly labour force survey conducted by Statistics South Africa. During the first quarter of 2019 (January to March), there was an unemployment rate of 7.9% amongst South African graduates (Stats SA, 2019).

The South African Graduate Employers Association (SAGEA) conducts a yearly survey amongst graduates across the country to highlight preferred employers in specific industries. During 2019, 2168 South African graduates completed the 10th annual SAGEA employer awards survey (SAGEA, 2019). In the information technology industry, three related sectors were acknowledged namely IT consulting, IT hardware and software, and banking. Table 2 provides an overview of the top nine IT-related employers in South Africa based on graduate votes.

Table 2: Top IT-related employers for graduates in South Africa (SAGEA, 2019)

IT sector	**Top employer**	**Runner up (1)**	**Runner up (2)**
IT consulting	Microsoft	International Business Machines (IBM) Corporation	Amazon
IT hardware and software	Accenture	Deloitte	PricewaterhouseCoopers (PWC)
Banking	Standard Bank	First National Bank	Nedbank

The duration of a graduate programme is normally 12 months, with some programmes running for up to 18-24 months (Standard Bank, 2019). Some companies also provide internships during or after the completion of studies that can stretch for 10 – 16 weeks (Amazon, 2019, Accenture, 2019). Graduate programmes in South Africa are typically located in Johannesburg, with some companies offering programmes in other large cities such as Cape Town, Durban and Bloemfontein (Microsoft, 2019, PricewaterhouseCoopers, 2019, Deloitte, 2019, First National Bank, 2019). Tertiary degrees required are in Information Technology, Computer Science and Engineering, among others. Preferred technical skills include experience with C++, C, C#, Python, Java, Javascript, and DevOps (Microsoft, 2019, Amazon, 2019, IBM, 2019). Typical soft skills wanted in the IT industry include written and verbal communication, problem solving, creativity, time management, team work and a willingness to learn (IBM, 2019, Deloitte, 2019, Nedbank, 2019, Taylor, 2016).

Career paths available from these nine employers include, but are not limited to, software development, cloud architecture, cyber security, machine learning, business analytics, robotics, IT auditing, user experience design, and IT consulting. Understanding and explaining the context of these types of careers and the required skills can prove to be difficult for academics with no related experience. For this reason, industry involvement in higher education is critical to provide a clearer and richer picture of what IT students should know to follow these career paths in South Africa.

3 Elements of the study

The FMA model showcases three important elements of research namely the framework of ideas (F), the methodology (M) and the area of concern (A) (Checkland & Holwell, 1998). During the research process it is important that learning takes place for each element. Figure 1 shows a rich picture of the research using the FMA model to indicate the key elements of this study in the field of higher education for Information Technology.

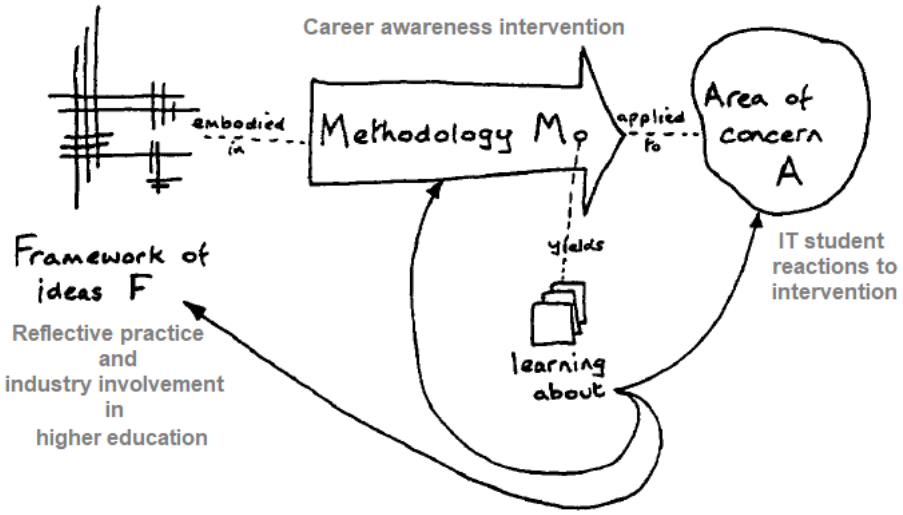


Figure 1: The FMA model depicting key elements of this research (adapted from Checkland & Holwell, 1998)

Elements of the research according to the FMA model is:

- Framework of ideas (F):
  - To enrich the field of reflective practice by reviewing its origins towards improving the awareness of the professional practitioner through reflection.
  - To enrich the field of higher education by giving consideration to industry involvement in an Information Technology curriculum.
- Methodology (M):
  - To plan and execute an intervention strategy towards promoting career awareness among IT students in a South African context.
- Area of concern (A):
  - To understand the experiences of IT students in reaction to the intervention strategy.
  - To indicate any resulting suggestions towards bridging the gap between higher education and industry.

3.1 Research methodology

For the purpose of this research, an interpretivist approach is taken with the aim of understanding the reactions of IT students to an intervention strategy that promotes career awareness. Interpretive research comprises of knowledge that is only gained through social constructions and puts emphasis

on the intricacy of human sense making (Klein & Myers, 1999). Relativism is seen as the ontological stance of interpretivism (Scotland, 2012), and is the opinion that reality is subjective and that it depends on the individual person (Guba & Lincoln, 1994). Interpretive studies provide a deeper understanding than factual or objective accounts of phenomena (Orlikowski & Baroudi, 1991). The epistemological stance of interpretive research is that researchers build motives that account for the manner in which subjective connotations are shaped and sustained in a specific situation. A researcher cannot detach himself from the scenario that is under investigation and for this reason needs to understand the significant factors that affect the interpretations made by diverse societies (Myers, 2009).

Qualitative research approaches are generally used in interpretive research as the researcher aims to gain a richer understanding of the subject (Oates, 2006). Interpretive research methods include case studies, ethnographies, interviews and qualitative questionnaires. An interpretive researcher may use coding techniques such as interpretive content analysis to identify themes in the data (Myers, 2009). In qualitative research, code saturation indicates when a sufficient number of participants have been interviewed. Two approaches to saturation as a guide to sufficient sample sizes in qualitative research are suggested (Hennink et al., 2016). Approximately 9 interviews are needed for code saturation (an understanding of the concrete codes), and between 16 and 24 interviews are needed for meaning saturation (adding additional meaning to subtle conceptual issues missed in concrete codes). These are only provided as a guideline and will vary from one study to the next.

The eight step process for qualitative content analysis by Zhang and Wildemuth (2009) is used as a guideline for preparing the data, processing the data for traceability and reporting on the findings. Klein and Myers (1999) provide a set of principles that can be followed for interpretive field research. The fundamental principle of the hermeneutic circle is applied throughout the qualitative data analysis to ensure that an understanding of the complex whole is attained by understanding the meaning of its subsequent parts and the relationships between those parts. This is achieved by identifying a unit of analysis, developing a coding scheme, coding all the text and assessing the coding consistency as suggested by Zhang and Wildemuth (2009).

4 Planned intervention strategy

In this section, the background information for the research is provided, along with the career awareness approaches applied as part of the intervention strategy. The section ends in an overview of the data collection and analysis process.

4.1 Background

An IT project module is presented in the final semester of an Information Technology curriculum at a university in South Africa. The objective of the module is to occupy students in a project-based environment that simulates their future working-environment. The project scopes are received from industry partners in order to ensure that the assessments offered are on industry-standard. For IT students to be fully aware of the options that are available to them, different forms of industry involvement are suggested to further ensure career awareness. Before we can reflect on the intervention strategy implemented during the course of this module, an overview of the environmental factors not changed or not in the control of the researcher is first provided. As the research is conducted in South Africa, socioeconomic influences apply to the circumstances of the students. A large percentage of the South African population lives in poverty and for this reason movements such as #FeesMustFall has emerged to contest for free Higher Education. Subsequently, subsidy is limited, and only a small portion of the student population have the means to privately fund their studies.

The university where the research was conducted is situated in a small town, approximately 100 kilometres (km) from the largest city. Opportunities for internships and work-integrated learning is limited in this area. The nearest industrial area is approximately 10 km from the university and access to funding for transport is limited which further restricts opportunities for work experience during the course of the degree. Creative ways are needed to bring students and industry together. Other factors beyond the

control of the researcher for this module include the number of study hours allocated, the position of the module in the degree, and the contact sessions assigned during the semester.

4.2 Intervention strategy

Different approaches to raising career awareness were suggested in the literature review (Table 1). As part of the intervention strategy towards promoting career awareness among IT students, the following approaches are applied in context of the exit-level IT module (Table 3):

Table 3: Summary of approaches taken towards an intervention strategy

Type of intervention	**Career awareness approach applied from Table 1**	**Description and context of type of intervention in module**
Intervention 1: Conceptual link between skills and employability	A6, A10	An introductory class explaining the need for specific skills development and how these are addressed during the course of the module towards employability was presented. It was experienced that exit-level IT students are more motivated to complete their assessments when they understand the importance thereof in context of their future careers. A short presentation based on research findings was offered to the students explaining which skills industry tend to find lacking in IT graduates, and how the planned activities for the semester intended to improve these skills.
Intervention 2: Opportunities to connect with practitioners	A4	Job opportunities were posted on the central learning management system (LMS). The researcher had a good relationship with the university's career centre. All job opportunities relating to IT was shared with the researcher, who subsequently posted these opportunities in a central location on the module site on the LMS. The researcher also posted any other job opportunities she became aware of through the course of the semester.
Intervention 3: Guest lectures by industry	A4, A5, A7, A8	Guest lectures were presented on the industry project scopes released for the module. Industry partners were also able to provide a clearer context of how related skills are developed in their environment, and highlighted the importance of technical concepts that students were not familiar with yet.
Intervention 4: IT seminar	A3, A4, A5	A full-day IT seminar was hosted with the aim of promoting career awareness and providing a platform for possible job opportunities. Eight companies each presented a 45 minute session that provided context of their company goals, opportunities available and skills to develop to join their ranks. Two speakers were previous alumni of the university, and had started their own businesses as entrepreneurs. Other companies had IT departments working in fields of agriculture, artificial intelligence, robotics, systems applications and products (SAP), and engineering. Most of the companies travelled more than 100 km to present at the seminar.
Intervention 5: Hackathon	A2	Company A hosts a yearly hackathon. A hackathon is an event where students come together to collaboratively work on a computer programming brief. These events are hosted by companies to scout for talent among future graduates. Students were asked to indicate whether they would like to participate in the hackathon if the researcher made transport available (Company A is located more than 100km from the university). Due to logistical constraints only the first eight students who indicated interest were involved in this intervention. The students were subdivided into groups with students from other institutions – aimed at testing their team work and interpersonal skills.
Intervention 6: PBL environment	A1, A7, A8	The module is presented using a project-based learning pedagogy, where real-world project scopes are used to prepare the future IT graduate on what to expect when they enter the workforce. Each project scope is received from industry, and the development specifications provided are based on authentic

		software that is used in industry. The university attempts as far as possible to provide licensed software that conforms to industry standards.
Intervention 7: Collaborative competitions with industry	A1, A4, A8, A11	A competition was hosted in collaboration with an industry partner exclusively to the 3rd year IT group. Having an industry partner's buy-in for the development of future IT graduates is crucial. A good relationship exists between the researcher and Company A. The project scope received from Company A was used as part of a competition among the exit-level IT students. Industry practitioners from Company A evaluated the projects and chose the top three winners. All winners received a prize and an interview invitation from Company A. The 1st place winner also received a bursary to extend their studies with an IT Honours degree at the specific university (organised by the researcher with the relevant faculty in the university).

The only approach that could not be implemented was work-integrated learning/work-based learning/ work placements [A9], and the socioeconomic reasons for this were discussed in Section 4.1. The remainder of these approaches are aimed at improving the reflective practice of IT students towards making informed career choices.

The reflective practice of the researcher is also enhanced by reflecting on approaches that may promote career awareness among IT students (reflection-in-action), as well as receiving feedback from students on approaches that were/ were not useful (reflection-on-action). Through this dual process of reflection, an improved strategy can be suggested for future iterations of the intervention. The IT curriculum is improved and a stronger link to industry is emphasised, and also, an enhanced student experience in promoting career awareness is achieved.

4.3 Empirical study on student response

The purpose of this paper is to present an intervention strategy for promoting career awareness among information technology (IT) students in a South African context, followed by a reflection thereof based on qualitative data collected from students. In order to understand the student experience of the intervention, the following sections provide context of student feedback received.

Data collection

The research was undertaken at a university in South Africa as part of an exit-level IT module. In an attempt to understand the students' experiences of the intervention, they were asked to participate in an interpretive data collection method to obtain feedback. An interpretive questionnaire was created using Google Forms and the link was made available to the students though the LMS after the conclusion of the module. The nature of the questionnaire was interpretive with the aim of understanding student background and opinions relating to their experiences. Completion of the interpretive questionnaire was voluntary. The interpretive questionnaire did not request identifiable data and could be completed in their own time ensuring a level of anonymity. The interpretive questionnaire consisted of mostly open-ended questions (qualitative data) to obtain richer feedback on the approaches taken during the course of the module. A limited amount of the data was quantitative in nature to provide demographic and required background information. Open coding was used to analyse the qualitative data and descriptive statistics were used to present the quantitative data. From 86 students that completed the module, 32 students completed the voluntary interpretive questionnaire. Due to the qualitative format of the interpretive questionnaire, and the rich feedback received – this method produced similar qualitative data volume to that of traditional transcribed interviews. For the purpose of this study, 32 responses are considered sufficient for the substantial volume of feedback received, considering that code saturation and meaning saturation occur between 9 - 24 interviews as discussed (Hennink et al., 2016).

Data analysis process

Quantitative data was analysed in Microsoft Excel using its basic descriptive statistic features. Atlas.ti version 8.4 was used as scientific software tool to create codes and groups for the qualitative data. In

order to review the data according to the fundamental principle of the hermeneutic circle, the following data analysis process was followed for traceability and rigour:

- A directed approach was taken, coding the data specifically in context of answers provided that related to an experience of career awareness.
- Each individual question with its 32 answers was coded based on the codes identified from the previous questions. Each question made use of existing codes and produced additional codes.
- When the final question was coded, the process was restarted at the first question to validate whether codes that had been produced in subsequent questions were not overlooked when the process was started.
- The codes for all questions were re-evaluated three times to validate the coding consistency. Similar codes were merged, renamed, or removed if redundant, which resulted in a final set of 26 unique code names across all qualitative data.

Data representation

Bio & prior career-related experience

From the 32 responses received, student gender and racial information are as follow: 6 African females, 8 African males, 4 Caucasian females, 11 Caucasian males, 1 female of mixed race and 2 students that preferred not to indicate their gender or race.

16 students indicated that they had no prior work experience, 8 students had work experience through opportunities provided by the university (student assistants, supplementary instructors, and community engagement projects), 5 students had completed IT internships or vacation work, and 3 students had some form of part-time work experience.

18 out of 32 students indicated that pursuing an IT-related degree was *not* their first choice.

Employment for the following year

Out of 32 students, 12 students (3 African and 9 Caucasian) indicated that they had employment in IT-related fields for the following year. Of these 12 students, 7 had prior work experience (2 African & 5 Caucasian students). Of the remaining 5 students that did not have prior work experience, 3 students received their employment offers after an industry hackathon was attended.

Of the remaining 20 students who did not have employment yet, 5 students indicated that they were still waiting to hear from employers, 6 students indicated that they wanted to complete a related honours degree first, 2 students indicated that they were not sure whether they would pass all the required modules for the degree, 1 student declined an offer due to an expected salary bracket that would not cover his study loan repayment, and 6 students indicated that they did not have work yet without providing a reason.

Intervention 1

Intervention 1 was targeted at making students aware of which 21st century competencies members from industry found lacking in IT graduates (supported through research). Students were informed how each activity and intervention that formed part of the module was targeted at improving at least one of the mentioned skills. There was an implicit assumption of the value of the intervention as it increased student motivation to commit to projects. For this reason no questions specifically targeted at their experience of this intervention was asked during the data collection. There was however student feedback relating to this intervention identified through the application of the hermeneutic circle principle in other responses:

> *"It improved my knowledge on what to expect from the projects we will be doing and the elements (types of skills) that I need to work on"*

> *"I honestly believe that currently, with [this module], a great effort is being made to address this in a way that allows us to gain some understanding of the work environment and skills needed in a practical way that doesn't interfere with our studies."*

Intervention 2

From a central folder where known job opportunities are regularly posted for this specific group, 20 out of 32 students indicated that they had applied for at least one of the available positions. The students were asked why they had or had not applied for the listed opportunities, which resulted in qualitative

responses. Figure 2 depicts codes identified for this question, and these codes were subsequently divided under two groups indicating whether the response demonstrated career awareness or not.

Name	Grounded	Groups
Applied with at least one successful outcome	7	[Demonstrates career awareness]
Did not apply due to offer elsewhere	3	[Demonstrates career awareness]
Applied with unsuccessful outcomes	6	[Demonstrates career awareness]
Applied for at least one job opportunity, waiting for feedback/ interview	3	[Demonstrates career awareness]
Applied for one or more job opportunity on LMS~	20	[Demonstrates career awareness]
Applied for at least one job opportunity, but not sure if degree will be passed	1	[Demonstrates career awareness]
Does not plan on working the following year	1	[Did not explicitly demonstrate career awareness]
Did not apply, wants to continue with postgraduate studies first	4	[Did not explicitly demonstrate career awareness]
Did not apply for any job opportunities on the LMS	13	[Did not explicitly demonstrate career awareness]
Missed the deadline to apply	1	[Did not explicitly demonstrate career awareness]
Did not apply, not sure whether degree will be passed	1	[Did not explicitly demonstrate career awareness]

Figure 2: Atlas.ti extract of codes identified in context of job listings provided on the LMS.

Example responses include:

> *"I have applied for 3 opportunities, and was successful in one of them."*

> *"I haven't applied to any of the posted job opportunities, because I had already accepted another offer I received, which reflected my personal interest and career aspirations better."*

Intervention 3

Students were asked to provide reasons for why guest lectures are useful or not useful. They were also asked in a follow-up question to provide any additional topics they would like to have guest lectures on. All students indicated that guest lectures are useful, and provided feedback such as:

> *"They give an overview of the industry that we will be working in as well as open our minds to opportunities we were not aware of before."*

> *"Guests are useful in a sense that they have deeper understanding of the concept, since they work on it practically."*

Students also suggested additional guest lecture topics they would have found valuable which include:

> *"Maybe a general lecture on what skills, tools and techniques we should research and need in order to be effective when entering the marketplace, not a specific business. This could be based off of current and projected trends."*

> *"The way software is used and expected to be designed at a professional level, mostly the way the industry expects a junior developer to view and solve business requirements and expectations."*

Intervention 4

Students were asked to explain why IT seminars are beneficial. As it was the first time the intervention had been held at the university, students were also asked to elaborate on whether it should be a yearly event.

> *"It exposes us to different fields in IT and keeps us updated on the current and future changes. It prepares students for the workplace."*

"It is an event that exposes students that would not have the opportunity on their own to get familiar with industry and industry trends and gives them an opportunity to interact with professionals before their first interview."

"IT seminars should be a yearly event, as it opens up a load of information for students. Information which is useful as well as present opportunities, they would have otherwise not been exposed to."

Intervention 5

Only 6 students from the participants indicated that they had attended a hackathon of any kind. Students who had attended benefitted greatly from the opportunity, whereas students who had not attended any hackathons demonstrated deep regret.

"It gave me the feel of the work environment, how you always have to be on your toes and stick to a deadline as well as being inventive in terms of how you solve problems."

"I got to know about easier ways to do certain things. Ways which the university doesn't provide."

"The students who attended [a] Hackathon received numerous job opportunities, so by not attending I didn't get the same level of exposure."

"I missed out on opportunities that could have changed my life."

Intervention 6

Intervention 6 represents the project-based learning strategy followed for the module. Research supports the use of PBL towards improving 21st century competencies. Students completed 3 projects during the course of the module. The first project was a research report on concepts that featured in the other projects. The remaining 2 project scopes were received from industry, aimed at familiarising students with techniques and software that the respective companies use on a daily basis. The value of PBL was noted in student responses:

"…gave me a good understanding of how to work in a team and fast moving environment"

"I learned the importance of management of skill, work, tasks and mainly time."

"The importance of SOLID principles, what MVC is, how to better the code quality with code refactoring and how to test small sections of code when errors/bugs occur during development."

Intervention 7

Intervention 7 was the competition hosted by the university in collaboration with Company A. Students could enter their third project (scope received from, and competition judged by, staff of Company A). The first place winner received an IT Honours bursary from the university. All winners received a prize and invitation to an interview from Company A. The number of entries were limited and many students indicated that they struggled with time management, prioritised other school work, or felt that their projects were not good enough to enter.

"I entered the [competition] for the project 3 [scope received from Company A]. I entered hoping to win to the honours bursary and a shot at a job at [Company A]."

"I feel that my project and group project was not good enough to enrol in the competition"

"I wanted to attend but unfortunately my lack of time management did not allow this as I had too much work to do on other projects at the time."

Current career awareness

To understand their current level of career awareness, students were asked which career paths they planned to follow after graduation compared to what their ideal career paths would be if they had the required skills (Table 4).

Table 4: A comparison between planned and ideal career paths.

Planned IT career path after graduation	Ideal IT career path if students had the required skill level
Software development and programming (14 students)	Software development and programming (7 students)
Cyber security (4 students)	Other non-IT careers (film maker, veterinary, writer, engineer etc.) (6 students)
Don't know yet (3 students)	Ethical hacking (4 students)
Business intelligence (3 students)	Game development (3 students)
Network administration (2 students)	Project management (3 students)
System analysis (2 students)	System analysis (3 students)
Other non-IT careers (film industry, engineering) (2 students)	Robotics (2 students)
Database administration (1 student)	Database administration (1 student)
Academia (1 student)	Academia (1 student)
	Network engineering (1 student)
	Business intelligence (1 student)

The student reactions, opinions, experiences and any other feedback relating to the interventions was analysed in context of their perceived level of career awareness. Seven questions targeted at feedback about specific interventions and suggestions for improving career awareness, with 32 qualitative responses per question, were open coded in Atlas.ti. Figure 3 provides a summary of 26 unique codes identified in the data.

Name	Grounded	Groups
Industry contact session provides context between Higher Education and employment	10	[Career awareness explicitly indicated - resulting from contact
Attended an industry contact session with positive experience	73	[Career awareness explicitly indicated - resulting from contact
Industry contact session provides realisation of the diverse IT career opportunities available	7	[Career awareness explicitly indicated - resulting from contact
Industry provides deeper understanding of concepts than universities do	9	[Career awareness explicitly indicated - resulting from contact
Industry contact session results in self-reflection of own skill level	13	[Career awareness explicitly indicated - resulting from contact
Industry contact session provides an opportunity to make an informed decision about career path	9	[Career awareness explicitly indicated - resulting from contact
Industry contact session highlights available job opportunities	9	[Career awareness explicitly indicated - resulting from contact
Industry contact session provides an overview of industry expectations	36	[Career awareness explicitly indicated - resulting from contact
Industry contact session results in employment offer	4	[Career awareness explicitly indicated - resulting from contact
Industry contact session provides overview on current and future trends	14	[Career awareness explicitly indicated - resulting from contact
Did not attend a provided industry contact session	17	[Career awareness not explicitly indicated]
Did not attend an industry contact session and shows regret	18	[Career awareness not explicitly indicated]
Did not attend an industry contact session, due to poor time management	9	[Factors that may prevent career awareness]
Did not attend an industry contact session due to other projects that took priority	13	[Factors that may prevent career awareness]
Attended an industry contact session with negative experience	5	[Factors that may prevent career awareness]
Did not attend an industry contact session, plans to continue with postgraduate studies	2	[Factors that may prevent career awareness]
Suggestion: Add a discussion panel with recent IT graduates during seminar	3	[Improving career awareness - Additional suggestions for cont
Suggestion: Provide more practical examples used in industry	2	[Improving career awareness - Additional suggestions for cont
Suggestion: Internships as reward for completing an industry project	1	[Improving career awareness - Additional suggestions for cont
Suggestion: Promote source control for team projects from first year level	3	[Improving career awareness - Additional suggestions for cont
Suggestion: Make site visits to industry companies available	1	[Improving career awareness - Additional suggestions for cont
Suggestion: Use industry projects in the learning environment	4	[Improving career awareness - Additional suggestions for cont
Suggestion: Provide an industry crash course/ workshop on difficult concepts	8	[Improving career awareness - Additional suggestions for cont
Suggestion: Add a general overview session of IT vocations during seminar	4	[Improving career awareness - Additional suggestions for cont
Suggestion: Use competent industry partners	2	[Improving career awareness - Additional suggestions for cont
Suggestion: Host regular events throughout the duration of a degree	25	[Improving career awareness - Additional suggestions for cont

Figure 3: Career awareness codes and groups extracted from Atlas.ti.

The next section provides a discussion and reflection on the results.

5 Discussion on findings

Reflecting on the background information, it is concerning that more than half of the participants (18) indicated that studying an IT-related degree was not their first choice. Motivation to complete studies and find employment is stronger when a student is passionate about their chosen career path. This may be a fundamental issue as South African universities are accepting students into programs that are not necessarily an appropriate choice for the student.

Research has shown that exposure to work environments or work-integrated learning promotes stronger career awareness. One half of the students (16) indicated that they have no work experience, which is problematic when reviewing current job listings in South Africa – even for most junior developer opportunities companies require a minimum of one to two years of working experience. The other half of students is split equally between students who have work experience due to opportunities provided internally by the university (8), and students who have worked in contact with industry (8). Even though opportunities provided by the university are still considered work experience, there is a certain level of comfort and safety which do not provide the students with the reality of what industry will be like. This increases the concern as only 8 students (25%) have industry related experience that they can add to their CV's that could count towards work experience when applying for junior level jobs.

In order to aid the students in finding employment, a central folder was updated with job opportunities on the module site on the LMS – of which 20 students indicated that they applied for one or more of the opportunities. 6 of the 20 students already had successful outcomes. In total only 12 students had employment for the following year by November (the South African academic year is from January to December). Of the students that already had employment, only 3 were black Africans. This statistic was surprising as there is continuously an increase in the number of opportunities available to BEE (black economic empowerment) candidates. 5 students that had employment for the following year, had prior work experience and an additional 3 students with no work experience received job offers after attending a hackathon. This indicates that the 8 students who received job offers for the following year, had some form of contact with industry first.

The career awareness level of students indicated a comparison between intended career paths and ideal career paths where most students were heading into a software development and programming environment. Interestingly, where only 2 students indicated that they intended to follow non IT-related careers, when asked for an ideal career, this number increased to 6 students. This again might be due to the number of students who indicated that studying IT was not their first choice. A constant interest was noted between cyber security and ethical hacking.

From the 26 codes identified in the qualitative data analysis, four groups were identified in context of career awareness as depicted in Figure 3. The four groups indicate respective themes in the qualitative data, which are: 1) Career awareness explicitly indicated – resulting from contact session with industry, 2) Career awareness not explicitly indicated, 3) Factors that prevent career awareness and 4) Improving career awareness – additional suggestions for contact sessions with industry.

In context of the theme 'Career awareness explicitly indicated – resulting from contact session with industry', the following codes identified provide reasons for why industry involvement in HE is crucial for promoting career awareness (these can also be seen as the benefits of industry involvement in higher education). Industry contact sessions:

- Provide context between higher education and employment
- Provide realisation of the diverse IT career opportunities available
- Provide deeper understanding of concepts than universities do
- Result in self-reflection of own skill level
- Provide an opportunity to make an informed decision about a career path
- Highlight available job opportunities
- Provide an overview of industry expectations
- Provide an overview of current and future trends
- Result in employment offers

In context of the theme ‘Factors that may prevent career awareness’ when involving industry in higher education could include:

- Students that are planning to continue their studies with a postgraduate degree feel that it is not necessary to focus on their career path yet.
- Students feel overwhelmed in the final year of their undergraduate degree, and additional opportunities made available to them for industry participation may be forfeited to ensure that other projects not related to the specific module are completed on time.
- Students may forfeit opportunities made available to them to interact with industry due to poor time management skills. Some activities required project demonstration to industry partners, and a large number of students did not have a completed project by the given deadline.
- Some students that attended contact sessions with industry indicated negative experiences that may prevent their career awareness such as: the perception that only the top performing students will receive job offers, and workplace jargon that was used too often resulted in a partial understanding of concepts.

In context of the theme ‘Improving career awareness – additional suggestions for contact sessions with industry’, the following codes were identified and can be used as guidelines to improve future iterations of the intervention strategy taken:

- General:
    - Host regular events throughout the duration of the IT degree
    - Promote source control for team projects from first year level
    - Use competent industry partners
- At exit-level:
    - Offer internships as reward for completing an industry project
    - Make site visits to industry companies available
    - Use industry projects in the learning environment
- During guest lectures:
    - Provide more practical examples used in industry
    - Provide an industry crash course/ workshop on difficult concepts
- During IT seminars:
    - Add a general overview session of IT vocations
    - Add a discussion panel with recent IT graduates

The two codes identified in context of responses that did not explicitly indicate career awareness, were respectively ‘did not attend a provided industry contact session’, and ‘did not attend an industry contact session and shows regret’. The former code was used when students did not specify their reasons for non-attendance. The latter code highlighted regrets of non-attendance such as being deprived of opportunities for learning, skills development, networking, team building with new people, and experiencing a real work environment.

The hackathon hosted by Company A proved most influential. Students who attended hackathons felt that it had greatly impacted their life in a positive way, either by resulting in a job opportunity or in a learning opportunity for growth. Seven of the eight students that were transported to the hackathon hosted by Company A received job offers.

An area for improvement was noted in the competition hosted in collaboration with industry. A limited number of students entered the competition. Reasons for not entering the competition indicated that their projects were incomplete, other commitments took priority, that they did not fully understand the requirements or felt that their projects were inadequate. Students who did enter the competition indicated their reasons as winning a bursary to further their studies, competing against other students to compare their skills and for a possible job opportunity. Only one of these reasons support career awareness (possible job opportunity), which indicates that this approach needs further planning to increase efficiency.

6 Implications of findings: Guidelines towards bridging the IT theory-practice gap

Through the reflective practice approach adopted in this study, general guidelines for bridging the gap between IT theory and IT practice became evident. Reflecting on the approaches highlighted for promoting career awareness, it became clear that there are two main themes that encompass all approaches identified. The two main themes are respectively the provision of context-based pedagogy, and opportunities to connect with practitioners. All other approaches subsequently become guidelines that any facilitator can incorporate in context of promoting career awareness among IT students. Additional guidelines were added that were implicitly identified in the findings under a third and final theme for institutional guidelines. The interventions applied in this study are mapped to the guidelines for reference. Student feedback is also provided to further refine the guidelines and to provide evidence of their usefulness. These additional quotations were not used in previous sections of the paper, and highlights the saturation of information received in this qualitative study. Table 5 provides structured guidelines for promoting career awareness among IT students in in South Africa, towards bridging the IT theory-practice gap.

Table 5: Guidelines for promoting career awareness among IT students

<table>
<tr><td colspan="3">Theme 1: Provide context-based pedagogy</td></tr>
<tr><td>Guideline</td><td>Examples of interventions</td><td>Student feedback</td></tr>
<tr><td>Incorporate real-world assignments into the curriculum
Integrate authentic tools used by practitioners in industry
Make explicit connections for the students between content and related careers
Make conceptual links for the students between the skills developed and employability
Embed reflection of the approaches taken for long term impact</td><td>• Provide overview sessions to explain which skills typically needed in IT graduates are addressed by which activities in a module
• Explain the context of content covered so that students can understand where they would typically use the skill or tool by linking it to typical careers
• Use educational environments that simulate the industry environments such as project-based learning for IT
• Use real project scopes received from industry partners or community projects, and not ‘made-up’ projects
• Make sure to use relevant and current technologies for completing projects that are used in industry
• Embed reflective practice methods such as reflective journaling or feedback sessions that encourage deeper reflection. Students tend to understand the value of approaches taken after they have critically reflected on the impact it had on their ability to deliver working artefacts.</td><td>“You become well aware of what to expect and planning on how you can incorporate your skills with the ones you acquire from [industry]”
“[An overview] gives good insight into what the employers expect and what it is like to work in the industry”
“I have a better understanding on how to implement MCV as well as the other frameworks”
“Use industry-related projects”</td></tr>
<tr><td colspan="3">Theme 2: Provide formal and informal opportunities to connect with practitioners</td></tr>
<tr><td>Guideline</td><td>Examples of interventions</td><td>Student feedback</td></tr>
<tr><td>Provide career fairs and seminars
Provide exposure to working environments
Encourage partnerships between the university and industry organisations
Provide opportunities for work-integrated learning/ work-based learning/ work placements</td><td>• Arrange guest lecturers on current industry topics that are relevant to a project scope
• Organise a full-day IT seminar with multiple companies providing an overview of their business operations and available opportunities
• Encourage attendance at company-hosted hackathons
• Share known job opportunities with students
• Provide opportunities hosted in collaboration with industry such as competitions where the prize is an interview at the company</td><td>“[Attending a hackathon] has impacted my life in a huge way, it has opened a big opportunity to receive an interview from the company hosting the hackathon and helped me get a job”
“The IT seminar is useful because you get an opportunity to hear about industry and what is happening in local industry and what they are using.”</td></tr>
<tr><td colspan="3">Theme 3: Implicit guidelines for the institution to sustain career awareness among students</td></tr>
</table>

Guideline	Motivation	Student feedback
Industry involvement should take place from day one	It is natural to start implementing industry interventions at exit-level with the aim of 'last-minute' rectifications towards bridging the IT theory-practice gap. This is however not a long term solution as learning needs to be nurtured continuously for reflective practice to take place. Exposing students to industry interventions from their first year of study can only improve their career awareness, by highlighting their preferences earlier, and making them aware of their skills that need further development.	"Start having workshops about work industry from first year." "Start industry readiness in 1st year" "Industry should be invited regularly not only for final years but for second and first years"
Industry buy-in is crucial for continued support	Lecturers cannot attempt to promote career awareness on their own. They do not necessarily have the extended IT experience to provide industry insight. It is crucial to have support from at least one IT company. This may mean having repeated meetings to understand the value of the partnership. One way of fostering a relationship with industry is asking them to provide input on IT graduates' shortcomings, and improving the curriculum to address their concerns. When companies experience positive collaboration, they will become increasingly involved.	Numerous students indicated that they would like workshops or crash courses from industry, that we could provide internships for the top performing students, and that we should provide more industry related projects that can be practically implemented in the real-world. To encourage industry to participate in these activities require fostering long-term relationships.
Provide industry training for lecturers	In many instances, lecturers were students who become academics through postgraduate studies, and rarely have any extended industry experience. Especially in a fast-changing field such as IT, it is difficult for lecturers to keep abreast with new developments if they are not actively involved in the field. It is recommended that IT lecturers should continuously be subjected to in-field training and workshops – to provide improved instruction to future IT graduates.	"[Industry] explains things from a point of view completely different to the lecturer and enable some to finally understand." "[Industry] works with the concepts daily and can give a very clear precise image of it."
Assign a passionate educator to facilitate the process	Not all lecturers are equally interested in student development. For some, lecturing is a calling, and for others, it is merely a vocation. Finding a passionate educator that will manage the process of organising industry seminars, accompanying students to IT hackathons, and sourcing project scopes that conform to industry standards is central to the success of an intervention strategy. This may mean that involved lecturers will require a reduced teaching load in order to do industry research.	"…in the IT industry, things change and grow at a rapid pace, so one needs an individual who touches base on almost a daily basis with all the industries and has experience on how [the environment works]."

7 Conclusion and future work

The purpose of this paper was to present an intervention strategy for promoting career awareness among information technology (IT) students in a South African context, and was followed by a reflection thereof based on qualitative data collected from students. The need for the research can be summarised in two student quotations that highlighted why career awareness is necessary to make informed decisions. One student requested an overview of "how to know what you will be good at", while another student asked for "presentations about all the different directions that we can go into with [a] BSc IT

[degree]". These quotes indicate that IT students on the verge of completing their degree cannot make explicit connections between their skills and suitable careers, and that they need guidance on the different career paths available within the South African IT industry.

In order to achieve the purpose, literature reviews were presented on reflective practice and approaches to raise career awareness. The need for reflective practice was discussed as a core activity required to promote self-awareness for both the researcher, reflecting on the intervention strategy for improved career awareness, as well as the student's need to reflect on their career aspirations. Approaches to raise career awareness among students were discussed in context of industry involvement. A brief overview of the typical career path of an IT student in South Africa was also provided to further emphasise the need for career awareness.

An instructional design of an intervention strategy for an exit-level IT module was presented, where the activities that formed part of the intervention strategy were mapped to approaches for raising career awareness from literature. Only one of the approaches for promoting career awareness could not be implemented, work-integrated learning (WIL). Reasons for this were provided in context of a socioeconomic discussion. The value of WIL is evident in literature, and creative approaches for its implementation could be suggested. If purposeful collaboration with local companies can be achieved, possible partnerships can take place for vacation work, or for easier access, projects could be managed on location at the university if the company allows it. This approach needs further research and planning.

One of the approaches highlighted, was specifically to *embed reflection of approaches taken for long-term impact*. During a research-based presentation at the start of the module, students were prompted to reflect on the current skills required in the IT industry, by indicating how these skills would be addressed during the course of the semester through different activities and approaches. This was not a formal method of reflection, and an assumption was made that implicit reflection took place throughout the course of the module while students had to use the skills indicated. An interesting aspect revealed during the research was the concept of reflective journaling. It is not a new approach to reflection, but has only been documented in the context of information technology education over the past two decades. If IT students can be persuaded to engage in reflective journaling it can further enhance their reflective practice for professional development through a formal method of reflection. With further research, future iterations of the career awareness strategy may include reflective journaling as a requirement for embedding reflection.

After the intervention strategy was completed, students were asked to provide feedback on the approaches that were applied. Qualitative data was analysed and indicated themes of career awareness in the data that either demonstrated that the students were explicitly aware of their future careers, or that it was not evident whether they were reflecting on their careers. From the data analysis, conclusions could be made by reflecting on the perceived benefits of involving industry in higher education to raise career awareness, factors that may prevent career awareness among IT students, and valuable suggestions made by students to further enhance the intervention strategy. This, in return, resulted in a set of guidelines towards bridging the IT theory-practice gap presented in the previous section.

Unrelated to this paper, and also possibilities for future investigation, the research highlighted elements of concern:

- Students continue with postgraduate studies because they do not feel ready to enter the IT workforce.
- Determining the individual contributions of team members to a project is challenging but could be addressed by using tools for source control.
- Universities are accepting students into programmes that are not recommended for their skills and interests, which affects their motivation and commitment towards completing the degree.

The paper addressed a gap in literature in context of the current need for career awareness among IT students in a South African context, with suggestions made for an intervention strategy that promotes

career awareness through the involvement of industry in higher education. Additional research is required to address the factors that may prevent career awareness among IT students as highlighted in the discussion, as well as the concerns raised above.

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Article 4: Guideline development

Through the iterative nature of the design science research approach followed in this study, this article adds explicit guidelines towards bridging the gap between IT theory and IT practice.

Article 4 presents approaches that can be implemented to promote career awareness among IT students. The implication of the research results in guidelines that contribute towards bridging the IT theory-practice gap. These guidelines are divided into two themes: guidelines for best practice in general IT pedagogy, as well as, guidelines for industry involvement in IT higher education.

The previous article (Article 3) provided four guidelines that form part of best practice for general IT pedagogy (Figure 6.1), which is supplemented in this article with an additional four guidelines. One guideline that is found in both articles pertains to *embedding reflection for long-term impact* – this guideline was merged and was discussed in the previous chapter. Figure 7.1 provides a high-level overview of the additional guidelines formulated for general IT pedagogy.

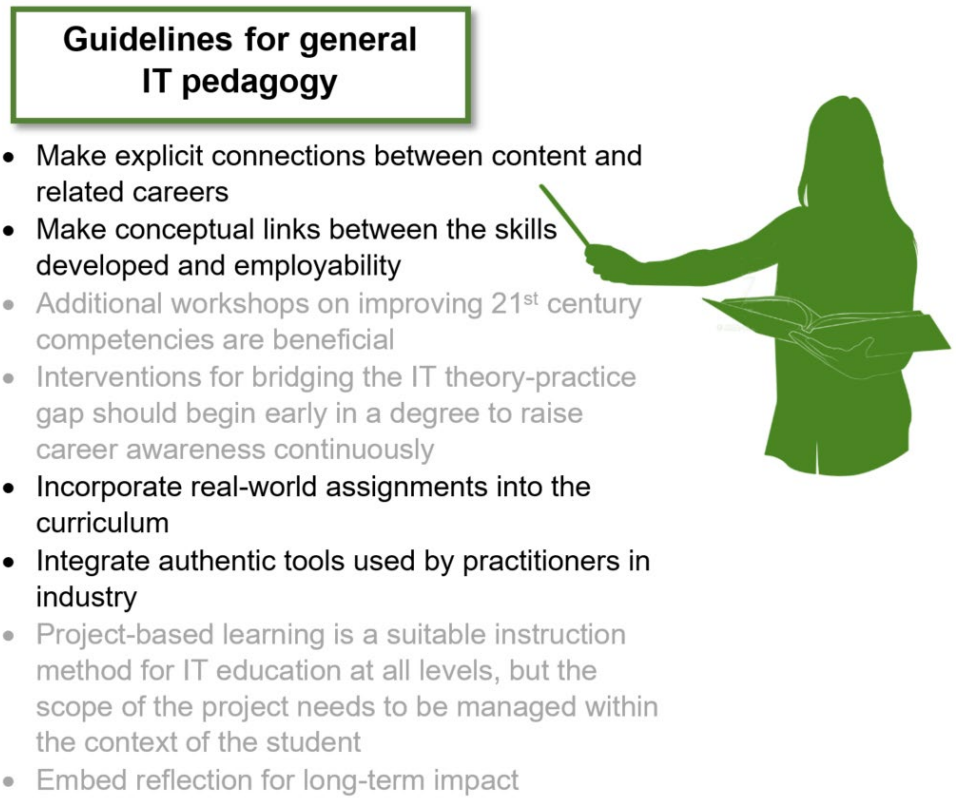


Figure 7.1: Guidelines for general IT pedagogy

Table 7.1 provides a discussion and context on each guideline that has been added to the guidelines for general IT pedagogy.

Table 7.1: Description of guidelines for general IT pedagogy

Guideline	Description
Make explicit connections between content and related careers	Explain the context of the content covered during a lecture so that students can understand where they would typically use the skill or tool by linking it to relevant IT careers. There is a misconception among IT students that you can only become a programmer with an IT degree. You may want to have an open discussion, or structured presentation on typical IT vocations, and their related responsibilities and required skills. This overview requires accurate market research and talking to members from the IT industry.
Make conceptual links between the skills developed and employability	An introductory class of a module should outline the planned activities for the semester. It is useful, and recommended, to explain which skills typically needed in industry (and that are found lacking in IT graduates) are addressed by the activities planned in the module. Students are more motivated to commit to the activities if they understand why it contributes to their employability.
Incorporate real-world assignments into the curriculum	Use educational environments that simulate the industry environment, such as project-based learning in IT higher education. Use real project scopes received from industry partners, or community projects, and not *thumb-sucked* project briefs. If it is challenging to obtain a scope from an industry partner, read recent news articles that are focused on your discipline and use a breaking story as a topic for a project. Keep project topics real and relevant.
Integrate authentic tools used by practitioners in industry	Use relevant and current technologies that are used in industry to complete projects. You should be able to identify which technology stacks, front-end platforms, and database software are most relevant currently in the IT sector from the research conducted as part of the intervention strategy, or the research conducted to identify which skills are relevant.

It is important to note that these guidelines are expressed in a generic manner, which imply that they can be used by any individual who wants to improve best practice for pedagogy in their discipline towards bridging the theory-practice gap.

Article 4 also highlights the importance of industry involvement in higher education and the role it plays in contributing towards bridging the IT theory-practice gap. Figure 7.2 provides a high-level overview of these adapted guidelines.

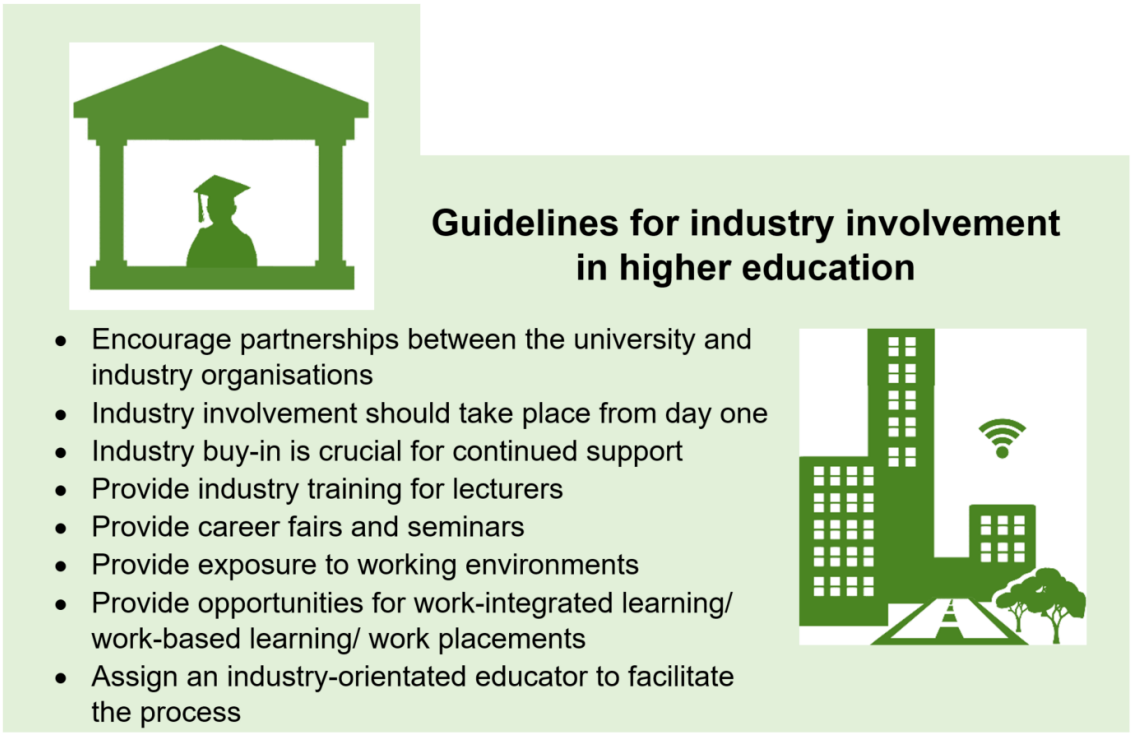


Figure 7.2: Guidelines for involving industry in higher education

Table 7.2 provides a discussion and context on each guideline that forms part of involving industry in higher education.

Table 7.2: Description of guidelines for involving industry in higher education

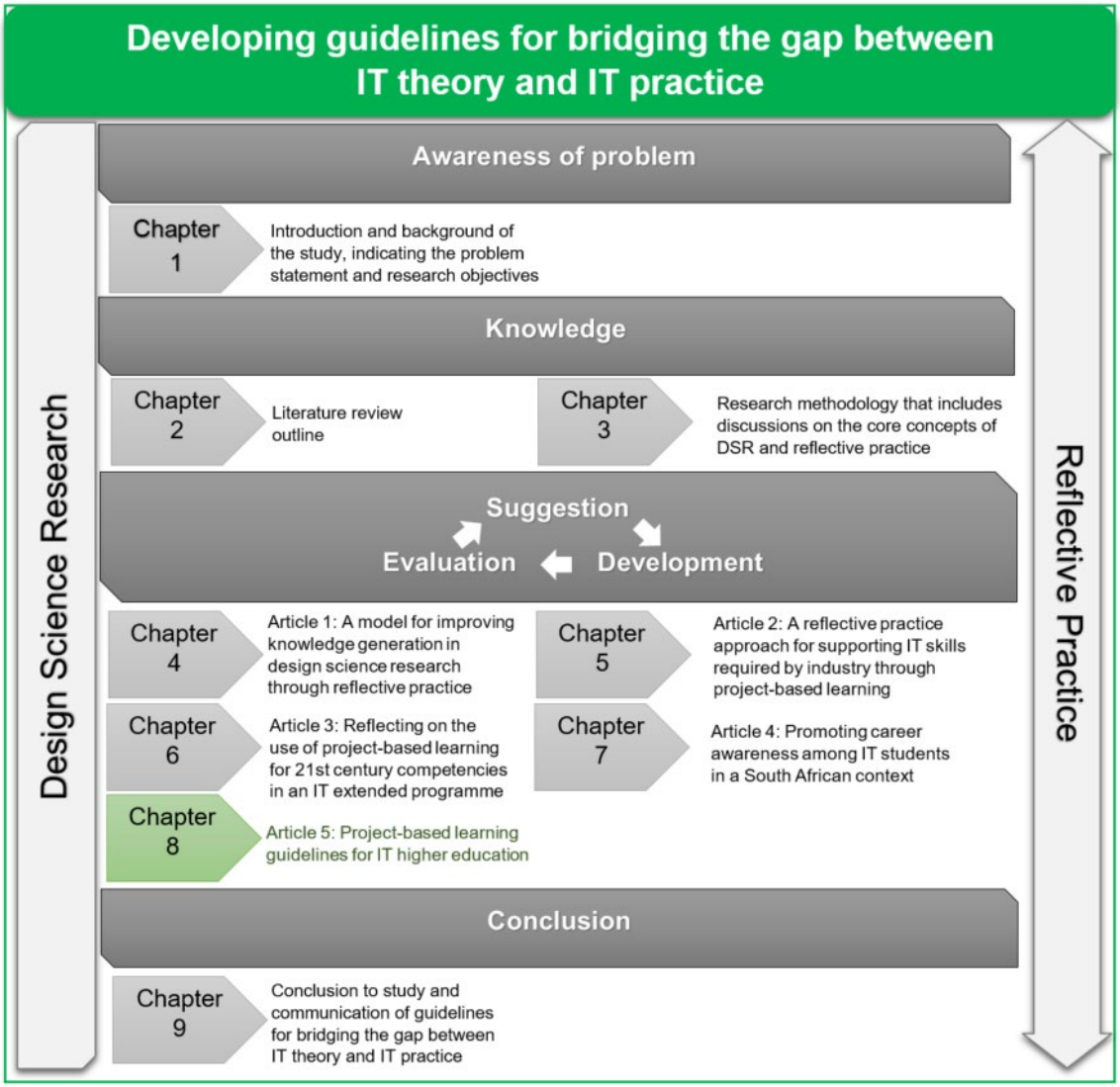
Guideline	Description
Encourage partnerships between the university and industry organisations	Invite industry members to take part in an advisory board to ensure that the curriculum is current and relevant. Arrange guest lecturers on current industry topics that are relevant to a project scope. Provide opportunities hosted in collaboration with industry, such as competitions where the prize is an interview at the company. Arrange internships as reward for developing the best project according to an industry brief. Arrange job-shadowing days on the premises of the industry-partner. More often, industry partners are willing to take part in these activities because it gives them direct access to top performing students.
Industry involvement should take place from day one	It is natural to start implementing industry interventions at exit-level with the aim of 'last-minute' rectifications towards bridging the IT theory-practice gap. This is, however, not a long-term solution as learning needs to be nurtured continuously for reflective practice to take place. Exposing students to industry interventions from their first year of study can only improve their career awareness, by highlighting their preferences earlier, and making them aware of their skills that need further development.
Industry buy-in is crucial for	Lecturers cannot attempt to promote career awareness on their own. They do not necessarily have the extended IT experience to provide industry insight. It is crucial to have support from at least one IT

continued support	company. This may mean having repeated meetings to understand the value of the partnership. One way of fostering a relationship with industry is asking them to provide input on IT graduates' shortcomings, and improving the curriculum to address their concerns. When companies experience positive collaboration targeted at their needs, they will become increasingly involved.
Provide industry training for lecturers	In many instances, lecturers were students who became academics through postgraduate studies, and rarely have any industry experience. Especially in a fast-changing field such as IT, it is difficult for lecturers to keep abreast with new developments if they are not actively involved in the field. It is recommended that IT lecturers should continuously take part in in-field training and workshops – so that they, in turn, can provide improved instruction to future IT graduates.
Provide career fairs and seminars	Organise a full-day IT seminar with multiple companies, where they provide an overview of their business operations and available opportunities. Career fairs and seminars provide insight into industry expectations, highlight available job opportunities, encourage self-reflection on own skill levels, and are an eye-opener in terms of the diverse careers available in IT. Other sessions that could be included in career fairs or seminars are panel discussions with recent IT graduates to share their experiences, and workshops/crash courses on industry-relevant IT concepts.
Provide exposure to working environments	Encourage attendance at company-hosted hackathons. Share known job opportunities with students on the university's learning management system. Make opportunities available for site visits.
Provide opportunities for work-integrated learning/ work-based learning/ work placements	The value of WIL, WBL and work placements is evident in literature, and creative approaches for its implementation could be suggested. If purposeful collaboration with local companies can be achieved, possible partnerships can take place for vacation work, or for easier access, projects could be managed on location at the university if the company allows it.
Assign an industry-orientated educator to facilitate the process	Not all lecturers are equally interested in student development. For some, lecturing is a calling, and for others, it is merely a vocation. Finding a passionate educator who will manage the process of organising industry seminars, accompanying students to IT hackathons, and sourcing project scopes that conform to industry standards is central to the success of an intervention strategy. This may mean that involved lecturers will require a reduced teaching load in order to do industry research.

These guidelines are expressed in a generic manner, implying that they can be applied in any discipline when guidance is needed on how to involve industry in higher education.

The next chapter contains an article that provides guidelines for project-based learning specifically when used in IT higher education.

CHAPTER 8: PROJECT-BASED LEARNING GUIDELINES FOR IT HIGHER EDUCATION



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Preamble to Article 5

Article 5 is entitled *Project-based learning guidelines for IT higher education*. This article was pending submission to an accredited journal at the time this thesis was published.

This is the final article presented in this research study. The article comprises literature reviews that address the background and context of PBL in IT higher education. This article is a result of reflecting on the experiences of using PBL in context of entry-level and exit-level IT students throughout this study. The novelty of this paper lies in a set of guidelines that is presented in Section V, which can be used to guide the use of project-based learning specifically for IT projects in IT higher education. The implementation of the guidelines in context of three projects is provided in Section VI to demonstrate its effectiveness. The guidelines derived in this paper compliments the primary objective of the study by contributing to guidelines that can bridge the gap between IT theory and IT practice.

Project-based learning guidelines for IT higher education

ABSTRACT It is extremely difficult to adapt higher education at the same pace as the fast-changing nature of the information technology (IT) sector. Creative ways are needed to accommodate the continuous changes in the IT industry, without needing to change the structure of the curriculum. As the IT industry comprises of project teams in project environments, a suitable instructional approach for IT higher education is project-based learning (PBL). A project-based learning strategy also allows for the instruction of current technologies to be implemented with relative ease within its boundaries. As PBL can be adapted to include current and relevant technologies in the IT industry, it also contributes to skills development that is required in the IT industry. General guidelines and characteristics for project-based learning are followed across the board for all disciplines on a trial and error basis. Some guidelines may not be directly applicable to IT higher education, while other needed guidelines do not exist because they are domain-specific. The purpose of this paper is to present guidelines for project-based learning that is specifically relevant to IT higher education. The guidelines are formulated using popular characteristics of project-based learning from literature and adapting them to the context of IT projects, and additional guidelines are added based on specific requirements of IT projects that are relevant to professional practice. A literature review matrix is presented as evidence of sources where the guidelines were adapted from. Three demonstrations of project-based learning in IT higher education are presented to demonstrate the utility of the proposed guidelines. A reflection on the learning experience follows each demonstration and informs improved practice for the next. The project-based learning guidelines for IT higher education can be used by educators who find it challenging to assess whether they are implementing a suitable PBL approach. Additionally, following the guidelines may contribute towards bridging the skills gap between IT higher education and the IT industry.

INDEX TERMS Project-based learning, information technology, higher education, guidelines.

I. INTRODUCTION

The goal of this article is to formulate guidelines for effectively using project-based learning, specifically in the information technology (IT) higher education sector. The need for the guidelines is emphasised in research that indicates how challenging it can be for facilitators to assess whether they are implementing an acceptable approach to project-based learning (PBL) [1, 2]. Without clear guidance of what a project-based learning strategy should resemble, it is challenging for facilitators to evaluate the quality of their PBL approach, or to understand where improvement is needed [3]. More so, "education policymakers are increasingly demanding evidence to guide decisions about whether to adopt an educational reform or instructional innovation" [3].

Project-based learning emphasises deeper learning to develop skills relevant to university life and future careers [4, 5]. The goals of a PBL approach align well with the development of higher-level thinking skills and interpersonal skills [3]. Specifically in IT higher education, project-based learning shows evidence of developing relevant IT skills, teamwork, communication, time management, and collaborating with diverse individuals [6]. Project-based learning is a student-centered approach that targets advanced skills such as analysis, evaluation, and synthesis, but can also be supported by teacher-centered approaches to communicate required knowledge, and to demonstrate specific skills [7].

In this article, a general overview of the background of project-based learning is provided. A discussion on how project-based learning has been applied in IT higher education, and similar fields, follow. This leads into a discussion on the importance of reflective practice in project-based learning. Thereafter, a set of coherent guidelines for project-based learning in IT higher education is presented which were formulated from PBL characteristics in literature, as well as core IT project requirements. The set of guidelines are given in response to the literature that indicates how

challenging it can be to assess whether an acceptable approach to PBL is being implemented without guidance. A demonstration of the application of the guidelines is presented last, using three IT project-based learning examples.

II. PBL OVERVIEW

"Project-based learning is a model that organises learning around projects" [1]. The first foundational introduction of project-based learning was by William Heard Kilpatrick [8], which referred to it as the 'project method', and was inspired by the philosophies of John Dewey [9]. Kilpatrick's idea of the project method centered on "an activity undertaken by students that really interested them" [10]. The activity was typically in the form of a project, with four distinctive student-centered phases: purposing, planning, executing, and judging [11]. Thomas and Kilpatrick both stressed that intrinsic motivation, deeper learning, and student-centered inquiry were central benefits of project-based instruction [12]. Project-based learning (PBL) is based on three principles: learning takes place for a specific context, active participation in the learning process is expected, and learning goals are reached though the sharing of knowledge in social interactions [13]. PBL is an instructional methodology that facilitates student learning through student-centered projects [14], and is often cited as a preferred method to traditional teaching strategies. Comparative studies of PBL and traditional instruction offer insight into the significance of project-based learning as preferred method to master content and relevant skills [11]. However, traditional instruction is perceived to have less management responsibilities than project-based instruction has. Other authors have made the argument that PBL is no more demanding than traditional instruction, can be implemented with limited resources, and within the same timeframe [15]. Project-based learning is seen as superior in some aspects to traditional summative assessment, as it is designed to deliver outcomes not adequately evaluated through traditional methods [14, 16].

Project-based learning often uses performance-based assessments, which provides a platform for evaluating 21st century competencies such as critical thinking, reflection, and problem solving – which are difficult to measure [17]. Project-based learning exposes students to a variety of workplace skills such as communication, teamwork, self-management, flexibility, and collaboration [3, 18, 19]. Through PBL, students learn to be independent by setting goals, planning and organising project requirements, developing collaboration skills, and learning at their own level [20]. Project-based learning can be an effective learning tool for lower achieving students, "students with special needs, low-income students, and students with limited English proficiency" [3]. PBL has been used in many different environments, ranging from primary school, to secondary school, to higher education [12]. PBL is inquiry-based instruction where authentic, real-world problems drive the learning context and lead to meaningful experiences [15, 21]. The value of project-based learning lies in the construction of a concrete artefact or end product [12, 22, 23]. The skills trained through artefact creation assists in self-regulation and taking ownership of the learning process [24], with the aim of students becoming self-directed whilst applying higher order thinking skills [11]. PBL delivers increased levels of student engagement, problem-solving skills development, transferability of skills, and an improved interest in the subject matter [1, 25]. Successful project-based learning relies on the facilitator's ability to provide motivation, guidance, and scaffolding appropriate to the context of the students [12]. Facilitators who support the development of skills, instead of focusing on standard assessment achievements, can more easily implement and align with a PBL curriculum, however, developing a coherent PBL curriculum is one of the most difficult aspects of project-based learning [3]. A literature review of interdisciplinary project-based learning as an instructional method for a variety of undergraduate engineering and computer science degrees highlighted the need for collaboration with industry for skills development, embedding employability skills in curriculum planning, and developing effective methods for assessing employability skills [26]. Project-based learning has been widely adopted to develop employability skills in universities, indicating that discipline content need not be sacrificed for the development of employability skills when project-based learning is used effectively.

III. APPLICATIONS OF PBL IN IT HIGHER EDUCATION

The use of PBL is popular in engineering, computer science, and information technology degrees due to the expected artefact creation that is typical of these project-based environments. One example is a model for project-based learning that was implemented in two engineering subjects [27]. Seventy students provided feedback on the impact of the PBL strategy taken. The study concluded that team-based PBL is a suitable pedagogy for improving student engagement, and supporting skills such as problem-solving, report writing, and critical thinking. Project-based learning is a practical approach to skills development in any field and can be used to evaluate the skill levels of students in a collaborative environment that simulates an industry setting. A PBL approach in computer science provides an environment to practice and develop workplace skills that are challenging to simulate in traditional lecture settings [28]. PBL promotes professional skills, discipline and time management skills, in a similar manner as the professional world would demand. For IT projects, the use of agile methodologies to manage PBL teams in computer science education is recommended [29].

Project-based learning does have challenges in its implementation, specifically the manner in which tasks are divided amongst teams in a project, as there is a perceived dissatisfaction in teams where two or more women are grouped with men [30]. Male students tend to take on the role of programmer, while female students are tasked with the role of documenter. Men are more likely to gain technical experience through PBL activities, while women more often build on project management and communication skills [30]. While the acquisition of any new skills is a step in the right direction, the structure of PBL activities should ensure that technically skilled students are also produced from the historically underrepresented groups in computer science and engineering. A gap between academic education and the role of the university was also noted [29]. The authors were surprised that excellent programmers failed the degree due to poor perceived academic performance, while students who struggled with coding passed the degree based on good academic performance. This issue emphasises the need for more practical based curriculum in IT degrees, considering that the field of information technology is constantly evolving. Research on the benefits and challenges of project-based learning in IT higher education needs further development.

The use of projects in IT higher education is expected due to the fact that the IT industry is comprised of project environments [31]. This suggests that a project-based learning environment has the potential to not only train technical IT skills, but also contribute to a robust understanding of entrepreneurship, data analysis, computational thinking, critical thinking, creativity, and other 21st century skills. Project-based learning is a suitable pedagogy that can address the IT skills gap experienced worldwide [32-35], as it supports the IT graduate's development through real-life experiences [31]. For best practice, a project-based learning environment should encourage continuous reflective practice for professional development [3, 36, 37].

IV. REFLECTIVE PRACTICE IN PROJECT-BASED LEARNING

At its core, project-based learning is a reflective practice approach to solving a project-based problem. In PBL, active engagement and reflection contributes to experiential learning as students need to collaborate on, and contribute to, the outcome of the project [22]. It is difficult to assess the reflection that takes place on learning [6], but research continuously places emphasis on the importance of reflection, self-evaluation, and peer assessment in project-based learning [20, 37-39]. It is crucial to make time for "students to reflect deeply on the work they are doing and how it relates to larger concepts specified in the learning goal" [39]. Students' conceptual knowledge is developed through a systematic process of documenting the learning process, and reflecting on the experience [40]. It is important that both the learner and the facilitator take time to reflect. "Throughout a project, students - and the teacher - should reflect on what they're learning, how they're learning, and why they're learning" [37]. Reflection can take place through methods such as autoethnography and reflective journaling [41].

Students should be encouraged to think about what they are doing while they are doing it, and after they have done it, to improve the manner in which they will address similar problems in future [42]. This approach of dual reflection is referred to as reflective practice. Reflective practice is a professional learning and development strategy focused on improving practice. It is "a dialog of thinking and doing through which I become more skilful" [42]. Even when professional practitioners engage in problem solving, they do so through reflection. Research on the implementation of project-based learning strongly suggests that the reliability of a PBL strategy centres on its contribution to professional development [3]. Reflective practice is central to professional development, and is considered as a method to transform implicit knowledge into explicit knowledge through experience [43]. For this reason, reflective practice is considered central to the success of a project-based learning strategy, towards cultivating professional development in students.

V. GUIDELINES FOR PBL IN IT HIGHER EDUCATION

Thomas [1] made an observation two decades ago that is still problematic today – "there continues to be a lack of consensus on what constitutes PBL" [3]. Condliffe and colleagues [3] recommend aspects to be cautious of when constructing design principles for PBL:

- Design principles should be measurable,
- Design principles should address both content and assessment,
- Design principles should be informed by practice,
- Research on design principles should investigate adaptation.

Following the recommendations made above, Table 1 provides a coherent set of guidelines that can be used for effective project-based learning in IT higher education. It is important to note that there are limited PBL guidelines specifically for IT education in the literature, where most only exist from research that applies generic PBL principles. As such, the guidelines presented below were formulated using the general characteristics of what

constitutes good PBL, and were adapted to the scope of information technology projects. Additional guidelines that are specific to IT projects were added for value. The aim of the guidelines, if implemented properly, is to ensure greater alignment between IT higher education and the IT industry. This in return will develop the necessary skills that make IT students more employable.

TABLE 1: PBL guidelines for IT higher education

PBL guidelines for IT projects in higher education	[44]	[45]	[46]	[3]	[12]	[36]	[2]	[20]	[37]	[22]	[23]	[47]	[38]	[14]	[1]	[48]	[49]
The primary objective of a PBL environment for IT students is to focus on *improving specific 21st century competencies* and *IT skills*.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Project-based learning is central to the IT curriculum, and is not viewed as a separate activity at the end of a module.	x	x	x	x		x		x				x		x	x	x	x
Every IT project has specific educational goals as set out in the curriculum.	x	x	x	x						x		x			x	x	x
An IT project in a PBL environment is designed to encourage reflective practice in both the student and the facilitator.			x	x	x	x	x	x	x	x		x	x	x	x	x	x
For an IT PBL environment to be successful, support is needed from colleagues and faculty management.	x	x			x	x						x		x			x
The scope of an IT project should be *significant*, *realistic* and *industry-related*.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
IT students should be allowed to have a voice and choice *appropriate to the context* of the project.	x		x	x	x		x	x	x	x					x	x	x
IT projects should result in IT artefacts.	x	x	x	x		x	x	x		x	x	x		x	x	x	x
The use of appropriate technology in IT projects is *expected* and not a nice to have.	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
The project scope should be well defined with enough time allocated for in-depth inquiry.	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x
An IT project should start with a driving question that makes the student think about the project over a period of time before actually starting with the creation of an artefact.				x	x		x	x	x	x	x		x	x	x	x	x
Intrinsic motivation for IT students and the need to know are re-enforced with tools such as guest lectures from industry or building *real* solutions for *actual* projects.				x	x	x	x	x	x	x		x	x		x	x	x
Facilitator guidance should be appropriately managed with scaffolding sources that further improve the *need to know* of the student.	x		x	x	x	x	x	x		x	x	x	x	x	x	x	x
Teamwork is emphasised to simulate working environments in the IT industry.	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x
Learning by doing is emphasised through active participation throughout the IT project	x	x		x			x						x	x	x	x	x
Time management is crucial in IT projects.	x	x	x	x	x		x	x	x	x			x	x	x	x	
Use appropriate agile methodologies to manage IT teams.		x	x														
Encourage the use of source control software to manage and track code changes, and to determine team member contribution.	x																
User stories will guide the creation of simplified software requirements in an IT project		x	x														
Assessment practices for IT projects should include critique, revision, and rubrics.	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x
Motivation to deliver quality IT projects is improved when external audiences such as community or industry members are involved and act as evaluators of the artefact.		x		x	x	x		x	x	x	x	x		x	x		x

A discussion of the guidelines in context of IT higher education follows, and is structured according to the process flow in Figure 1.

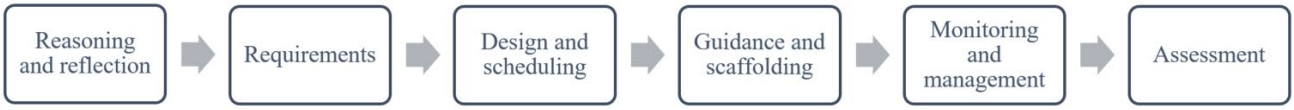


FIGURE 1: PROCESS FLOW FOR PBL GUIDELINES

A. REASONING AND REFLECTION

Guidelines that form part of the *reasoning and reflection* criteria provide context to the objectives of adopting a project-based learning strategy.

The primary objective of a PBL environment for IT students is to focus on *improving specific 21st century competencies* and *IT skills* - Before planning a project-based learning activity, ask yourself, "which skills do I hope will be developed through this PBL activity?" The nature of a project-based learning environment lends itself to skills development, but it is up to the facilitator to determine which skills need to be developed. As a PBL environment resembles an IT industry environment, specific skills development activities can be incorporated with relative ease. For example, weekly demonstrations to train soft skills, and specific development platforms to train technical skills.

Project-based learning is central to the IT curriculum, and is not viewed as a separate activity at the end of a module - When planning to use a project-based learning approach, you need to begin with the end in mind. The project is the central activity in the module, and all other activities are planned in such a way that it supports the development and improved outcome of the project. Educators tend to go about their semester in the traditional manner, and then add a project that covers some of the aspects that were discussed during the semester. This is not the correct approach to PBL (as indicated by Thomas). A successful PBL strategy is goal-driven, and is built around the project.

Every IT project has specific educational goals as set out in the curriculum - All modules that form part of a degree have module outcomes. Furthermore, all study units that form part of a module have study unit outcomes. When formulating your project-based learning activity, you should take cognisance of the learning outcomes that need to be met. This is an important element that forms part of the administrative documentation of the institution, where a coherent strategy must be documented demonstrating how module objectives were met.

An IT project in a PBL environment is designed to encourage reflective practice in both the student and the facilitator - A project-based learning activity is formulated through reflective practice, and encourages reflective practice. PBL activities for IT projects aims to improve the professional development of the student, by guiding the student to become a reflective practitioner. The PBL environment also improves the reflective practice of the facilitator, who needs to adapt her problem-solving skills in the context of each individual project.

B. REQUIREMENTS

Guidelines that form part of the *requirements* criteria provide context to aspects that need to be considered before planning a project-based learning activity.

For an IT PBL environment to be successful, support is needed from colleagues and faculty management - Faculty support is important when specific tools and platforms are required. You may also need other consumable resources such as brown paper and stationery for creative planning sessions. Support may also be needed when the facilitator wants to attend workshops or industry training sessions to improve her own skills related to facilitating the project-based learning activity. Support from colleagues may be required in the form of evaluation assistance, as assessing PBL artefacts can be time-consuming.

The scope of an IT project should be significant, realistic and industry-related - It is recommended to use industry project scopes as part of a project-based learning environment for IT students. Using authentic project briefs will encourage the commitment students have towards completing the project. Community projects are also ideal for PBL activities if there is a need in the community, because the students then feel that they are contributing to a real solution. If it is not possible to obtain a project scope from industry/ the community, do market research on industry-relevant topics that are currently in the headlines, preferably using wicked problems that will develop the critical thinking and problem solving skills of the student.

IT students should be allowed to have a voice and choice appropriate to the context of the project - Entry-level and exit-level IT students are motivated by different types of projects. For entry-level students, consider using a voting platform where students can suggest, and then vote for, the project scope that they would like as a topic. The facilitator should shortlist the topics based on their suitability and relevance to most/ all students. For exit-level students, a multifaceted project scope can be used that explains the industry problem in context of different role players, where an

administrator might need a desktop application, a client might need a web application, and a driver might need a mobile application. The student can then choose which role player's problem s/he wants to solve.

IT projects should result in IT artefacts - A demonstrable artefact is expected at the end of an IT project-based learning activity. These include, but are not limited to, software documentation, systems, applications, and research reports.

The use of appropriate technology in IT projects is expected and not a nice to have - It is important to integrate authentic software and tools as part of your IT project-based learning activity. From the market research you've conducted to determine which tools and software are appropriate, you should be able to make a list of requirements for faculty management. For IT degrees, faculties usually have specific budgets available for upgrade and maintenance of the IT infrastructure. Some technology stacks offer educational licenses, such as Visual Studio. There are also open source platforms that are widely used and that can be implemented, such as Python.

C. DESIGN AND SCHEDULING

Guidelines that form part of the *design and scheduling* criteria provide context to aspects that should be implemented while planning a project-based learning activity.

An IT project should start with a driving question that makes the student think about the project over a period of time before actually starting with the creation of an artefact - The driving question is a neutral open-ended question that will lead students to investigate processes or procedures that might be useful for the PBL activity. The driving question is given at the start of a module, or before the project commences, to focus the direction of the investigation. An example of a driving question is, "where can I host a website for free that will include free database storage of at least X megabytes per month?" Students will start researching possible hosting platforms without needing to know what the project is about. The open-ended question will also keep them thinking about the project, holding interest and motivation for when the project scope is released.

The project scope should be well defined with enough time allocated for in-depth inquiry - There should be no ambiguities in the project scope. This does not necessarily mean that you need to provide a bullet list of instructions. An effective manner of structuring briefs for IT projects is in narrative format. Write a problem statement from the views of the respective role players in the project. The time allocated to completing the project should be fair, and can only really be assessed through active involvement of the facilitator. IT projects are generally scheduled between 4-6 weeks (depending on the scope), with the assumption that the students have dedicated development time during every week where facilitator guidance is available.

D. GUIDANCE AND SCAFFOLDING

Guidelines that form part of the *guidance and scaffolding* criteria provide context to the manner in which the facilitator should provide support and direction in the project-based learning activity.

Intrinsic motivation for IT students and the need to know are re-enforced with tools such as guest lectures from industry or building real solutions for actual projects - For increased motivation, arrange an industry guest lecture that accompanies the industry project scope. Students are inspired by practitioners, and will reflect deeply on the experience. Real projects for real clients also improve motivation to complete the project, especially community projects that are completed with the aim of alleviating a real problem. For example, a local animal shelter that requires a free website where they can upload pictures of pets that are up for adoption.

Facilitator guidance should be appropriately managed with scaffolding sources that further improve the need to know of the student - When structuring project scopes, make sure to add web links to resources that will be useful to complete the project. Also provide links to other similar projects, or similar problems experienced, to motivate the student's search for solutions. As part of the planning for a PBL activity, the supporting activities can also be scaffolded in such a way that an important piece of information is revealed every week to maintain the interest of the students.

E. MONITORING AND MANAGEMENT

Guidelines in the *monitoring and management* criteria provide guidance for important aspects that should form part of IT projects towards the professional development and employability of the IT student.

Teamwork is emphasised to simulate working environments in the IT industry - Where possible, team projects should be incorporated when using project-based learning. The IT industry comprises of IT teams that create IT projects. Students need to work in teams where they are unfamiliar with their team members. Working with new people will develop teamwork and time management skills, more so than working in teams with friends. A suggested number of members per team is 4 – taking on roles such as the business analyst, back-end developer, front-end developer, and database administrator.

Learning by doing is emphasised through active participation throughout the IT project - Project-based learning aims to encourage student reflection. There is a transition from 'knowing through making' the artefact, to 'learning by doing' what is best practice for developing artefacts. Students that do not actively participate in the project will miss out on the chance to learn from peers and mentors in a controlled environment.

Time management is crucial in IT projects - One of the biggest challenges for IT graduates is to adjust to the demanding deadlines of the IT industry. Training time management is essential in an IT PBL activity, and can be coached by setting time constraints on different activities that form part of the project, weekly feedback sessions, and time boxing demonstrations so that students learn how to highlight the most important items in their projects first.

Use appropriate agile methodologies to manage IT teams - IT companies use agile development methodologies, such as DevOps, Extreme Programming, Scrum, and Kanban, to manage their workflow. Educating students on the methodologies that are available, and providing training in at least one method is recommended. For example, Scrum is a useful methodology that demonstrates how to plan backlog items, sprints, and daily stand-up meetings. The approach can be supported by using a visual work-pull system such as a Kanban board that tracks the progress and contribution of all team members. Brown paper sheets and sticky notes work well for a tactile display, or alternatively an online platform such as Trello can be used.

User stories will guide the creation of simplified software requirements in an IT project – Creating user stories is a standard approach to defining software requirements for a system. A user story typically describes the type of user, what the user wants to do, and why the user wants to do it. From a user story, functional and non-functional requirements of the system can be specified. To mimic professional practice, it is important to emphasise the development of core functional requirements first. For example, if the client wants an online booking system for their hotel, the core functional requirement of the system would be the ability to *make a booking.* Items such as e.g. registration and login features are secondary, and should be focused on *after* the booking item is functional. Discourage the development of unnecessary 'nice to haves' that were not part of the project brief, or postpone development thereof until all core functional requirements have been implemented first.

Encourage the use of source control software to manage and track code changes, and to determine team member contribution - A standard requirement in IT practice is the use of source control. Source control, or version control, is a software program that manages and tracks code changes, providing a history of code that was developed, logged, and merged. The benefits of source control include access to previous versions of a project that was in workable condition, and shared access in teams to work on the same code. Examples of source control platforms are Git, Azure DevOps, and BitBucket. In IT student projects, the extended benefit of implementing source control, is the ability of the facilitator to see how long the team has been working on the project, and who has been working on the project. The software keeps track of the dates when code was committed, and by who the code was committed. Another benefit is that students cannot use the excuse that "my project was working just this morning", because your response will be "then run your previous code commit that was working on your source control platform".

F. ASSESSMENT

Guidelines that form part of the *assessment* criteria provide recommended evaluation practices for IT projects.

Assessment practices for IT projects should include critique, revision and rubrics - Project assessment during development should include 5-10 minute stand-ups where a student/ team highlights what has been completed so far, items that were struggled with, and what needs to happen next. This activity develops their verbal communication and presentation skills. It is recommended that every project brief should have an accompanying project rubric. A detailed

rubric provides the students with a checklist of items that need to be completed, and eliminates the possibility of inconsistent marking as all students/ teams are scored using the same criteria.

Motivation to deliver quality IT projects is improved when external audiences such as community or industry members are involved and act as evaluators of the artefact - It is recommended that public audiences take part in the evaluation of the final artefact. Students will be motivated to produce quality artefacts when they know that members from the industry will be evaluating their work, and in turn, this will provide industry with an opportunity to scout for talent. When using community projects, members from the community can also be invited to evaluate the artefact. Careful consideration should be given to how the marks are awarded when using novice or unknowledgeable judges from the community. If you are unable to arrange public audiences, ask colleagues for assistance with evaluating the projects. An unfamiliar face will encourage professional demonstrations.

VI. APPLICATION OF GUIDELINES IN IT PBL EXAMPLES

In this section, three demonstrations of how the PBL guidelines could be implemented in the context of IT higher education are presented. A background of each project is provided first. The first two projects demonstrate partial application of the guidelines, and the last project demonstrates full application of the guidelines. Each demonstration is followed by a reflection on the outcome of the project, which in turn highlights concerns to take note of, as well as recommendations for best practice.

A. DEMONSTRATION 1: MOBILE APPLICATION FOR NON-PROFIT ORGANISATION

An apolitical non-profit organisation approached the local university to assist them with developing a mobile application (app). The mobile app would be distributed to the local community to report and manage service delivery concerns not addressed by the municipality. The project brief was given to a team of 13 exit-level IT students as part of a project-based learning activity. The PBL activity was seen as an opportunity to contribute to a community project, to develop their IT skills, and to gain work-related experience that could be added to their curriculum vitae's (CV's). Table 2 provides an overview of how the PBL guidelines were implemented in this project.

TABLE 2: Demonstration 1: Partial application of guidelines

PBL guidelines for IT projects in higher education	Mobile application for local non-profit organization to report and manage service delivery issues
Reasoning and reflection	
The primary objective of a PBL environment for IT students is to focus on *improving specific 21st century competencies* and *IT skills*.	The project reinforced soft skills such as written and verbal communication, presentation, research, time management, and team work. Technical skills were trained through the use of specific platforms for front-end, and back-end development, database administration, and integration of the system components.
Project-based learning is central to the IT curriculum, and is not viewed as a separate activity at the end of a module.	The project brief was released in an IT capstone module to selected high academic achievers. The module centers on project-based learning, as the students that are enrolled for this module complete four IT projects during a semester as part of formative and summative assessment.
Every IT project has specific educational goals as set out in the curriculum.	The project brief satisfied the following (among other) educational outcomes of the IT capstone module: • Advanced ability to effectively implement all practical skills acquired during the course of the degree with a view to prepare the student for industry, • Ability to communicate effectively in a variety of formats (oral, written, visual and electronic) to diverse audiences and for various purposes such as demonstrating projects, • Ability to interact and collaborate effectively with others, and to work as part of a team, in diverse social, cultural and linguistic contexts.
An IT project in a PBL environment is designed to encourage reflective practice in both the student and the facilitator.	The project was challenging for the students to complete. They needed to reflect continuously to find solutions for problems that surfaced during development. The project leader also had to engage in reflective practice to continually adjust the manner in which guidance was given to the students. Both the student team and team leader, reflected on the outcomes of the project, post demonstration.
Requirements	
For an IT PBL environment to be successful, support is needed from colleagues and faculty management.	The non-profit organisation initially contacted the department management. The project was delegated to the IT capstone module. A staff member (who was not the lecturer of the module) was assigned as project leader. Meetings were held continuously between the lecturer, the project leader, management, and members from the organisation. A separate venue was made available for the team, where students could collaborate and set up a server specifically for this project.
The scope of an IT project should be *significant*, *realistic* and *industry-related*.	The project brief required a mobile app to be developed that could be distributed to the local community to report and manage service delivery concerns not addressed by the municipality. A requirement for the mobile application was that it should have online functionality, as well as offline functionality for community members that did not have access to data coverage while travelling. Once the person was able to access data coverage, the information saved in offline

	mode would be uploaded and sent to the organisation.
IT students should be allowed to have a voice and choice *appropriate to the context* of the project.	The project requirements were specified before releasing the brief. Selected students could choose whether they wanted to participate in the project, and the students could choose an appropriate platform for the mobile app by substantiating the choice through research.
IT projects should result in IT artefacts.	The IT artefacts that were delivered in this project was a mobile application, as well as supporting project documentation.
The use of appropriate technology in IT projects is *expected* and not a nice to have.	Students had access to a venue with dedicated computers for this project. A Linux server was set up specifically for this project. Students selected Faveo as a development platform, as it is a ticket-based support system built using the Laravel framework for PHP.
Design and scheduling	
An IT project should start with a driving question that makes the student think about the project over a period of time before actually starting with the creation of an artefact.	A specific driving question was not provided. The selected students did however receive a short verbal summary of the project idea when they were recruited. Once the project commenced, some students already contributed valuable ideas to the project – indicating that they had reflected on what was expected prior to project commencement.
The project scope should be well defined with enough time allocated for in-depth inquiry.	After the first meeting with management, the verbal discussion around the project idea and requirements were outlined in a project brief. Students had approximately 10 weeks to deliver the artefact and accompanying documentation.
Guidance and scaffolding	
Intrinsic motivation for IT students and the need to know are re-enforced with tools such as guest lectures from industry or building *real* solutions for *actual* projects.	No guest lectures were provided for this project. Students were motivated to take part in the project as it was a solution to be implemented to assist the local community.
Facilitator guidance should be appropriately managed with scaffolding sources that further improve the *need to know* of the student.	The project leader was an experienced programmer, who assisted students with development questions, and referred students to sources they could use to complete the project.
Monitoring and management	
Use appropriate agile methodologies to manage IT teams.	The project leader implemented Scrum to manage the workflow of the team. He did however indicate that he was not familiar with how the agile methodology worked, and only implemented a partial understanding of the process.
Teamwork is emphasised to simulate working environments in the IT industry.	A dedicated team of 13 students were assigned to the project. 15 students were originally selected based on their marks and diverse backgrounds. 2 students opted not to participate in the project. The team could use the dedicated venue provided for them to collaborate on the project, simulating an IT industry environment.
Learning by doing is emphasised through active participation throughout the IT project	As the project progressed, some students started contributing less to the project. This was reflected in their marks, as well as in their soft and technical skills post project – indicating that the students who actively participated had a deeper learning experience.
Time management is crucial in IT projects.	A deadline was given for the project, where the mobile app was demonstrated to the public during a marketing event of the university. The internal deadlines were however not abided by, as the students spent most of the last week before demonstration trying to finalise the project, and ended up demonstrating a partially functional artefact.
Encourage the use of source control software to manage and track code changes, and to determine team member contribution.	Students were required to use GitHub as a source control platform for both the mobile application, and the project documentation.
User stories will guide the creation of simplified software requirements in an IT project	Students were unaware of the value of user stories for defining functional requirements, and started the project according to the details in the brief.
Assessment	
Assessment practices for IT projects should include critique, revision, and rubrics.	The students had continuous critique and revision, based on feedback received from the project leader. However, a rubric was not compiled for this project. The project leader gave an impromptu mark for each individual student, based on their presentation, and contribution to the project.
Motivation to deliver quality IT projects is improved when external audiences such as community or industry members are involved and act as evaluators of the artefact.	The project was demonstrated at a marketing event hosted by the university. Members from the non-profit organisation, as well as the general public, could ask questions and interact with the mobile application which was pre-loaded on tablets.

When the deadline arrived, the mobile application was not fully functional and could not be handed over to the community partner. The project was considered unsuccessful. Reflecting on the outcome of the project, a few factors contributed to the incomplete artefact, and should be considered when using community projects:

- An assumption was made that students who are high academic achievers would be the best candidates to include in the project. This was not the case, as many of these students demonstrated limited programming skills. This was a concerning experience throughout the project, as the academic achievement documented on their student records did not match the expectation of a working artefact by such 'skilled' students. This issue was raised in the literature review as well. There is a misconception in higher education that strong academic achievement implies strong

domain specific skills. In information technology, this seems increasingly not to be the case. From the thirteen students that were part of the team, only four were directly involved with the development – three male programmers, and one female database administrator. The remaining nine students participated in research and documentation. The balance in this project was not ideal – as the functionality of the artefact rested on the skills of four out of thirteen team members. It is recommended that future community projects, where the resulting artefact is especially critical, are distributed to balanced teams of programmers, documenters, and researchers - regardless of their academic achievement. Skilled students can be identified by asking their previous lecturers for recommendations, reviewing previous projects they had participated in, or perhaps hosting a time-boxed class hackathon where their critical thinking, problem-solving, and technical skills can be evaluated in real time. Alternatively, the project brief can be distributed to all students, resulting in multiple artefacts to choose from. An example of this is discussed in the third demonstration.

- The direct involvement of community partners should be carefully managed. More often, members from the community are not domain experts, or knowledgeable in the field of information technology. This project was the first community project of its kind that the university took part in. There was a level of inexperience on how to manage the involvement of the community partner, and as such, they attended many of the development team meetings for input and feedback. This was a mistake – as their passion for the project was clear, but overwhelmed the inexperienced students, and caused a great deal of confusion and 'back-and-forth' dialog on project requirements during development. The continuous revision of project requirements was not expected prior to starting the project, and added to the missed deadline. In future, the client should not have direct access to the student development team on a continuous basis, apart from pre-planned meetings such as a project overview and motivation before project commencement, one or two feedback session during the project to demonstrate the functionality of core requirements, and hand-over. The client communication should be limited to the project leader – who should assess which information to make the development team aware of. This concern highlights the need to employ sustainable agile methodologies to manage the IT student teams – and the client.

B. DEMONSTRATION 2: WEB APPLICATION FOR INDUSTRY BUSINESS INTELLIGENCE (BI) PROJECT

An industry partner provided a project brief for exit-level IT students. The project required the development of a model-view-controller (MVC) web application which would provide visualisations of, and insights into, a provided dataset. Access to the system needed to be securely managed by user registration and login. The recommended approach was to use ASP.NET Core MVC. However, regardless of which technology stack was used, the industry partner requested that students use a design pattern (preferably the repository pattern) to complete the project. The data was provided in CSV format and required the students to store the data in a NoSQL data source. The project was completed individually as students could enter their project in a competition hosted by the university in collaboration with the industry partner. The competition provided the industry partner with a platform to scout for talent. Table 3 provides an overview of how the PBL guidelines were implemented in this project.

TABLE 3: Demonstration 2: Partial application of guidelines

PBL guidelines for IT projects in higher education	Industry web app BI project
Reasoning and reflection	
The primary objective of a PBL environment for IT students is to focus on *improving specific 21st century competencies* and *IT skills*.	Soft skills such as communication, presentation, time management, and research were trained during this project. Technical skills such as learning how to use design patterns and software architecture were trained.
Project-based learning is central to the IT curriculum, and is not viewed as a separate activity at the end of a module.	The project brief was distributed in an IT capstone module. The module centers on project-based learning, as the students that are enrolled for this module complete four IT projects during a semester as part of formative and summative assessment.
Every IT project has specific educational goals as set out in the curriculum.	The project brief satisfied the following (among other) educational outcomes of the IT capstone module: • Integrated knowledge and clear understanding of, as well as an ability to correctly evaluate and apply new trending technologies to different areas of specialisation within the field of information technology, • Coherent understanding of the different ways of implementing new and trending technologies in the field of information technology, • Ability to be self-directed and lifelong learners, who are able to work independently, utilise resources effectively, and exercise initiative.
An IT project in a PBL environment is designed to	The students were familiar with C# development in a .NET platform, albeit at different skill levels. They constantly had to engage in reflective practice to find resources for creating the solution. The

encourage reflective practice in both the student and the facilitator.	facilitator's reflective practice was engaged during the development process as problems emerged, such as challenging deadlines, and students that struggled to comprehend what was required of them.
Requirements	
For an IT PBL environment to be successful, support is needed from colleagues and faculty management.	As the project relied on a non-relational database, as well as business intelligence features, the facilitator invited the database lecturer and the decision support systems lecturer to assist with queries during the development of the system. The project was an individual project-based learning activity, and the demonstration assessment of 93 enrolled students would be a daunting task. The facilitator requested assistance from additional staff members to evaluate the projects. Six evaluators assisted with the assessment on project demonstration day. The computer laboratory (lab) manager ensured that all the related software requirements were installed.
The scope of an IT project should be *significant*, *realistic* and *industry-related*.	The brief was received directly from an industry partner. The students were made aware that this type of brief would represent typical responsibilities when they entered the workforce. The project brief centred on BI concepts, relevant to the specific department the brief was received from.
IT students should be allowed to have a voice and choice *appropriate to the context* of the project.	The brief suggested preferable platforms that the students should use – as this was relevant to the platforms the industry partners used. However, the brief outlined that the recommended platforms were only a suggestion and that students could ultimately choose which platforms they wanted to develop the solution in.
IT projects should result in IT artefacts.	The project resulted in a web application that had CRUD (create, read, update, delete) functionality. The IT artefact had to display interactive visualisations of the dataset received as part of the project brief. No project documentation was required.
The use of appropriate technology in IT projects is *expected* and not a nice to have.	It was recommended to use ASP.NET which is an open source web framework developed by Microsoft. The software was installed for use in the computer lab. Students could use any tool for data visualisations, such as Power BI which was also installed in the lab.
Design and scheduling	
An IT project should start with a driving question that makes the student think about the project over a period of time before actually starting with the creation of an artefact.	A specific driving question was not given for this project. Instead, the project brief was released to students two weeks prior to the guest lecture. In this way, they could start doing research on the project so that they could ask specific questions to the guest lecturer before commencing with the project.
The project scope should be well defined with enough time allocated for in-depth inquiry.	A detailed project brief was received from the industry partner that outlined the specific requirements the project had to satisfy. Students had approximately 10 weeks to complete the project, however, the project did run concurrently with two other projects for 7 weeks.
Guidance and scaffolding	
Intrinsic motivation for IT students and the need to know are re-enforced with tools such as guest lectures from industry or building *real* solutions for *actual* projects.	A guest lecture was presented on the project scope by an IT practitioner from the industry partner that provided the project brief. The IT practitioner also made a live recording of the presentation that was released to the students for review.
Facilitator guidance should be appropriately managed with scaffolding sources that further improve the *need to know* of the student.	The project brief contained useful hyperlinks to online resources that the students could refer to. The video presentation of the guest lecture was also a helpful resource that students could go back to when they were struggling. The module facilitator, as well as the database lecturer, and the decision support systems lecturer were available for consultation during the project development. The IT practitioner also made herself available via email correspondence. A student peer who was well versed in the technology stack also presented a short workshop for his peers.
Monitoring and management	
Use appropriate agile methodologies to manage IT teams.	The use of an agile methodology was not specified in the project brief.
Teamwork is emphasised to simulate working environments in the IT industry.	The project was completed individually as it formed part of a competition hosted in collaboration with the industry partner. The top three projects were invited for interviews at the industry partner.
Learning by doing is emphasised through active participation throughout the IT project	Students did not actively participate in this project, and spent more time on their first two projects that ran concurrently with this project. Two weeks before the deadline, a student peer presented a workshop in which most of the students participated for last minute attempts at developing the project.
Time management is crucial in IT projects.	As the project deadline arrived it was evident that the students had spent more time on their first and second project which ran concurrently with this project. A decision was made to extend the demonstration deadline by two weeks. The students were able to demonstrate improved quality projects.
Encourage the use of source control software to manage and track code changes, and to determine team member contribution.	The use of source control was not explicitly specified in this project. Some students did use professional source control software, other students used Google Drive as a regular dump site for the projects, and the rest did not use any source control software. This was problematic, as the students that experienced the most problems with demonstrating their projects did not have a previous version committed to a source control platform that they could roll back to.
User stories will guide the creation of simplified software requirements in an IT project	Students were aware of user stories and how to create them, but the activity was not specifically requested during project development. Students used the rubric as a guideline for core functional requirements.
Assessment	
Assessment practices for IT	For this project, there were no specific feedback sessions for critique and revision. A rubric was

projects should include critique, revision, and rubrics.	provided that highlighted the core functionality required of the project. The rubric also assisted in ensuring that the six respective evaluators graded students using the same criteria.
Motivation to deliver quality IT projects is improved when external audiences such as community or industry members are involved and act as evaluators of the artefact.	The project was demonstrated in two parts. Students who wanted an opportunity to work at the industry partner registered for the competition. There were eight students that took part in the competition, and these projects were judged by three IT practitioners from the industry partner. These students received rich feedback on best practice in industry. The remaining students demonstrated their projects on a project day at the university where six evaluators graded their projects. One of the evaluators was an IT practitioner from a different industry partner that acted as external moderator.

Only eight students had the confidence to demonstrate their projects to the industry partner for the competition, of which only one student was female. The remaining projects demonstrated on the project demo day varied in quality. Some students had exceptional deliverables, while other projects presented were only partially functional. Reflecting on the outcome of this project-based learning activity, a few concerns were highlighted:

- These projects are completed as part of a capstone module for "IT developments". Traditionally, a capstone module should test the knowledge and skills developed during the course of a degree, and not repeat any basic information that formed part of other modules. The module outcomes do outline that students should be made aware of new technologies and how they are implemented. However, the experience during this module was that the basic concepts that students (were supposed to have) learned during their first and second year of study needed to be extensively reinforced. There was a misalignment in expected prior knowledge of the students, and the skills they actually possessed. A comment made by a student post project hinted at a possible reason for this, as he indicated how much he was enjoying the capstone module because he had not programmed since his second year of study. This comment is especially concerning in an information technology degree as there should be a consistent balance of theoretical knowledge and practical application through programming activities. The modules that are marked as prerequisites of the capstone module should contain practical exercises that the project-based learning activities can build on. The problem might occur because of a misalignment in previous module content that should feed into the capstone module, or facilitation of the module content, or both. An IT degree as a whole should be seen as a project-based learning curriculum – and if that's the case, the capstone module is the summative assessment of the degree, supported by all other formative modules in the degree that ultimately feed into it. In future, greater effort should be made to ensure alignment between all modules that feed into the capstone module.
- Managing guidance and scaffolding for project briefs received from industry is important, especially if the purpose of the industry project is to create an opportunity to scout for talent. With community projects, the main objective of the project brief is to solve the client's problem – and the manner in which the problem is solved is secondary to this objective. With industry projects, the main objective of the project brief is to test the student's capabilities of completing the project requirements using specific instructions for technology stacks, design patterns, and databases to use. Solving the problem is extremely beneficial, but it is secondary to this objective. The specific technology restrictions might be difficult for the facilitator to communicate as lecturers rarely have industry experience. For this reason, it is highly recommended that a guest lecture from an IT practitioner (that was involved in formulating the brief) is provided for the students. The guest speaker can then also specify to which extent students are allowed to use available tools and templates found online. Students also accept domain specific knowledge more readily from practitioners as there is a shared assumption that practitioners know more about how technology is used in the industry. It is recommended to arrange the guest lecture a week or two after the project brief is released, so that students have enough time to prepare questions on any uncertainty in the requirements.
- Managing IT project deadlines are tricky. If you provide too much time, students think they have too much time, and then only start with the project a week before it is due. If you provide too little time, students constantly complain about all the assignments and tests that they need to complete in the next week or two, and that the deadline is unreasonable. For IT projects, reasonable timelines are between four to six weeks, depending on the scope of the project. However, it is generally experienced that students tend to leave their projects for the last minute – a week or two before the deadline. For this reason alone, facilitator guidance is needed in the form of weekly reviews or feedback – to ensure that the students constantly work on the project. A facilitator cannot take a passive stance and leave the students to deliver the artefacts at the end of the six week period. To mimic professional practice, it is necessary to again emphasise the need for agile methodologies to manage IT student teams. When students need to deliver feedback during weekly sprint reviews, they are forced to *do something* every week.

C. DEMONSTRATION 3: MOBILE APPLICATION FOR LOCAL SQUASH COURT

Committee members from the local squash club approached the capstone module facilitator for the development of an online booking system for their eight squash courts. The then process of court bookings included any member or non-member booking a court telephonically or in person at the club itself. The bookings were written down on a paper-based timetable. The time slots were allocated in 30 minute intervals, however, the normal booking made by users was usually 60 minutes. The bookings were taken by the squash court staff. This method of court bookings was troublesome and had resulted in a loss of income for the club due to various reasons. Students were tasked with alleviating the problem by creating a user friendly application that would simplify the squash courts booking process. There was no funding available for the project, and students had to find creative ways to develop and host the application for free with the least required maintenance.

TABLE 4: Demonstration 3: Full application of guidelines

PBL guidelines for IT projects in higher education	Online booking system for local squash club
Reasoning and reflection	
The primary objective of a PBL environment for IT students is to focus on *improving specific 21st century competencies* and *IT skills*.	This project developed soft skills in the form of problem-solving, critical thinking, communication, presentation, research, time management, and team work. Technical skills were developed through the students' choice of development platform.
Project-based learning is central to the IT curriculum, and is not viewed as a separate activity at the end of a module.	The project brief was distributed in an IT capstone module. The module centers on project-based learning, as the students that are enrolled for this module complete four IT projects during a semester as part of formative and summative assessment.
Every IT project has specific educational goals as set out in the curriculum.	The project brief satisfied the following (among other) educational outcomes of the IT capstone module: • Critical analysis of alternative approaches to software development and the ability to offer value-driven and logical arguments for considered decisions, • The implementation of an appropriate software choice for a specific problem scope and to evaluate the effectiveness of the implementation, • The ability to identify, analyse, critically reflect on and address complex problems related to project development with theory-driven arguments in the form of project documentation.
An IT project in a PBL environment is designed to encourage reflective practice in both the student and the facilitator.	Students had to constantly reflect on whether their selected platforms were addressing the problem, and how they needed to adapt to complete the project. To evaluate the value of reflective writing, the facilitator requested that each student submit a one page self-reflection of their experience with the project. These self-reflections added unquestioned value as the students reflected deeply on their learning experience, highlighting aspects that they fell short on, and would pay more attention to in future. The facilitator also reflected on these documents, realising the importance of the feedback students received during development, and an unexpected repeating thought that students would prefer to be divided into groups with strangers in future. The reason being that they struggled with commitment and output when working with friends.
Requirements	
For an IT PBL environment to be successful, support is needed from colleagues and faculty management.	A request was made to management for expendable items in the form of stationery, sticky notes, and brown paper for hands-on workshops held with student teams to do project planning.
The scope of an IT project should be *significant*, *realistic* and *industry-related*.	A scope was requested from the squash club committee members, which was refined by the facilitator in an appropriate manner for an IT project brief. The project was a realistic scope, for a real client.
IT students should be allowed to have a voice and choice *appropriate to the context* of the project.	The project brief was distributed to the students that outlined the problem statement for the project. Students were to research feasible solutions that would have the least financial impact to host, and require minimal maintenance.
IT projects should result in IT artefacts.	The project resulted in web applications for an online booking system. Accompanying project documentation included a research document outlining their choices for hosting platforms with any fees attached, as well as a user manual for the application.
The use of appropriate technology in IT projects is *expected* and not a nice to have.	Students had access to the generally available software in the computer lab that included Visual studio, Python, Java etc. But they were encouraged to research new technologies that would best solve the client's problem. Other platforms that the students made use of included Google Sites and WordPress.
Design and scheduling	
The project scope should be well defined with enough time allocated for in-depth inquiry.	A project brief outlined the project requirements. Students had six weeks to complete the project.
An IT project should start with a driving question that makes the student think about the project over a period of time before actually starting with the creation of an artefact.	A driving question was provided for this project, two weeks before the project commenced. Students were asked to start thinking about this question: "where can I host a website for free that will include free database storage of at least 100 megabytes per month?" Additionally, students had to write a research report for their previous project, and one of the topics were different types of applications with their advantages and disadvantages. The previous research project ensured

	that students had some related prior knowledge before starting this project.
Guidance and scaffolding	
Intrinsic motivation for IT students and the need to know are re-enforced with tools such as guest lectures from industry or building *real* solutions for *actual* projects.	A guest lecture was not presented for this project, but one of the committee members made himself available via email communication for any questions regarding the brief. Students were also able to visit the squash club to get a feel for the non-functional requirements. Students were motivated by an arrangement made with the chairperson of the squash club, in which he indicated that he would provide commendation letters for the top three projects which the students could add to their CV's.
Facilitator guidance should be appropriately managed with scaffolding sources that further improve the *need to know* of the student.	Scaffolding exercises included a research section on mobile applications in their first project, prior to this project. As part of the project brief, hyperlinks to useful resources were provided to guide their inquiry. During a Scrum workshop, students created user stories to assist with identifying project requirements (see next guideline).
Monitoring and management	
Use appropriate agile methodologies to manage IT teams.	The facilitator hosted a Scrum workshop for the student teams. It was an interactive workshop in which students learned how Scrum works, how to create user stories, and identify core functional requirements as backlog items. Students had to practice the values of Scrum for the duration of the project.
Teamwork is emphasised to simulate working environments in the IT industry.	Teams consisted of four members each. Students could self-select team members. The teams selected one member to be their scrum master. There were 23 teams in total.
Learning by doing is emphasised through active participation throughout the IT project	Active participation was encouraged through the use of a Kanban board. Every team member had to indicate what they were busy with through the big visual brown paper board, by moving backlog items (on sticky notes) to their individual *to-do lists*, then to *started*, *in progress*, and *completed*. Team member contribution could clearly be seen on the Kanban board, which assisted in keeping students honest and committed to the project.
Time management is crucial in IT projects.	To assist with time management, the facilitator acted as product owner for the project. A sprint review was held every two weeks during which the teams had to indicate where they were in the project, what should happen next, and what they were struggling with. These sprint reviews were handled in a similar manner as a daily standup – taking approximately 5 to 10 minutes per team.
Encourage the use of source control software to manage and track code changes, and to determine team member contribution.	Teams were encouraged to use source control but it was not expected. A number of teams did use source control, but many students struggled with the platforms, and ended up using Google Drive as a shared dump site.
User stories will guide the creation of simplified software requirements in an IT project	During the Scrum workshop, students were guided on how to create user stories based on the problem statement of the project brief. From the user stories, the facilitator demonstrated how to identify core functional requirements, a process flow, and sprint goals.
Assessment	
Assessment practices for IT projects should include critique, revision, and rubrics.	Students received constructive criticism (and praise) during the facilitator guided sprint reviews. A detailed rubric was provided that emphasised the core requirements of the project. A section was added to the rubric for items that were grouped under 'bonus marks' – but the rubric specified that bonus marks were only considered if *all* functional requirements were completed.
Motivation to deliver quality IT projects is improved when external audiences such as community or industry members are involved and act as evaluators of the artefact.	The module facilitator graded the projects on a scheduled project demonstration day. The top six projects were invited to improve their projects for an extended deadline to demonstrate the project to the squash club committee members. The committee members were pleased with the outcome, and selected the top three projects to receive commendation letters. The top project has been implemented as a fully functional system used by the squash club.

The project resulted in successful deliverables, and satisfied clients. Learning from previous experiences through reflection - a few adjustments in the PBL strategy contributed to the success of this project:

- Instead of choosing academically strong students in a similar fashion as in the first demonstration, the project brief was released to the entire exit-level IT group. In total, 23 teams created 23 artefacts of varying quality. Six projects were selected after the internal demonstration day, and these teams had an additional four weeks to improve their projects, liaise with the client on any queries etc. The six teams all demonstrated their projects to three representatives from the squash club committee, who chose the three best projects to receive commendation letters. What was not surprising, was that the teams were made up of both academically strong and average achievers, and in most cases the average achievers contributed the most to the development of the artefact. What was surprising (but expected after demonstration 1) is that the skill levels of these students were not reflected in their marks. This highlights a bigger issue that universities might be guilty of, especially in IT higher education, which is that there is too much focus on theoretical work (book smarts) and not enough practical application thereof as expected in an IT degree. The implication of this misalignment is specifically evident when companies are recruiting from exit-level IT students based on a minimum mark. The high achieving students that they are recruiting may not necessarily meet their technical skill demands, and also vice-versa, they might be missing out on ideal programmers for their company based on the perception that their grades reflect their skill level.

- Implementing an agile methodology for IT team management proved extremely successful. Instead of the client having direct access to the students, the module facilitator acted as product owner in the client's stead. This meant that the module facilitator needed to know and understand the project brief very well, as well as the agile methodology. The module facilitator attended a 2-day workshop on Scrum held for in-house staff members of an industry partner (herein lies the benefit of nurturing lasting relationships with industry partners). A shortened version of the central concepts was presented as part of a hands-on workshop with the students – outlining why it is important to use agile methodologies, explaining the scrum process and its events, contextualising the scrum process for how a student team might use it, creating a Kanban board, defining user stories, and identifying functional and non-functional requirements. Student participation and motivation during the workshop was very high, as it was a new process that they were learning that is actively used in industry. Once the project started, sprint reviews under the guidance of the module facilitator were scheduled at the end of week 2 and week 4. During the first sprint review, it was evident that students missed the emphasis on creating core functionality first – with most teams having started with the registration and login pages. To steer students in the right direction, they were told that the first question that would be asked during evaluation on demo day was "Can I make a booking?", and if the answer was no, they would promptly receive 0 for the project. A rubric was also released at this point in which it was highlighted that any additional features would be considered for bonus marks, but *only if the core requirements were functional first*. This strategy proved effective, as all but one team were able to demonstrate booking functionality during the sprint reviews at the end of week 4.
- The use of the brown paper Kanban board with sticky notes played a vital role in keeping students honest about their contributions to the project. The big visual work-pull display clearly indicated who was busy with which parts of the system, who had contributed the most, and who was not contributing at all. In the student reflections, a number of students indicated that they were skeptical of the team project as they knew their friends would 'sponge' on their efforts. They indicated that it was a relief that the Kanban board clearly showed who was not doing their part, that the module facilitator made an effort to put freeloaders on the spot during the sprint reviews, which ultimately made every team member contribute to the project. Only two teams opted to use digital Kanban boards, which was still effective but not as highly visual as the big brown paper boards.
- In this PBL activity, student voice and choice was strongly emphasised through the fact that they could use any platforms that would solve the client's problem at minimum to no cost, and with the least amount of post implementation maintenance. It was however experienced that while students were still experimenting with different platforms during the first sprint review (week 2), the impending doom of a 0 for core functionality not working scared some student teams into using platforms that they were familiar with, and that was not necessarily a cost effective solution.
- The overall experience of this project was very positive, with students indicating that they had learned a lot, and clients indicating that they were pleasantly surprised by the quality of the artefacts presented. The winning team's project was implemented with minor revisions, they received encouraging commendation letters to add to their CV's, and they were ultimately given an additional incentive at the discretion of the community partner.

VII. CONCLUSION

This paper presented a set of guidelines for using project-based learning effectively in IT higher education. The guidelines were formulated from existing characteristics of PBL in literature, and were supplemented with guidelines that are specifically relevant for IT projects. The novelty of the paper rests specifically on the guidelines that were formulated as part of the monitoring and management of IT PBL activities. These guidelines are specific to the IT sector, and emphasises aspects that should be part of IT PBL activities to mimic professional practice.

The need for the guidelines was emphasised in literature, where it was highlighted that educators find it challenging to assess whether a suitable PBL approach is being implemented. Additionally, after reflecting on the demonstrations of the guidelines, it was noted that universities might be placing too much emphasis on theoretical work at the disadvantage of practical experience expected in an IT degree. Project-based learning is a solution towards including more practical content in an IT degree, as well as preparing students for industry. Following the PBL guidelines proposed in this research may contribute towards bridging the gap between IT theory (higher education) and IT practice (industry).

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Article 5: Guideline development

Through the iterative nature of the design science research approach followed in this study, this article adds explicit guidelines towards bridging the gap between IT theory and IT practice.

Article 5 presents guidelines for project-based learning in IT higher education formulated from PBL characteristics in literature, as well as core characteristics that are relevant to IT projects in practice. The novelty of the paper lies in the guidelines that are specific to the IT industry, ensuring that greater alignment is achieved between IT theory and IT practice. The guidelines are grouped according to six steps that can be followed to formulate a PBL strategy. Figure 8.1 provides a high-level overview of the guidelines formulated for project-based learning in IT higher education.

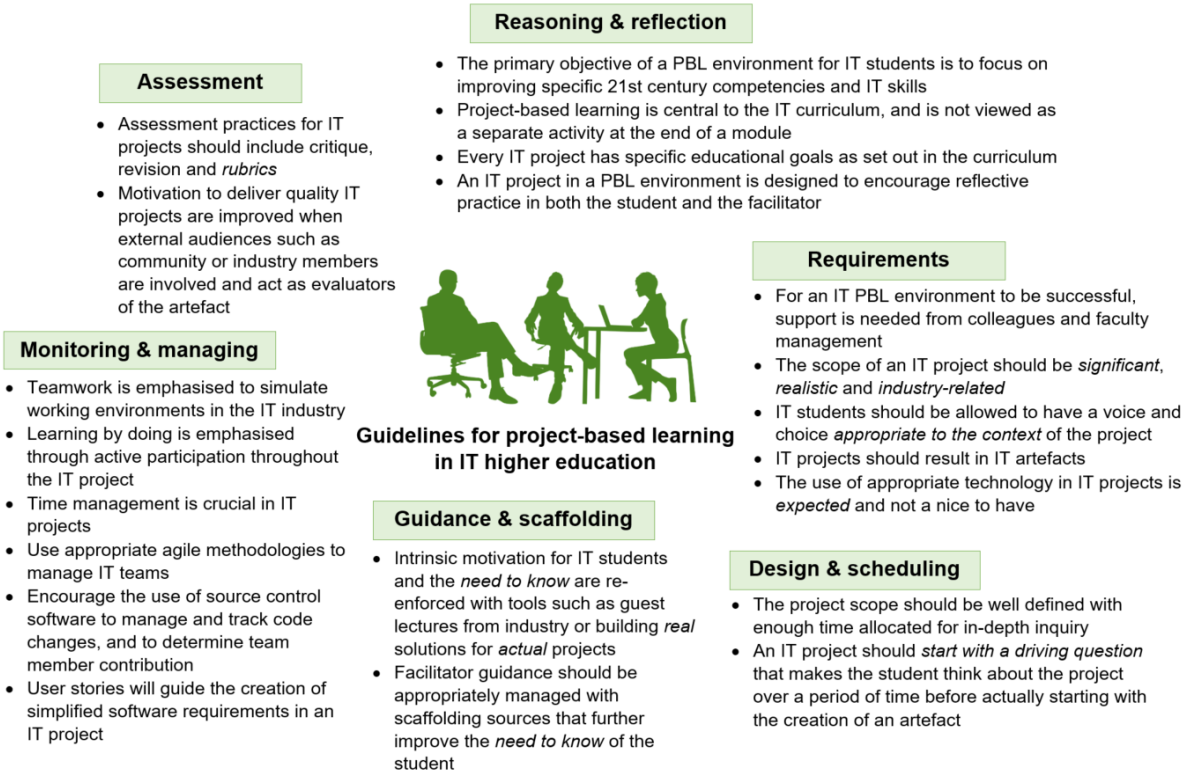


Figure 8.1: Guidelines for project-based learning in IT higher education

Table 8.1 provides a discussion and context on each guideline formulated for the effective use of project-based learning in IT higher education.

Table 8.1: Description of guidelines for project-based learning in IT higher education

Reasoning and reflection	
Guideline	**Description**
The primary objective of a PBL environment for IT students is to focus on *improving specific 21st century competencies* and *IT skills*	Before planning a project-based learning activity, ask yourself, "which skills do I hope will be developed through this PBL activity?" The nature of a project-based learning environment lends itself to skills development, but it is up to the facilitator to determine which skills need to be developed. As a PBL environment resembles an IT industry environment, specific skills development activities can be incorporated with relative ease. For example, weekly demonstrations to train soft skills, and specific development platforms to train technical skills.
Project-based learning is central to the IT curriculum, and is not viewed as a separate activity at the end of a module	When planning to use a project-based learning approach, you need to begin with the end in mind. The project is the central activity in the module, and all other activities are planned in such a way that it supports the development and improved outcome of the project. Educators tend to go about their semester in the traditional manner, and then add a project that covers some of the aspects that were discussed during the semester. This is not the correct approach to PBL (as indicated by Thomas). A successful PBL strategy is goal-driven, and is built around the project.
Every IT project has specific educational goals as set out in the curriculum	All modules that form part of a degree have module outcomes. Furthermore, all study units that form part of a module have study unit outcomes. When formulating your project-based learning activity, you should take cognisance of the learning outcomes that need to be met. This is an important element that forms part of the administrative documentation of the institution, where a coherent strategy must be documented demonstrating how module objectives were met.
An IT project in a PBL environment is designed to encourage reflective practice in both the student and the facilitator	A project-based learning activity is formulated through reflective practice, and encourages reflective practice. PBL activities for IT projects aim to improve the professional development of the student, by guiding the student to become a reflective practitioner. The PBL environment also improves the reflective practice of the facilitator, who needs to adapt her problem-solving skills within the context of each individual project.
Requirements	
Guideline	**Description**
For an IT PBL environment to be successful, support is needed from colleagues and faculty management	Faculty support is important when specific tools and platforms are required. You may also need other consumable resources such as brown paper and stationery for creative planning sessions. Support may also be needed when the facilitator wants to attend workshops or industry training sessions to improve her own skills related to facilitating the project-based learning activity. Support from colleagues may be required in the form of evaluation assistance, as assessing PBL artefacts can be time-consuming.
The scope of an IT project should be *significant*, *realistic* and *industry-related*	It is recommended to use industry project scopes as part of a project-based learning environment for IT students. Using authentic project briefs will encourage the commitment students have towards completing the project. Community projects are also ideal for PBL activities if there is a need in the community, because the students then feel that they are contributing to a *real* solution. If it is not possible to obtain a project

	scope from industry/the community, conduct market research on industry-relevant topics that are currently in the headlines, preferably using *wicked problems* that will develop the critical thinking and problem-solving skills of the student.
IT students should be allowed to have a voice and choice *appropriate to the context* of the project	Entry-level and exit-level IT students are motivated by different types of projects. For entry-level students, consider using a voting platform where students can suggest, and then vote for, the project scope that they would like as a topic. The facilitator should shortlist the topics based on their suitability and relevance to most/all students. For exit-level students, a multifaceted project scope can be used that explains the industry problem within the context of different role players, where an administrator might need a desktop application, a client might need a web application, and a courier might need a mobile application. The student can then choose which role player's problem s/he wants to solve.
IT projects should result in IT artefacts	A demonstrable artefact is expected at the end of an IT project-based learning activity. These include, but are not limited to, software documentation, systems, applications, and research reports.
The use of appropriate technology in IT projects is *expected* and not a nice to have	It is important to integrate authentic software and tools as part of your IT project-based learning activity. From the market research you have conducted to determine which tools and software are appropriate, you should be able to make a list of requirements for faculty management. For IT degrees, faculties usually have specific budgets available for upgrade and maintenance of the IT infrastructure. Some technology stacks offer educational licenses, such as Visual Studio. There are also open source platforms that are widely used and that can be implemented, such as Python.
Design and scheduling	
Guideline	**Description**
The project scope should be well defined with enough time allocated for in-depth inquiry	There should be no ambiguities in the project scope. This does not necessarily mean that you need to provide a bullet list of instructions. An effective manner of structuring briefs for IT projects is in narrative format. Write a problem statement from the views of the respective role players in the project. The time allocated to completing the project should be fair, and can only really be assessed through active involvement of the facilitator. IT projects are generally scheduled between 4 and 6 weeks (depending on the scope), with the assumption that the students have dedicated development time during every week where facilitator guidance is available.
An IT project should *start with a driving question* that makes the student think about the project over a period of time before actually starting with the creation of an artefact	The driving question is a neutral open-ended question that will lead students to investigate processes or procedures that might be useful for the PBL activity. The driving question is given at the start of a module, or before the project commences, to focus the direction of the investigation. An example of a driving question is, "where can I host a website for free that will include free database storage of at least X megabytes per month?" Students will start researching possible hosting platforms without needing to know what the project is about. The open-ended question will also keep them thinking about the project, holding interest and motivation for when the project scope is released.
Guidance and scaffolding	
Guideline	**Description**
Intrinsic motivation for IT students and the *need to know* are re-enforced with tools such as guest lectures from industry or building *real* solutions	For increased motivation, arrange an industry guest lecture that accompanies the industry project scope. Students are inspired by practitioners, and will reflect deeply on the experience. Real projects for real clients also improve motivation to complete the project, especially community projects that are completed with the aim of alleviating a *real* problem. For example, a local animal shelter that requires a free website

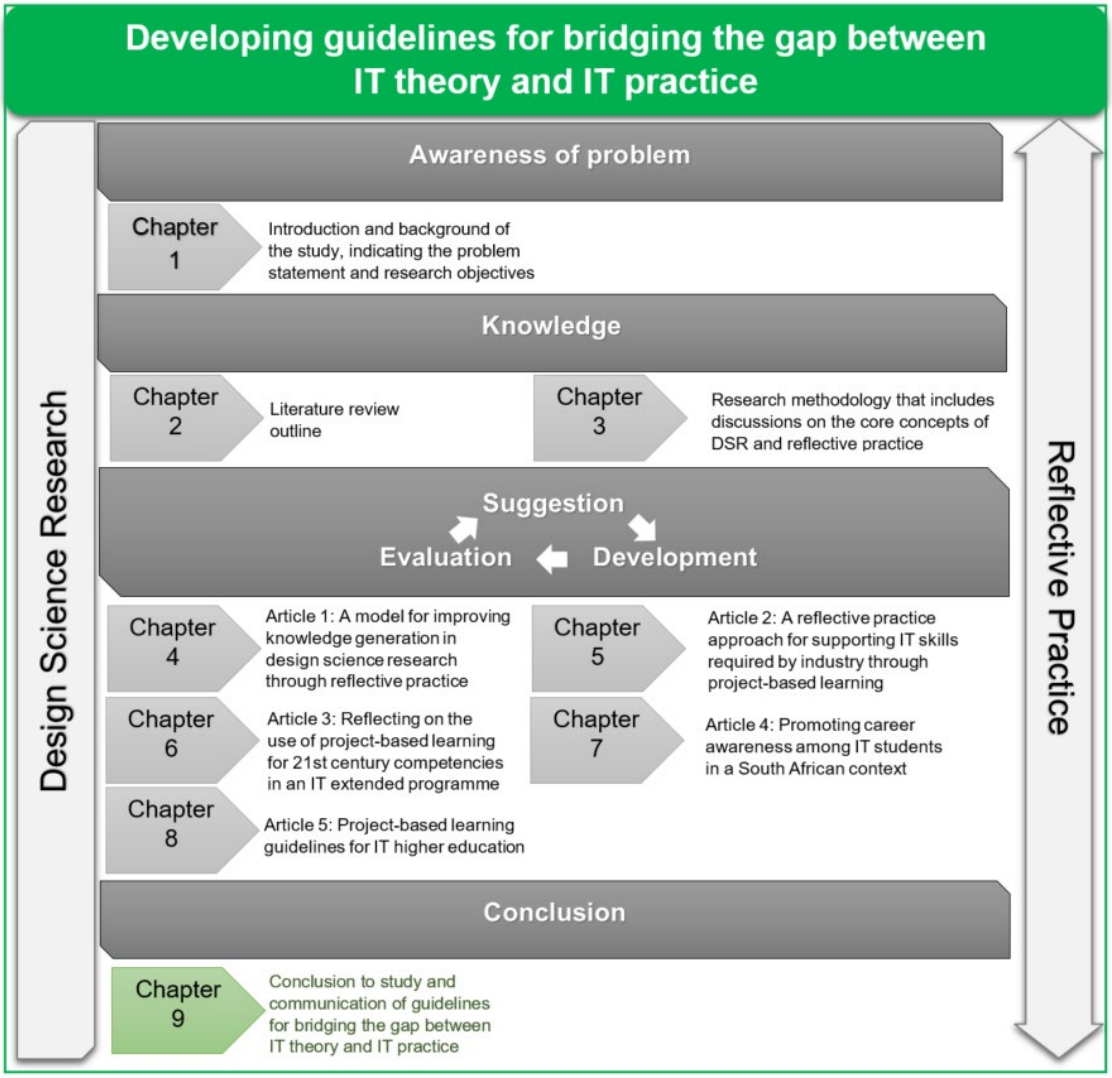
for *actual* projects	where they can upload pictures of pets that are up for adoption.
Facilitator guidance should be appropriately managed with scaffolding sources that further improve the *need to know* of the student	When structuring project scopes, make sure to add web links to resources that will be useful to complete the project. Also provide links to other similar projects, or similar problems experienced, to motivate the student's search for solutions. As part of the planning for a PBL activity, the supporting activities can also be scaffolded in such a way that an important piece of information is revealed every week to maintain the interest of the students.
Monitoring and managing	
Guideline	**Description**
Teamwork is emphasised to simulate working environments in the IT industry	Where possible, team projects should be incorporated when using project-based learning. The IT industry comprises IT teams that create IT projects. Students need to work in teams where they are unfamiliar with their team members. Working with new people will develop teamwork and time management skills, more so than working in teams with friends. A suggested number of members per team is 4 – taking on roles such as the business analyst, back-end developer, front-end developer, and database administrator.
Learning by doing is emphasised through active participation throughout the IT project	Project-based learning aims to encourage student reflection. There is a transition from '*knowing through making'* the artefact, to '*learning by doing*' what is best practice to develop artefacts. Students who do not actively participate in the project will miss out on the chance to learn from peers in a controlled environment.
Time management is crucial in IT projects	One of the biggest challenges for IT graduates is to adjust to the demanding deadlines of the IT industry. Training time management is essential in an IT PBL activity, and can be coached by setting time constraints on different activities that form part of the project, weekly feedback sessions, and time boxing demonstrations so that students learn how to highlight the most important items in their projects first.
Use appropriate agile methodologies to manage IT teams	IT companies use agile development methodologies, such as DevOps, Extreme Programming, Scrum, and Kanban to manage their workflow. Educating students on the methodologies that are available, and providing training in at least one method are recommended. For example, Scrum is a useful methodology that demonstrates how to plan backlog items, sprints, and daily stand-up meetings. The approach can be supported by using a visual work-pull system such as a Kanban board that tracks the progress and contribution of all team members.
Encourage the use of source control software to manage and track code changes, and to determine team member contribution	A standard requirement in IT practice is the use of source control. Source control, or version control, is a software program that manages and tracks code changes, providing a history of code that was developed, logged, and merged. The benefits of source control include access to previous versions of a project that was in workable condition, and shared access in teams to work on the same code. Examples of source control platforms are Git, Azure DevOps, and BitBucket. In IT student projects, the extended benefit of implementing source control is the ability of the facilitator to see how long the team has been working on the project, and who has been working on the project. The software keeps track of the dates when code was committed, and by who the code was committed. Another benefit is that students cannot use the excuse that "my project was working just this morning", because your response will be "then run your previous code commit that was working on your source control platform".
User stories will guide the creation of simplified software requirements in an IT project	Creating user stories is a standard approach to defining software requirements for a system. A user story typically describes the type of user, what the user wants to do, and why the user wants to do it. From a user story, functional and non-functional requirements of the system can be specified. To mimic professional practice, it is important to emphasise

	the development of core functional requirements first. For example, if the client wants an online booking system for their hotel, the core functional requirement of the system would be the ability to make a booking. Items such as e.g. registration and login features are secondary, and should be focused on after the booking item is functional. Discourage the development of unnecessary 'nice to haves' that were not part of the project brief, or postpone development thereof until all core functional requirements have been implemented first.
Assessment	
Guideline	**Description**
Assessment practices for IT projects should include critique, revision and *rubrics*	Project assessment during development should include 5- to 10-minute stand-ups where a student/team highlights what has been completed so far, items that were struggled with, and what needs to happen next. This activity develops their verbal communication and presentation skills. It is recommended that every project brief should have an accompanying project rubric. A detailed rubric provides the students with a checklist of items that need to be completed, and eliminates the possibility of inconsistent marking as all students/teams are scored using the same criteria.
Motivation to deliver quality IT projects is improved when external audiences such as community or industry members are involved and act as evaluators of the artefact	It is recommended that public audiences take part in the evaluation of the final artefact. Students will be motivated to produce quality artefacts when they know that members from the industry will be evaluating their work, and, in turn, this will provide industry with an opportunity to scout for talent. When using community projects, members from the community can also be invited to evaluate the artefact. Careful consideration should be given to how the marks are awarded when using novice or unknowledgeable judges from the community. If you are unable to arrange public audiences, ask colleagues for assistance with evaluating the projects. An unfamiliar face will encourage professional demonstrations.

The guidelines presented in this article propose that project-based learning is a solution towards including more practical content in an IT degree, as well as preparing students for industry. Following the PBL guidelines proposed in this research aims to contribute towards bridging the gap between IT theory (higher education) and IT practice (industry).

The next chapter concludes the study and assimilates the design science research approach followed in this research, by presenting the final artefact – *guidelines for bridging the gap between IT theory and IT practice.*

CHAPTER 9: CONCLUSION



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9.1 Introduction

The primary objective of this study was to develop guidelines for bridging the gap between IT theory (standard IT teaching practices at university) and IT practice (the required industry-related skills). This chapter presents the proposed guidelines in a consolidated format.

A discussion is provided on how the research objectives were met (Section 9.2), which leads to a demonstration of the guidelines for bridging the IT theory-practice gap (Section 9.3). As this research is rooted in reflective practice, a meta-reflection of my learning experience is presented in Section 9.4. Limitations of the research are highlighted in Section 9.5.1, and is followed by a discussion on future research (Section 9.5.2). The thesis is concluded in Section 9.6, which presents a brief summary of the research within context, and *food for thought* on the implications.

9.2 Research objectives addressed

An article format was followed in this research, and as such, the research objectives were addressed in multiple articles. In this section, the secondary research objectives are addressed. As this study followed a design science research approach, the objectives are discussed within the context of the phases of the DSR process model that they were structured in, in Chapter 1 (Table 1.1). This section provides discussions on how each objective was met. Ethical considerations of the study were discussed in detail in Section 3.5.4.

9.2.1 DSR phase: Awareness of problem

Table 9.1 provides an overview of the objectives in this research that formed part of the *awareness of problem* phase. The manner in which each objective was addressed is discussed sequentially.

Table 9.1: Secondary objectives in the *awareness of problem* phase

Theoretical • To define the research problem • To describe the literature concepts that are significant for further investigation • To motivate the suitability of the research methods proposed to conduct the research

Knowledge required to *make a suggestion*:

- To provide a shared understanding of design science research as a paradigm for artefact creation
- To provide a shared understanding of the relationship between design science research and reflective practice
- To provide a shared understanding of reflective practice for professional development

Chapter 1 provided context to the research problem, which, in summary, was defined as a gap that was experienced between the skill level of recent IT graduates delivered from university, and the skill level of IT graduates expected by IT employers. The research problem was presented based on an extensive literature context of similar concerns experienced in a general setting globally, a similar IT skills gap currently experienced internationally, and a local concern for the increased risk that South Africa might not be producing enough *skilled* IT professionals to meet industry demands.

Within the context of this research, it was highlighted that an improved approach to higher education instruction would assist in better preparing the future IT graduate. As there are multiple types of instructional approaches available, the literature context provided in Chapter 1 alluded to the effectiveness of **project-based learning** for **developing IT skills** towards bridging the gap between IT higher education and the IT industry. Central to its process, and to professional development, **reflective practice** was a clear choice as theoretical framework to guide the instruction of project-based learning, the process followed to conduct the research, and the reflection of the researcher. Early observation of the manner in which the research findings would be most coherently presented suggested the development of guidelines for bridging the IT theory-practice gap – so that the implications of the research could be extended for use in other research, or for application in similar scenarios. The development of the guidelines were structured in the paradigm of **design science research**, and from a pragmatic stance, the most practical way to start solving the problem was to *talk to the central role players*.

DSR was specified as the chosen paradigm for this study, as the focus of the research was repeatedly emphasised as the *development of the guidelines as an artefact*. Even though the study included interpretive methods as part of the evaluation of the artefact, and that during the development of the artefact a limited form of emancipation took place, the context of these aspects was limited to its usefulness in *developing* a consolidated set of guidelines for bridging the IT theory-practice gap. A detailed discussion was provided on why the research was not structured in the paradigms of positivism (Section 3.2.1.2), interpretivism (Section 3.2.2.2), or critical social theory (Section 3.2.3.2).

Chapter 3 provided an overview of DSR and its methods, and discussions on how DSR was used in this research. An argument was made for guidelines to be considered as an artefact, within the context of research that indicated typical DSR artefacts as methods, constructs, instantiations, and models (Section 3.2.4.2). The most notable study to mention is Gregor and Hevner's seminal article for the positioning of DSR for maximum impact. In the article, they proposed guidelines, among other methods, for DSR, and specified that they used a DSR approach to construct the guidelines (which they then viewed as a DSR artefact). A similar approach was followed in this research.

A philosophical discussion on reflective practice was provided in Section 3.3.5 by reflecting on the work of John Dewey, Herbert Simon, Donald Schön, and other prominent researchers. The section provided a theoretical discussion on the background of reflective practice, and how it relates to professional development. A logical argument was made for the need for reflective practice in design science research. Dewey, an educational pragmatist, focused his work on inquiry and reflection, and inspired the development of reflective practice by Schön. As a pragmatist, Dewey's work was also linked to design science research, which is rooted in pragmatism. Many DSR researchers specify that reflection only takes place towards the conclusion of a project, which is a shared perception with Dewey, who specified that reflection should take place *on experience,* i.e. after the experience has happened. An assertion was made that this is a questionable approach to reflection, from Schön's reflective practice point of view, which specifies that reflection should take place *during and after* the experience to improve learning. Schön's dual view of reflection was supported in this research, and subsequently led to a proposed model to generate explicit knowledge in design science research through reflective practice. The model formed part of an objective in the *suggestion* phase, and is discussed in the next section. It is important to note that reflective practice, as the theoretical framework of this research, was discussed within the context of every article in this thesis.

9.2.2 DSR phase: Suggestion

The manner in which the objectives that formed part of the *suggestion* phase (Table 9.2) were addressed is discussed in this section.

Table 9.2: Secondary objectives in the *suggestion* phase

Theoretical • To provide a shared understanding of reflective practice as a method to improve explicit knowledge generation in design science research

- To provide a shared understanding of project-based learning as an instructional method that supports the development of 21st century competencies, soft skills, and technical skills
- To understand which industry-related skills IT graduates typically lack
- To understand how project-based learning can be implemented in an IT degree to improve the industry-related skills of future IT graduates

Chapter 4 presented the first article in this research. The article offered a model for generating explicit knowledge in design science research through reflective practice. A discussion on the epistemological assumptions of DSR was provided, followed by an overview of reflective practice, and a descriptive illustration of the experiential learning cycles authored by Kolb. The paper demonstrated how reflective practice could be embedded in the phases of the DSR process model to ensure that reflection takes place in each phase and not only in the conclusion phase. An example of the application of the model provided an overview of the DSR process that was followed to guide the development of the proposed guidelines for this research.

As part of a pilot study for this research, Article 2 in Chapter 5 highlighted which industry-related skills IT graduates typically lack. A discussion on the project-based learning approach that was adopted was circumscribed, indicating how PBL could be implemented at the exit-level of an IT degree. The article concluded with a suggested instructional plan for an improved PBL strategy to be implemented at exit-level. Article 3 in Chapter 6 reflected on the use of PBL towards improving IT extended students' 21st century competencies. The paper discussed the approach taken to implement PBL at entry-level of an IT degree. Benefits of the PBL strategy, as well as suggestions towards the improvement of the PBL strategy were provided.

Article 4 in Chapter 7 originally started as a feedback report on approaches that were implemented based on the suggestions made in Article 2. Students were asked to provide their insights and recommendations on an intervention strategy that was implemented in an exit-level module towards bridging the IT theory-practice gap. The data analysis revealed one central theme in the feedback obtained, which was not explicitly provided as part of the research objectives at the start of this study, but proved to be an important aspect towards industry-readiness, i.e. career awareness. This unexpected finding emphasised the fact that artefact creation takes place through a search process (as expected in design science research). The article also provided context to the importance of industry involvement in higher education.

Article 5 in Chapter 8 provided a literature paper on project-based learning. The article discussed the use of PBL in IT education, and provided three demonstrations of how PBL can specifically be used in IT higher education to develop 21st century competencies, IT soft skills, and IT technical skills. Article 2 to Article 5 provided demonstrations of how PBL can be implemented in an IT degree to improve industry-related skills.

9.2.3 DSR phase: Development

The *development* phase contains only one empirical objective (Table 9.3), for which a discussion on how it was met follows.

Table 9.3: Secondary objectives in the *development* phase

Empirical
• To develop guidelines for bridging the gap between IT theory and IT practice

As the DSR process model is iterative in nature, the development of the artefact in the research occurred in separate articles that highlighted distinct guidelines. Article 1 and Article 2 did not produce explicit guidelines that formed part of the primary objective of this research, but did result in implicit guidelines through the researcher's reflection, and were discussed in the respective article chapters. Article 3 discussed four explicit guidelines in the conclusion, targeted at continuous IT skills development throughout the degree. The implications of the findings in Article 4 resulted in valuable guidelines that were structured within the context of promoting career awareness in an IT degree. Article 5 provided important guidelines on the use of PBL specifically within the context of IT higher education. The guidelines were adapted at the end of each respective chapter according to themes for formulating an intervention strategy, identifying crucial IT skills, best practice for general IT pedagogy, effective project-based learning in IT higher education, and involving industry in higher education. The collective set of developed guidelines is presented in Section 9.3.

9.2.4 DSR phase: Evaluation

In this section, the objectives related to the *evaluation* phase (Table 9.4) are addressed.

Table 9.4: Secondary objectives in the *evaluation* phase

Empirical
• To identify which aspects of the guidelines should be evaluated by specific role players. • To conduct interpretive data gathering methods with relevant role players in order to understand the problem experienced, and the value of implemented approaches, from their respective perspectives • To use interpretive data analysis methods on the qualitative data gathered in order to identify themes in the data

- To evaluate and improve the effectiveness of the developed guidelines by demonstrating them in an IT degree and reflecting on the analysed data

For the evaluation phase, objectives were formulated to satisfy the need for artefact assessment. The evaluation of the artefact included understanding who the central role players were, asking them for feedback, and analysing the expected qualitative data. The research methodology paper in Article 1 provided a demonstration of the research process followed in this study. An unexpected finding in this article was that the central role players were limited to IT students and members from the IT industry. An explanation for why IT lecturers were excluded from the research was provided in the article. In Article 2, members from the IT industry were asked to provide feedback via written interviews on the skills they found lacking in IT graduates. A conventional approach to open-coding was used to find themes in the qualitative data, and provided categories for relevant IT soft skills, expected IT technical skills, advanced IT technical skills, and suggested recommendations for additional learning (internships/certifications etc.). This article was a pilot study that informed the direction of the research. The article highlighted current IT skills that should be focused on, and resulted in a suggested PBL approach for exit-level students that would address the development of the skills identified in the research. During the analysis of Article 2, it was noted that some of these skills should be trained earlier in an IT degree, and a PBL approach within the context of IT extended students was also adopted. In Article 3, the IT extended students were asked to complete a reflective sheet to provide feedback on the PBL strategy, and to make suggestions on how it could be improved. The qualitative data was analysed using a directed approach to open-coding, resulting in benefits of the PBL strategy, as well as recommendations towards improving the strategy. The paper also presented the first explicit guidelines that centred on continuous IT skills development in an IT degree.

In Article 4, exit-level IT students were asked to provide feedback on the approaches implemented in the module (via interpretive questionnaire), based on the suggestions made in Article 2. Initially, a conventional approach to open coding was taken, which highlighted early on that career awareness was a central theme in the data. Qualitative analysis of the data was restarted using a directed approach to open coding within the context of the theme of career awareness. This approach resulted in valuable findings such as the benefits of involving industry in IT higher education, and suggestions to enhance IT career awareness further. The implication of the findings resulted in a set of guidelines for promoting career awareness among IT students, but that were also vital towards bridging the IT theory-practice gap. Article 5 provided guidelines for the effective use of project-based learning in IT higher education to improve the IT skills and work-readiness of IT students. The guidelines were

constructed through a literature review of prominent PBL characteristics, as well as characteristics that PBL should have within the context of IT higher education. The usefulness of the guidelines was demonstrated using three PBL examples from IT higher education.

9.2.5 DSR phase: Conclusion

Table 9.5 provides the objectives that form part of the *conclusion* phase. These objectives are presented in this chapter, as the final chapter of the research. Section 9.3 communicates the guidelines for bridging the gap between IT theory and IT practice. Through a meta-reflection, recommendations are made within the context of the research in Section 9.4. Section 9.5 provides discussions on the limitations and future direction of the research.

Table 9.5: Secondary objectives in the *conclusion* phase

Theoretical
• To communicate a set of guidelines for bridging the gap between IT theory and IT practice • To communicate recommendations within the context of a reflection on the research • To communicate the limitations of the study • To suggest possibilities for future research that can supplement the guidelines for bridging the gap between IT theory and IT practice

9.3 Guidelines for bridging the gap between IT theory and IT practice

In this section, the primary objective of the research is met by demonstrating the guidelines that were developed for bridging the gap between IT theory and IT practice. The guidelines are presented under respective themes that were inspired by the articles. Explicit guidelines were not provided in every article, as discussed in Section 9.2.3, but additional guidelines were implicitly identified through the researcher's reflective practice. The following guideline themes are presented in this section:

- Guidelines for industry involvement in higher education (explicit guidelines inspired by Article 4)
- A collection of guidelines for the industry-orientated educator:
  - Guidelines for formulating an intervention strategy (implicit guidelines inspired by Article 1)
  - Guidelines for identifying crucial IT skills (implicit guidelines inspired by Article 2)
  - Guidelines for general IT pedagogy (explicit guidelines inspired by Article 3 and Article 4)
  - Guidelines for project-based learning in IT higher education (explicit guidelines inspired by Article 5)

Each theme is represented by an illustration of how the guidelines inform the next theme. The collective set of guidelines presented in this section forms part of the *guidelines for bridging IT theory and IT practice*. A high-level overview of the guidelines is provided in the illustrations.

9.3.1 Guidelines for involving industry in higher education

Figure 9.1 depicts the guidelines that form part of the theme *guidelines for industry involvement in higher education*. These guidelines were given explicitly in Article 4, and were adapted within the context of this theme. The figure demonstrates how the final guideline from this set, which is *assign an industry-orientated educator to facilitate the process*, leads into the next theme that contains guidelines for the industry-orientated educator. An explanation of the guidelines were given in Chapter 7, Table 7.2.

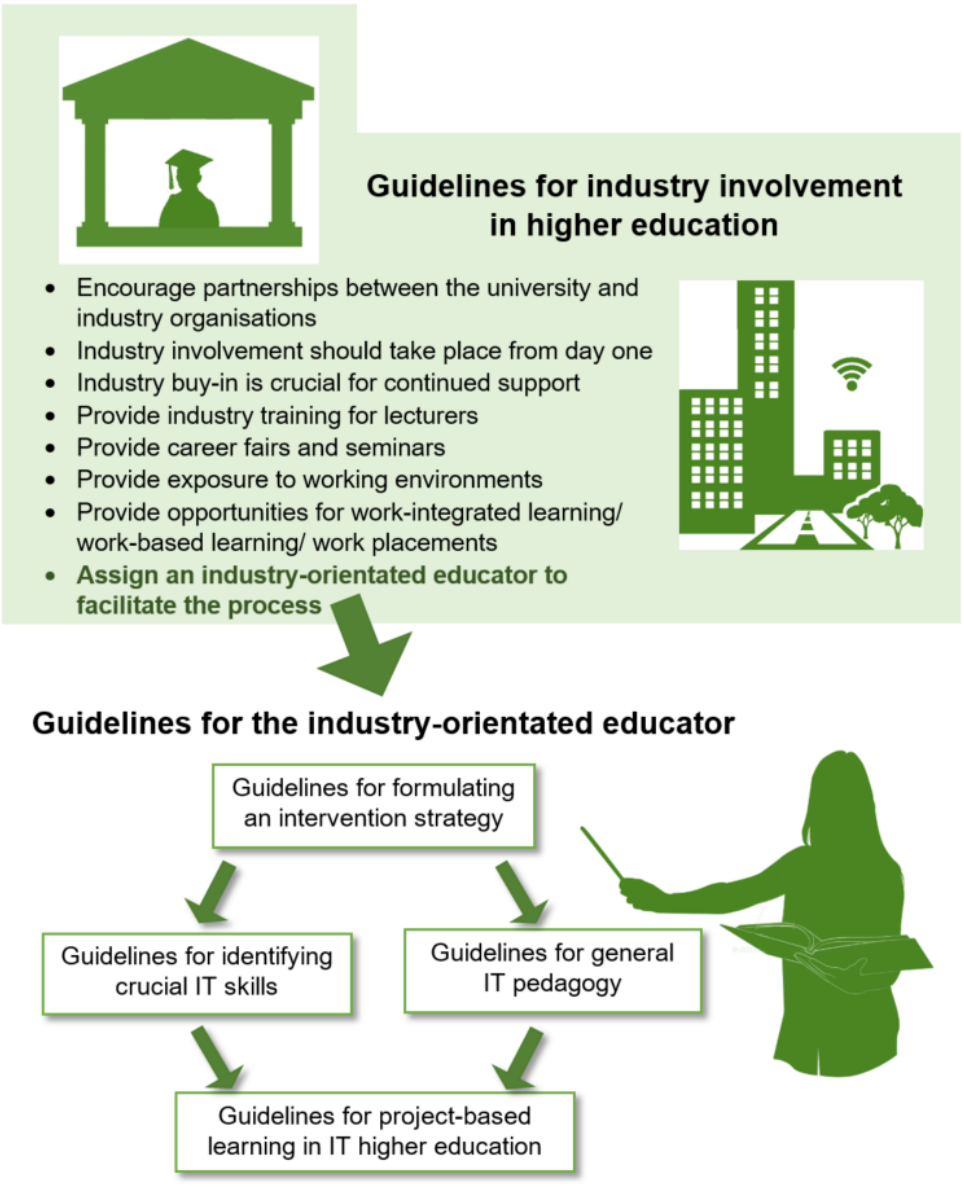


Figure 9.1: Guidelines for industry involvement in higher education

9.3.2 Guidelines for the industry-orientated educator

In this section, *guidelines for the industry-orientated educator* are discussed within the context of four subthemes. Figure 9.2 provides a high-level overview of the respective guidelines that are structured according to the subthemes *guidelines for formulating an intervention strategy* (explanation of guidelines can be found in Chapter 4, Table 4.1)*, guidelines for identifying crucial IT skills* (explanation of guidelines can be found in Chapter 5, Table 5.1)*,* and *guidelines for general IT pedagogy* (explanation of guidelines can be found in Chapter 6, Table 6.1, and extended in Chapter 7, Table 7.1)*.* Guidelines for project-based learning in IT higher education contain extensive information and is depicted in Figure 9.3 (explanation of guidelines can be found in Chapter 8, Table 8.1).

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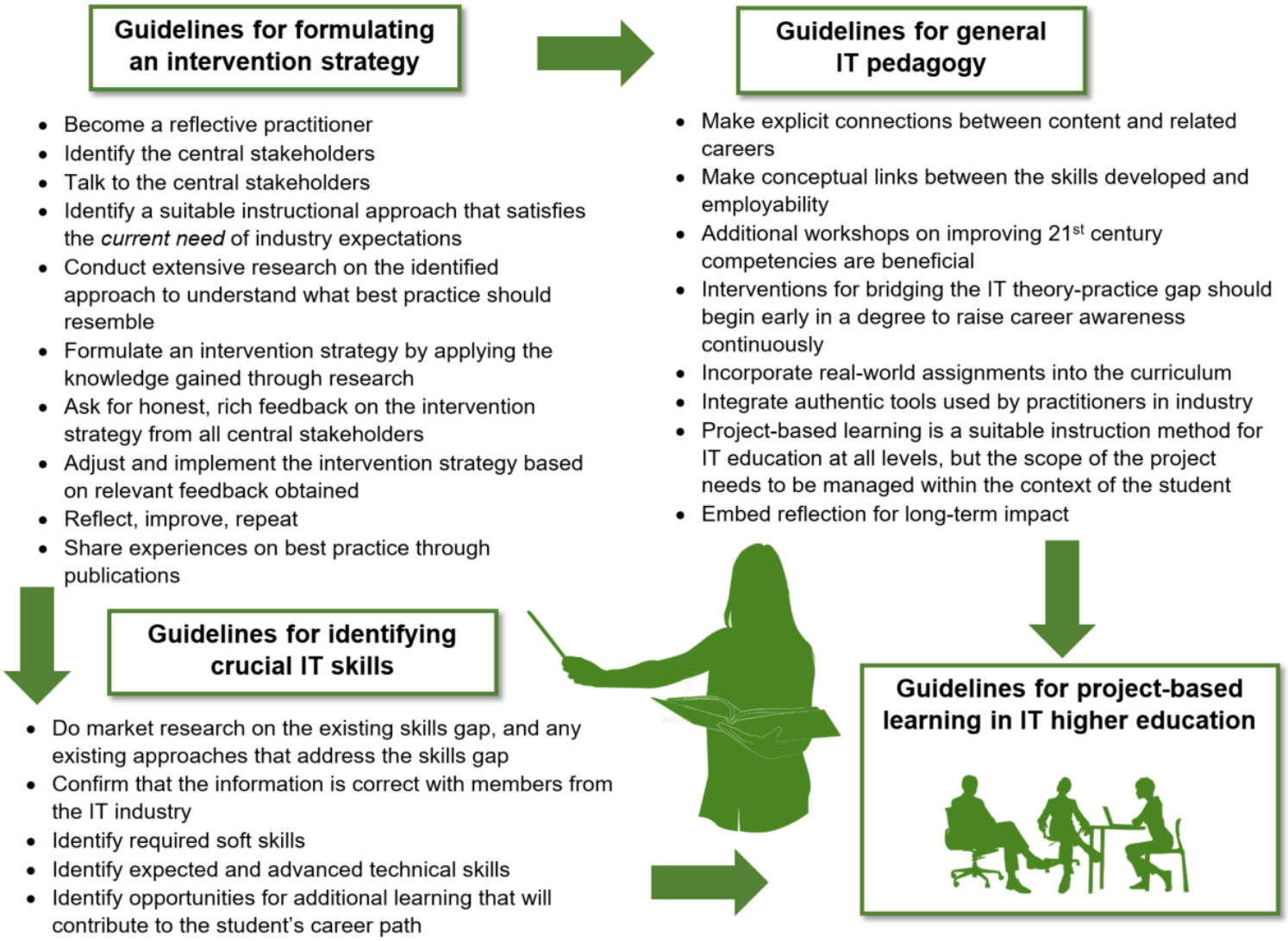


Figure 9.2: Guidelines for the industry-orientated educator

Reasoning & reflection

- The primary objective of a PBL environment for IT students is to focus on improving specific 21st century competencies and IT skills
- Project-based learning is central to the IT curriculum, and is not viewed as a separate activity at the end of a module
- Every IT project has specific educational goals as set out in the curriculum
- An IT project in a PBL environment is designed to encourage reflective practice in both the student and the facilitator

Assessment

- Assessment practices for IT projects should include critique, revision and *rubrics*
- Motivation to deliver quality IT projects are improved when external audiences such as community or industry members are involved and act as evaluators of the artefact

Monitoring & managing

- Teamwork is emphasised to simulate working environments in the IT industry
- Learning by doing is emphasised through active participation throughout the IT project
- Time management is crucial in IT projects
- Use appropriate agile methodologies to manage IT teams
- Encourage the use of source control software to manage and track code changes, and to determine team member contribution
- User stories will guide the creation of simplified software requirements in an IT project



Guidelines for project-based learning in IT higher education

Requirements

- For an IT PBL environment to be successful, support is needed from colleagues and faculty management
- The scope of an IT project should be *significant*, *realistic* and *industry-related*
- IT students should be allowed to have a voice and choice *appropriate to the context* of the project
- IT projects should result in IT artefacts
- The use of appropriate technology in IT projects is *expected* and not a nice to have

Guidance & scaffolding

- Intrinsic motivation for IT students and the *need to know* are re-enforced with tools such as guest lectures from industry or building *real* solutions for *actual* projects
- Facilitator guidance should be appropriately managed with scaffolding sources that further improve the *need to know* of the student

Design & scheduling

- The project scope should be well defined with enough time allocated for in-depth inquiry
- An IT project should *start with a driving question* that makes the student think about the project over a period of time before actually starting with the creation of an artefact

Figure 9.3: Guidelines for project-based learning in IT higher education

9.4 Reflection

This section is written in first person as a reflection of my learning experience during this research process. I make recommendations along the way, and highlight important aspects that cannot necessarily be addressed in academic research. Traditionally, a section provided on reflection in a thesis is written as reflection *on* the experience, i.e. *after* the experience of writing the research. As a reflective practitioner, I present this section both by providing an overview of thoughts I considered during my reflection-in-action, and a discussion of my experience through reflection-on-action.

9.4.1 Reflection-in-action: IT skills development and project-based learning

When I read *educating the reflective practitioner* by Schön (1987), I was surprised that the theory-practice gap was also an issue more than 30 years ago. His work on a reflective practicum was exemplary, and highlighted the same concerns I found myself dealing with day in and day out in higher education. “If professions are blamed for ineffectiveness and impropriety, their schools are blamed for failing to teach the rudiments of effective and ethical practice” (Schön, 1983:8). This quote strongly relates to the reason I chose to follow this path for my PhD research. I heard so many IT practitioners complain about the poor skill levels of IT graduates, and the lack of a basic understanding of IT concepts that they thought students should have acquired at university. I had to take a moment to reflect, “What were we doing wrong?” And so, multiple conversations with different role players led to the conclusion that IT higher education was not keeping up with IT practice. I did not know how to solve the problem immediately, after all, I do not have industry experience. *Many* lecturers do not have industry experience. Very few IT lecturers know how to execute basic coding principles that are applied in practice. We use textbooks that were written by other academics and researchers. Are we not the blind leading the blind? How, then, can it be expected that IT lecturers can effectively train future IT practitioners? Through more research? Said Schön (1987:10), “There has been a growing perception that researchers, who are supposed to feed the professional schools with useful knowledge, have less and less to say that practitioners find useful”. Is the current path that we are following in IT higher education really best practice? These were only some of the questions that I struggled with.

Especially in a discipline such as information technology where the rules change constantly, we (academia) need to adapt at a faster pace. Reflecting on the problem experienced, I thought a good place to start was to ask members from the IT industry, “What are the typical skills that IT graduates lack?”. The answers I received to this question piloted my research.

The traditional method of written examinations in an IT degree never really made sense to me – in this day and age, practitioners need not recall information, it is acceptable in practice to use search engines to find the answer. In fact, it is encouraged. Theoretical content *is* necessary to build a working knowledge of important aspects. However, theoretical content can be reinforced through activities that form part of formative assessment that support the summative project in which the knowledge should be practically applied. Students reflect deeper on the implications of theoretical knowledge when it is practically implemented.

What *is* explicitly needed in the IT industry is the potential to adapt to the needs of the organisation, i.e. different platforms, different people, different settings, different clients etc. There is a need for emotional intelligence that is presented through soft skills, and there is a need for adaptability in the application of technical skills. After much research and conversations, I came to the conclusion that project-based learning in higher education could address both of these needs, because it resembles the real-world IT environment.

Being honest with myself, I had to realise that the boundaries of what traditional education can offer for the discipline of information technology is limited, and that I need to critically reassess whether we are doing what is best for the IT students. Even the students knew that they were learning more through a project-based learning approach than with traditional methods, as I have mentioned in some of my articles.

The skills gap experienced in South Africa should be a concern to all IT educators, and we should be called to action to find creative ways to bridge the gap. In this research, I have made a start, but my journey is far from finished. And as it should be, if I am to claim that I am a reflective practitioner. I have suggested guidelines for formulating an intervention strategy, and I have suggested guidelines for identifying the crucial IT skills that IT curricula should centre on. These guidelines are straightforward, but can make an impact if the aim is to create a stronger alignment between university and industry.

The issue of career awareness came up during the research. We implicitly know that we can do many *things* with an IT degree, but how many *things* can we explicitly name? I was not confident that I knew the answer, so I spent the last two years attending industry workshops, meetings with industry partners, and arranging industry seminars for my IT students. Recently, I shadowed a ‘scrum of scrums’ planning day held at an industry partner just so that I could *understand* how project requirements were planned in practice. These activities form part of my own reflective practice for professional development as an IT lecturer, so that I can enhance the learning experience of my students with *current* and *accurate* industry examples.

A concern raised during the course of this research requires critical reflection to address it in a way that will bring about change. The item is not listed as future research in this chapter, because it represents a '*wicked problem'* that will not be solved easily: *universities are accepting students into programmes that are not recommended for their skills and interests, which affects their motivation and commitment towards completing the degree*. This, in turn, influences the skill levels of these students when they do eventually graduate because they were not necessarily passionate about their chosen career path. The suggested guidelines alone cannot bridge the IT theory-practice gap because its success depends largely on the desire of students registered for an IT degree to *want* to become IT practitioners. This concern is a 'bigger issue' that I have noticed from reading many papers on intervention strategies presented in research, because it is not something that can be controlled by the researcher. We (academics/educators/researchers) can only *attempt* to solve the problem through innovative artefacts for improved instruction. We cannot guarantee its success, as we can only "lead the horse to the water, and not make it drink." As a pragmatic reflective practitioner, I can attempt to persuade the horse of the value that water provides, the elements it is made up of, the limitless examples of its usefulness… However, if the horse really wants a soda – I cannot force it to enjoy the water.

For now, I can only encourage reflective practice for professional development among my IT students. As with the words of Dewey (1974:151):

> "[The student] has to see on his own behalf and in his own way the relations between means and methods employed and results achieved. Nobody else can see for him, and he can't see just by being 'told', although the right kind of telling may guide his seeing and thus help him see what he needs to see."

9.4.2 Reflection-on-action: The research approach and experience

The work of Dewey and Schön inspired me to become a reflective practitioner. Reflective practice should be at the core of professional development for the academic, the researcher, the practitioner, and the student. I am a pragmatist at heart, but I also believe in thinking about what I am doing, while I am doing it, and after I have done it so that I can improve best practice. In this research process, my primary focus was on solving the IT skills gap problem that I had experienced. However, I also knew that because this was an important issue worldwide, I needed to reflect on the approaches that would best aid in solving the problem for the most people. I did not want to simply make recommendations within my research context and move on. I wanted my research to result in *something* that *everyone* could use that would hopefully address the skills gap problem.

Even though I read a great deal of research that was aimed at making a difference, or that reported on successful approaches towards bridging the skills gap, I was missing the single source that I was looking for: a how-to manual for keeping IT higher education *current* and *relevant*. There were many suggestions, a great deal of research stating that there is a skills gap issue, and multiple authors making recommendations that we should *do something about it*. However, that was mostly where it ended – with recommendations highlighting that there is indeed an issue and that we should do something about the issue. I found limited research where the authors *actually did something about it* that could be extended to other research. This was concerning to me as I wanted to take action, but could not find a comprehensible source to tell me how. This also strengthened my argument made in the previous section – researchers and academics know how to frame problems and possible solutions from research – but because we have limited industry experience, we do not actually know how to start solving the skills gap problem.

I believe that the reason that I found so little 'how-to' research is because of the *emancipation elephant* in the room. Most of the studies, admirably, were trying to find ways to emancipate the group of students they were experiencing the problem with. And because the focus was evidently only on emancipation, the findings were *limited* to the context of that specific group. An opportunity was repeatedly missed to see 'the bigger picture' – a desperately needed approach of sorts that could be generalised so that *multiple* groups could eventually be emancipated. However, to define such an approach requires a pragmatic attitude – to first focus on building and testing a solution, where the goal is not emancipation, but rather *only* on developing a solution, so that it could ultimately be extended to a wider audience.

I needed guidance towards aligning my content with industry standards, and because I could not find these guidelines, I dedicated my PhD to developing these guidelines – for me, and for others like me who want to ensure that we are taking responsibility for aligning our content with what is used in practice. For the development of these guidelines, I needed a research approach that would inform the development process, and from a pragmatic stance, design science research was the clear choice. The phases of DSR naturally followed the phases my research was going through, from becoming aware of a problem, to making suggestions, to developing and evaluating the artefact, and back to making suggestions and so on. It was the right choice, because this research resulted in an artefact that can be generalised to similar problems experienced by other researchers and academics – a how-to set of generalisable guidelines for bridging the gap between IT theory and IT practice.

My research experience of following the article format was both beneficial and challenging. With traditional theses, there is more room to make mistakes because you are writing up your research as you go along. It is easier to go back and change something that no longer works within your research context. The traditional thesis format uses a problem-oriented approach. With the article format, you need a clear overview of where the research needs to lead so that the articles complement each other. It is definitely not as easy as it sounds. An article format uses a goal-orientated approach, which supported my pragmatic approach to finding a solution.

A limitation of the article format was that it reduced the richness of the information that I received through countless hours of informal conversations with students, with lecturers, and with members of industry. Articles need to be more concise and scientific, and as such I felt that there was value in my informal data that could not be presented in the articles. It was the value found in the implicit findings, methods, and information that cannot be fully discussed in research publications because formal methods were not used. However, this did not discourage me. Through the use of design science research, embedded with reflective practice, I was able to deliver the artefact I set out to develop.

9.5 The checklist for DSR studies

The DSR checklist created by Hevner and Chatterjee (2010:20) provides eight questions that need to be answered to evaluate the acceptance of a DSR study. It was suggested in Section 3.4.4 that these questions be addressed in Chapter 9, to demonstrate the research rigour of this design science research study (Table 9.6).

Table 9.6: The DSR checklist answered

1	What is the research question (design requirements)?
The research questions were, respectively: • Which industry-related skills does an IT graduate need and typically lack? • Is project-based learning a suitable instructional method for IT skills development, and how can it be implemented in an IT degree to introduce industry-related IT skills? • How can a set of guidelines be developed for bridging the IT theory-practice gap in order to improve the skills of IT graduates required by industry? • How can reflective practice support the development of these guidelines (a design science research artefact) by generating explicit knowledge? From the research questions, the design requirement needed was a developmental methodology to guide the development of the proposed guidelines as an artefact. Design science research was chosen as a paradigm, because of its methods that can be followed to develop artefacts.	
2	**What is the artefact? How is the artefact represented?**
The artefact is a set of guidelines towards bridging the IT theory-practice gap. The guidelines are considered an artefact based on the paper from Gregor and Hevner (2013) in which they stated that they used a DSR approach to develop guidelines that formed part of their publication. Guidelines can	

be considered as a *method* based on the artefact classification types as discussed by March and Smith (1995). A method includes techniques, principles, or recipes to perform tasks. The guidelines were constructed over multiple scholarly publications, subject to peer-review of other academics, and are presented in this chapter as a coherent collection.	
3	**What design processes (search heuristics) were used to build the artefact?**
The DSR process model from Vaishnavi, Kuechler, and Petter (2004/2019) was used to guide the development of the artefact. I proposed a model to improve knowledge generation in the DSR process model through reflective practice, an article that has been published in an accredited journal. This adapted model was used to structure the study (Article 4). The adapted model follows the phases of the DSR process model, but loops through a cycle of experiential learning per phase to promote reflective practice in the design process. The research process naturally followed the phases of the DSR process model.	
4	**How are the artefact and the design processes grounded by the knowledge base? What, if any, theories support the artefact design and the design process?**
The development process of the artefact was grounded in the design science knowledge base. The prescriptive and descriptive knowledge that formed part of this research was discussed in Section 3.4.2, and was rooted in pragmatism, DSR assumptions, and DSR methods. A theoretical discussion provided context to the relationship between pragmatism, design science research, and reflective practice (Section 3.3.5) – the theoretical framework on which the design process of the guidelines depended.	
5	**What evaluations were performed during the internal design cycles? What design improvements are identified during each design cycle?**
From a pragmatic stance, interpretive methods were used to obtain rich data from central role players that informed the development of the guidelines. Each article that formed part of this study was subject to its own evaluation methods, which consisted of qualitative data gathering methods. Rigour in the data analysis was achieved by following scientific principles such as those provided by Klein and Myers (1999). The data was also coded for traceability according to the steps for qualitative data analysis by Zhang and Wildemuth (2009). The findings from the analysis highlighted approaches that worked, and that required improvement. Each paper contributed new guidelines after evaluation.	
6	**How is the artefact introduced into the application environment and how is it field-tested? What metrics are used to demonstrate artefact utility and improvement over previous artefacts?**
The focus of this research was on the development of the guidelines as an artefact, and as such the study concludes with the entire set of guidelines that were developed incrementally over multiple articles. The collection of guidelines has not been field-tested, as they are now presented in this concluding chapter. Subsets of the guidelines were field-tested through the implementation of iterative knowledge gained from every article that informed the strategy of the next article.	
7	**What new knowledge is added to the knowledge base and in what form (e.g. peer-reviewed literature, meta-artefacts, new theory, a new method)?**
The research contributes to the DSR knowledge base in the following ways: • Peer-reviewed published articles • A model to improve explicit knowledge generation in design science knowledge research through reflective practice (Level 2 contribution to the DSR knowledge base as a *model*) • The resulting artefact – guidelines for bridging the gap between IT theory and IT practice (Level 2 contribution to the knowledge base as a *method*) • A demonstration of a collection of guidelines built using a DSR approach (Level 1 contribution to the DSR knowledge base as an *instantiation* – an example of a developed artefact using DSR rules)	
8	**Has the research question been satisfactorily addressed?**
The implemented DSR approach resulted in the successful development of the artefact. This study can be referred to as an example of how DSR can be used to develop guidelines as a DSR artefact.	

9.6 Limitations and future work

This section outlines the limitations of the research, and opportunities for future research.

9.6.1 Limitations of the research

Limitations of the research can be summarised as follows:

- The research was directed by a pilot study where industry members provided feedback on the skills that IT graduates typically lack when entering the workforce (Article 2). The number of participants in the qualitative pilot study was relatively small and the data analysis findings cannot be generalised. The number of participants limited the data received, however, it was not limited within the context of information that is currently relevant in the IT industry. The suggested specific skills from this paper were not explicitly integrated in the guidelines for this study, but were instead accommodated through generic guidelines that recommend conducting current and relevant market research to determine what the skills need is.
- As this was a DSR study, the research concludes on the presentation of the artefact. The collection of guidelines provided in this chapter was not reviewed by academics or members of industry, but was evaluated in part during the development of the guidelines in the scholarly publications that form part of this study. Future research in response to this thesis will include critical reviews to assess the acceptance of the guidelines by academics and practitioners. The proposed research will include the perceptions that IT lecturers have of the practical application of the guidelines, and also, the perceptions of IT industry on the feasibility of the guidelines to solve their problem.

9.6.2 Future research possibilities

Opportunities for future research can be summarised as follows:

- Based on the last limitation listed in Section 9.5.1, the guidelines developed in this research stem from a pragmatic stance to *solve the problem* (IT skills gap). As a pragmatic reflective practitioner, the need for the development of the guidelines was also intrinsically motivated by a *desire for change*. However, in the scope of this research, my first priority was to develop the guidelines using methods for development within the context of design science research. For the purpose of best practice in development, I needed to limit the impact of the research to *understanding the problem* first. Future research will include studies where the guidelines are implemented within the context of emancipating the oppressed IT student. I will then adjust my research strategy to action research, within the context of critical social theory.
- To determine the usefulness of the guidelines as a DSR artefact (classified as a *method*), future research will include implementing the guidelines within different contexts of IT groups to support its generalisability.

- This thesis as a coherent whole is also an example of a DSR artefact, as the document exists because of a DSR approach followed to conduct the research. I have not yet come across any publications that recall the experiences of writing a PhD in this manner. However, McKenney and Van Den Akker (2005) provide a model article of how DSR can be used to report on artefacts that are in the form of documentation, and that were constructed following a DSR approach. This suggestion needs further research for feasibility.

9.7 In conclusion: "So what?"

A traditional overview of the outcomes of the research is provided – for the reader who started their reading journey here; followed by the implications of the research, given in response to the ***so what?*** question.

This chapter concludes the research. It is a demonstration of the *conclusion* phase of the DSR process model, and represents 'the moment' in DSR research when a resulting artefact can be presented. To summarise the research that led up to this moment, a high-level outline of the research elements of this study is depicted in the FMA model (Checkland & Holwell, 1998) in Figure 9.4.

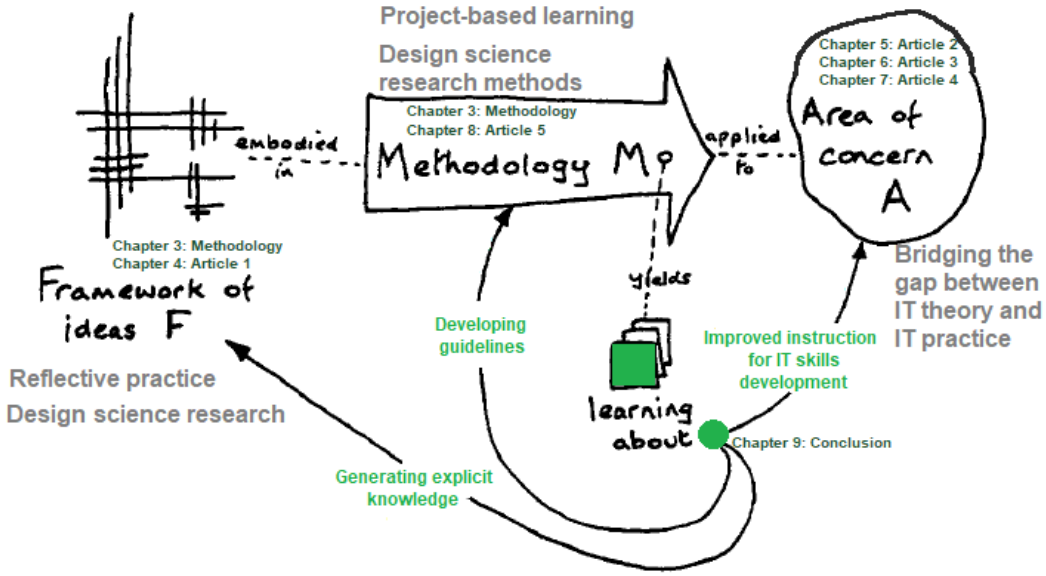


Figure 9.4: Research elements of this study

The primary objective of this study was to develop guidelines for bridging the gap between IT theory (standard IT teaching practices at university) and IT practice (the required industry-related skills). This objective was formulated based on the central research problem: IT students lack certain skills when entering the IT workforce. The study was built on the

theoretical framework of reflective practice within the context of the design science research paradigm (for artefact creation). DSR methods, such as the DSR process model, were used to guide the research. An adapted model was demonstrated, which used reflective practice to explicitly generate knowledge in the DSR process model (Article 1).

Five articles were included in this *article format* thesis. Article 2 to Article 5 demonstrated how project-based learning was used as the instructional approach to simulate an IT industry environment, and how IT skills were subsequently developed through the PBL strategy. Qualitative feedback was collected from IT students and IT practitioners. The data was analysed using open coding to find themes in the information. The distinct themes found in the data of the respective articles inspired guidelines for bridging the IT theory-practice gap, which were presented in this chapter (Section 9.3). The type of guidelines that were developed in this research can be summarised as follows:

- Guidelines for industry involvement in higher education
- Guidelines for the industry-orientated educator, comprising:
    - Guidelines for formulating an intervention strategy
    - Guidelines for identifying crucial IT skills
    - Guidelines for general pedagogy
    - Guidelines for project-based learning in IT higher education

The combined set of guidelines listed above falls under the theme of *guidelines for bridging the gap between IT theory and IT practice*.

The study contributed to the knowledge base of design science research, by demonstrating an adapted DSR process *model* enriched with reflective practice, by developing a DSR artefact in the form of a *method* (set of guidelines), and by demonstrating how DSR guidelines can be used to build an artefact (an *instantiation*).

So what?

The adapted DSR process model presented in Article 1 for explicit knowledge generation can be applied within the context of other disciplines to structure the research in a professional and academic manner. The model is an abstract process (not limited to a specific domain), which implies that it is generalisable to other research.

The guidelines formulated in this research can also be extended to other studies or disciplines, and are not limited to the problem experienced within this research context. Guidelines that

contain specific reference to IT concepts can be substituted with any other discipline-specific concept, which makes the application of these guidelines generalisable to other research.

In conclusion, this study is a good example that future researchers can use when guidelines need to be developed, and a design science research approach is followed for the development. This PhD study as a whole can be seen as a DSR artefact in the form of documentation, as the document exists because of a DSR approach followed.

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APPENDIX A: CODE OF CONDUCT FOR RESEARCHERS

CODE OF CONDUCT FOR RESEARCHERS

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As a researcher of the North-West University (NWU), I subscribe to the rules of the NWU Institutional Research Ethics Regulatory Committee (IRERC), all applicable policies of the NWU as well as all national and international laws and regulations applicable to my field of study. Furthermore, I commit myself to abide by the ethical principles and responsibilities as set out in the Singapore statement on Research Integrity (22 September 2010), in any and all research endeavours that I undertake as a researcher of the NWU.

The four major principles of research integrity to which I will adhere and that will guide my research are:

- Honesty in all aspects of research
- Accountability in the conduct of research
- Professional courtesy and fairness in working with others
- Good stewardship of research on behalf of others

Consequently I will also adhere to the following ethical responsibilities:

1. I will take responsibility for the originality and trustworthiness of my research.

2. I will stay abreast of and adhere to all institutional, national, and international laws, regulations, and policies applicable and related to my research.

3. I will at all times employ appropriate research methods, base my conclusions on critical analysis of the evidence and report my findings and interpretations fully and objectively.

4. I will keep clear and accurate records of all research that I have conducted in a manner that will allow verification and replication of my work by others, if applicable.

5. I will, where applicable, share my data and findings openly and promptly, in line with external funding rules. This will be done as soon as possible after I have had an opportunity to establish priority and ownership claims.

6. I will take responsibility for my own contributions to publications, funding applications, reports and other representations of my research. I will also and only include authors who meet valid authorship criteria.

7. I will acknowledge the names and roles of those who made significant contributions to my research in publications, including writers, funders, sponsors, and others, but do not meet authorship criteria.

8. In my peer reviews, I will provide fair, prompt and rigorous evaluations and I will respect confidentiality when I review others' work.

9. I will disclose all conflicts of interest (financial and other) that could compromise the trustworthiness of my work in research proposals, publications, public communications, and in review activities.

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12. I will respond to irresponsible research practices or conduct, by taking prompt actions as set out in the procedures of the university. I will also protect those who report misconduct in good faith, to the best of my abilities.

13. I will endeavour to create and sustain an environment that encourage research integrity through education of students, research teams and peers, as well as abide by policies, and reasonable standards for advancement.

14. I will at all times weigh societal benefits against the risks inherent in my work.

Name:
J.T. Janse van Rensburg
20398999

Signature:



Date:

1 September 2017

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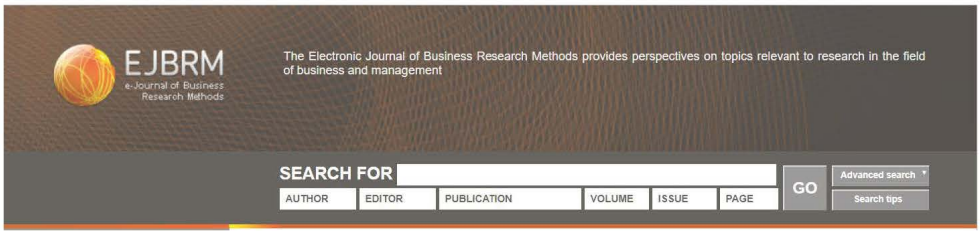
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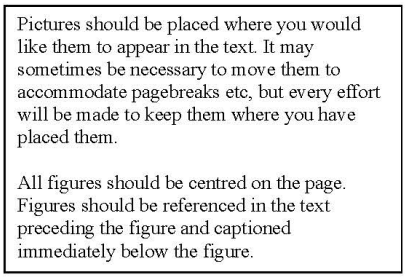


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Dolan, S.L., Garcia, S. and Auerbach, A. (2003) "Understanding and Managing Chaos in Organisations", *International Journal of Management*, Vol 20, No. 1, pp 23–35.
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$$x + y = z \tag{1}$$

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References (in MathPhySci, to be used for computer science proceedings)

1. Smith, T.F., Waterman, M.S.: Identification of common molecular subsequences. J. Mol. Biol. **147**, 195–197 (1981). doi: 10.1016/0022-2836(81)90087-5

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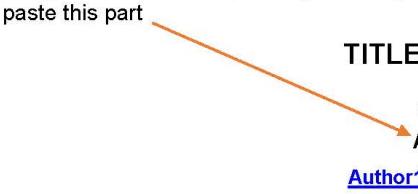
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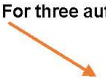
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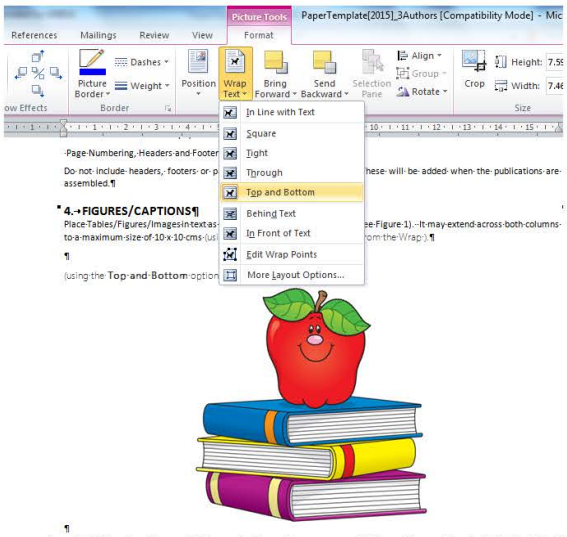


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Ainsworth, S. E., Bibby, P. A., & Wood, D. J. (1998). Analysing the costs and benefits of multireprentational learning environments. In P. van Someren, P. Reiman, H. Boshuizen, & T. de Jong (Eds.), *Advances in learning and instruction: Learning with multiple representations* (pp. 120–134). Oxford: Elseveier Science.

Carlsen, D. D., & Andre, T. (1992). Use of a microcomputer simulation and conceptual change text to overcome student preconceptions about electric circuits. *Journal of Computer-based Instruction*, 19, 105–109.

APPENDIX G: ARTICLE 3 - AN EXAMPLE OF A REFLECTIVE SHEET

Please help me improve the project-based nature of [redacted]
by answering some questions ***voluntarily***.
This form is completely anonymous and by answering these questions you can provide suggestions for what to improve on next year.
Submitting a completed copy of this reflective sheet indicates that you provide consent for this information to be published in research anonymously.
Please note that you are welcome to withdraw your responses at any time – just let me know.

Are you: Male _____ Female _____ Prefer not to say ___

Did you enjoy programming in Scratch? Yes _____ No _____
Why/ Why not? _____
_____
_____

==========
TAKE A MOMENT AND REFLECT ON THE ACTIVITIES THAT FORMED PART OF [redacted]
==========

SEMESTER TESTS

ST1 & ST2: Scratch
For ST1, there was a preparation class where I explained similar questions as in the test as part of practice. For ST2, you had the opportunity to practice one of the two questions in the test before the time.

Which method of preparation did you prefer? ST1 _____ ST2 _____
Why did you prefer this method? _____
_____
_____

ST3: Theory eFundi test
Which theory topics can you remember from this module? Name 3:
_____
_____
_____

==========

ASSIGNMENTS

Assignment 1: Video game concept creation – Design Thinking activity
As part of preparation for this assignment, you took part in the Marshmallow Challenge (design and development activity with spaghetti, tape, string and a marshmallow). In the next period, you completed assignment 1 which was a design activity to plan a concept for a video game.

Did you enjoy the game concept creation assignment? Yes _____ No _____
Why/ Why not? _____
_____
_____

Did you enjoy the Marshmallow Challenge? Yes _____ No _____
Why/ Why not? _____
_____
_____

Assignment 2: Research project

Was the training on how to write professional documentation helpful? Why/ Why not?

_____
_____
_____

Did you know how to reference correctly before you completed this assignment?
Yes _____ No _____ Why/ Why not? _____
_____

Was it easy / difficult to conduct research for this project? Why/ Why not?

_____
_____

==========

EXAM PROJECT

For the examination you had to create a project-based game with documentation.

Which method of examination do you prefer? Written exam _____ Project-based _____
With which method do you think you learn more? Written exam _____ Project-based _____

Why do you prefer the method indicated above?

_____
_____

Which part of the exam project did you contribute most to?
Practical _____ Documentation _____ Why? _____
_____

==========

If you reflect back on these activities, which skills did you improve during the course of [redacted]?

Presentation skills: Yes_____ No _____ Why? _____
Communication skills: Yes_____ No _____ Why? _____
Professional writing: Yes_____ No _____ Why? _____
Critical thinking: Yes_____ No _____ Why? _____
Problem solving: Yes_____ No _____ Why? _____
Attention to detail: Yes_____ No _____ Why? _____
Research skills: Yes_____ No _____ Why? _____
Design skills: Yes_____ No _____ Why? _____
Programming skills: Yes_____ No _____ Why? _____

What can I do to improve the module? _____
_____
_____

Thank you for taking the time to complete this! JT

APPENDIX H: ARTICLE 4 - AUTHOR GUIDELINES FOR THE HIGHER EDUCATION, SKILLS AND WORK-BASED LEARNING JOURNAL

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e.g. Harrow, R. (2005), *No Place to Hide*, Simon & Schuster, New York, NY.

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Surname, Initials (year), "Title of article", *Journal Name*, volume issue, pages.

e.g. Capizzi, M.T. and Ferguson, R. (2005), "Loyalty trends for the twenty-first century", *Journal of Consumer Marketing*, Vol. 22 No. 2, pp. 72-80.

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e.g. Moizer, P. (2003), "How published academic research can inform policy decisions: the case of mandatory rotation of audit appointments", working paper, Leeds University Business School, University of Leeds, Leeds, 28 March.

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Title of Encyclopedia (year) "Title of entry", volume, edition, Title of Encyclopedia, Publisher, Place of publication, pages.

e.g. *Encyclopaedia Britannica* (1926) "Psychology of culture contact", Vol. 1, 13th ed., Encyclopaedia Britannica, London and New York, NY, pp. 765-71.

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APPENDIX I: ARTICLE 4 – AN EXAMPLE OF THE INTERPRETIVE QUESTIONNAIRE

[redacted] interpretive questionnaire

[redacted] interpretive questionnaire

This interpretive questionnaire forms part of JT's PhD research - Bridging the gap between IT theory and IT practice.

The purpose of this interpretive questionnaire is to determine which opportunities you found helpful towards bridging the gap between university and industry, and which other opportunities you would have wanted to have. Some of the opportunities made available to you during 2018 include project-based learning using industry projects, an IT seminar and a CV and Interview workshop.

The interpretive questionnaire is anonymous so please feel free to give honest answers and recommendations. I will not know who you are and as you have finished with the module, your answers cannot influence the outcome of your marks :)

I will use the information received to keep improving the module so that students are better prepared for industry. I will also use the generalised findings for publication purposes so that other researchers or academics can use the information.

Thank you for taking the time to complete this survey, I really appreciate and value your feedback!

* Required

1. **I understand the purpose of the survey and I agree to take part in the PhD research.** *
   Mark only one oval.
   - ◯ Yes
   - ◯ No

Contact with industry during 2018

When answering questions in this section, reflect on the opportunities that were made available to you to have contact with industry.

2. **I regularly post job vacancies and other opportunities in a dedicated folder on eFundi. Have you applied for any of these opportunities?** *
   Mark only one oval.
   - ◯ Yes
   - ◯ No

3. **If your answer to the previous question was yes - please indicate how many opportunities you have applied for and if you were successful. If you answered no - why have you not applied for any of these opportunities?** *

4. **Britehouse gave a guest lecture on the project scope as well as an overview of MVC and code refactoring. Why do you think guest lectures are / are not useful?** *

5. **Which other topics would you have liked to have guest lectures on by industry?** *

6. **An IT seminar was held on 20 August 2018 where 8 companies gave a short lecture on what their companies work on and the opportunities available at their companies. Why do you think an IT seminar is/ is not useful?** *

7. **Why should the IT seminar be / not be a yearly event?** *

8. **Have you attended any Hackathons during 2018?** *
   Mark only one oval.
   - ◯ Yes
   - ◯ No

9. **In which way has attending/ not attending Hackathons during 2018 impacted your life?** *

[redacted] interpretive questionnaire

10. **For which reason(s) did you or did you not enter the [redacted] competitions?** *

Skip to question 11.

Preparing you for industry

Reflect on workshops attended and projects completed for [redacted] during 2018.

11. **In which way did you find the workshop on research skills and professional writing held on 23 July 2018 useful / not useful?** *

12. **In which way did you find the workshop on CV and interview skills held on 10 September useful/ not useful? Which techniques from this workshop have you implemented?** *

13. **Project 1 - research report on architectural patterns, advanced design principles, unit testing and code refactoring. Which skills do you think you improved on completing this project?** *

14. **Project 2 - which aspects of the Cyber Security project/[redacted] project was useful/ not useful? Which skills did you improve on completing this project?** *

15. **Project 3 / Exam project - MVC. How did project 1 prepare/ not prepare you for the exam project?** *

16. **Project 3 / Exam project - MVC. Which skills do you think you improved on completing this project?** *

Skip to question 17.

Self reflection

Reflect on your overall performance and improvement during the course of the degree. Think about how prepared you are to enter industry.

17. **What is your gender?** *
Mark only one oval.
- ◯ Female
- ◯ Male
- ◯ Prefer not to say
- ◯ Other: _____

18. **What is your ethnic group? (options as given on Wikipedia)** *
Mark only one oval.
- ◯ Black african
- ◯ White
- ◯ Coloured
- ◯ Asian
- ◯ Other
- ◯ Prefer not to say

19. **How old are you?** *
Mark only one oval.
- ◯ 17-22 years
- ◯ 23-28 years
- ◯ 29-35 years
- ◯ 36+ years
- ◯ Prefer not to say

20. **Elaborate on any work experience you have.** *

21. **Was studying IT your first choice when you left high school?** *
Mark only one oval.
- Yes
- No

22. **You are on the verge of completing an IT-related degree. Which career path are you planning to follow? (Please note that this does not necessarily have to be an IT-job)** *

23. **Do you have employment for 2019? Please elaborate on your answer.** *

24. **If you had all the required skills, what would your dream job be?** *

What else?

Reflect on the workshops, seminar, industry projects, guest lectures etc. that were made available to you as an attempt to help bridge the gap between university and industry.

25. **Do you have any other suggestions, recommendations or ideas that would be useful towards bridging the gap between university and industry?** *

APPENDIX J: ARTICLE 4 – PROOF OF ACCEPTANCE

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10-Jan-2020

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