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A framework for facilitating functioning knowledge in a computer-based instruction end-user computing service course

by

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Dedication

In 1985, an ordinary rural woman of peasantry means with an extraordinary and audacious vision was involved in a bicycle accident on her way home from St Pius Kumusoro, a rural primary school in Zimbabwe. She had just pleaded with the school's headmaster to keep her son in school for a few more days until the next cattle market day where she and her husband would sell an animal and pay her son's school fees. The woman spent an agonising nine months in hospital and succumbed to her injuries on 6 May 1986. Since that day, I have made a commitment that, for as long as I breathe, I would read and ensure that her dream is fulfilled. I dedicate this thesis to my departed mother, Winfredah Chasara Katsenga Zhakata, who paid the ultimate sacrifice for my education.

Abstract

Title:	A framework for facilitating functioning knowledge in a computer-based instruction end-user computing service course.
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Most South African universities, like many such institutions in the developing world, enrol a first-year student without the requisite digital competencies to be fully functional in the information world. The end-user computing service course – a computer literacy course designed for students who do not major in computer sciences – is common among South African institutions of higher learning. The use of computer-based instruction systems in end-user computing service courses at South African universities is widespread.

The use of computer-based instruction systems has many benefits for pedagogy, including continuous and round-the-clock access to an instructional system for students. Facilitators are relieved of mundane tasks and innovative instructional approaches, such as blended learning, flipping the classroom and open learning, become possible. Literature indicates that an overreliance on such systems for instruction is detrimental, as the learning environment fails to promote deep thinking and the performance of tasks with understanding. Current models on technology use in instruction offer generalised guidelines that do not take into account the unique nature of the end-user computing service course. New guidelines for promoting functioning knowledge in computer-based instruction in end-user computing service courses are necessary.

This study explores the use of computer-based instruction systems in an end-user computing service course and recommends Technology Role in Exploring Learning Orientations (TRELO), a framework for promoting functioning knowledge. Design science research approaches are adopted to guide the conception of the research problem and the development of the framework for promoting functioning knowledge (solution). The problem-solving process involves understanding the nature of functioning knowledge in an end-user computing service course and suggesting the role of computer-based instruction systems in supporting learning

processes that promote functioning knowledge. The framework presents six kinds of knowledge that constitute functioning knowledge in an end-user computing service course. The first two, declarative computer knowledge and disciplinary knowledge focus primarily on knowledge acquisition and concept formation. The next two, computer utilisation knowledge and disciplinary innovation knowledge, indicate knowledge application. The last two, computing reflection and disciplinary reflection, focus on appraising learning actions.

Illustrative demonstrations show that computer-based instruction systems play three supportive roles in promoting functioning knowledge. Firstly, a content delivery role aids the acquisition of the declarative knowledge that is necessary for concept formation. Secondly, a productive role promotes constructive learning and knowledge use. Finally, the systems play a discursive role that enables reflective thoughts and insights to be shared. The framework is also compatible with current higher educational instructional methodologies, such as the flipped classroom approach, blended learning and open learning. The framework is also consistent with two renowned taxonomies for specifying educational learning outcomes, Bloom's taxonomy and the structure of observed learning outcomes (SOLO) taxonomy. The TRELO framework is offered as an interdisciplinary learning artefact in the field of computer application.

Declaration

I, Norwell Zhakata, declare that the thesis presented and entitled, “A framework for promoting functioning knowledge in a computer-based instruction end-user computing service course” is the product of my own work and effort. Resources that are used have been referenced and acknowledged to the best of my ability. I undertake to remedy any objections raised as soon as is possible.

Signed

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N. Zhakata
April 2019

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And whatever you do, in word or deed, do everything in the name of the Lord Jesus, giving thanks to God the Father through Him (Colossians 3:17).

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Contents

List of figures

List of tables

Glossary of terms and abbreviations

End-user computing Service course	A computer literacy course offered to students who are not majoring in computer studies/sciences.
NQF	National Qualifications Framework. The South African legal system for the registration, classification and recognition of national educational qualifications.
SAQA	The South African Qualifications Authority. The South African statutory body that advances the objectives of the NQF and oversees their implementation.
Declarative computer knowledge	Factual knowledge about the computer artefact. It involves understanding the hardware and software aspects that make the computer useful as a tool for solving problems.
Declarative disciplinary knowledge	Facts about disciplinary subject content such as germination theory in agriculture, demand and supply principles in economics or pedagogical techniques in education.
Computer utilisation knowledge	Practical knowledge that emphasises the active use of the computer artefact such as working with spreadsheet formulae, typing word-processing documents or sending emails.
Disciplinary innovation knowledge	The adaption and extension of disciplinary knowledge in solving problems using computer systems. It is the invention and generation of computing solutions to problems by using insights from disciplinary knowledge.
Computing reflection	Appraising learning experiences based on the knowledge of the computer artefact and its utilisation by assessing whether the artefact was applied optimally.
Disciplinary reflection	The process of appraising the way disciplinary knowledge has been applied in crafting a solution.

The end-user computing service course knowledge matrix	An integrated conceptual structure depicting the six 'types of knowledge' characteristic of the end-user computing service course knowledge, namely, declarative computer knowledge, declarative disciplinary knowledge, computer utilisation knowledge, disciplinary innovation knowledge, computing reflection and disciplinary reflection.
Learning orientations	A learning process depicting or emphasising one of the six types (facets) of the end-user computing service course knowledge matrix.
Explorations	Learning processes that incorporate all of the six learning orientations of the end-user computing service course knowledge matrix.
TRELO	Technology Role in Exploring Learning Orientations. An integrated conceptual framework for promoting functioning knowledge that illustrates the role of computer-based instruction systems in each of the learning orientations of the end-user computing knowledge matrix.

Chapter 1: Introduction

1.1 Introduction

Computing and digital literacy skills are critical at a time when the world economy is moving into the Fourth Industrial Revolution. Information literacy skills are indispensable (Suri, 2018). A survey of the level of South African schoolchildren's access to training in computing skills indicated that a significant number of them do not have access to computer resources at school (Lundall & Howell, 2008). As a result, these students enter tertiary education or the world of work computer-illiterate. Many South African universities offer introductory computer literacy courses to equip their students with basic digital competency skills.

This research studies the use of computer-based instruction systems in a university end-user computing course. It also recommends a framework for promoting functioning knowledge. Functioning knowledge is the performance of a task with understanding (Biggs & Tang, 2007). The end-user computing course is traditionally referred to as computer literacy. Study materials from a South African University, the Cape Peninsula University of Technology (CPUT) indicate the skills that are taught in the end-user computing course as computer operation, word-processing, spreadsheet processing, database processing, presentation, internet-use and emailing (CPUT, 2017).

The International ICT Literacy Panel (2007:1), a group of instructors, technology experts and scholars convened by the United States Education and Testing Services Unit, defines information and communication technology (ICT) literacy as "using digital technology, communications tools and/or networks to access, manage, integrate, evaluate and create information in order to function in a knowledge society". The Panel goes on to reiterate that ICT literacy should go beyond the mastery of computer usage skills to include critical and cognitive skills in the application of technical skills and knowledge. Shume (2013) warns against technological fundamentalism in technology education, which Orr (2002) explains as an excessive and pathological fixation with technology's ability to solve humanity's problems without an understanding of how these tools fit into life's larger purpose. Shume (2013) recommends that ICT education or technology education must lead to digitally literate citizens who are analytical and understand the impact of technology on society and individuals.

End-user computing originated as a discipline in which non-programmers could gain knowledge of creating working computer applications (Goodall, 1997; Hill & Barnes, 2011). Chapman (2013) explains that the course draws students from university disciplines that are not computer sciences. She uses the term “service course” to describe this phenomenon. The end-user computing course aims to equip learners with the knowledge to solve real business problems through the competent use of computer skills (South African Qualifications Authority (SAQA), 2018). Lotz-Sisitka and Raven (2009) describe that kind of knowledge as applied competence. They highlight that the notion of applied competence became critical in democratic South Africa when the designers of the National Qualification Framework (NQF) attempted to extend education and training beyond mere skills training.

Applied competence is the ability to complete a task with understanding and reflection (Lotz-Sisitka & Raven, 2009). Reflection, also called reflexivity, is the ability to adapt acquired knowledge and practice to new situations (McKay, Mosidi, & Lotz, 2000). Lotz-Sisitka and Raven (2009) explain that applied competence is underpinned by three interconnected abilities: practical competence, foundational competence and reflexive competence. Foundational competence is the ability to understand the knowledge behind the actions. Practical competence is the ability to consider a range of possible actions in real-life setups and decide on an appropriate action to follow. Reflexive competence is the ability to integrate both practical and foundational competencies in contextual problem-solving and adapt these competencies to new circumstances. A concept that is closely related to applied competence in a university context is functioning knowledge. This is explained in the following paragraphs.

1.1.1 Functioning knowledge

The notion of functioning knowledge emanates from a need to impart knowledge that goes beyond just knowing about concepts (Biggs, 2003). The modern learner needs knowledge that empowers action and judgement, while also improving adaptation techniques in solving complex real-life problems (Organisation for Economic Cooperation and Development (OECD), 2018). The notion of functioning knowledge is closely related to that of deep learning as it emphasises the application of knowledge in real-life contexts and reflects on the use of knowledge (Biggs & Tang, 2007). Biggs and Tang (2007) state that deep learning, also called functioning knowledge, is a higher level of academic engagement that is above memorising. Deep learning focuses on describing, explaining, relating, theorising and applying concepts. Deep learners seek to understand how individual pieces of information fit into the greater scheme of things and how this information is applicable to real-world situations (Laird, Shoup, Kuh, & Schwarz, 2008). The opposite of deep learning is surface learning. Surface learning is a peripheral and non-committal approach to learning that is associated with rote learning. Such learning is done with a getting-it-over-with attitude (Biggs & Tang, 2007). Millis (2010) adds that surface learning does not formulate connections or logical links between phenomena, but rather treats concepts in isolation while accepting and memorising knowledge uncritically.

Botma, Van Rensburg, Coetzee and Heyns (2015) developed a conceptual framework that shows how theoretical concepts could be transferred to real work environments. The framework elaborates on the fact that functioning knowledge is promoted by enacting communities of learning and designing learning outcomes that direct learning towards the application of knowledge. The community of learning has students, facilitators and field experts who interact to develop the students' cognitive, communication and analytical skills. The framework illustrates that learning transfer occurs by activating new knowledge, engaging new information, demonstrating competencies and applying them in a real-world setup.

Botma et al. (2015) explain that effective "knowledge construction" takes place when existing knowledge is invoked and integrated with the immediate concepts that learners are encountering. The author advises that a high level of competency is achieved when learning activities are specifically designed to improve performance. In addition, the learning activities must be student centred and aligned with multisensory learning activities for effective learning to take place.

1.1.2 Technology and instruction

The use of computer-based instruction in teaching end-user computing courses in the South African higher education landscape is widespread. The sales office of Cengage South Africa, a company that offers a computer-based training system called Skills Assessment Manager (SAM), claimed that at least 12 South African universities were using the system in 2017 (see Appendix 3). Tony Bate presented two considerations for using computers in education in 1986 (Bate, 2016). The first option was to use the computer as a channel of communication. In that context, the computer would be used as an assistive tool to enhance the two-way interaction between teachers and their learners (Bate, 2016). The second consideration was the use of the computer as a replacement teacher that would be dedicated to teaching the students. These observations were made before the explosion of the internet, the world wide web, social media, massive open online courses (MOOCs), multimedia instruction technology, Moodle and many other technologies that are used in education today. Three decades later, in 2016, the author stated that the key considerations regarding technology use in education have changed. Now, focus is on how computers should replace teachers through automation and how technology should be used to empower both learners and teachers (Bate, 2016).

The use of computer-run software in supporting training is referred to as computer-based training (Hesham, 2003). Dumbleton (2001) explains that computer-based training systems enable students to learn with minimal support from instructors and to access assessments online. In addition, the systems provide rich, interactive learning modes that use multimedia and track learner activity, which enables an instructor to monitor progress. Chien and Chang (2012) advance that institutions benefit from reduced workforce requirements and lecturers benefit from the reduced demands of physically delivering instructional content, while students benefit from flexible learning options. Computer-based instruction allows instructors to dedicate their time to students who need help, while technology teaches the rest of the class (Twigg, 2011). The instructional technology allows students to practice on an ongoing basis, and provides opportunities for detailed, frequent and timely feedback that improves the quality of the learning process (Schilling, 2009; Chien & Chang 2012).

Instruction technology supports individualised, self-paced and self-directed learning (Piccoli, Ahmad, & Ives, 2001). Staker and Horn (2012) illustrate flexible instructional models that became possible as a result of technology use in instruction. Students who learn partly through contact tuition and partly through online delivery methods have greater control over their learning time, path and pace.

Common computer-based instruction systems in use are Cengage's SAM, Pearson Education's MyLab IT and McGraw-Hill Higher Education's SimNet (Hill, 2011).

An efficacy study on the impact of using SAM in teaching end-user computing skills claimed several benefits. The research asserts the following:

- Some 90% of the instructors who used the system believed that it increased their productivity.
- Some 73% of the instructors and 69% of their students indicated that the system increased their interest and engagement with the course content.
- Some 82% of the instructors and 81% of their students viewed the system as key in preparing students to use Microsoft applications in the real world.
- Students indicated that the top three benefits of the system were 24-hour access, step-by-step instructions and the ability to learn at their own pace.

Mueller and Strohmeier (2011) stress the importance of research in the effective design of instructional technologies and how they enhance the learning process. Stegeman and Zydney (2010) call for more research in the use of technology in education with a particular emphasis on strategies that promote critical thinking and the transfer of knowledge from academic thinking into practical application and settings.

Chapman (2013) studied whether the use of computer-based instruction systems in learning Microsoft (MS) Office skills increases students' motivation to learn. The study found that students who are taught MS Excel[1] using computer-based instruction systems are usually frustrated because they lack the technical background needed to succeed in the course. The study also observed that the system supports many, but not all features of the real application. Ali and Wibowo (2016) observed that a complete reliance on computer-based instruction systems might be detrimental, as the teacher's roles and responsibilities in instruction may become diminished. Ciornei (2013) acknowledges the benefits of computer-based instruction systems when demonstrating the step-by-step instructions to carry out a particular computer operation. The author, however, points out that controlling the step-by-step mental activity discourages learners from being creative, entrepreneurial and initiative.

[1] A spreadsheet computer application

Several models are available to guide the use of technology in the classroom. Amory (2015) discusses three: the technological pedagogical content knowledge (TPACK) model, Sims's Design Alchemy and Diana Laurillard's conversational model. Mayes and Fowler (1999) proposed a three-stage model where learning is seen as a continuous process and understanding is built through gradual refinement.

1.2 Instruction design and technology use

This section considers principles of instructional design, as outlined in the Design Alchemy framework of Rod Sims (Sims, 2015) and guidelines on technology use from three sources. These are the TPACK framework of Mishra and Koehler (2009), the three-stage framework of Mayes and Fowler (1999) and Laurillard's (1993) conversational framework. The selection of this literature should not be considered as exhaustive, but as classical.

1.2.1 Rod Sims's Design Alchemy

Rod Sims's Design Alchemy approach is not strictly focused on technology use in instruction. It is, rather, a learner-centered approach to learning environment design. The Design Alchemy pedagogy is underwritten by dynamically interlinked concepts that are illustrated in Figure 1.1.

Figure 1.1: The Design Alchemy framework. Source: Sims (2015:31)

The Design Alchemy teaching approach is rooted in sound pedagogical theory (constructivism, social learning, situated cognition, experiential learning and “connectivism”). These are covered in detail in Chapter 2. According to Sims (2015:31), the following key elements should be included in the learning environment:

- Inclusivity: A learning environment should accommodate the learners’ “gender, culture, spiritual and experiential factors”.
- Activity: Learning is an active process and knowledge is acquired through doing something.
- Problem-solving: Learning is a problem-solving activity.
- Context: Learning, as a problem-solving process, has situational contexts that define the specifics of how to solve a problem.
- Social interaction: Learning happens in social interactions where learners and teachers collaborate and share insights.
- Creativity: Learning leads to tangible artefacts that form the basis of assessment.
- Emergence: Learning design should allow for spontaneity and the pursuit of alternative thoughts.

The author claims that it is possible to design a learner-centered learning environment by aligning “learning outcomes, learning activities and assessment” without even considering the content (Sims, 2015:30).

1.2.2 The technological pedagogical content knowledge framework

The TPACK framework is premised on the proposal of Shulman (1986) that good teachers possess a special kind of knowledge called pedagogical content knowledge. Pedagogical content knowledge is the skill to relate what is taught (content) to how it should be taught effectively (Cochran, 1997). The TPACK framework explains how technological tools should be aligned for effective instruction (Mishra & Koehler, 2009). Mishra and Koehler (2009) explain that effective teachers have three kinds of knowledge: subject content knowledge, knowledge on how to teach and the knowledge to use technology effectively. They categorise these three, tightly linked kinds of knowledge as content knowledge, pedagogical knowledge and technological knowledge.

Content knowledge emphasises the subject knowledge that the instructor will facilitate, while pedagogical knowledge encompasses all the instructional strategies that educators use. Technological knowledge focuses on the instructor's skill to incorporate various learning technologies during instruction (Koehler et al., 2014). The three kinds of knowledge interact dynamically to enact the four components of the TPACK framework: technological content knowledge (TCK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TCK) and technological pedagogical content knowledge TPACK (Koehler et al., 2014).

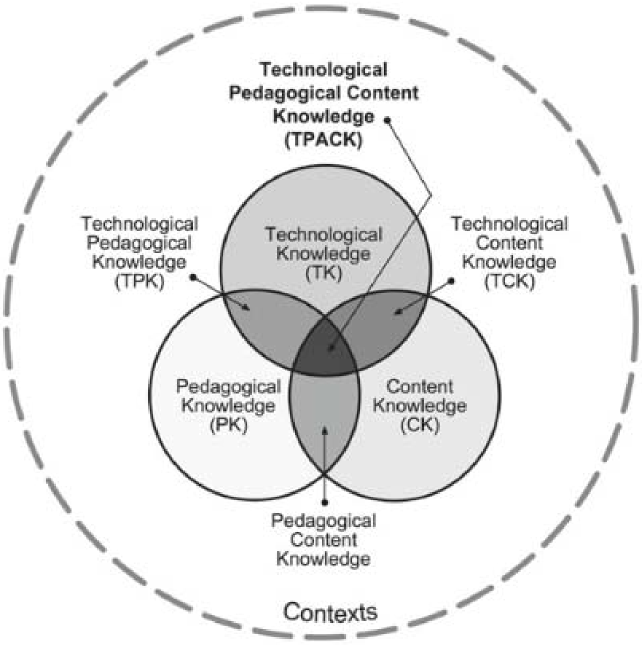


Figure 1.2: The TPACK framework

Source: Spector et al. (2014:101)

Figure 1.2 illustrates the dynamic relationship among the knowledge components of the TPACK framework.

Koehler et al. (2014:102) explain the framework as follows:

- Technological content knowledge "refers to knowledge of the reciprocal relationship between technology and content". As a result, the disciplinary knowledge that is possessed is limited by what technology can afford.
- Pedagogical content knowledge is "an understanding of how particular topics, problems or issues are organised, represented and adapted to the diverse interests and abilities of learners and presented for instruction" [citing Shulman (1986:8)].

- Technological pedagogical knowledge is “an understanding of what teaching and learning activities can be accomplished using the technology that is available”.
- Technological pedagogical content knowledge is “knowledge about the complex relations among technology, pedagogy and content that enable teachers to develop appropriate, context-specific teaching strategies”.

1.2.3 Mayes and Fowler’s three-stage framework

The three-stage framework of Mayes and Fowler (1999) comprises three phases of learning: conceptualisation, construction and dialogue. Learning begins with conceptualisation when the student interacts with the teacher (Hadjerrouit, 2008). This initial interaction exposes the learner to new concepts (Bati, Gelderblom, & Van Biljon, 2014). The construction phase involves creating concepts, combining them and using them to accomplish a task (Hadjerrouit, 2008; Bati et al., 2014). The dialoguing phase is accomplished through conversing, reflecting and extending concepts to a new setting (Hadjerrouit, 2008).

Mayes and Fowler (1999) align the three-stage learning cycle with the characteristics of courseware that are used in instruction. There are three types of vital instruction courseware. Primary software supports the presentation of concepts and the subject matter, which is why it is useful during the conceptualisation phase. Secondary courseware is concerned with presenting the tools that support the completion of performance-based tasks and activities. It supports the constructive learning stage. Tertiary courseware provides the tools that support dialogue among learners, their peers, teachers and collaborative partners. It supports the dialogue phase of learning.

1.2.4 Laurillard’s conversational framework

Laurillard (1993) argues that academic knowledge is descriptive and discursive, and if students remain stuck in experiences, their competence will not grow. Consequently, the author claims that “there is no escape from the need for dialogue, no room for mere telling, nor practice without description, nor for experimentation without reflection, nor student action without feedback” (Laurillard, 2002:135). The author extends that effective teaching takes a learner from the specifics of experience to the “generalisable”. The characteristic learning encounter comprises four processes: discursive, interactive, adaptive and reflective. These do not necessarily have to occur at the same time. Discursive processes present and expose conceptual differences between the teacher and the students. Adaptive processes involve changing the learner's world view to that of the teacher. Interactive processes enable students to acquaint themselves with ideas and try them out. Reflective processes enable learners to reflect upon their experience and build their own conceptualisation of reality.

The conversational framework leads to a typology of learning experiences that show learning experiences, the form of media and the appropriate technology to support the dialogue. Table 1.1 presents how Clinch (2005) views the role of different media forms in support of learning experiences.

Table 1.1: Learning media and learning experiences { TA \l "Table 1.1 Learning media and learning experiences: (Clinch, 2005)" \s "Table 1.1 Learning media and learning experiences: (Clinch, 2005)" \c 1 **}**

Learning experience	**Method or technologies**	**Media forms**
Attending, apprehending	Print, TV, video, DVD	Narrative
Investigating, exploring	Library, CD, DVD, web resources	Interactive
Discussing, debating	Seminar, online conference	Communicative
Experimenting, practising	Laboratory, field trip, simulation	Adaptive
Articulating, expressing	Essay, product, animation, model	Productive

Source: Clinch (2005)

Table 1.1 illustrates that different technological media support learning dialogue differently. Passive technology, such as print, video, podcasts and broadcasts, support narrative attending and apprehending. On the other hand, learning technologies that involve learners, such as simulations and virtualisation, promote adaptation, experimentation and practice.

1.2.5 Considerations for functioning knowledge

The frameworks presented in this section (Rod Sims's Design Alchemy, the TPACK framework, Mayes and Fowler's three-stage framework and Laurillard's conversation framework) are sound pedagogical instruments that can be transferred to the teaching of end-user computing as a service course. The Design Alchemy approach provides crucial guidance on designing effective learning environments, irrespective of the learning content. The TPACK framework of Mishra and Koehler (2009) explains how educators can align technological tools for effective instruction. It explicates the various kinds of knowledge that support the process. However, the framework is conceived as a generalised instructional guide that is not contextualised to the reality of the end-user computing course. The various kinds of knowledge described in the TPACK framework do not focus on the end-user computing service course.

The explanation of Mayes and Fowler (1999) on the use of computer courseware provides important insight into the role of computer-based systems in instruction. The role of primary software in the presentation of concepts that are crucial in the initial stages of conceptual development during instruction is explained.

Secondary courseware encompasses instructional tools that support the construction and completion of performance-based tasks and activities. Tertiary courseware provides the tools to support dialogue among learners, their peers, teachers and collaborative partners. Similarly, the conversational framework of Laurillard (1993) explains how different instructional technologies support particular learning activities without paying any particular attention to the use of computer-based instruction systems in teaching and learning or how crucial functioning knowledge can be achieved.

The research problem is presented in the next section.

1.3 Statement of the problem

It can be argued that the frameworks discussed in Section 1.2 are generally applicable to all processes of teaching and learning. The frameworks, however, do not focus on end-user computing service courses and how functioning knowledge can be promoted. There is no explanation of the nature of functioning knowledge in an end-user computing course. There is also no direction on how instructional technologies, like computer-based training systems, could be used in such contexts to facilitate functioning knowledge. The abovementioned instructional models provide crucial insight on technology use in instruction. However, they lack the preciseness of implementation when it comes to promoting functioning knowledge in the end-user computing service course.

There are no clear recommendations on how teaching and learning activities in the end-user computing service course could be conceived and executed in a way that allows students to acquire knowledge that is functional and useful in their disciplines. It is, therefore, worthwhile to explore how functioning knowledge can be promoted in computer-based instruction in an end-user computing service course. Research by Xu, Shanna and Jaggars (2014) reveals that the mere presence of technology in an instructional environment does not guarantee positive educational outcomes. The authors advise that technology only benefits pedagogy if it is used appropriately. Thus, this research focuses on addressing the research questions that are outlined in sub-section 1.3.1

1.3.1 Research questions

Main research question: How can functioning knowledge be facilitated in a computer-based instruction end-user computing service course?

The main question is operationalised by posing four further sub questions that seek to establish a deeper understanding of the use of computer-based instruction systems in end-user computing service courses and to propose guidelines for promoting functioning knowledge.

Sub-question 1: What is the nature of functioning knowledge in an end-user computing service course?

This sub question seeks to unearth the phenomenon of the end-user computing service course, and to establish what should be considered as functioning knowledge in the course. The question is premised on the argument that facilitating functioning knowledge begins with a firm understanding of the nature of functioning knowledge in the end-user computing service course.

Sub-question 2: How are computer-based instruction systems used in teaching end-user computing service courses?

This question requires an in-depth observation and understanding of how computer-based instruction systems are used to teach end-user computing service courses.

Sub-question 3: **What aspects promote functioning knowledge in a computer-based instruction end-user computing course and how can they be organised into a coherent framework?**

The third sub question focuses on determining the key aspects of knowledge in an end-user computing service course and computer-based instruction systems that can be used to promote functioning knowledge, as well as determining how these can be organised into an operable artefact.

Sub-question 4: How applicable is the framework identified in sub question 3 in promoting functioning knowledge in a computer-based instruction end-user computing service course?

The question focuses on demonstrating the framework's utility. An illustration of how the framework can be used to promote functioning knowledge in a computer-based instruction end-user computing service course is provided.

1.3.2 Research objectives

The research objectives are aligned to the main research question and the sub questions.

Main objective: Study the use of computer-based instruction systems in the end-user computing service course in order to recommend a framework for facilitating functioning knowledge.

Sub-objective 1: Understand the nature of functioning knowledge in a computer-based instruction end-user computing service course in order to gain the insights that are necessary to promote functioning knowledge.

Sub-objective 2: Study the use of computer-based instruction systems in teaching end-user computing courses in order to gain the insights that are necessary to promote functioning knowledge.

Sub-objective 3: Identify the aspects that promote functioning knowledge in a computer-based instruction end-user computing service course and organise them into a conceptual framework for promoting functioning knowledge.

Sub-objective 4: Illustrate how the conceptual framework identified in Sub-objective 3 can be applied to facilitate functioning knowledge in a computer-based instruction end-user computing service course.

This study makes a vital contribution when one considers the upsurge in South African higher education institutions' use of computer-based instruction in teaching end-user computing skills. It is rational to be concerned that the uncritical use of computer-based instruction in teaching end-user computing courses risks producing graduates with a limited understanding of how such end-user computing knowledge can be used to solve real-life problems. The use of computer-based instruction must lead to computing knowledge that is functional and useful in solving real-life problems.

1.4 Significance of the study

The study focuses on getting a deeper understanding of the end-user computing service course and how computer-based instruction could be used to promote functioning knowledge. This thesis contributes to the approaches used in teaching the end-user computing course by bringing new insights into the nature of the subject beyond the content that is outlined in textbooks. The research explores and presents a heightened understanding of the nature of end-user computing service course knowledge and provides a framework as an additional toolkit for end-user computing instructors and course designers. At a conceptual level, there is a strong indication that insights obtained from this study are applicable and extendable to other similar university courses such as applied statistics, academic literacy, communication skills and research methods that are offered as service courses.

The university's faculty committee for research ethics granted approval for the research to be conducted (see Appendix 6).

1.5 Thesis outline

This document comprises seven chapters.

Chapter 1 presents the challenges faced when computer-based instruction systems are used to teach end-user computing service courses at universities. The argument is that computer-based instruction systems provide instruction that is limited to drills and is focused on low-level computer operation skills. There is a need for guiding principles on how computer-based instruction systems may be used in a way that promotes functioning knowledge.

Chapter 2 focuses on reviewing the literature by presenting two strands of literature that are crucial to the research problem. The first strand explores the key theories that shape learning and instruction. It is revealed that learning is a participative process in which learners construct their own understandings based on the constraints and opportunities that the environment affords. The constructivist theory is presented as having a powerful influence on the design of technology-driven learning environments. The second strand focuses on exploring the use of instructional technologies in pedagogy with a particular emphasis on computer-based instruction and the transformative dimension of technology use in instruction. The design features of SAM, a popular computer-based instruction system that is used to provide training in end-user computing skills, are highlighted.

Chapter 3 presents the research methodology. The study involves solving a problem in the practical and theoretical domains. The design science research method is selected as an overall guide in the design of the solution, from conceptualisation to conclusion. The research embeds a qualitative study that was used to gather contextual information about the problem, which forms an understanding of the nature of the end-user computing service course. The qualitative study focuses on gathering vital insights from end-user computing service course instructors and cross-disciplinary experts on the essence of the end-user computing service course. It extends to an observation of the use of computer-based instruction in practice and a study of some of the curriculum documents used to teach the course.

Chapter 4 presents the study's findings on the nature of the end-user computing course and how computer-based instruction systems are used in teaching it. It is observed that the end-user computing service course is offered to students in their first year at university to equip them with digital literacy skills. End-user computing instructors and cross-disciplinary experts agree on the need to empower students with computing knowledge that is applicable and useful in their respective disciplines. It is also observed that computer application knowledge in an end-user computing course has two contexts. The utilisation context emphasises the use of computing knowledge to solve routine problems, while the innovative context is driven by disciplinary knowledge when digital solutions to problems are crafted.

Chapter 5 proposes the Technology Role in Exploring Learning Orientations (TRELO) framework that can be used to promote functioning knowledge in an end-user computing service course. Learning orientations are defined as specifically designed learning contexts that lead to a particular outcome in the end-user computing service course. The framework is based on the perceived interdisciplinary nature of the end-user computing service course. Six learning orientations that lead to functioning knowledge in the end-user computing service course are presented. It is advanced that functioning knowledge in the end-user computing service course is achieved by setting up learning programmes that touch on these six learning orientations. The key role of the computer-based instruction systems in each of the learning orientations is explained.

Chapter 6 focuses on evaluating the framework by demonstrating its fitness for purpose. The evaluation is done using illustrative scenarios and analytical arguments based on educational literature. Typical scenarios are constructed and used to demonstrate the framework’s utility in enacting learning environments that facilitate functioning knowledge.

Chapter 7 concludes the thesis by offering the theoretical contributions of this study and possible areas for future research. The main contribution is the TRELO framework that end-user computing instructors can use to set up learning programmes that promote functioning knowledge. The framework is also offered as an artefact that can be used to facilitate interdisciplinary learning that involves computing skills in any other discipline, such as agriculture, hospitality management or commerce.

Chapter 2: Literature review

2.1 Introduction

The main research question of this study is framed as "how can functioning knowledge be facilitated in a computer-based instruction end-user computing service course". Chapter 1 explained that the notion of functioning knowledge implies performing a task with understanding. It also indicated that the end-user computing service course is a computer literacy course offered to university students whose major subject is not computer related.

A viable starting point in seeking a solution to the problem of promoting functioning knowledge in computer-based instruction in an end-user computing service course is a deeper understanding of how students learn. Educational theories that have influenced and shaped the process of teaching and learning are useful in providing this understanding. Moreover, a solution to the problem of promoting functioning knowledge in an end-user computing service course can only be useful if it is rooted in sound educational theory. The next section focuses on exploring how students learn, and explaining some of the practices that shape the field of teaching and learning. This is followed by an exploration of the literature on technology use in education. A particular emphasis is placed on the role of computer-based instruction systems in pedagogy and the transformative dimension of technology use in instruction.

2.2 How students learn

Ertmer and Newby (2013:43) explain that "the way we define learning and what we believe about the way learning occurs has important implications for situations in which we want to facilitate". The section begins with an exploration of the notion of knowledge. This is followed by an exposition of some of the tenets and theories that have shaped the practice of teaching and learning. The section concludes by exploring some practices in pedagogy that are pertinent to this study. Concepts such as the definition of learning objectives are explored.

2.2.1 Towards a definition of knowledge

Biggs and Tang (2007) explain functioning knowledge as the performance of a task with understanding. The authors contrast functioning knowledge with declarative knowledge to emphasise the characteristics of functioning knowledge. They define declarative knowledge as comprising verifiable scientific facts that are expressible and taught in lectures and written in books. An exploration of the notion of knowledge is crucial if it is to be taken that teaching and learning activities are aimed at developing knowledge or knowledgeable students. This is done by briefly tapping into a body of literature that is dedicated to understanding knowledge and its management.

In a precursor article that explains modern knowledge management theory, Nonaka (1994) explains that knowledge is a multifaceted phenomenon with many layers of meanings. What Biggs and Tang (2007) describe as declarative knowledge could be likened to what Nonaka (1994) explained as explicit knowledge: facts that are "codable" and expressible in formal language.

Drawing on the philosophical works of Michael Polanyi (1966), Nonaka (1994) contrasts explicit knowledge with tacit knowledge. Tacit knowledge is expressed as personal and "deeply rooted in action, commitment and involvement" (Nonaka, 1994:16). Nonaka (1994) developed a framework that illustrates how organisational knowledge is created through social processes that involve the spiral conversion of tacit knowledge to explicit knowledge.

The framework presents four modes of knowledge creation: externalisation, internalisation, socialisation and combination. Externalisation is the conversion of tacit knowledge into explicit knowledge, where personalised knowledge is coded for articulation and put into reproducible forms from which others can learn. Internalisation is the conversion of explicit knowledge into tacit knowledge. It involves processes in which explicitly coded facts are converted into individualised knowledge. The conversion of explicit knowledge to tacit knowledge indicates knowledge creation through socialisation processes among beings in a master-apprentice fashion where the learner gains knowledge by imitating an expert. Combination is the growth of knowledge by merging explicit facts.

Cook and Brown (1999) criticise and expand on the propositions of Nonaka (1994) by suggesting two parallel perspectives of understanding knowledge, which they describe as the epistemology of possession and practice. The epistemology of possession conceives knowledge as something that can be possessed. Thus, declarative knowledge and explicit knowledge could be seen as belonging to the epistemology of possession, as it can be put forward that human beings are capable of possessing such codified knowledge. The epistemology of practice views knowledge in the context of action. It focuses on what is done with the possessed knowledge. Cook and Brown (1999) describe it as know-how or knowledge used in action.

It is evident from the discussion above that providing an exact and exclusive definition of knowledge is impossible and runs the risk of contradiction. There are, however, conjectures about knowledge in the discussion that can provide a safer perimeter within which to work. Three such proposals are put forward. The first is that knowledge is a "thing". Nonaka (1994) describes explicit knowledge as codified and convertible from one form to another, which is much the same as the explanation of Cook and Brown (1999) of the epistemology of possession that conceives knowledge as something that can be packaged, parcelled and possessed in the head.

The second proposal is that knowledge is action or implied in actions. Cook and Brown (1999) write about "know-how", implying the knowledge that is used in action. Lastly, it is advanced that knowledge is a process. While know-how denotes the knowledge that is used in action, it is difficult to isolate the definition of knowledge from the processes that create it. Nonaka (1994) identifies four processes: socialisation, externalisation, internalisation and combination, as forms of knowledge creation. One, more, or all three conjectures of knowledge – knowledge as a thing, knowledge as action and knowledge as a process – would be implied in instances where the concept of knowledge is used in this thesis.

2.2.2 Theories of learning

The propositions of Nonaka (1994) and Cook and Brown (1999) on knowledge have significance in the later discussions of this research. These propositions are, however, not prominent in the field of pedagogy. Instead, they have made an impact in the fields of organisational sciences where scholars in knowledge and innovation management have used these to explain how organisations can create and maintain a competitive advantage on the basis of superior knowledge. The practice of teaching and learning has remained bound to and heavily influenced by its founding theories in the fields of philosophy, psychology and the sociology of education. The next paragraphs explore some of these foundational theories in education, as identified by Kay and Kibble (2015). These theories are behaviourism, social cognitive learning theories, social-cultural theories and constructivism.

Behaviourism has roots in the works of Skinner and Pavlov, who suggested that educationists should focus on understanding the observable aspects of the learning process, such as the learners' actions (behaviours), in response to stimuli (the environment) (George, 2017). According to this school of thought, learning is strongly associated with behaviour modification in response to external stimuli and has little to do with mental processes or the mind (George, 2017). Learning is viewed as the acquisition of stimuli and modification of behaviours in response to the environment (Schunk, 2012). Watson, an early behaviourist, considered psychological development to be primarily shaped by environmental factors, rather than by genetics or heredity, and consequently boasted that any healthy child could be moulded into any professional irrespective of his or her talents or genes (Reese, 2001).

Social cognitivist learning theorists agree with behaviourists by acknowledging that environmental stimuli affect behaviour, but advance that cognitive processes play a superior role in learning (Kay & Kibble, 2015). Albert Bandura, the theory's proponent, explains that cognitive aspects such as awareness of stimuli and expectations of future events influence a learner's response to stimuli (Bandura, 1977). The social cognitivist argues that humans are not driven solely by inner mental processes. Nor are they driven directionless by the environment. Human behaviour results from a three-way interaction among three key determinant factors: personal, behavioural and environmental (Bandura, 1986). Social learning educationists claim that learning happens through modelling, that is, by watching and imitating what others do (Bandura, 1977).

The social-cultural approach to learning emphasises the effect social interaction, history and culture have on learning, thinking and pedagogy.

The social-cultural approach is closely associated with the work of Vygotsky (1978), who states the following:

> "Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (inter-psychological) and then inside the child (intra-psychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts" (Vygotsky, 1978:57).

Learning is seen as happening through individuals' socialisation into appropriate ways of thinking, interpreting and behaving, which then becomes internalised and systemised into ways of thinking and interpreting (Vygotsky, 1978). Social cultural theorists explain that learning originates in the social processes between and among individuals who then internalise these cultural and social processes into a new individual awareness (Liu & Matthews, 2005). This individuality comes from the mind's ability to construct its own personalised understandings and meanings (Liu & Matthews, 2005). Cole (1996) emphasises that learning is tightly woven into the social reality in which human beings find themselves and argues that the mind is not limited to what is in the head or body, but extends to all that involves human actions, events and the artefacts they use.

Piaget (1967) explains that learning occurs when the cognitive apparatus is modified to accommodate new experience. The mind constructs mental schemes to accommodate new reality into a reality created by the mind. This involves constructing mental schemes that are more or less close to reality. The author emphasises the importance of action in learning by explaining that knowledge is not the collection of ready-made aspects, but is continuously built through action. To this effect, Piaget (1967) wrote that all knowledge, thus learning, is tied to action, and knowing about something involves making it part of a process that involves action.

2.2.3 Experiential learning

Kolb (1984) explains that people learn by reflecting on their experience, and extends the proposition by asserting that knowledge is created by transforming experience in a four-stage cyclic process (see Figure 2.1). Experiential learning comprises four learning modes: concrete experience, reflective observation, abstract conceptualisation and active experimentation. In response to changing circumstances, a creative tension among the four learning modes results in new knowledge. Experience is obtained through concrete encounters with a phenomenon and abstract conceptualisations, and is transformed into new knowledge through reflective observation and active experimentation (Kolb & Kolb, 2009). The learner experiences, reflects, thinks and acts in response to changing learning situations in a circular fashion (Kolb & Kolb, 2009) (see Figure 2.1). Observations and reflections are based on concrete experiences and lead to ideas and concepts that underwrite new actions (Kolb & Kolb, 2009).

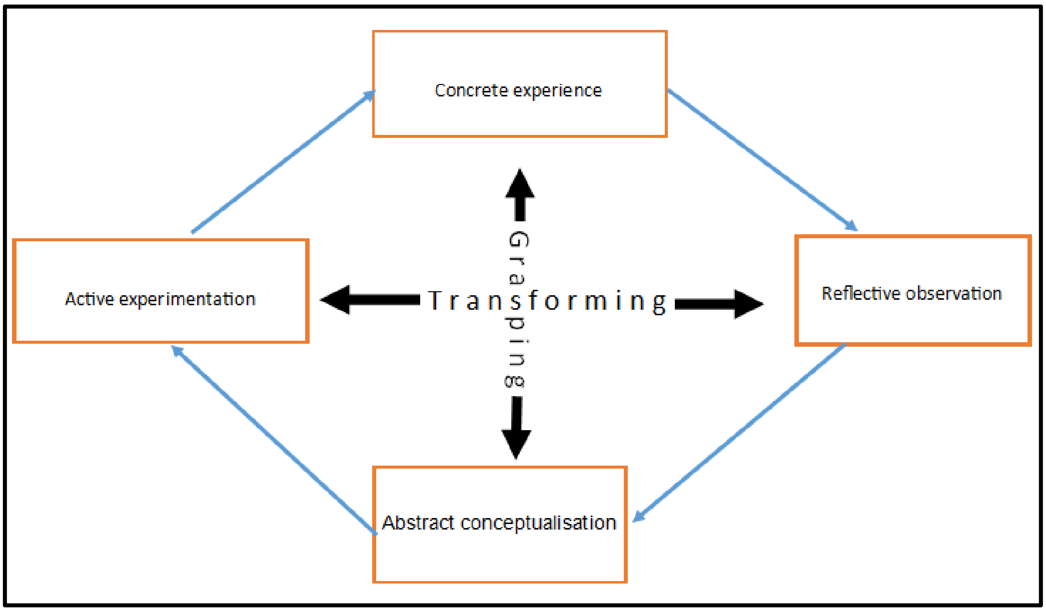


Figure 2.1*: The experiential learning model*

In the experiential learning process, learners:

> "involve themselves fully, openly and without bias in the new experiences (concrete experience). They must be able to reflect on and observe their experience from many perspectives (reflective observation). They must be able to create concepts that integrate their observations into logically sound theories (abstract conceptualisation), and they must be able to use these theories to make a decision and solve problems (active experimentation)" (Kolb, 1984:30).

Passarelli and Kolb (2012) explain the nature of experiential learning by outlining the following:

- Learning is recursive and occurs continuously through experiences when knowledge is created, modified and recreated.
- Experiential learning is constructive. The process is facilitated by a learner's beliefs and preconceived ideas. These beliefs and preconceptions are tested, modified and integrated into the process of creating knowledge in a constructivist fashion.
- Learning is a conflict-driven process. Knowledge is created through repetitive actions that touch on reflection and action on one side, and feeling and thinking on the other.
- Learning involves the whole being and is not relegated to the cognition alone. It involves thinking, feeling, perceiving and behaving.
- A student's behaviour is shaped by their environment. Learning is thus influenced by the learner's interactions with the environment.

Prominent educationist, John Dewey, understood that learning is situated and that it involves experiencing, thinking and reflecting (Hammond, Austin, Orcutt, & Rosso, 2001). Dewey points out that "… thinking, or knowledge-getting, is far from being the armchair thing it is supposed to be … Hands and feet, apparatus and appliances of all kinds are as much a part of it as changes in the brain" (Dewey, 1916:13–14). Dewey further explains that thinking is mental, not because of something that goes into the brain, but because of the actions that people perform using physical objects. Cook and Brown (1999:60) emphasise this by indicating that learning is rooted in acts of both cognition and action. They write that "by knowing we do not mean something that is used in action, or something necessary to action, but rather something that is part of action"; therefore, "knowing is dynamic, concrete and relational". Dewey's pragmatic doctrine advises that knowing is something we do. It is an "aspect of action, not something assumed to underlie, enable or be used in action" (Cook & Brown, 1999:63). Understanding, therefore, involves both involvement and action because "participation thus dissolves dichotomies between cerebral and embodied activity, between contemplation and involvement, between abstraction and experience: persons, actions and the world are implicated in all thought, speech, knowing and learning" (Lave & Wenger, 1991:52).

Lave and Wenger (1991) understood that confining learning to the classroom situation inadequately addresses what learning is about. The classroom falls short of other legitimate contexts that underwrite effective learning because the “school content” does not exist in isolation. Thus, the restriction of end-user computing to the mastery of specific procedures can be seen as reproducing the same shortcomings that Lave and Wenger (1991) observe when learning is confined to classroom setups. The authors claim that school-forged contexts are incapable of affording a proper background for understanding.

Brown, Collins and Duguid (1989) present three different contexts for experiential learning. The authors use students, “just plain folks” and practitioners to highlight the differences between the kind of knowledge that is obtained from traditional school environments and the knowledge that is obtained from situated learning contexts. Students in conventional schools and university environments operate on fixed and structured learning schedules. They use symbols to learn, reason with predetermined laws and solve well-defined problems to produce fixed meanings. “Just plain folks” are people who learn primarily through social and cultural apprenticing, such as midwives, tailors, quartermasters and butchers. Practitioners’ activities originate from the cultures and environments in which they operate, and the environment forms the basis on which they create meanings and construct their understanding (Brown et al., 1989).

2.2.4 Situated cognition

The work of Lave and Wenger (1991) and Brown et al. (1989) on situated learning highlights the importance of situational contexts in problem-solving. The ethnographic studies of Lave (1988) illustrate that a problem-solving process that is conducted in the problem’s environment is different from the one inside the learner’s head, as it is typically associated with the schooling environment. Brown et al. (1989) support this argument. They highlight that offloading the cognitive task onto the environment is an efficient problem-solving process, as the problem-solver can use the environment as a tool to solve the problem. This process is exemplified by dairy-loaders who use the configuration of the crates they are filling to count how many items they have loaded into them (Brown et al., 1989).

Similarly, a person who needs 48 eggs only needs to observe that each of the “holes” in the four crates has an egg in it (Brown et al., 1989). Situated cognition eliminates the cognitive engagement that is required to count the number of eggs. Authentic problem environments provide quicker access to the solution in a manner that artificial classroom environments may normally not allow. Situated cognition in authentic learning environments reduces the cognitive effort that is required to solve a problem because the problem is tied to the means of solving it (Brown et al., 1989).

Classroom learning theorises phenomena, while authentic learning immerses the learner into the contexts of applying the concepts, thereby promoting the creation and application of functioning knowledge (Brown et al., 1989). Functioning knowledge in the end-user computing service course must, therefore, be based on the concrete experiences of the authentic contexts in disciplines such as agriculture, hospitality management or development studies that university students study.

2.2.5 Constructive learning

Most traditional learning theories, especially behaviourism, have a hidden assumption that knowledge is transferred intact from the teacher’s mind to that of the learner (Bodner & Geelan, 2001). The constructivism theory, though not very recent, has become popular in instructional design and pedagogy (Bednar, Cunningham, Duffy, & Perry, 1991). Although there are many strands of constructivist thinking, the central notion in constructivism is that people construct knowledge with their minds, as well as with their observations and experiences. Constructivism could be viewed as both a philosophical paradigm and a theory of learning (Fosnot, 1996). As a philosophy, it belongs to the same side as relativism and opposes realism, objectivism and positivism (Bodner & Geelan, 2001). It emerged from the school of subjective empiricism and strongly opposes the claims of an observer-independent reality, rational thinking and all other forms of deductive logic (Hardy & Taylor, 1997). It dispels the notion that it is possible to achieve knowledge that reflects an objective and independent reality (Johnson, 1987).

Relativism, the philosophical divide to which constructivism belongs, advances that observations are influenced by the individual’s background, beliefs, theories and hypotheses (Bodner & Geelan, 2001). Von Glasersfeld (1995), a radical constructivist, even argues that the notion of an independently observed reality is a myth.

Constructivists accept a “viable approach” to reality that treats knowledge as mental constructions that create and make sense from experiences (Hardy & Taylor, 1997). The notion of viability emphasises the fact that constructed knowledge does not have to match any reality “out there”, but needs to fit within a human being’s mental constructs (Hardy & Taylor, 1997). Mental constructs that are useful and satisfy the test of experience are then retained and considered as viable knowledge (Von Glasersfeld, 1984).

Constructivism rose to prominence as a theory of learning to counter the behaviourists’ emphasis on learning that is based on stimuli response and places the responsibility of learning on the educator (Jones & Brader-Araje, 2002). In a behaviourist context, knowledge is treated as a “thing” that can be packaged, transmitted and acquired (Scheurman, 1998). In constructivist philosophy, the learner is viewed as an active and creative agent that actively constructs what it knows by organising its experiential encounters (Husen & Postlethwaite, 1989). Davis, Maher and Noddings (1990) state that learners have their own toolkits for constructing knowledge and meanings, and advise that the teacher’s role is to provide the challenges, support and settings that will encourage the construction of knowledge. The constructivist theory has support from proponents of technology-based learning (Linn, 1998). Gilakjani, Leong and Ismail (2013) observe a close relationship between technology and constructivism, and indicate that the implementation of one benefits the other.

Bodner and Geelan (2001) explain that knowledge is continually built and tested for viability in constructive learning processes. The measure of knowledge shifts from true or false judgements to viability and functionality. Polkinghorne (1992) highlighted this shift. He states that understanding knowledge requires a shift from metaphors of correctness to those of utility. Learning involves a change of emphasis from a true or false kind of judgement to assessing whether something is viable or not (Bodner & Geelan, 2001). This is an important observation for end-user computing instruction where graduates are expected to provide operational and working solutions to business problems that are mostly contextual. Business contexts and problems are rarely identical or duplicate versions of previous encounters. Therefore, the notion of knowledge viability supports the argument that facilitating the end-user computing course extends beyond telling students what it is or what a computer program can do.

The learning process should allow learners to explore and acquire the kind of knowledge that emphasises an understanding of what works and what does not.

Constructivist teachers understand that learners are beings who bring their individuality into the classroom based on their lived experiences (Seimears, Graves, & Gail, 2012). This is in contrast to the "blank slate" assumption of behaviourists where learners are treated as blank canvases on which a teacher will paint or that teachers will fill with knowledge (McLeod, 2017). Constructivists realise that learners bring a collection of lived experiences, knowledge and beliefs that are used in the creation of new meanings, and that these preconceptions, which are tied to experience, filter and affect learning and understanding (Jones & Brader-Araje, 2002).

Vygotsky (1978) observed a gap between a learner's actual development level and that which they can achieve under the supervision of a more capable person. This concept is called the Zone of Proximal Development (ZPD). Teachers, tutors and peers provide the extra guidance that is needed to improve the learners' abilities from the level at which they are to a higher level of capability. Brooks and Brooks (1999) provide an extensive list of constructivist practices that should be observed by teachers. Some of these are presented below:

- Constructivist teachers accept and encourage student autonomy and initiatives in which learners are allowed to frame their own questions and find the answers. In addition to being solution providers, they are also problem finders. This idea is reinforced by Taber (2006), who emphasised that learning is something that the learner does; it is not something that is imposed on the learner.
- Learning must be based on raw data: physical objects that can be manipulated to encourage learners to build their own abstract concepts and understanding from the real-life phenomenon.
- Assessment should be driven by active terminology such as "classify", "analyse", "predict" or "create" because what is heard affects how thought processes are conducted.
- Constructivist learning environments should be learner-driven. Student responses should shape lessons, shift instructional strategies, and alter the way content is formulated and presented. This is not to be confused with

dereliction of the teacher's leadership role, but as Brooks and Brooks (1999) advise, educators must create teaching moments around learners' topical issues.

- Instructors should encourage learners to develop their own understandings instead of taking meanings from the teacher. Learners develop their understanding by probing as opposed to being told what to learn.
- There should be active engagement between the teacher and the learner, and among the learners. Social interaction reinforces learners' own convictions and offers the opportunity to learn from others.
- Questioning should be thoughtful and open-ended by encouraging debates and discussions that challenge initial convictions. In solving the contradiction, learners construct new meanings and understandings.
- Constructivist teachers allow learners to synthesise and construct their arguments. They do not promote a competitive "race to raise a hand" among students.
- Constructivist teachers encourage learners to use metaphors because metaphors allow them to create holistic visions and imagery of the concepts on which they will be working.
- Constructivist teachers nurture curiosity among learners by allowing learners to discover concepts and apply them.

The constructive approach to knowledge creation has important implications for instructional design in end-user computing courses. It emphasises the need for careful consideration of the instructor's roles, the courseware, the nature of the content and how it is presented. The design and implementation of the courses should consider the fact that learners bring their own knowledge and understandings with them to the learning experience, hence the need to understand which gap needs to be filled and how it should be filled. The next section explores some practices that are prevalent in teaching and learning, with a special emphasis on constructive alignment.

2.3 The practice of teaching and assessment

This section considers some practices that are pertinent to the practice of teaching and learning. It begins by presenting two broad approaches that are used in professional knowledge development: the bottom-up and the just-in-time approaches. This is followed by an exploration of the notion of constructive alignment, which is seen as crucial in designing learning programmes. After that, common approaches used in specifying learning objectives are reviewed. The section concludes with a focus on concepts that guide teaching for functioning knowledge.

2.3.1 Professional knowledge development

The traditional bottom-up approach and the just-in-time approach are two broad teaching and learning strategies that are used when building professional functioning knowledge (Biggs & Tang, 2007). The bottom-up approach focuses on introducing simpler, more basic concepts first, and building content progressively towards complex concepts (De Silva & Feez, 2016). It is the traditional teacher-centered approach in which learning is driven by direct instruction, repeated readings, rote learning and programmed teaching (Tompkins, Campbell, Green, & Smith, 2015). Learners copy and attempt activities repetitively and memorise concepts during learning processes (Kalantzis, Cope, Chan, & Dalley-Trim, 2016). On the other hand, the just-in-time learning approach focuses on seeking knowledge as and when it is needed by availing knowledge resources that satisfy an individual's immediate needs (Kahn, Santos, Thao, & Ehlers, 2007).

The next paragraphs examine how teaching and assessment can be aligned to achieve the desired learning outcomes. The two predominant methods for specifying teaching and learning objectives – Bloom's taxonomy and the structure of observed learning outcomes (SOLO) taxonomy – will also be discussed.

2.3.2 Constructive alignment

The constructive alignment pedagogical framework of Biggs (2003) recommends that all aspects of the teaching and learning process, such as the curriculum, its outcomes, teaching methods and assessment, be aligned to each other. The "constructive" notion acknowledges that learners create meaning through learning activities, while the "alignment" aspect suggests that learning activities should be set up in a way that supports the achievement of intended learning outcomes (ILOs). Biggs (2003) indicates that three steps must be taken to achieve a constructively aligned learning programme. Firstly, the ILOs must be defined by specifying the required competencies in terms of the topic, the content and the desired level of understanding. Secondly, the teaching and learning activities that lead to the achievement of the ILOs must be chosen. Finally, learners must be assessed for the attainment of the specified learning outcomes.

Biggs and Tang (2007) reiterate the importance of the constructive alignment principle by emphasising that the teaching and learning activities must be aligned with the learning outcomes. As a result, assessment tasks must also be aligned to or mirror the ILOs to force the learner to study according to the ILOs in the curriculum and not according to what they expect to find in an examination. However, Tam (2014) advises that, while strict adherence to the notion of constructive alignment and ILOs is desirable in a learning programme, care should be taken to improve the learning process, as opposed to following design rigidity.

2.3.3 Specifying learning outcomes

The tertiary education system is guided by sets of ILOs (De Bruijn, 2016), which are the indicative statements of what is expected of the learner in terms of knowledge, understandings and demonstrable abilities (Gibbs, Kennedy, & Vickers, 2012). Learning objectives determine the nature of knowledge and competencies that are targeted in a learning activity. Several taxonomies and systems of setting up learning objectives are used in academia. Yildirim and Baur (2016) discuss four taxonomies: The Engineering Education Research (EER) taxonomy, Fink's taxonomy, Bloom's taxonomy, and the SOLO taxonomy.

The EER taxonomy is a subject-specific taxonomy that is used to guide teaching and assessments in the field of engineering (Finelli, Borrego, & Rasoulifar, 2015). Fink's taxonomy, on the other hand, focuses on the significance of learning by including the humane dimensions of learning, such as self-understanding and care (Stanny, 2016). Bloom's taxonomy describes a learner's development in terms of the affective, psychomotor and cognitive domains (Gibbs et al., 2012). Its revised version has six cognitive levels that start with remembering, followed by understanding, application, analysis and evaluation, and ending with creation (Anderson & Krathwohl, 2001). Remembering and understanding represent lower-level cognitive skills, while application, analysis, evaluation and creation indicate higher-level thinking skills (Stanny, 2016).

Critics of Bloom's taxonomy question the notion of a sequential hierarchy of cognitive levels. The argument of Fadul (2009) persuades that an attempt to compartmentalise and stratify learning processes, and consequently cognitive processes, into distinct segments is not consistent with the holistic and interconnected nature of cognition. Fuller et al. (2007), who are researchers in computer science, stated that computing instructors did not find Bloom's synthesis and evaluation levels to be useful when considering the learning objectives of computer programming. They advance that application skills are the most important abilities that computer programmers should strive to achieve by citing the computing curricula of the Association for Computing Machinery (ACM). These curricula emphasise a demonstration of applied competencies.

The SOLO taxonomy, which was developed by Biggs and Collins, attempts to avoid the shortcomings of Bloom's taxonomy by suggesting that learning comprises two categories: surface and deep learning (Hattie & Brown, 2004). The process of learning is observed by Biggs and Collins (1982) as operating at five levels: prestructural, unistructural, multistructural, relational and extended abstract (see Table 2.1).

Table 2.1: The structural learning model of { TA \l "TABLE 2.1 Biggs and Collis' (1982) Structural Learning Model" \s "TABLE 2.1 Biggs and Collis' (1982) Structural Learning Model" \c 1 }Biggs and Collins

Structural level	**Observed learning outcomes**
Prestructural	The task is engaged, but the learner is distracted or misled by an irrelevant aspect that belongs to a previous stage or mode.
Unistructural	The learner focuses on the relevant domain and picks one aspect with which to work.
Multistructural	The learner picks up more relevant or correct features, but does not integrate them.
Relational	The learner integrates parts of the structure with each other so that the whole has a coherent structure and meaning.
Extended abstract	The learner generalises the structure to take in new and more abstract features that represent a higher mode of operation.

Source: Ivanitskaya, Clark, Montgomery, and Primeau (2002:105)

The prestructural level indicates a stage where the learner does not understand the concepts. At the unistructural and multistructural levels, understanding is seen as an increase in the volume of concepts that the learner acquires. At the unistructural level, the learner understands a single aspect of a concept. At the multistructural level, they increasingly acquire more of the same concept, but their understanding remains disjointed. At the relational level, the learner restructures the multistructural concepts to create an integrated system of knowing. The understanding is then extended to other dimensions at the extended abstract level. Learning is thus seen as a hierarchical process of acquiring knowledge, where higher levels build on lower levels. Deep understanding is achieved by relating concepts. In the surface-level approach, which operates at the unistructural and multistructural levels, understanding focuses on singular concepts first. The learner then acquires more of the same concept (Hattie & Brown, 2004). Deep learning, which operates at the relational and extended abstract levels, indicates a qualitative integration of the many concepts into a coherent system of knowing that can be extended to new settings (Hattie & Brown, 2004).

2.3.4 Teaching for functioning knowledge

The SOLO taxonomy, like many other taxonomies, uses verbs to indicate the ILOs for both declarative and functioning knowledge. Declarative knowledge, as indicated earlier, is knowing about facts, details and concepts. It can be assessed at both the surface and deep levels (Biggs & Tang, 2007). Functioning knowledge, on the other hand, involves using, applying, integrating, relating and extending knowledge to solve problems and can similarly operate at both the surface and deep levels (Biggs & Tang, 2007). Table 2.2 indicates that the unistructural and multistructural levels operate at the surface level of learning, while the relational and the extended abstract levels indicate deep learning. Declarative knowledge and functioning knowledge can either be at the surface or the deep level. Memorising, identifying and reciting factual information demonstrate surface and declarative knowledge at the unistructural level. Counting, matching and ordering indicate the use of functioning knowledge at the surface and unistructural levels. Theorising, hypothesising and generalising indicate a deep understanding of declarative knowledge at the highest extended abstract level. Reflecting, improving, inventing, creating and solving unseen problems represent the deep utilisation of functioning knowledge at the extended abstract level.

Table 2.2: Teaching for declarative and functioning knowledge{ TA \l "TABLE 2.2 Teaching for Declarative and Functioning Knowledge" \s "TABLE 2.2 Teaching for Declarative and Functioning Knowledge" \c 1 }

Level	**Structure**	**Declarative knowledge**	**Functioning knowledge**
Surface	Unistructural	Memorise, identify and recite	Count, match and order
	Multistructural	Describe and classify	Compute and illustrate
Deep	Relational	Compare and contrast, explain, argue and analyse	Apply, construct, translate, solve near the problem and predict in the same domain
	Extended abstract	Theorise, hypothesise and generalise	Reflect and improve, invent, create, solve unseen problems and predict to unknown domain

Based on Biggs & Tang (2007)

Biggs & Tang (2007) indicate that functioning knowledge is rooted in application, which is why it is necessary to create learning environments where students have to apply the knowledge they have acquired. They propose case-based learning, group work and work-based learning as some of the activities that promote functioning knowledge and underwrite application in the process.

Two important insights into the nature of functioning knowledge can be drawn at this stage. Firstly, that functioning knowledge comprises elements of declarative knowledge that must be acquired by the learner. Secondly, it is the use of declarative knowledge in performing tasks such as counting, constructing, solving and inventing that makes the knowledge functional.

The next section explores the role and impact of technology in instruction with a special emphasis on computer-based instruction. The transformative dimension of technology use in instruction is also explored.

2.4 Technology use in instruction

Technology has found widespread acceptance in pedagogy and its use has transformative implications in academia (Salmon, 2014). Computer-based instruction systems can provide tuition, while educators retain control of the course's design and content (Chien & Chang, 2012). Gilakjani et al. (2013:51) indicate that technology brings relevant, real-world experience to the classroom by stating the following:

> "Instead of the static teacher-centered environment where the students act as receivers of information from a single source, the classroom becomes an active setting full of meaningful activity where the student is made responsible for his or her learning. The students are engaged in meaningful activities such as problem-based learning projects, browsing the internet in search of information for a report, or the preparation of presentation assignments. Software and hardware become tools used by the students to create a product to be presented to teachers and fellow students so that they may review, learn or critique in a collaborative manner."

The changes in the use of technology in pedagogy make it challenging to have static and universal definitions for terminology used to describe technology use in instruction. Thus, there is no universal agreement on the meaning of terms such as computer-based training, computer-based instruction, computer-assisted learning, computer-managed learning, online learning, multimedia instruction technology and digital multimedia instruction. The growth of the internet in recent years has also introduced new terms such as web-based instruction and web-based learning. Hesham (2003) notes that most of these terms focus on the same basic principle with a slight change in dimension, application and emphasis.

2.4.1 Computer-based instruction

The terms computer-based training and computer-based instruction are often used interchangeably to refer to what Akram, Ather Tousif and Rasul (2012) view as an interactive instructional approach in which the computer takes the place of an instructor. Computer-based instruction has been in existence since the 1960s, when projects such as Programmed Logic for Automatic Teaching Operation (PLATO) were used to offer drill-and-practice sessions (Saettler, 1990). According to Bhalla (2013), computer-based instruction falls into three broad categories: computer-aided learning, computer-managed instruction and computer-assisted instruction. Bhalla (2013) states that computer-managed instruction and computer-assisted instruction focus on the administrative use of computer systems in supporting traditional teaching practices. The context in which the author defines the terms emphasises the use of technology in aspects such as preparing lecture notes, demonstrations, projects, textbooks, learning resources and the handling of student assignments. The focus is not on the use of computer systems as a means of instruction, so it does not warrant further analysis in this research. The focus of this research is what Bhalla (2013) describes as computer-assisted instruction: the use of computer systems to offer instruction through drill-and-practice sessions, tutorials and simulations. Table 2.3 provides a summary of the typical features of such a computer-assisted instruction system.

Table 2.3: Features of a computer-assisted instruction system{ TA \l "Table 2.3 Features of a Computer Assisted Instruction System" \s "Table 2.3 Features of a Computer Assisted Instruction System" \c 1 }

Computer-assisted instruction	
Method	**Description**
Tutorial	Presents information, asks questions, monitors responses, provides feedback and keeps records
Drill and practice	Presents items to work on, provides feedback on correctness, makes notes on incorrect responses and summarises results
Simulation	Approximates real-life situations, controls expenses, accesses inaccessible information and performs operations
Gaming	The computer acts as a competitor, judge, and scorekeeper in a motivational format

Problem-solving	Solves basic problems related to calculation, experiments and explorations, and maintains the database

Source: Bhalla (2013:178)

This study will use the more generic and readily recognisable term "computer-based instruction" to signify what Bhalla (2013) calls computer-assisted instruction. Table 2.3 indicates that such systems offer instruction through drill-and-practice sessions, tutorials, simulations, games and problems that are programmed into the computer system. The drill-and-practice technique is used to demonstrate concepts and skills to learners through repeated exposure as learners practice what they have learnt (Andriotis, 2016). Lim, Tang and Kor (2012) explain that the drill-and-practice method of learning perfects learning through repetition. Computer-based instruction systems that are used in the end-user computing service course use simulation techniques to mimic a real-life software environment. Ali and Wibowo (2016:18) define these kinds of simulations as "moving objects, pointing substances or any other form of animation" that simplify explanations.

2.4.2 Computer-based instruction systems used in end-user computing

The South African higher education landscape has seen a recent increase in the use of computer-based instruction systems in training end-user computing skills (see Appendix 3)[2]. These systems are distributed by textbook manufacturers (Ali & Wibowo, 2016). The common ones are Cengage Learning's SAM, Pearson Education's MyLab IT and McGraw-Hill Higher Education's SimNet (Murphy, Sharma, & Rosso, 2012). The systems feature guided practical activities, simple activities, complex case projects, test banks, simulators, document checkers and mechanisms to include outside projects (Hill, 2011).

The SAM system, which is popular in the South African higher education sector, provides instruction in introductory computer application skills in MS Word, MS Excel, MS PowerPoint, MS Access, MS Outlook, MS Windows and MS Internet Explorer (Cengage Learning, 2014). The system uses simulated Microsoft applications and can track student activities (Stauffer, 2016). The SAM learning design is based on four steps: introduce, observe, practice and apply (Cengage Learning, 2016).Students are introduced to a concept, followed by a short video

[2] This communication from a Cengage South Africa salesperson indicates the names of South African higher education institutions that use its SAM computer-based instruction system to teach end-user computing skills.

demonstrating and explaining the task that has to be accomplished. They then complete practice and evaluative activities to reinforce what they have mastered (Cengage Learning, 2016).

Computer-based instruction systems such as SAM have interfacing capabilities with learning management systems (LMSs) such as Moodle and Blackboard. LMSs assist in course administration by delivering materials, tracking student assignments and progress, keeping records and facilitating collaboration (Lopes, 2014). Pappas (2016) explains that LMSs have personalised learning experience and analytical features that allow instructors to view students' engagement dashboards and generate analytical reports that show students' progress and engagement in the course. In addition, these systems are programmed to detect students' online actions and behaviours that have an impact on their performance.

The next section focuses on the impact that instructional technology, including computer-based instruction systems, has on the practice of teaching and learning.

2.5 The impact of computer technology on pedagogy

The previous section highlighted the fact that computer-based instruction systems improve teaching and learning processes through content delivery and inbuilt analytics that show student progress and engagement. This section focuses on the transformative dimension of technology use that is beyond the classroom, but extends to a revolution in the way teaching and learning are done. One such revolution of the transformative dimension of technology is what is commonly referred to as blended learning.

2.5.1 Blended learning

The concept of blended learning, like most concepts that are used in the fast-changing technological landscape, has different meanings, depending on the source one engages. Oliver and Trigwell (2005) indicate that there is pedagogical confusion as to what blended learning focuses on. The confusion is on whether the blending refers to a mixture of teaching methodologies or to a mixture of the learners' educational experiences, or both.

Early explanations of blended learning, such as the one Singh (2003) offers, emphasised the idea that blended learning denotes the mixing of teaching approaches. Singh and Reed (2001) defined blended learning as a learning programme that improves outcomes by using multiple delivery methods.

Singh (2003) provided the following five learning experiences that explained blended learning as a mixture of some sort:

- Mixing offline and online learning: The focus is on mixing online learning materials (internet-based resources) with offline content, such as textbooks, notes and traditional classroom-based learning.
- Mixing self-paced and collaborative learning: Self-paced learning is learner-driven, solitary and based on on-demand learning. Collaborative learning is the use of online collaborative tools to enhance the learning process by promoting the benefits of group learning.
- Mixing structured and unstructured learning: Structured learning is pre-planned, directed and timed, whereas unstructured learning allows learners to engage on topics and thread through the content as it comes.
- Mixing custom content and off-the-shelf content: Custom content is learning material that is specially designed for a particular learning requirement or institute. The custom content is then mixed with “off-the-shelf” material: content that is generic to the subject, industry or practice.
- Mixing practice and performance support: The blending focuses on mixing prior knowledge that is acquired during pre-training and performance support knowledge that is supplied during practice to enable participants to perfect their practice.

The concept of blended learning has since evolved to what Garrison and Kanuka (2004) describe as a carefully considered integration of face-to-face classroom instruction with internet-driven learning activities. This shift is evident in the way Salmon (2014) describes blended learning as a combination of traditional teaching methods and learning technologies. The essence of the “blend” in blended learning is now the extent to which learners are educated through face-to-face encounters and electronically mediated media. This innovative approach to blended learning is explained in the works of Horn and Staker (2011) and Staker and Horn (2012).

Christensen, Horn and Staker (2013) summarise the emerging trend in their definition of blended learning, which describes it as a learning process in which a student partly experiences instruction in a physical teacher-led classroom and partly through online channels.

Consequently, Horn and Staker (2012) document success in learning programmes where students learn partly at brick-and-mortar schools and partly through online delivery. They highlight that this new approach to blended learning has the benefit of flexibility, as students can determine when to learn, how fast to learn and where to learn. The authors provide four implementation modalities of such a blended learning approach: rotation models, the flex model, the self-blend model and the enriched virtual model.

2.5.2 The rotational approach to blended learning

Staker and Horn (2012) provide four blended learning rotational models. They all involve some form of fixed interchange between online learning and teacher-led activities, such as face-to-face tuition, group tutoring, projects or in-class assignments. The four rotational models are the station, laboratory, individual and flipped classroom rotation modalities.

The station rotation modality

In the station rotation model, students move from one station to another in a contained classroom or group of classrooms based on a predetermined timetable or as determined by the instructor.

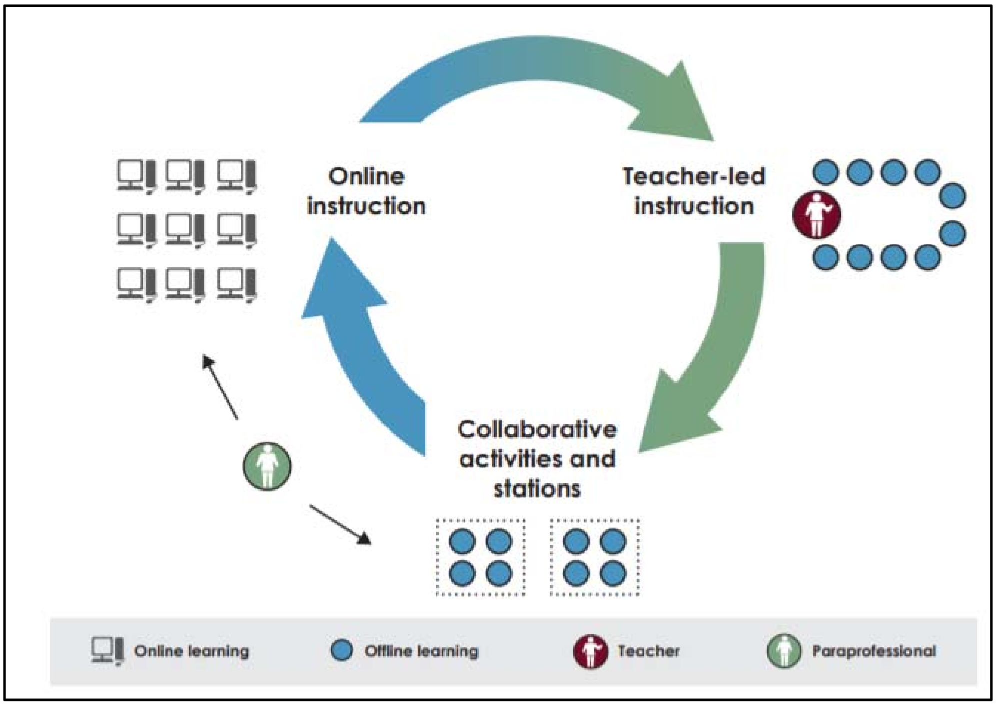


Figure 2.2: The station rotation model

Source: Staker & Horn (2012:9)

Figure 2.2 illustrates the implementation of the station rotation modality in a single learning room. The instructor could start by introducing a concept to the whole class. The learners then split up into smaller groups to collaborate, discuss, debate or work further on the topic's activities. The learners could then move on to online-mediated platforms to do further research on a concept or prepare a written submission for evaluation under the guidance of semi-professionals or teaching assistants.

The laboratory rotation

The laboratory rotation modality is a scheduled campus-based rotation during the study of a course or courses. This model requires a learning centre that is specially designed to facilitate online learning. Students move from their various courses (buildings) to a laboratory that is equipped with online learning tools such as a high-speed internet connection with access to web resources. The laboratory rotation is similar in principle to the station rotation, but the two differ on the scale of the rotation. The laboratory rotation is done across campus buildings or laboratories and learning centres, while the station rotation is confined to specially designed positions (stations) in a single learning room. Figure 2.3 illustrates the laboratory rotation blended learning implementation of Staker and Horn (2012).

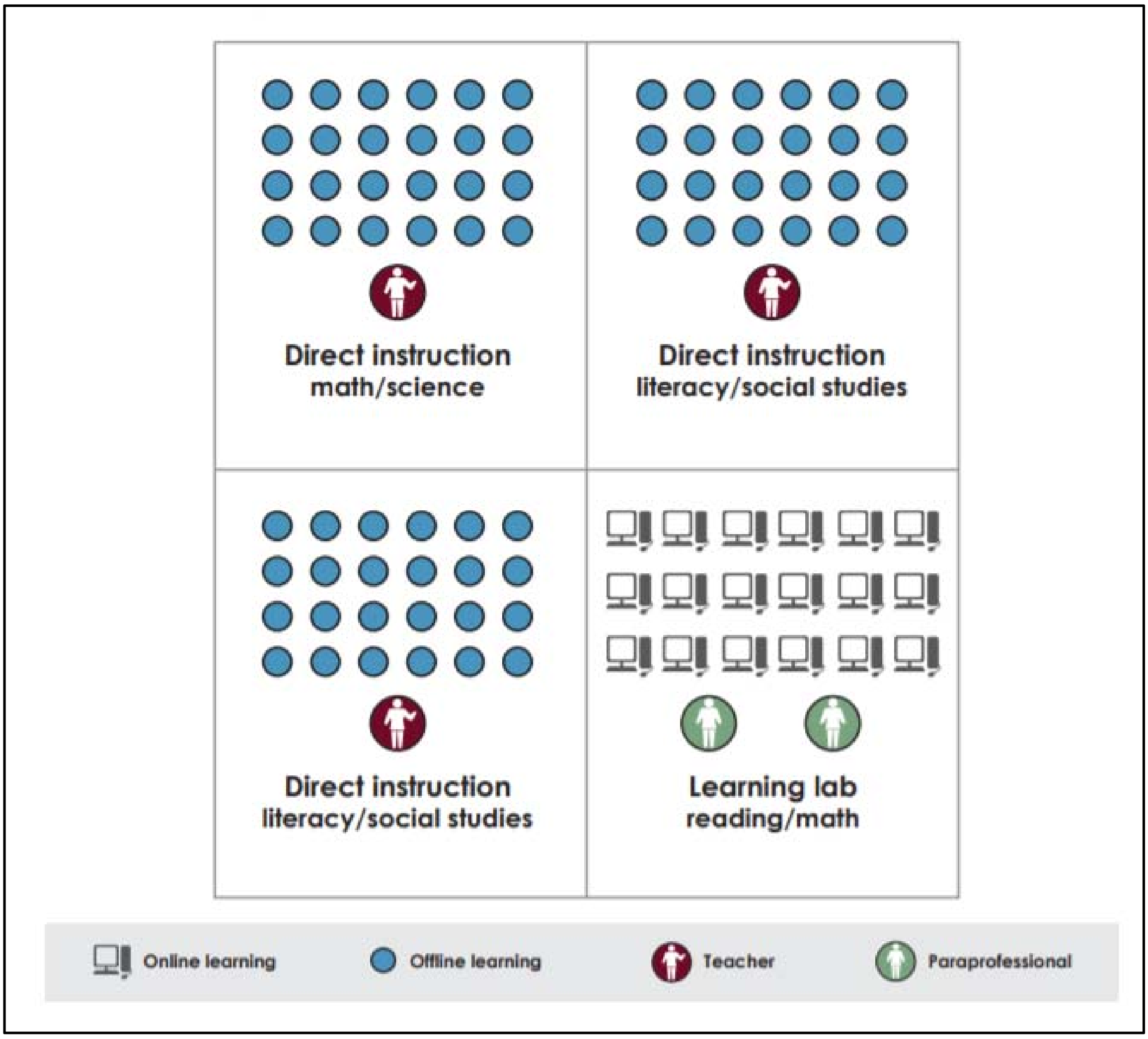


Figure 2.3: The laboratory rotational model

Source: Staker & Horn (2012:10)

The laboratory rotation model depicted in Figure 2.3 illustrates four learning centres. Three are dedicated to teaching specialist subjects such as Mathematics, Social Studies and Literacy. The fourth learning centre is equipped with high-speed internet access and multimedia resources that students can use to read, research or access courseware such as computer-based instruction systems.

Individual rotation

The individual rotation modality described by Staker and Horn (2012) is implemented by rotating individual students based on a customised schedule (see Figure 2.4). The educator designs a unique rotational schedule for each learner, depending on his or her needs. The educator may start by giving the whole class a lesson. The individual learner may then move to a large group, a small group, a personal trainer or a learning laboratory for further engagement. The modality is flexible as the learner does not necessarily have to attend every station. The setup Staker and Horn (2012) present in Figure 2.4 is based on the Carpe Diem Collegiate in the USA, which uses a centralised learning laboratory with several online stations that are manned by paraprofessionals. Students rotate between seminar, face-to-face tuition, group, class, intervention and learning laboratory stations on the basis of an individually customised timetable.

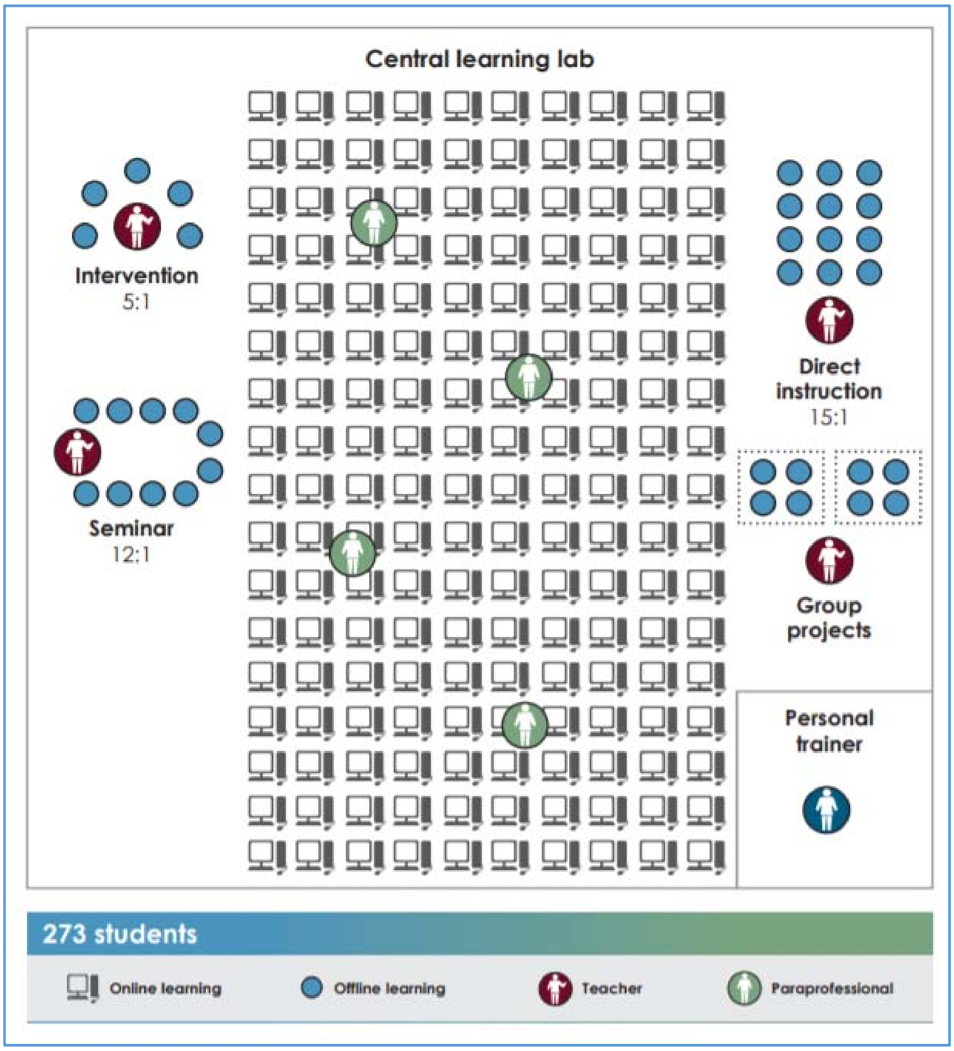


Figure 2.4: Individual rotation model

Source: Staker & Horn (2012:12)

The flipped classroom

The flipped classroom is an instructional methodology that advocates a paradigm shift from the traditional learning approach where teachers "deliver" content in class and students do activities at home (Cabi, 2018). Surface learning or rote memorisation is discouraged in favour of active learner involvement in the learning process (Ritchhart, Church, & Morrison, 2011). The approach allows learners to interact with the content in a way that is consistent with their learning styles as they have time to reflect on their learning needs and develop their own connections with the course material (Roehl, Reddy, & Shannon, 2013).

According to Roehl et al. (2013), the approach affords both the teacher and the learner more time to actively interact and solve problems during class-time. The learner can always replay the learning material and learning continues even in the absence of the teacher or the learner (Roehl et al., 2013). The flipped classroom approach, which is illustrated in Figure 2.5, uses online electronic platforms to give learners the "lecture content" that could be in the form of videos or prepared reading. Students go through these before the lecture and then use the class-time to work through problems, advance their knowledge and collaborate with others (Tucker, 2012).

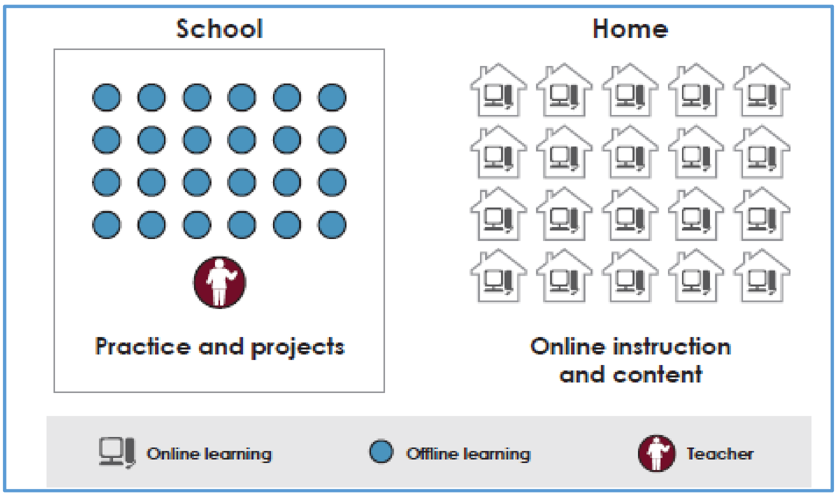


Figure 2.5: The flipped classroom model

Source: Staker & Horn (2012:11)

2.5.3 The non-rotational models

The three non-rotational blended learning models that Staker and Horn (2012) present are the flex, self-blend and enriched virtual models.

The flex model

The flex model uses an online medium to provide the bulk of the teaching, while instructors provide support on a site and needs basis. Students use an individually customised schedule to attend face-to-face support, small-group instruction, group projects and individual tutoring.

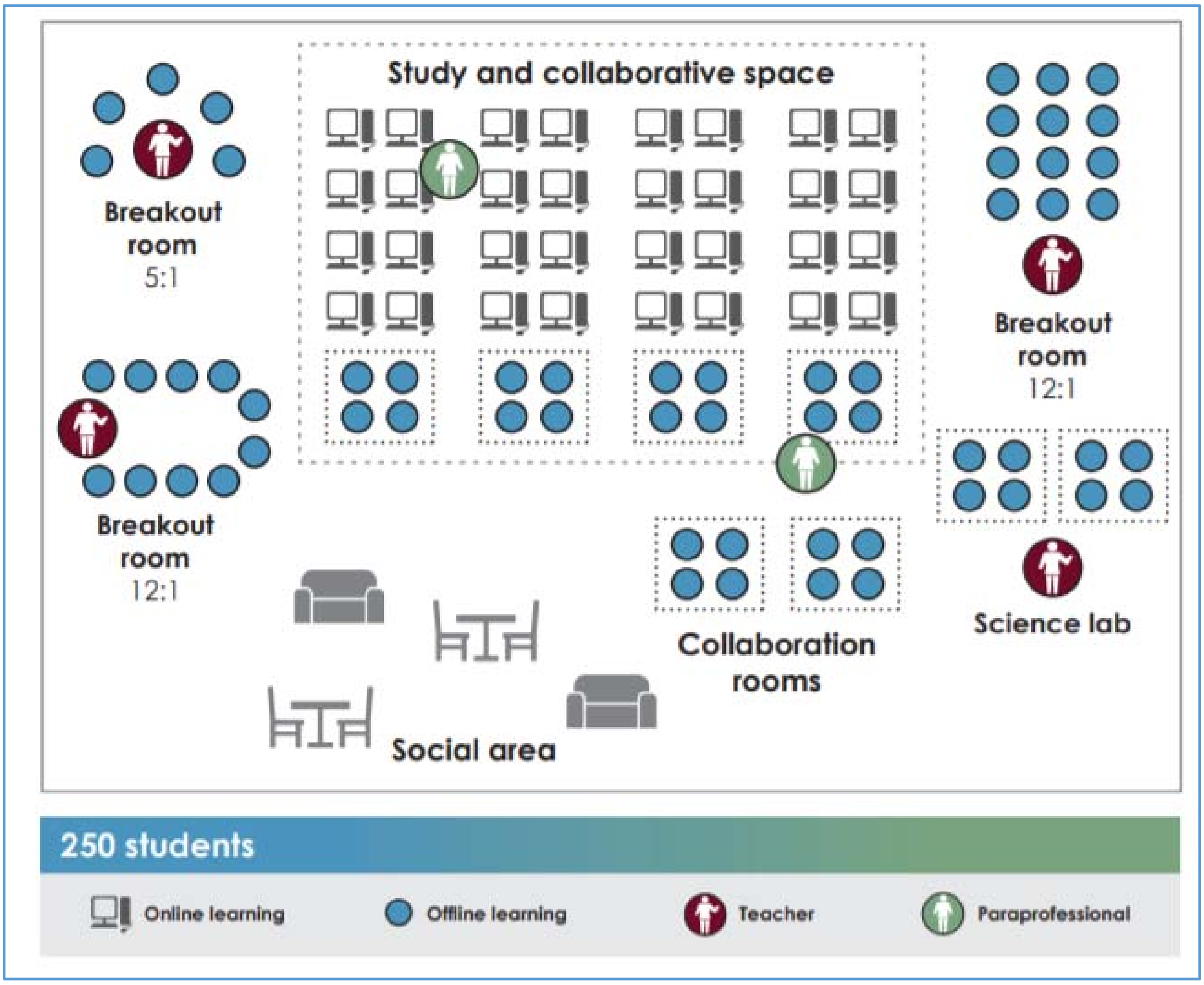


Figure 2.6: The flex model

Source: Staker & Horn (2012:13)

The San Francisco Academy, which is cited in Staker and Horn (2012) and illustrated in Figure 2.6, uses a central online laboratory to deliver the bulk of the learning content. The system has customised dashboards that indicate a learner's progress and individual needs. The learners are then directed to the appropriate support stations that best address their needs. These support stations could be a collaboration room, large, medium or small tuition classroom or break-out room with small group discussions that are led by the instructor.

The self-blend model

Learners who attend a conventional school but choose to do some courses online use the self-blend model. The objective is usually to increase their qualification Grade Point Average (GPA) or Admission Point Score (APS) in a South African context, or to augment the knowledge of the subjects that they are being taught conventionally.

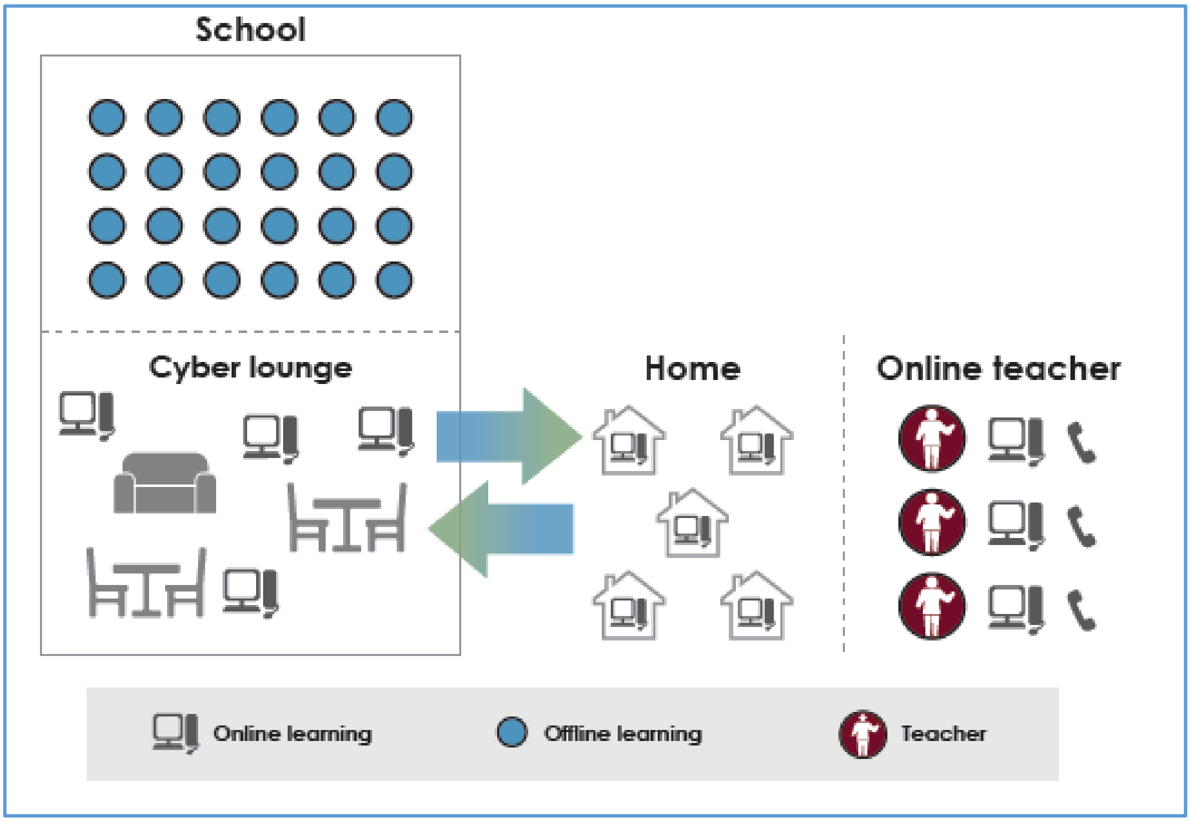


Figure 2.7: The self-blend model

Source: Staker & Horn (2012:14)

The blending aspect lies in the fact that learners get to experience both online learning and conventional face-to-face schooling (Staker & Horn, 2012). Figure 2.7 illustrates how learners can attend a traditional school for the bulk of their studies, but have options to access online tuition for an extra course or to boost their understanding of school subjects.

Enriched virtual model

In the enriched virtual model, student time is divided between attending a physical school and virtual online-mediated courses at school or at home. In this model, learners do not attend a physical school daily. The Albuquerque eCADEMY, which is cited by Staker and Horn (2012), has learners that meet their teachers face-to-face at a school to receive course orientation at the beginning of the course. They then have the option to do the remainder of the course at home through online-mediated channels, as long as they pass the course.

The next section concludes this chapter and highlights insights that are vital for the research problem.

2.6 Conclusion

The literature presented in this chapter highlighted the fact that the learner constructs knowledge in a process that is mediated by the environment. The learning process is social and constructive. The process of teaching and learning is guided by a system of ILOs that shape learning and assessment activities. Instructional technology and computer-based instruction systems create flexible and learner-centered learning environments. Teachers and technology play facilitative roles and enact environments that allow knowledge construction to occur.

Computer-based instruction is the use of computer systems to offer instruction through drills, which are demonstration and simulations that are programmed into a computer system. Examples of computer-based instruction systems that are used in offering end-user computing courses are SAM, MyLab IT and SimNet. The use of transformative technology in instruction promotes active learner engagement and brings flexibility to instruction in terms of the time, place and pace of learning. Several implementation modalities of the blended learning approaches that Staker and Horn (2012) present show the successful transformation of learning environments where technology drives instruction.

Functioning knowledge is the ability to use, apply, integrate, relate and extend knowledge to real-life problems. The literature does not, however, indicate the essence of key terms such as applying, integrating, relating and extending knowledge in the context of the end-user computing service course. There is a need to ascertain the nature of functioning knowledge in the end-user computing service course. Furthermore, there is no direction on how this functioning knowledge can be facilitated in teaching and learning environments where computer-based instruction systems are used as the primary means of instruction. The role of instructional technology in promoting functioning knowledge in end-user computing is also not spelt out. These questions will be explored in chapters 4 and 5. Chapter 3 presents the research methodology of this study. The chapter spells out the philosophies that shape this study and the approaches that are used to solve the research problem.

Chapter 3: Research methodology

3.1 Introduction

This chapter focuses on explaining the methodology of this study. Research is a systematic and guided search for answers (Kumar, 2011). It is undertaken to "understand, describe, predict or control" a phenomenon and to empower practitioners in a particular field (Mertens, 2005:02). A research methodology is the plan that informs how methods are selected and used in the research process. (Crotty, 1989; Scotland, 2012:) Similarly, Somekh and Lewin (2005:346) view research methodology as "the collection of methods or rules by which a particular piece of research is undertaken" and the "principles, theories and values that underpin" its particular approach. Saunders, Lewis and Thornhill (2012) use the metaphor of an onion to illustrate the underlying principles that shape how the research problem-solving process unfolds. The onion illustrated in Figure 3.1, shows an outer layer that represents the philosophy in which the research is wrapped. The research philosophy influences the approaches that are used in the problem-solving process. The approaches lead to the implementation of particular strategies. The strategies, in turn, determine the choice of methods. Consequently, the methods determine how the research data that is used to solve the problem is collected and analysed.

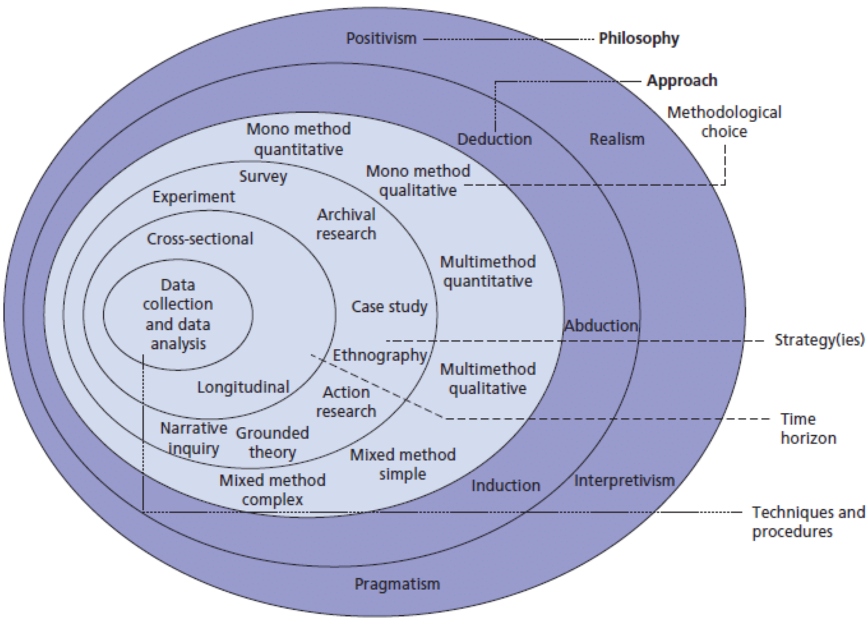


Figure 3.1: The research onion: Source (Saunders, et al., 2012:128)

Using Saunders. et al's (2012) illustration of the research process as an onion, the rest of this chapter is organised as follows. Section 3.2 outlines the philosophical considerations for this research in terms of the key philosophical tenets such as ontology, epistemology, axiology and paradigms. Section 3.3 delves into literature on research design where the suitability of quantitative, qualitative, mixed method and multimethod approaches are considered. A suitable research method for this research is chosen in Section 3.4. Research strategies and a motivation this study's strategic options are presented in sections 3.5 and 3.6. Key data sources are discussed and presented in Section 3.7. Sections 3.8, 3.9 and 3.10 present the analytical framework for the data that is collected, the ethical considerations for this research and the conclusion of this chapter.

3.2 Research philosophy

Saunders et al. (2007) explain that a research philosophy influences how knowledge is conceived and developed. The three key terms that help identify a researcher's philosophical approach are ontology, epistemology and axiology.

3.2.1 Ontology

Ontology is the branch of philosophy that focuses on the study of the "being" of things or "their being" by focusing on the "what is" of a phenomenon (Smith, 2003). It concerns itself with the philosophical definition of reality. Three ontological positions – objectivism, subjectivism and pragmatism – may be considered (Saunders et al., 2007).

Objectivism is a philosophical point of view that treats reality as measurable. Biddle (2014) explains that objectivist reality is absolute and facts are what they are. Reality cannot be defined by human interpretation, personal opinion, social norms or divine ruling. Biddle (2014:5), therefore, argues that people's "ideas or beliefs do not make reality what it is, nor can they directly change anything about it; they either correspond to the facts of reality, or they do not". Subjectivism, on the other hand, looks at reality from a perceptual angle by emphasising what Remenyi, Williams, Money and Swartz (1998) call the reality of the situation. It draws from the interpretivist thinking that knowledge is socially constructed and brought forward by human beings (Saunders et al., 2007). Collins English Dictionary (2012) explains subjectivism as the philosophy that advances that there are no absolute values for reality, but mere variables on a continuum.

Pragmatism is a philosophical approach that encourages researchers to choose the methods that are most applicable and relevant to their situation. It does not follow the traditional conventions of logical reasoning, such as deduction and induction, but rather uses abduction (Rylander, 2012). Abduction is a philosophical approach to generate novel explanations and solutions to a phenomenon by applying interpretive inferences that jump from observations to explanatory accounts based on minimal theory (Josephson, 1994). James (1907) argues that the pragmatic approach emphasises the practical implications of arguments. While ontology focuses on the "what" of phenomena, epistemology concerns itself with how people come to know about the phenomena.

3.2.2 Epistemology

Epistemology is a philosophical study that focuses on explaining what should be accepted as viable knowledge in a particular field (Saunders et al., 2007). It answers questions on how knowledge is acquired, how the researcher goes about the research process, and how these discoveries are reported (Babbie, 2016). Saunders et al. (2007) provide three philosophical positions that may shape a researcher's epistemology: positivism, realism and interpretivism.

Positivism operates on the notion of objectivity (Bodner & Geelan, 2001). It applies models and methods of natural sciences in solving problems (Burrell & Morgan, 1979). Myers (2009) and Bernstein (1983) agree that, in the positivist world, experience is objective and observations are independent of the investigator. Bernstein (1983) adds that positivist theories are artificial models that seek to generalise phenomena using logical deductions. The forerunner of positivist thinking, Comte (1907), asserted that the (positivist) philosophy aims to generalise scientific thinking and systematise social reality.

Consequently, positivist research in information systems is accomplished through formal proportions, quantifying variables, hypothesis testing and inferential analysis (Orlikowski & Baroudi, 1991). Realism is similar to positivism in expressing that reality is practical and exists independent of the mind (Saunders et al., 2007). Saunders et al. (2007) discuss two strands of realism: direct realism and critical realism. Direct realism proposes that knowledge is realised in the way we sense and observe the world. Critical realism, on the other hand, advances that what is experienced in the world are sensations or rather images of the real world.

Interpretivism is a philosophical position that recognises that reality is better understood by analysing how people assign meaning to phenomena (Orlikowski & Baroudi, 1991). In interpretive research, knowledge is discernible in the way people use language, shared meanings and their consciousness to access reality (Myers, 2009). Interpretive research does not separate facts from the meanings that human agents ascribe to them, and research data is bound to the theory that is used to create meaning (Bernstein, 1983). This is different to positivism where data is used to derive explanations deductively and independently of the researcher's opinion. The conclusions that are put forward in interpretive research are arrived at from the researcher's interpretations (Bernstein, 1983). This creates what Myers (2009) describes as a "subject-subject" or "double hermeneutic" relationship between the research and the researcher. The double hermeneutic phenomenon recognises the fact that researchers are also subjects in the research, as both their interpretations and the research participants' contributions jointly shape the research outcomes (Myers, 2009). Consequently, the conclusions of interpretive research are not validated by mathematical measurement, but by the quality of reasoning that is employed when ascribing meaning to the research observations (Walsham, 1993).

3.2.3 Axiology

Axiology is a philosophical position that speaks to the value of research and, as a result, influences a researcher's pursuits and choices (Saunders, Lewis, & Thornhill, 2012). It is a study of research ethics that influences the foundations on which social projects are identified, and falsification is reduced in research efforts (Hill,1984).

Another key term used in research to examine its philosophical grounding is "paradigm" (Saunders et al., 2007).

3.2.4 Philosophical paradigms

Paradigms should be viewed as the belief system that reveals how the researcher sees the world and ultimately shapes the position of the research on issues such as its ontology, epistemology and methodology (Guba & Lincoln, 1994). A philosophical paradigm explains how research is conducted by bringing to the fore the scientific models that are used in solving the problem (Kuhn, 1970). Research paradigms expose the underlying thinking that a researcher uses to organise their observation and reasoning (Babbie, 2016). They are the lenses that are used in understanding reality and reveal the assumptions that direct how theory is built in the research (Burrell & Morgan, 1979). Hughes (2010) explains that a research paradigm is a way of viewing the world and in a way shapes the way a researcher thinks about the problem.

Different taxonomies are used to describe research paradigms. Babbie (2016) mentions eight paradigms that are applicable in social science research, while Guba and Lincoln (1994) discuss four paradigms: positivism, post-positivism, critical theory and constructivism. Myers (2009) identifies positivism, interpretivism and the critical paradigm as common in information systems research. Burrell and Morgan (1979) present four sociological research paradigms: functionalist, interpretive, radical humanist and radical structuralist

Hassard (1991) explains the four paradigms of Burrell and Morgan (1979) as follows: the functionalist paradigm assumes that society has a “concrete” and orderly existence. The functionalist researcher, therefore, tends to be divorced from the research by using scientific methods that are objective and value free. The interpretive paradigm, on the other hand, is subjective and perceptive. Reality is decoded from the meanings that human elements attach to the phenomenon. Radical humanism emerges from interpretive thinking. This critical approach is consistent with interpretive thinking and acknowledges that the social world tends to defy objectivism (Burrell & Morgan, 1979). Radical humanists who apply a critical approach argue that the quest for truth and knowledge should encompass transformative and emancipative dimensions (Myers, 2009). This critical paradigm acknowledges the need to free human thought processes from the enslaving and overbearing effects of history, social, political and cultural systems (Orlikowski & Baroudi, 1991). Saunders et al. (2007) explain radical structuralism as an analysis of society through the power dynamics and nature of conflicts that are at play.

3.2.5 Philosophical considerations for this study

This study's main focus is investigating how functioning knowledge can be facilitated in a computer-based instruction end-user computing service course. The following questions are posed to guide the process of clarifying the study's philosophical position:

- What is the study's epistemological position?
- What is the study's ontological position?

Axiology deals with the value of research and ethical issues. A discussion of the ethical considerations undertaken for this research is presented in a later section that deals with data collection and the recruitment of research participants.

The epistemological position

Interpretivism is selected as the plausible epistemological position if a philosophical choice has to be made among positivism, realism and interpretivism. It can be argued that the notion of functioning knowledge is a human construct that is subject to the meanings and interpretations that human beings attach to it. The research problem is hinged on the keyword "how". It is therefore sustainable to argue that the "how" of a subjective phenomenon is best addressed by applying perceptual arguments in the same way that Remenyi et al. (1998) advise when explaining this phenomenon. On the other hand, positivist and realist epistemological positions attempt to quantify and objectify phenomena. Therefore, it is difficult to perceive how an attempt to promote functioning knowledge in an end-user computing service course could possibly be sustained through statistical measurement and evaluation.

The ontological position

As has already been put forward, ontology is the philosophical study of the "being" of things or "their being" and focuses on the "what is" of phenomena. The three ontological positions that are advanced by Saunders et al. (2007) – objectivism, subjectivism and pragmatism – can be considered in the context of the research question that aims to investigate how functioning knowledge can be facilitated in a computer-based instruction end-user computing service course. The research problem is framed using the keyword "how". This approach directs the research efforts towards real-life practical and prescriptive solutions. It is a real-life problem-solving process. Cross (2006) indicates that the pragmatic philosophical position is consistent with solution-seeking and design-based modes of enquiry. It allows the use of “multiple methods, different worldviews and different assumptions, as well as different forms of data collection and analysis” (Creswell, 2003:12). Pragmatism is thus seen as the ontological position that is consistent with this research.

3.3 The research approach

The approach of a research process is closely related to its epistemological position. Saunders et al. (2007) explain the two traditional reasoning and logical approaches that are used to create knowledge: deduction and induction. They explain that the deductive approach begins by developing a theory or a hypothesis about the problem. The next stage involves designing a strategy to test the hypothesis to confirm or disprove it. The deductive approach works well with positivist and quantitative techniques. The inductive approach, on the other hand, operates by collecting data first and then using it to develop a theory. Induction is consistent with interpretive approaches where researchers observe a phenomenon and attach meanings and interpretations that lead to theory.

Another approach to reasoning and knowledge creation is abduction, an approach that was developed by pragmatist Charles Sanders Peirce (1839 to 1914) (Fischer, 2001). Fischer (2001) explains that Peirce’s abductive logic uses explanatory hypotheses to create knowledge. The approach begins by presenting a resultant phenomenon and then building an explanatory thesis. This reasoning comes after observing a phenomenon and then using theory to build an explanation. Peirce, as cited in Fischer (2001), explains the difference between deduction, induction and abduction by indicating that deduction proves what a phenomenon must be; induction illustrates what the phenomenon is; and abduction suggests what it may be.

Deductive reasoning does not seem to address the research problem adequately. The solution does not require proof of what functioning knowledge in a computer-based instruction end-user computing course is. An illustration of how functioning knowledge could be promoted is required. An inductive approach would be useful in explaining the nature of functioning knowledge in an end-user computing course. The inductive approach helps to understand the nature of functioning knowledge. However, what is important in the context of the research problem is an illustration of how functioning knowledge can be promoted in an end-user computing service course. The research problem hinges on the explanatory hypothesis. Abductive reasoning seems appropriate for the research problem at hand. It is possible to create an illustration of how functioning knowledge could be promoted in an end-user computing service course based on observations of the course and using theory to explain it. Demonstrations can then be conducted to illustrate that the creation works. This research thus uses abductive reasoning to solve the research problem, which aims to investigate how functioning knowledge can be facilitated in a computer-based instruction end-user computing service course.

In terms of the applied logical reasoning, the research approach has an impact on the research design. The next section provides background literature on research design before focusing on the design approach that is chosen in this research.

3.4 Methodological choices

This section explores literature that is pertinent to the choice of a research methodology by considering the applicability of qualitative, quantitative and mixed method approaches in addressing the research problem.

3.4.1 Quantitative research

The experimental strategy is inclined towards positivism, as it involves testing hypotheses in an environment where variables are controlled (Mukherji & Albon, 2014). The survey, like the experiment, is also deductive in nature as it involves collecting large amounts of data or inferential analysis (Saunders et al., 2007). The quantitative research approach uses mathematical measurements and models as tools for data analysis (Aliaga & Gunderson, 2002). There is an inherent assumption that knowledge claims can be made or refuted by mathematical and statistical measurements (Muijs, 2004). Leedy and Ormrod (2001) explain that there are three types of quantitative research: descriptive, experimental and causal-comparative. “Descriptive research involves the identification of attributes of a particular phenomenon based on an observational basis or the exploration of correlation between two or more phenomena” (Williams, 2007:66). The experimental design focuses on observing, measuring and reporting on the effects of interventions under controlled environments (Cash, Stankovic, & Storga, 2016). The causal-comparative design relates to a study of cause and effect in relationships between phenomena, and quantitative research is often contrasted to qualitative approaches.

3.4.2 Qualitative research

The nature and form of qualitative research are diverse and depend, to a large extent, on the field from which the researcher emerges (Roller, 2014). Denzin and Lincoln (2011) point out that qualitative research is mainly interpretive and centralised on the observer's viewpoint. Creswell (2007) further explains that qualitative research places a significant emphasis on the meaning that human beings or groups attach to a particular phenomenon. As a result, qualitative researchers collect data in naturalistic settings and use analytical processes that are pattern-forming. The selection of data sources in qualitative research is generally purposive, non-probabilistic and guided by the principle of theoretical saturation (Babbie, 2016). The notion of saturation, in its broadest sense, implies that sufficient data should be collected for the purpose of research (Sanders et al., 2017). Babbie (2016) specifies participant availability, judgement and referrals as some of the methods that are used to collect qualitative research data when it is not possible to access all the participants. Availability, also known as convenience sampling, is driven by convenience and feasibility factors, especially when the chosen participants are the only ones who are readily accessible (Saunders et al., 2012). Purposive selection is based on the researcher's judgement of the data sources (informants) that are most suitable and relevant to the research problem.

3.4.3 Mixed-method approach

Other researchers opt for the balance that emerges from the use of both qualitative and quantitative research methods. The mixed-method research approaches use qualitative and quantitative approaches in a single research project to address research problems that would not be answered fully when either qualitative or quantitative techniques are used in mutual exclusion (Creswell, 2013). The mixed-method approach will not be discussed in detail as this study adopts a multi-method approach to solving the research problem (see Section 3.4.4).

3.4.4 Multi-method approach

Saunders et al. (2007) illustrate that researchers have three options to choose from when designing the research method. They could use a mono-method, mixed-method or a multi-method approach. A mono-method is a single method that is used to solve a research problem in either an entirely qualitative or an entirely quantitative approach (Azorín & Cameron, 2010).

The mixed-method approach uses both quantitative and qualitative techniques to solve a single problem (Tashakkori & Creswell, 2007). The mixed methods and techniques could be implemented concurrently or sequentially, depending on the nature of the problem (Johnson, Onwuegbuzie, & Turner, 2007).

The multi-method approach applies two or more rigorous and independent methods that are triangulated to solve one big research problem (Esteves & Pastor, 2004). The mixed-method approach focuses on a mixture of qualitative and quantitative techniques, while the multi-method approach focuses on using many different methods in a single research project (Hunter & Brewer, 2015).

3.5 Research strategy

A research strategy explains how the process is logically organised to answer the research question by presenting a plan for data collection and its measurement and analysis (De Vaus, 2001). Saunders et al. (2007:130) indicate that the research design comprises the "research strategies, research choices and time horizons" that are chosen and implemented in research. They illustrate seven contexts on which a research strategy may be based: the experiment, the survey, the case study, ethnography, grounded theory, archival research and action research. The first two approaches (the experiment and the survey) emphasise a quantitative approach to research design, while the other approaches are more qualitative in nature. This research, as will be justified in later, has a qualitative contexts and a detailed explanation of experimental and survey strategies is omitted for brevity. This section presents a detailed analysis of a selection of qualitative research strategies.

Creswell (2007:37) outlines the following characteristics of qualitative research:

- It should be done in naturalistic settings. Research data needs to be collected at the place of experience by engaging with participants face to face.
- The key data collection instrument is the researcher who personally collects the data via interviews and observations to obtain first-hand accounts.
- Multiple sources of data should be considered. Rich qualitative insights depend on accessing, cross-validating and referencing different sources of the same data.
- Analytical methods are inductive. The researcher works from the bottom up and creates abstract themes from the data.
- Meanings are derived from participants. Research output should be shaped by the meanings participants ascribe to a problem and not the researcher's own understanding of the problem.
- The research design is emergent. The research processes emerge as the research progresses, accommodating changing scenarios such as the availability of more appropriate participants, and new questions and sites.
- The research is conducted under a theoretical lens. Qualitative researchers have a way of viewing and collecting research data that primes different aspects, such as culture, class struggle, social or political issues.

There are several qualitative research strategies. Saunders et al. (2007) explain five that are common in business research. These are the case study, ethnography, grounded theory, archival research (content analysis) and action research. Another qualitative research strategy is phenomenology. The next paragraphs explore six common types of qualitative research that are used in social sciences research: the case study, ethnographic design, phenomenological design, content analysis, the grounded theory approach and action research.

3.5.1 The case study strategy

A case study is an empirical investigation of a problem in its real-life context (Robson, 2002). Leedy and Ormrod (2001:149) explain that case studies focus on understanding "more about a little known or poorly understood situation". It is a method that provides mechanisms to examine and understand situations where their context is critical (Crowe et al., 2011). The same sentiment is echoed by Babbie (2016:302), who indicates that case studies focus on a "single instance of some social phenomenon".

Punch and Oancea (2014) highlight that the notion of a case is varied. The case could be individuals, roles, groups, communities, organisations, nations, decisions, policies, incidents or events. A case study is used to understand a phenomenon without interfering or tampering with any of its variables (Cavaye, 1996). The case study research could be exploratory, descriptive or explanatory (Yin, 1984). Case studies may be used to describe the nature of things or phenomena, to develop theory and to test it (Løkke & Dissing Sørensen, 2014).

Exploratory case studies usually precede other detailed studies by asking leading questions that are of importance to successive research (Zainal, 2007). Descriptive case studies are focused and intensive narratives of phenomena that seek to generate theory by identifying patterns and connections in the case involved (Mills, Eurepos, & Wiebe, 2010). Explanatory case studies examine data and phenomena to provide explanations that may lead to theory formation (Zainal, 2007). Case studies are common in qualitative information systems research where they are undertaken to understand the dynamics of information technology use in organisations (Orlikowski & Baroudi, 1991).

3.5.2 The ethnographic strategy

Ethnography is a qualitative sociological research approach that uses participation and the observation of societies over time to get an intimate understanding of their function (Denzin & Lincoln, 2011). It is a study of human experience at a close range (Genzuk, 1999). The approach is suitable for studying “beliefs, social interactions and behaviours” of societies (Naidoo, 2012:1). Ethnographic researchers must immerse themselves deeply into the contexts of participants to establish rapport (Elliott & Jankel-Elliott, 2003). The data collection methods in ethnographic research usually involve fieldwork and the participating observations of a researcher who lives and works like the observed (McGranahan, 2015).

Genzuk (1999) discusses three ideological principles that underpin ethnographic research: naturalism, understanding and discovery. Naturalism dictates that social research must be done in naturally occurring settings and through first-hand contact with participants. The argument put forward is that human experience cannot be inferred from artificial settings such as experiments or claims made by participants in interviews. The understanding principle stresses the fact that human behaviour and responses to stimuli involve interpretation and construction. Consequently, Genzuk (1999) argues that a researcher needs to understand the cultural base on which these interpretations and constructs are made. The discovery principle emphasises that ethnographic researchers use inductive reasoning to explain a phenomenon. Approaching a problem with a set of assumptions (hypotheses) blinds the researcher to other crucial depictions inherent in the data that may not be accommodated in the hypothesis.

Mabson, Jawad, Young and Daly (2016) summarise the ethnographic research method by indicating the following:

- People's actions are studied under naturalistic settings and usually involve a small group of people.
- The main source of data is informal conversations that are not structured.
- The analytical framework for data is usually interpretive and uses descriptions and explanations.

The author advises that there are no universally agreed methods of carrying out ethnographic research, but Blomberg, Giacomi, Mosher and Swenton-Wall (1993) proposed four crucial guidelines: a naturalistic setting, holism, non-judgemental description and members' point of view. A naturalistic setting denotes that ethnography studies are field-based. Data is collected from primary sources through observation, active participation and involvement. Holism implies that human behaviour and actions are understood in the context of a network of relationships that are part of one's existence. Non-judgemental observation implies that ethnographic researchers may not be prejudiced or judgemental. The ethnographic researcher may therefore not judge research participants' behaviour and actions using their own values and understandings. Descriptions of observation should be plain and portray an outsider's stance. This leads to the final point, which stresses that the prominent voice in ethnographic research is the participant's. Ethnographic researchers portray the world from the participant's view. Genzuk (2003) advises that, in as much as there should be substantive first-hand descriptions and direct quotations of the data collected and the setting upon which it was collected, there should also be a balance between these accounts and sufficient analysis and interpretation. This view is echoed by Eriksson and Kovalainen (2016), who indicate that sufficient description, as well as adequate analysis and commentary, should enable the reader to understand the interpretations and the explanations that are ascribed to it.

Ethnography is important in design-based research (Blomberg et al., 1993) as it encourages a participative observation of environments (Genzuk, 2003) that have artefacts that are objects of design. Designers use ethnographic methods such as cultural anthropology to understand how to design artefacts that conform to cultural practices (Cranz, 2016). A recent development in the ethnographic strategy is what Bichard and Gheerawo (2010) describe as rapid ethnography. This is a study of artefacts that are invented and reinvented at a faster pace than traditional ethnographic studies prescribe, forcing researchers to spend less time in the field. Mabson et al. (2016) outline the importance of ethnography to design research. A summary of their main arguments is presented in Table 3.1

Table 3.1: A summary of the use of ethnography in design research { TA \l "Table 3.1 the use of ethnography in design research Insitu (2016)" \s "Table 3.1 the use of ethnography in design research Insitu (2016)" \c 1 }

Use	Explanation
To gain design insights into the user's environment	An understanding of the environment in which the design artefact will operate helps designers create artefacts that are suitable to the environment.
To eliminate the designer’s world view	This minimises the inappropriate imposition of the designer’s world view on an artefact that will be used.
To optimise usage	In instances where users do not have sufficient know-how, design ethnographers engage with users to understand limitations to potential usage and the aspects that need refinement.
To understand the context of usage	The success or failure of technology is closely associated to the context of the environment in which it is applied.

To assist in providing the user with a fuller picture of the technology	New technologies provide challenges that may be difficult for the user to envision appropriately. Design ethnographers become partners in the joint discovery of the impact that the technology has on the user.
To gain a holistic picture of the user's operating context	Design engineers usually focus on providing a single-task solution, but the user's needs are integrated wholes.

Source: Mabson et al. (2016:8)

3.5.3 The phenomenological design

Phenomenological studies focus on understanding human experiences from the participants' point of view (Leedy & Ormrod, 2001). Pietkiewicz and Smith (2012) explain that phenomenology seeks to expose how things appear to individuals and emphasise the essential aspects that make them different from others. The authors add that the emphasis in phenomenological studies is on understanding people's perceptions of objects and events as opposed to collecting their descriptions of phenomena based on a set of rules, concepts or scientific formulations (Pietkiewicz & Smith, 2012).

In the past, a phenomenological analysis was seen as reductionist (Salice, 2016). The thinking was that it was possible to understand the essence of things themselves, independent of the researcher's conscience, through bracketing (Ladkin, 2014). To bracket is to set aside what the researcher knows in order to experience the essence of a phenomenon for what it is (Ladkin, 2014). Then phenomenology moved to a hermeneutical analytical context. The hermeneutical analysis is dual in that it involves participants making meaning of their life world, followed by the researcher's interpretation of the participants' meaning (Smith and Osborn, 2008). The phenomenological analysis moves between "emic" and "etic" modes by revealing participants' voices making sense of their reality and including the researcher's interpretation of the participant's voice (Pietkiewicz & Smith, 2012)

Phenomenological data is usually collected during lengthy interviews (Williams, 2007; Pietkiewicz & Smith, 2012), These interviews focus on unearthing the meaning of the participants' experience (Creswell, 1998). There is no particular restriction on the number of participants in a phenomenological study, but recruits are usually few and guided by the notion of theoretical saturation, as is usually the case in most qualitative studies (Pietkiewicz & Smith, 2014). The critical consideration in phenomenology is on whether the research aims to give a detailed account of a particular case or to create generalisations. In the former situation, the targeted number of recruits becomes less, while the number of recruits becomes greater in the latter case (Pietkiewicz & Smith, 2012).

3.5.4 The content analysis study or archival research

Content analysis is a "detailed and systematic examination of the contents of a particular body of material to identify patterns, themes, or biases" (Leedy & Ormrod, 2001:155). Williams (2007) specifies that content analysis is a review of the "forms of human communication" in artefacts such as books, films and newspapers. The author adds that the operationalisation of content analysis research involves two steps. The researcher starts by creating a frequency tally of the themes that would emerge from the data sources. This is followed by a statistical analysis that is reported quantitatively (Williams, 2007).

3.5.5 The grounded theory approach

The grounded theory approach emerged from a desire to generate theories from data and create knowledge that emerges from data as opposed to constructs that are derived from literature (Leedy & Ormrod, 2001). The grounded theory method advocates that theory must arise inductively from the collected data (Chesebro & Borisoff, 2007). The theory was founded by two sociologists, Barney Glaser and Anselm Strauss, who wanted a context-sensitive theory (knowledge) that would be bound to the data. It would be grounded in the data that is used to investigate the problem and therefore withstand refutation (Kenny & Robert, 2014). The two parted ways and went on to propose different prescripts on how the grounded theory methodology should be applied (Kenny & Robert, 2014).

The approach emphasises the analysis of social phenomena in a way that is independent of any preconceived constructs, ideas or hypothesis, arguing that a theory based on data is destined to last and withstand disproof because it would be tied to its data (Glaser & Strauss, 1967). The common data collection method used in grounded theory research is the interview (Ke & Wenglensky, 2010), but other approaches that yield qualitative data such as focus groups, conversations and observations are also applicable (Dick, 2005).

Ke and Wenglensky (2010) explain that relevancy is essential when sampling data sources for grounded theory research. Participants should be selected in a way that allows the discovery of multiple facets that may be inherent in the problem. Theoretical sampling is used in collecting preceding data, and initial responses determine the recruitment of further participants (Draucker, Martsolf, Ross, & Rusk, 2007). Theoretical saturation is a stage where responses that come from participants are no longer generating any new insights (Mason, 2010). The grounded theory uses a reality-checking process that challenges the emerging theory to strengthen it through a negative case analysis in which the researcher identifies cases that do not fit the data after forming a theory or proposition that is based on the data (Birks & Mills, 2015). This strengthens the researcher's chances of determining the exact locus of the emerging theory (Birks & Mills, 2015).

Ke and Wenglensky (2010) indicate that data analysis in grounded theory research is a search for the "actualities" behind the data. Leedy and Ormrod (2001) explain that the coding process that is used in the grounded theory approach comprises open coding, axial coding and selective coding. During the open coding process, the researcher breaks down the data; examines, compares and conceptualises it (Strauss & Corbin, 1990:61); and creates initial categories of explanations of the issue under study (Ke & Wenglensky, 2010). During axial coding, the grounded theory researcher assembles the open codes into a logic diagram (coding paradigm) that leads to concepts (Allan, 2003). These concepts are further regrouped and integrated to create higher-order categories that lead to theories (Allan, 2003).

3.5.6 Action research

Kemmis and McTaggart (2000) describe action research as a cyclic enquiry that is undertaken to improve practice by constantly switching between acting in practice and reflecting on these actions. They suggest that the action research cycle involves planning for change, acting on observations and reflecting on the process. Pant (2014) outlines that participatory action research consists of the following four principles:

- Empowered participation: Participants are actively involved from problem conception to solution dissemination.
- Commitment to action and change: This implies that action research is essentially a problem-solving process that involves creating an awareness of the problem, scoping an area of concern, identifying resources, designing solutions and evaluating the impact of the strategy.
- Collaboration: The research is conducted with both the researcher and participant defining and shaping the research outcome.
- Processes: Participatory action research brings solutions to real practice problems. It involves critically examining practice issues and raising concerns that serve as the basis for embarking on a solution development process.

Pant (2014) writes that the action research methodology is contextual and flexible. Consequently, researchers are advised to use multiple methods and unconventional means to bring about novel solutions to practical problems. The next section proposes the research method that was selected for this study.

3.6 Choice of research strategy or method

The preceding paragraphs presented some research strategies that are available for solving the research problem. This section motivates the research methods that were adopted for this study. It begins with a strategic consideration of the available options against the requirements of the research problem. This is followed by a discussion of the design science research method and an explanation of its suitability in addressing the research problem presented in this study.

3.6.1 Strategic considerations

Gregor (2006:620) provides a taxonomy of the following five types of theories generated in information systems research:

- Analytical: The focus is on stating what a phenomenon is, without providing relationships or causal explanations.
- Explanatory: The emphasis is placed on shedding light on the how, what, why and when of a phenomenon that is being researched. It is not predictive and therefore does not provide any “testable propositions”.

- Predictive: The focus is on illustrating what a phenomenon is and what it will be by providing verifiable predictions.
- Both explanatory and predictive: Verifiable propositions that explain phenomena are offered together with causal explanations.
- Designing and action based: Prescriptions for constructing artefacts are offered.

In light of the considerations of Gregor (2006) with regard to information systems research and the research strategies that were presented in the last section, the most suitable research strategy for this research can be chosen. The first consideration would be a decision on whether the problem can be addressed using quantitative or qualitative techniques. The notion of functioning knowledge is, arguably, a human construct that is subject to contested interpretation. The research problem is based on the notion of "how". It can be argued that it is highly contextual and that there is a design flavour to it. It is, therefore, logical to conclude that quantitative methods such as experiments, causal and comparative studies do not speak to the nature of the research question. On the other hand, qualitative strategies, such as the case study, ethnography, phenomenology, grounded theory, content analysis and action research, have properties that appeal to the research problem.

A case study could be undertaken to study selected institutions that are perceived to be successful in promoting functioning knowledge in end-user computing service courses. The observations could then lead to an identification of good practices that may be presented as recommendations. The challenge with this approach is that it does not lead to new or novel ideas on how functioning knowledge could be promoted in an end-user computing service course. It would be a mere observation and documentation of practices that are already in place.

Mabson et al. (2016) highlight that ethnography has its place in design-based research. The ethnographic approach allows researchers to gain design insights into the user's environment and understand contexts of technology usage. Ethnography would be useful in understanding the way end-user computing courses are taught in institutions. Researchers may become one of the "observer-actors" who are involved in the course to gain a deeper understanding of the subject. Such insights may lead to design recommendations. The limitation of this approach is that it does not provide an adequate or justifiable mechanism to influence changes in the practice of teaching end-user computing service courses.

Phenomenology, content analysis and grounded theory also focus on studying phenomena qualitatively. Ladkin (2014) writes that phenomenology exposes people to knowledge that is obtained from experience. The insights that are needed to understand the “nature” of functioning knowledge in an end-user computing service course could be obtained through phenomenological approaches. The researcher could interview actors who are involved in teaching and learning the end-user computing course to understand the meanings they attach to their experiences. An insightful analysis would then serve as a set of recommendations. A grounded theory approach could be used to analyse the contents of data coming from participants and create a theory about the nature of the end-user computing service course. Content analysis provides tools and techniques to analyse qualitative data and expose underlying themes. These strategies, however, just like case studies and ethnography, do not provide an adequate mechanism to address the “how” part of the problem.

It is apparent that the “how” aspect of promoting functioning knowledge in a computer-based instruction end-user computing service course has a design flavour to it. The research problem seeks to influence practice by identifying a way to promote functioning knowledge in an end-user computing service course. Action research, as has already been illustrated, provides a framework for practitioners to research their own activities in order to improve themselves or their situation. According to Stewart (2014), action research is a form of design research. Therefore, design science and action research provide plausible mechanisms to guide the solution-seeking process that this research envisages. The subsections that follow review design science literature and motivate the adoption of the design science research method as a suitable strategy for this research.

3.6.2 The design science research thinking

This subsection focuses on explaining the theory behind the design science research thinking by outlining its tenets. This is followed by an explanation of the nature of problems that are suitable for design science research and an indication of the types of solutions that emanate from design science research. Finally, the options that are available for implementing the design science research method are described.

Weber (2010) outlines two contrasting positions regarding design science thinking. The first position views design science research as a paradigm exhibiting a full-set of assumptions on studying social phenomena. The other position views design science as a research approach encompassing sufficient guidelines for the development of useful artefacts and the generation of transmissible insights. This study adopts the second definition as a template for the problem solving process. This stance is supported by Stewart (2014) who argues that design research is a form of action research or at least parallels it.

Design science research tenets

The design science methods seek to define ideas, rules and conventions that guide the construction of innovative and useful objects (Hevner, March, Park, & Ram, 2004). The method focuses on understanding the usefulness of design science research objects and proposing the possibilities that these artefacts bring about (Collins, Joseph, & Bielaczy, 2004; Hevner et al., 2004). The method has its roots in engineering sciences (Hevner et al., 2004) and exhibits characteristics of what Simon (1996) describes as the "sciences of the artificial". Simon (1996) realised that, whereas natural sciences focus on truth and necessity, design science generally focuses on the usefulness and contingency of objects. These are the possibilities that design objects bring about.

There is consensus in information systems literature that information systems research should lead to useful artefacts (Benbast & Zmud, 1999). Barab and Squire (2009) and Collins et al. (2004) advise that design science research should focus on understanding the complexity of solving real-world problems. Hevner et al. (2004) state that design science research advances ideas and practices that improve efficiency. It adds relevance to practice by facilitating the creation of effective organisational interventions (Collins et al., 2004).

Design science research methods provide prescriptions for the methods, techniques and principles that are used in constructing artefacts (Hevner et al., 2004). Design science research methods have rigorous philosophical formulations. There is both rigour and relevance in design science research, as is clarified by the suggestion of Myers (2009) that design science research is not consultation. As a result, the discipline immerses itself in both real-life and localised problems. Hevner et al. (2004)

illustrate that these philosophical formulations relate to the foundational theories that are used to understand the research problem and the methodologies that are applied in conducting the research. They explain that rigour and relevance are inseparable as truth is a product of academic rigour, while utility is realised in the application. The cyclic relationship shows that truth (rigour) informs artefact design, and utility (relevance) informs theory construction. It is sustainable, therefore, to reason that rigour and relevance inform each other in a fashion that is inseparable. In other words, theory needs practice and practice needs theory. As a result, design artefacts are instantiations of theory.

Hevner et al. (2004) provide guidelines for and characteristics of design science research in information systems as summarised in Table 3.2. In short, design science research produces artefacts that use technology to solve real problems. The efficacy of the solution is evaluated against its demonstrable utility and contribution to design methodology. Design science research is a rigorous search for effective solutions to real-life problems and presents solutions in a language that is accessible to both technocrats and management.

Table 3.2: The guidelines and characteristics of design science research{ TA \l "Table 3.2 A summary of the Characteristics of Design Science Research" \s "Table 3.2 A summary of the Characteristics of Design Science Research" \c 1 }

Characterisation	**Description**
Design as an artefact	Design science research produces usable artefacts.
Problem relevancy	Design science research artefacts address a real business problem.
Design evaluation	Design science research outputs are evaluated against demonstrable utility and efficacy.
Research contribution	Design science research contributes to design methodology, the artefact or its foundations.
Research rigour	Design science research applies rigorous and well-founded methods in the artefact's design and production.
Solution search	The process is a search for an appropriate and feasible solution to an existing problem.

Characterisation	Description
Communication	The communication of design science research outputs should be fit for both technocrats and management (users).

Source: Hevner et al. (2004)

The nature of problems suitable for design science

Gleasure (2015) proposes three types of research problems that are suitable for design science research, and provides guidelines on how research is carried out in each context. A summary of the three proposals is presented in Table 3.3. Firstly, design science research is proposed for problems that do not have documented implications on current practices. It means that practitioners are not effectively exploiting theoretical knowledge in the field. Design science research in such contexts leads to recommendations for changes in practitioner behaviour. The researcher would have observed practices and found a mismatch between theory and practice.

The second proposal is that design science research could be undertaken in situations where there are no effective or theoretical-practical solutions to a real-life problem. This leads to research that creates new generalisable hypotheses. Finally, design science research may be undertaken in situations where the challenges that define a particular problem may only be unearthed by undertaking a design process. The aim would be to learn through design.

Table 3.3: Research problems that are suitable for design science research

Research problem area	Guideline	Outputs of design science research
Contexts that lack implications based on existing theory	Undertaken when the prescriptive (implementation) aspect of the research problem is less mature than the theory that explains it	Leads to design recommendations based on contextual observations, tests and deductions from mature theories
Contexts that lack effective existing solutions	Undertaken in problems where there are no effective theoretical and practical solutions to the research problem	The researcher formulates a hypothesis that is generalisable and leads to grand theories by solving a current operational problem

Contexts where the phenomena can be "unearthed" through elements of design	Undertaken when important elements of the research problem may only become visible through the design process	Design science unearths dynamic and contextual aspects of the research problem that are not feasible through other "non"-intervention research approaches

The nature of solutions in design science

Design science research leads to both knowledge production and practical solutions to practice, and the extent to which both are addressed depends on the nature of the problem and the solution that is derived. Gregor and Hevner (2013) identify four instances of design science research and suggest their knowledge outputs. They use a Knowledge Innovation Matrix (KIM) to explain the four design science research outputs: invention, improvement, exaptation and routine design (see Figure 3.2). The taxonomy examines design science research problems in terms of the maturity of the application space and problem. Research problems that have high maturity are well researched and documented, while research problems with low maturity spaces are less well known and documented.

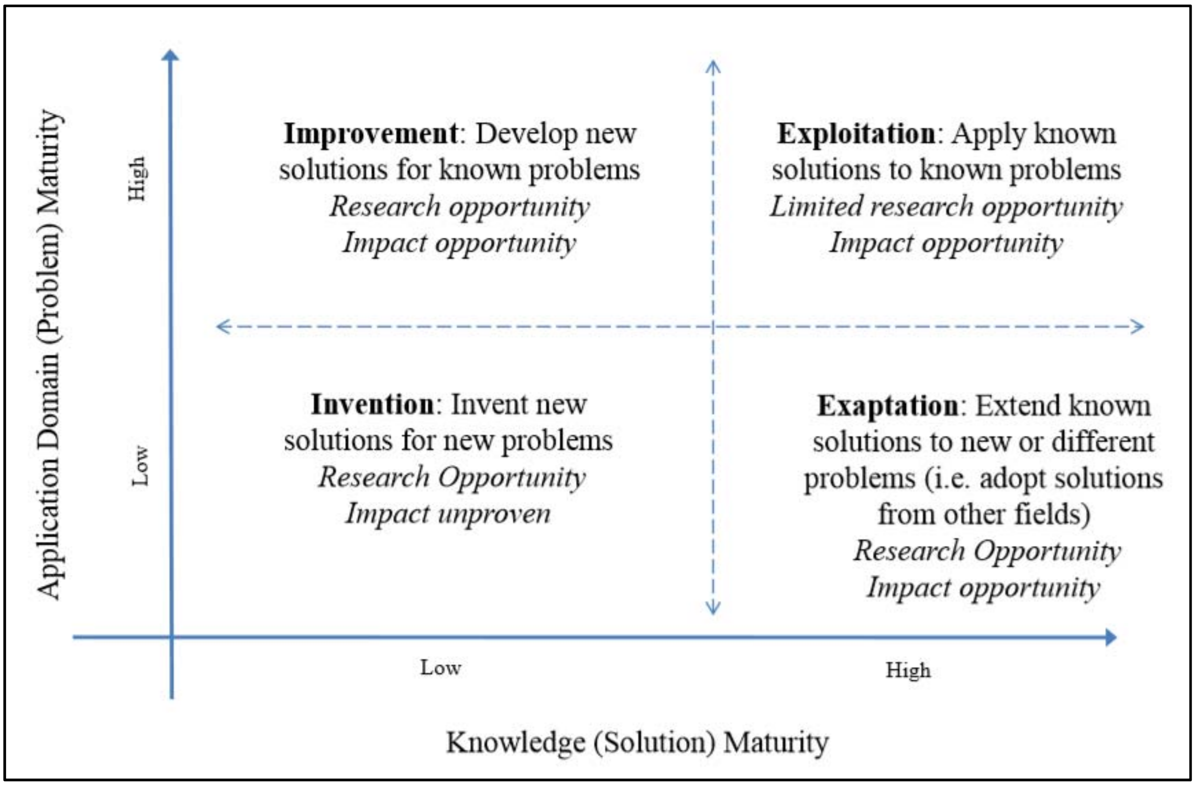


Figure 3.2: The nature of design science research solutions

Source: Gregor & Hevner (2013:221)

Gregor and Hevner (2013) explain the positioning of design science research output as follows: Inventions represent novel ways of approaching a problem, which lead to new solutions for new problems that have not yet been identified. The invention is achieved through exploratory searches that cover a complex problem, and involves cognitive skills, curiosity, imagination, creativity and insight into creating new solutions to new problems.

Improvements focus on designing and presenting new solutions to known problems. Exaptations are significant extensions of known solutions to a new problem, and push the boundaries of what is known. The opportunity for learning and knowledge production arises by extending what is known to new scenarios. Routine design (exploitation) exploits current knowledge. It focuses on solving known problems with known solutions and is, therefore, associated with knowledge use rather than knowledge creation. Gregor and Hevner (2013) summarise that the output of design science research depends on the emphasis that the researcher puts on the choice between theory and utility. Utility or pragmatically oriented design science research produces new and localised representations of artefacts, such as software products, while theory-driven research leads to well-developed grand theories.

The design science research problem solving process

Design science researchers ideally adopt methods that naturally flow from design science thinking in solving problems. Typical design science research methods have problem solving processes that are undertaken in phases (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008; Takeda, Veerkamp, Tomiyama, & Yoshikawam,1990; Kuechler & Vaishnavi, 2012). The design science research method of Takeda et al. (1990) comprises a cycle of five phases: problem awareness, suggestion, development, evaluation and conclusion. Peffers et al. (2008) outline a similar process that comprises problem identification and motivation, the definition of solution objectives, design and development, demonstration, evaluation and communication. The processes do not necessarily have to follow each other, nor do they have to occur from start to end. Contexts allow for the process to start from any point in the cycle (Peffers et al., 2008). The approach that is illustrated in Figure 3.3

comprises five phases: awareness of the problem, suggestion, development, evaluation and conclusion.

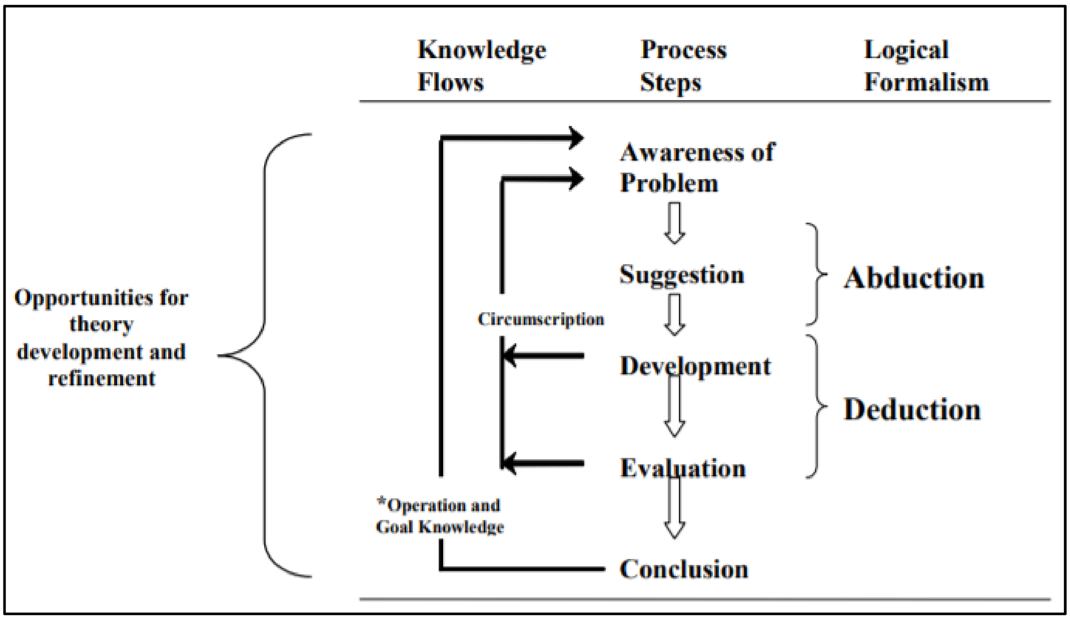


Figure 3.3: The design science research problem-solving process

Source: Kuechler & Vaishnavi (2008:7)

Figure 3.3 illustrates how the design science research process unfolds in information systems research. A common entry point into the process is a realisation and appreciation of the problem. This is an awareness of a practice-related problem that needs solving or improving (Kuechler & Vaishnavi, 2012). The realisation of a problem and its appreciation motivates better and alternative solutions (Peffers et al., 2008). The second phase – suggestion – is closely related to the awareness stage (Kuechler & Vaishnavi, 2008). It involves identifying the objectives of the desired solution to the problem (Peffers et al., 2008). A probable solution to the problem is conceived through the cognitive process of abduction, which entails studying facts and suggesting explanatory theories (Douven, 2017). At this stage, the supposed solution is imagined by aligning potential theories to contextual aspects of the problem (Kuechler & Vaishnavi, 2012). The implication is that existing knowledge, literature and kernel theories become tools that help us understand the research problem and that inform the construction of its solution.

The development phase is a creative phase in which the tentative conceptions obtained in the suggestion phase solidify into an operable artefact (Kuechler &

Vaishnavi, 2008). Contextual data regarding the problem is used to inform the construction of the solution (Kuechler & Vaishnavi, 2012). This phase involves building a solution from the tentative “abducted” understandings (Kuechler & Vaishnavi, 2012; Hevner et al., 2004), examining the problem situation, inferring from the available theory and aligning these with the desired outcome (Hevner et al., 2004). The result is an embodiment of abstract ideas into tangible and productive artefacts (Hevner et al., 2004).

The next critical stage is the evaluation of the design science research output, which is a productive artefact in most cases. There are multiple perspectives of what constitutes design science research output, as it could be a construct, a model, a method or instantiations (March & Smith ,1995). Kuechler and Vaishnavi (2008) explain that the evaluation is often an iterative process between development and evaluation. They add that the evaluation may include using carefully selected data and experiments to refine and extend the theory.

Peffers et al. (2008) suggest a demonstration that involves the application of the artefact to more or similar cases using simulation, experimentation or case studies. Gill and Hevner (2013) propose that the evaluation should be a demonstration that the artefact can fit and stand its ground in its operating environment. The evaluative framework for design science research of Pries-Heje, Baskerville and Venable (2008) explains what is evaluated, when the evaluation is done and how it is carried out. The “what” focuses on describing the outputs of design science research. These could be models, frameworks, algorithms or any perceivable artefacts. The “when” is a timing consideration that may be done before, during or after the artefact has been constructed. The “how” aspect describes methodological choices. Hevner et al. (2004) provide five methodological choices: observational, analytical, experimental, testing and descriptive.

Design science research concludes with a communication phase (Kuechler & Vaishnavi, 2012; Peffers et al., 2008). This last phase is not a grand finale, but a mere indication of the end of a particular design cycle (Kuechler & Vaishnavi, 2012). It is a “satisficing” process that communicates the artefact’s fit to the problem and an explanation of contexts in which it is good enough and reflects on what new knowledge has been generated and learnt (Kuechler & Vaishnavi, 2012).

Hevner et al. (2004) provide an alternative approach to the design science process. Two cycles of activities, a relevancy cycle and rigour cycle, are implied when solving design-based problems (see Figure 3.4).

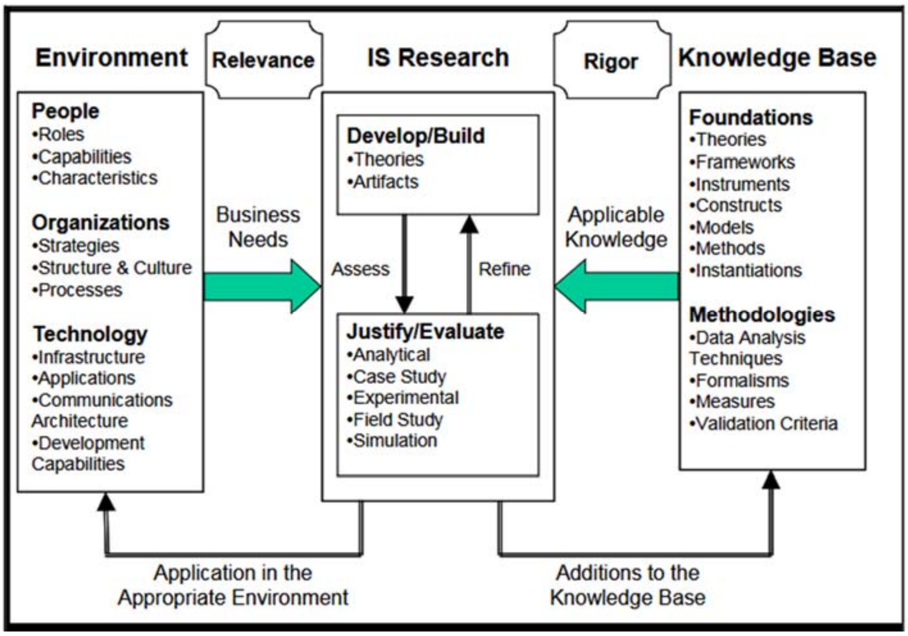


Figure 3.4: The design science research approach

Source: Hevner et al. (2004:80)

Figure 3.4 illustrates that people's roles, organisational processes and technology usage reveal problems that design science researchers are required to solve. This relevancy justifies the business need. An artefact is then built and developed by applying foundational theories, existing frameworks, instruments, constructs, models and methods to the problem. The artefact's utility may be justified through analytical arguments, case studies, experiments, field studies or simulations. Academic rigour emerges in the application of theories, literature and methods to the problem-solving process and the addition of insights to existing knowledge bases that are unearthed.

3.6.3 Applying design science strategy to the study

The preceding paragraphs explained that design science research methods provide prescriptions for research that result in the creation of useful artefacts. This research is carried out in the context of the design science method to provide prescriptions for practitioners on how functioning knowledge can be promoted in a computer-based instruction end-user computing service course. The choice of the design science research approach is motivated by two primary considerations: the character of the research problem and the suitability of design science research thinking in addressing the research questions. The search for prescriptions that promote functioning knowledge can be construed as a search for a design artefact that addresses a real business and practice-related problem. It is acceptable to conceive that developing these prescriptions conforms to both the relevancy and the rigour requirements of the design science research method. The prescriptions satisfy the practice dimension by outlining guidelines in the form of a framework that can be used to promote functioning knowledge in computer-based instruction end-user computing service courses. Rigour would be achieved through the application of widely accepted academic theories in conceiving the problem, collecting the data, analysing the data, designing the solution and evaluating it. The insights generated during the process also serve as theoretical additions to existing knowledge.

The design science research process outlined by Kuechler and Vaishnavi (2008) is used as a template to operationalise this study. Figure 3.5 illustrates how the design science research method is used to solve the research problem. The design science research problem-solving process begins with an awareness of the problem, followed by suggestions, development, evaluations and a conclusion.

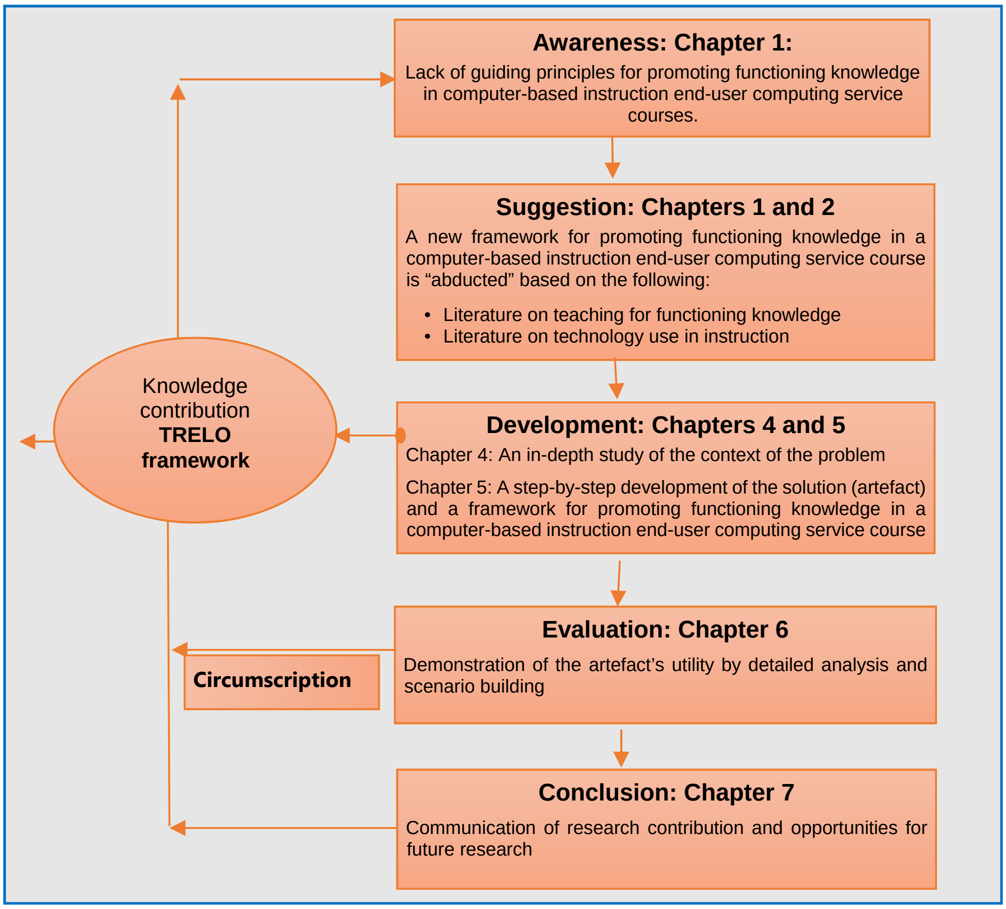


Figure 3.5: The problem-solving process in this research

Awareness and problem identification in the current research

The problem awareness is framed in the main research question:

How can functioning knowledge be facilitated in a computer-based instruction end-user computing service course?

Chapter 1 outlines a teaching and learning challenge in a university service course called end-user computing. The background literature that is explored in Chapter 1 highlights the importance of functioning knowledge. The extensive use of computer-based instruction systems in offering end-user computing service courses at South African universities is also highlighted. It is argued that there is no literature to guide how functioning knowledge can be promoted in a computer-based instruction end-user computing service course. It is also explained that the inconsiderate use of computer-based instruction systems in end-user computing service courses does not promote functioning knowledge. The lack of a mechanism or guidelines to promote functioning knowledge in a computer-based instruction end-user computing service course serves as the main problem of the research.

Suggestion

The suggestion phase is closely linked to the awareness stage (Kuechler & Vaishnavi, 2008). This phase focuses on obtaining detailed insights into the problem and providing suggestive guidelines on the solution that is sought. This study obtains these insights by reviewing literature on the pedagogic philosophy and technology use in instruction. Important design considerations arise from the literature review. The following insights on functioning knowledge are obtained from the literature review:

- The end-user computing course is meant to equip non-computing students with computing skills.
- Two crucial kinds of knowledge are conceivable in the teaching and learning of the end-user computing service course: declarative knowledge and functioning knowledge. Declarative knowledge comprises all the facts that can be taught and is well documented in theories and textbooks. Functioning knowledge is the active use of declarative knowledge in solving problems. It is the performance of a task with understanding.
- Functioning knowledge is made up of declarative knowledge.
- Learning goes beyond a mere reception of facts. It is active and involves acts of experiencing, thinking about and acting.

During the literature review, insights into instructional technology use were obtained. Mayes and Fowler (1999) and Laurillard (1993, 2002) advise that the technology that is used in instruction plays three crucial roles. Firstly, this technology plays a content delivery role, which mainly supports concept formation during teaching and learning. Secondly, it plays a productive role that supports active experimentation and the use of the computer software. Lastly, the instructional software supports discussions that are an important aspect of reflection.

Instructional technology also transforms traditional instruction. Students and instructors gain greater control over the learning pace, place and time (Staker & Horn, 2012).

Development

The development phase focuses on constructing a solution to the problem by examining the contextual data that characterises the problem, and by inferring the problem into the available theory to embed creative ideas into productive artefacts (Kuechler & Vaishnavi, 2012). In the context of this research, the result is the TRELO framework that serves as a design recommendation for facilitating the acquisition of functioning knowledge in computer-based instruction in an end-user computing service course. This development is done in two steps. The first step examines the contextual data around the problem. The second step involves embedding the insights into a productive artefact. This development stage is covered in greater detail in chapters 4 and 5.

Development: Step 1

The process of obtaining insights from the contextual data regarding the research problem is framed in the following two subquestions:

- Subquestion 1: What is the nature of functioning knowledge in an end-user computing service course?
- Subquestion 2: How are computer-based instruction systems used in teaching end-user computing service courses?

The insights that were obtained from answering these two questions are presented in Chapter 4. The data was drawn from the following sources:

- End-user computing service course instructors
- Programme leaders from the departments from which end-user computing students are drawn
- Curriculum documents that are used in teaching the end-user computing service course
- The researcher's own experiences in teaching similar courses

The techniques and instruments that were used in collecting the data are discussed in the section 3.5 (Identification of data sources)

Development: Step 2

The second step of the development phase is a step-by-step construction of guidelines in the form of a framework to facilitate functioning knowledge in a computer-based instruction end-user computing service course. The focus was on answering the following subquestion:

- Subquestion 3: What aspects promote functioning knowledge in a computer-based instruction end-user computing course and how can they be organised into a coherent framework?

These guidelines are developed and presented in Chapter 5. The result of this second stage in the development phase was a framework for promoting functioning knowledge in a computer-based instruction end-user computing service course. The framework was developed with guidelines from Botma et al. (2015) on how to develop a conceptual framework. The process involved identifying specific concepts, defining them, creating links, integrating them and finally aligning them into a coherent artefact. The framework proposes six learning contexts in the end-user computing service course that lead to functioning knowledge. Computer-based instruction systems play definitive roles in each context.

Evaluation

The evaluation stage answers Subquestion 4: How applicable is the framework identified in Subquestion 3 in promoting functioning knowledge in a computer-based instruction end-user computing service course?

This evaluation is presented in detail in Chapter 6. It is done analytically by presenting detailed arguments that illustrate the pedagogical tenets that make the framework useful in facilitating functioning knowledge in an end-user computing course. This is achieved by providing illustrative scenarios and cases where the framework can be applied in real-life teaching and learning setups. The emphasis is on indicating that the artefact can fit and stand its ground in its operating environment, as advised by Gill and Hevner (2013). This demonstration is achieved by the following:

- Demonstrating the artefact’s ability to support the acquisition of functioning knowledge in a computer-based instruction end-user computing service course

- Illustrating that the artefact is consistent with foundational theories that define pedagogy and instruction
- Showing that the artefact is in line with modern practices in higher education instruction such as the flipped classroom and blended learning

Disruptive and intrusive evaluation approaches that involve changing real-life events, such as implementing the framework in a course or curriculum, were not considered as feasible options in this research. The ethical implications of exposing students who are in a learning programme to a controlled experiment were considered as too dire. Time limitations also rendered the choices unfeasible.

Design science conclusion

The conclusion is presented in Chapter 7. New knowledge and insights are communicated.

Circumscription

The problem solving process incorporated elements of circumscription. Kuechler and Vaishnavi (2012) explain circumscriptive knowledge as being tied to contexts and acts of learning by construction so that valuable insight can be gained when things do not function according to theory. Consequently, the development and evaluation stages bring forth new circumscriptive insights that can only be obtained from the experience of constructing an artefact and evaluating it (Kuechler & Vaishnavi, 2012). Chapter 7 communicates the research findings and the contribution of the study to new knowledge. These would form the prescription (in the form of a framework) for promoting functioning knowledge in a computer-based instruction end-user computing service course.

3.6.4 How the problem-solving process unfolded

It is important to note that the problem-solving process is illustrated in a linear format for clarity. In reality, the process unfolded through many cycles of activities that touched on all phases and at times involved moving forward and backwards. This is illustrated in the last chapter. The next section discusses how contextual data regarding the research problem was collected.

3.7 Data collection and sources

Hevner et al. (2004) observe that people's actions, organisational structures, processes and the technology that is used in organisations create business problems that need solving. The researcher appreciated the need for a deeper understanding of the end-user computing environment before recommendations for promoting functioning knowledge could be designed. The researcher had to decide on the data sources that could provide answers to the research questions. Hevner et al. (2004) advise that design science research contextual data is embedded in people's actions, organisational processes and the technology used. The researcher identified the key people, organisational processes and the technology that would provide answers to the research subquestions.

3.7.1 Data sources for subquestion 1

Subquestion 1: What is the nature of functioning knowledge in an end-user computing service course?

This research subquestion has a phenomenological context because it seeks to establish the essential aspects of the end-user computing course that makes the course "unique or distinguishable from others" (Pietkiewicz & Smith, 2012:362). The aim is to understand which unique and distinguishable features of the end-user computing course are worth explaining. The subquestion requires a more in-depth exploration of the end-user computing service course phenomenon in a context that Padilla-Diaz (2015) states goes beyond what is explicit, but includes exploring the meanings that humans ascribe to it. Qualitative approaches, such as phenomenology, unearth a wealth of insights (Ladkin, 2014) by focusing on how participants relate their experiences with the phenomenon (Pietkiewicz & Smith, 2012). The appropriate method for collecting such first-hand accounts of participants' experiences is the semi-structured or in-depth face-to-face interview (Pietkiewicz & Smith, 2012).

The end-user computing phenomenon may also be understood by studying processes that are associated with the course. Processes are rich sources of design science research data (Hevner et al., 2004). The concept of a process is broad and diverse in information systems research. Hevner et al. (2004) narrow it to an understanding of the organisational structures, strategies and processes that have a bearing on the business need. Studying and understanding the teaching and learning processes involved in the end-user computing course can be a daunting process, as the entire system may involve parents, schools, classrooms, departments or even cultural setups. The constructive alignment framework proposed by Biggs (2003) and promoted by Biggs and Tang (2007), however, provides a feasible boundary of where such a study can be restricted. The constructive alignment indicates that a teaching and learning process comprises the following:

- Intended learning outcomes
- Learning activities designed to achieve the ILOs
- Assessment tasks that enable an assessor to judge whether the ILOs have been achieved as intended

These are usually spelt out in course and curriculum documents used in teaching the course.

Thus, the two major sources of data for the first question are the human actors involved in the course and the curriculum documents that are used. The next paragraphs examine the human actors and the curriculum documents that were selected for answering the first subquestion.

Determination of human participants

The two interacting beings in a typical traditional learning environment are the student and the instructor. The two, however, do not interact with the course in a similar fashion. The instructor interacts with the course as an expert and the student as a novice or beneficiary of the course. The Cambridge Dictionary (2019) [online] defines an “expert” as “a person with a high level of knowledge or skill relating to a particular subject or activity”. An expert in the end-user computing service course would understand how the subject is conceived, designed and implemented. This expertise would not only be confined to the end-user computing lecturers in the case of the end-user computing service course. End-user computing students are drawn from disciplines other than computer sciences (Chapman, 2013). The expertise of the academic programme leaders from which end-user computing draws its “service students” becomes an indispensable source of data needed to answer the research question. End-user computing students operate in the course as novices and were not considered as expert informants.

Understanding the lecturers' and programme leaders' "lived" experience and their expert opinion on the end-user computing course was emphasised. Other potential informants, such as curriculum designers, content designers and faculty deans, were considered, but were not included in the study. It could be argued that their ideas and opinions manifest in the way the subject operates at the curriculum implementation level. The two experts closest to the end-user computing course at its administration and facilitation level were thus construed to be the heads of department (programme leaders) from which the end-user computing students were drawn and the end-user computing lecturers.

Data collection from end-user computing lecturers

The researcher wanted to understand the end-user computing lecturers' interpretation of the nature of the subject content in the end-user computing course. A qualitative, semi-structured interview was selected as the best instrument for collecting data from the end-user computing lecturers. Semi-structured interviews provided an opportunity for face-to-face interaction with end-user computing lecturers to help the researcher understand their opinions and interpretations of the nature of the knowledge that was obtained and intended in the end-user computing service course. In this regard, the focal point of the interview was to understand what the lecturers construed to be the essence of the course. The end-user computing lecturers were asked to provide answers to the following questions that were crafted to provide answers to Subquestion 1.[3]

The full interview protocol and a sample transcript can be seen in Appendix 1. The following is an excerpt from the interview:

- Describe what you regard as the main focus of your end-user computing service course.
- Describe the types of learning activities and assessments that you use in the end-user computing course.

[3] Subquestion 1: What is the nature of functioning knowledge in an end-user computing service course?

- Explain the knowledge or skills you view as important to an end-user computing student.
- How can the end-user computing knowledge gained in your course help the students in their disciplines and careers?
- Describe the challenges you have faced in facilitating the subject and the strategies you have used to overcome these.

The interviews were allowed to flow naturally with the researcher prompting the participants to provide further information when necessary.

Recruitment of end-user computing lecturers

The researcher used convenience sampling and snowballing referrals to recruit the end-user computing lecturers to serve as expert informants. Taherdoost (2016) defines snowballing referral recruitment as a non-probabilistic sampling technique that involves requesting the participant to recommend other potential recruits. The author explains that this technique is appropriate for participants who operate in closed groups or professions.

Figure 3.6 illustrates the 10 end-user computing instructors who were recruited using the snowballing recruitment technique. A circle represents a participant who was approached and an arrow indicates the subsequent referrals that were made. The two vertical dashed lines (A1, A2 and A3) indicate an analytical process that was conducted after data collection to ascertain whether any new insights could be anticipated.

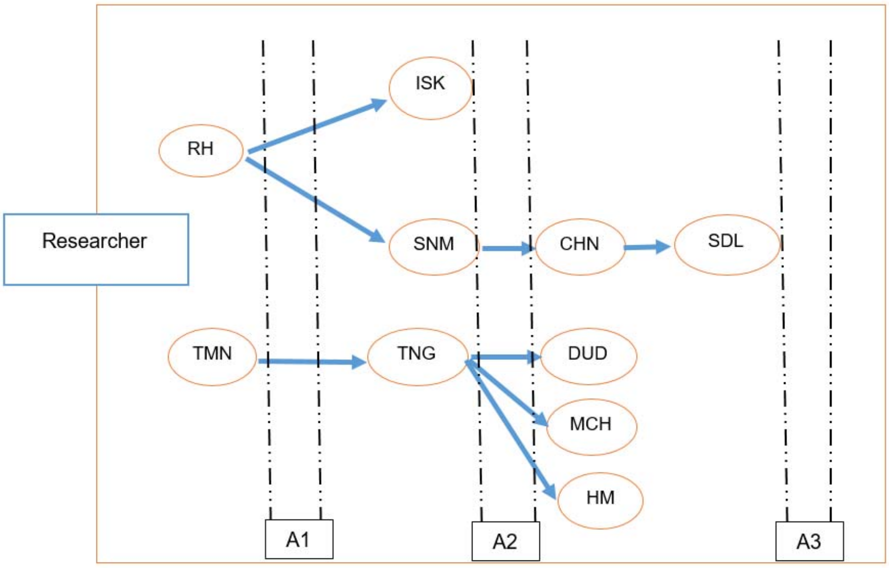


Figure 3.6: Recruitment of end-user computing lecturers

The researcher started the recruitment process by approaching the two end-user computing lecturers (RH and TMN)[4]. They were employed at the same institution as the researcher, a university in South Africa. This choice was based on the ease of access the researcher had to the informants and their willingness to participate. After that, the informants were asked to provide referrals and the referrals were asked to provide further referrals in a snowballing fashion until the researcher had gathered enough information to have gained a fair understanding of the nature of the end-user computing course to design and write recommendations for promoting functioning knowledge. The code comparison technique was borrowed from the grounded theory analytical process to ascertain the point of theoretical saturation. The use of the word "borrowed" is an indication that the code comparison method was not applied in its strict grounded theory conceptualisation where it is used for theory generation. It was used in this study to ascertain a "theoretical point" where data was deemed sufficient for design purposes.

Three analytical sessions were held. The first session was held after data had been collected from the first two participants. This allowed the researcher to refine the interviewing techniques and the questioning as further participants were recruited. The second analysis was performed after interviews had been conducted with the next

[4] All human participants in this research are identified by codes for confidentiality purposes.

three lecturers. The last one was done after data had been collected from the last five referrals, at which point the researcher decided that enough data had been collected for design purposes. Interviews were recorded, transcribed, edited and cross-validated with the participants to ascertain that their views had been captured accurately.

The spread of lecturers covered seven South African universities. It is important to note that some participants had taught the subject at more than one university. The end-user computing facilitators were asked to share their teaching experiences in their personal capacity and not as employees of a particular university. The participants provided informed consent in their personal capacities. In instances where references to particular institutions were made, inevitably, such references were removed from the interview transcripts for ethical reasons.

Characterisation of the end-user computing lecturers

The researcher noted the lecturers' qualifications and teaching experience, which were deemed to have an impact on their understanding of the end-user service computing course. End-user computing lecturers who hold a qualification at degree level and higher in a computer studies discipline were selected. Through their training and adherence to the requirements of the South African Qualifications Authority (SAQA), these lecturers can be expected to be able to effectively communicate academic, professional or occupational ideas to a wide range of recipients. They can also be expected to provide more in-depth insights, interpretations and solutions to problems (South African Qualifications Authority (SAQA), 2012). Table 3.4 provides a brief description and characterisation of each of the participants.

Table 3.4: End-user computing instructors who participated in the research{ TA \l "Table 3.5 End-computing instructors who participated in the research" \s "Table 3.5 End-computing instructors who participated in the research" \c 1 }

Code	Description	Post-school qualifications	University
RH	He had taught the course for two years. At the time of the research, he had taught the course with and without computer-based instruction systems. He used Cengage's SAM computer-based instruction system. His students were from agricultural disciplines.	Bachelor's degree in Computer Science	A recently established comprehensive university in South Africa
TMG	Her experience in facilitating end-user computing involves using computer-based instruction in circumstances where it had not been used before. She has three years' experience in using computer-based instruction systems such as SAM. She has facilitated the end-user computing service course to students from hospitality management, agriculture, commerce and economic disciplines.	Bachelor's degree in Computer Science and a Postgraduate Diploma in Education	A recently established comprehensive university in South Africa
ISK	He facilitates an end-user computing course that is designed for in-service educators to enhance their skills for using information technology in the classroom. He has facilitated the course for two years.	Honours degree in Computer Science	An established traditional university in South Africa
SNM	The participant is a learning technology specialist, having worked as both an end-user computing instructor and a designer of technology-enriched learning environments. She has taught end-user computing service courses to engineering students at two different universities in South Africa.	Master's degree in Computer Science	A university of technology, as well as an established comprehensive university
TNG	She has presented the subject to students from almost every conceivable discipline in a university setup. At the time of the data collection, she coordinated the end-user computing service course and had three end-user computing instructors under her supervision.	PhD in Computer Information, Master's, Honours and BTech degrees	Two comprehensive universities, one recent and one established, as well as a traditional university

Code	Description	Post-school qualifications	University
CHN	He has experience in using computer-based instruction systems, such as SAM, to present the course to students from agricultural disciplines and commerce.	Master’s degree in Computer Science	Two South African universities: one university of technology and one recently established comprehensive university
MCH	She has taught the end-user computing course at two South African universities. She has four years’ experience in using computer-based instruction (MyLab IT).	Master’s degree in Computer Science	A distance learning university and a new comprehensive university
SDL	He has two years’ experience in using computer-based instruction systems, such as SAM, to facilitate the course to mainly hospitality management and agriculture students.	BTech in Computer Science	Two South African universities: one university of technology and one recently established comprehensive university
DUD	Three years of teaching the course at a traditional university.	Master’s degree	Traditional university
HM	Taught the course for a semester using SAM.	PhD in Information Technology	An emerging comprehensive university

The lecturers who were interviewed had worked or were working at the following seven universities during the time of the research:

- University of Mpumalanga
- University of the Free State
- Tshwane University of Technology
- Walter Sisulu University
- Cape Peninsula University of Technology
- Nelson Mandela University

- University of South Africa

Data collection from programme leaders

The same interviewing technique used to collect data from end-user computing lecturers was used for programme leaders. The difference lay in the interview's focal point and the spread in the recruitment process. The focal point of the interviews with programme leaders was their insights into and interpretations of the purpose and value that the end-user computing service course brought to their programmes. The interviews were semi-structured and guided by the following questions (see the full interview protocol and a sample transcript in Appendix 2):

- Describe the end-user computing knowledge or skills that you think are important to your students.
- In what way does the knowledge gained in the end-user computing course help your students in their disciplines and careers?

Seven programme leaders were interviewed. They were chosen from a single institution, but they were spread across seven different specialisations and were experts in the fields of agriculture, education, hospitality management, commerce, biological sciences and development studies. Figure 3.7 illustrates the seven programme leaders who were consulted for their input on the end-user computing service course.

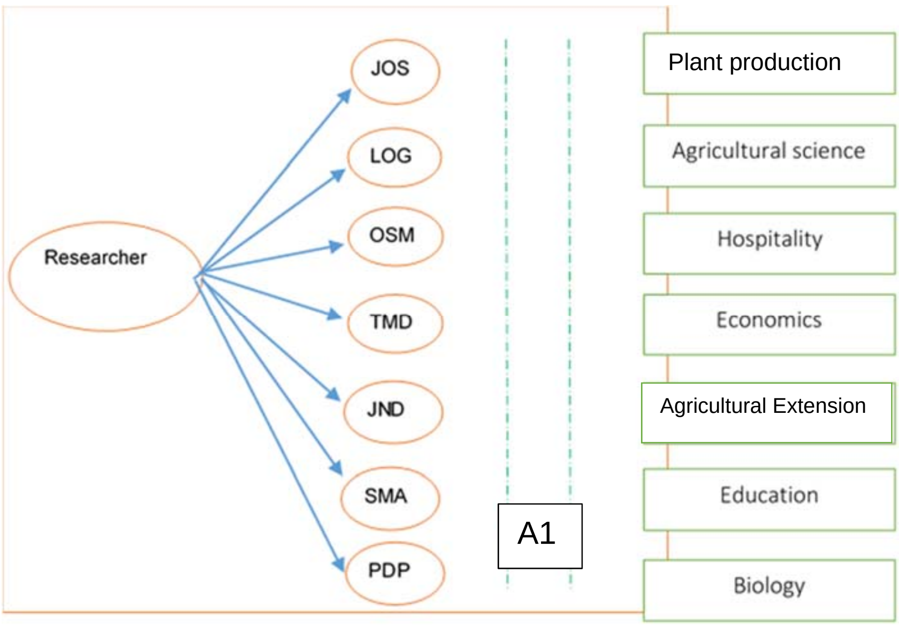


Figure 3.7: An illustration of the recruitment of programme leaders

The details about each participant are summarised in Table 3.5. Data was collected and analysed after the interviews had been conducted, and at this point, the researcher was satisfied that there was adequate information to inform the design process. The information presented in Table 3.5 indicates that the programme leaders who participated in this research were highly educated scholars, with five of them holding academic doctorates. Their leadership experience ranged from two to four years for junior academics, to more than five years in leadership roles for senior academics.

Table 3.5 Information regarding programme leaders{ TA \l "Table 3.6 Information regarding programme Leaders" \s "Table 3.6 Information regarding programme Leaders" \c 1 }

Programme leader	Educational level	Years of leadership	Programme lead
JOS	Master’s degree Postgraduate Diploma in Education	2	Diploma in Agriculture (Plant Production)
LOG	Master’s degree in Agricultural Sciences	3	BSc Agriculture
OSM	PhD in Hospitality Management	3	Diploma and Advanced Diploma in Hospitality Management
TMD	PhD in Social Sciences	2	Bachelor of Arts in Development Studies
JND	PhD in Agricultural Sciences	3	Advanced Diploma in Agricultural Extension
SMA	PhD in Educational Studies	10+	Education and Teacher Development

Programme leader	Educational level	Years of leadership	Programme lead
PDP	Professor of Biological Sciences	6+	Several qualifications in Biology and Conservation Ecology

Data collection from course documents

The researcher also examined curriculum documents in the form of course outlines and syllabi that are used in teaching the end-user computing service course. Using the constructive alignment principle outlined by Biggs and Tang (2007), the information that was required to understand the end-user computing course was obtained through an analysis of the learning objectives, the teaching and learning activities, and the prescribed assessments. The following questions were used as a guide in analysing the curriculum documents:

- What are the main aims of the course?
- What is the nature of the key teaching and learning activities?
- What are the key assessment activities?

Table 3.6 presents information on the curriculum documents that were analysed. The researcher studied four end-user computing service courses. The first was a course offered to students doing a diploma in the Agriculture programme. The second was an end-user computing course for students doing a course in Hospitality Management. The third was an ICT course designed for students training to be teachers. The last was the end-user computing course that was designed for first-year students in the Faculty of Engineering at a distance learning institution.

The selection was purposive and targeted the courses that focus on computer skills development in an end-user computing service course context. Hycner (1999) justifies purposive selection and indicates that the phenomenon dictates the method and not vice versa. The course documents were obtained from lecturers who were known to the researcher through his community of practice networks. These documents were publicly available in the form of published learning material that is distributed to students. The need for special ethical clearance to use the material beyond the traditional academic referencing was not deemed necessary. The course documents were drawn from three different South African universities.

Table 3.6: The curriculum documents that were analysed{ TA \l "Table 3.7: The curriculum documents that were analysed." \s "Table 3.7: The curriculum documents that were analysed." \c 1 }

Service course	Programme serviced	South African NQF level	Course credits	Document type	University description
End-user computing	Diploma in Agriculture	5	15	Learner guide	Emerging comprehensive university
Hospitality information systems	Diploma in Hospitality Management	5	15	Learner guide	Emerging comprehensive university
ICT in the classroom	Education	5	9	Student course booklet	Established traditional university
Ethical Information and Communication Technologies for Development Solutions	Engineering, Science and Technology students	5	12	Course outline	Distance learning university

This subsection focused on explaining how the data for the first subquestion was collected from end-user computing lecturers, programme leaders and curriculum documents. The next subsection explains how the data for the second subquestion was collected.

3.7.2 Data sources for subquestion 2

Subquestion 2: How are computer-based instruction systems used in teaching end-user computing service courses?

Three strategies were employed to gather further insights regarding how technology is used in training students in end-user computing service courses. Firstly, the ethnographic method was used to observe two lecturers who used the SAM computer-based instruction software to teach the end-user computing course over two semesters. Secondly, the researcher reflected on his two years' experience of teaching the end-user computing service course. Lastly, the documentation and training videos that are supplied with the computer-based instruction systems SAM and MyLab IT were studied to understand the functional features of these systems. The following key questions were crafted to guide the observations:

- How is the learning environment configured?
- What role does technology play in the learning process?

A summary of all the data sources that were used for the contextual data of the research, as expressed in the first two subquestions, is provided in the next subsection.

3.7.3 Summary of data sources for contextual data

Figure 3.8 provides an illustrative summary of the data sources and informants that were used to answer the first two subquestions. These two subquestions focus on the contextual data that characterises the research problem:

- Subquestion 1: What is the nature of functioning knowledge in an end-user computing service course?
- Subquestion 2: How are computer-based instruction systems used in teaching end-user computing service courses?

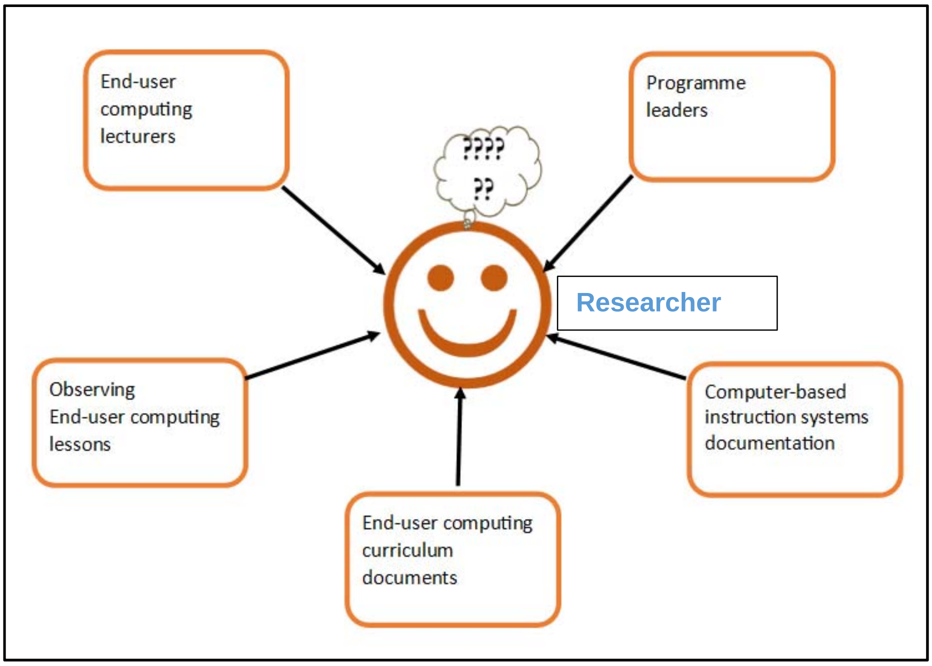


Figure 3.8: Data sources for subquestions 1 and 2

End-user computing curriculum documents, end-user computing lecturers and programme leaders answered the first subquestion. The researcher's own experiences, observations of lecturers who used computer-based instruction systems and an analysis of the documentation that was supplied with computer-based instruction systems were used to answer the second subquestion.

The next section focuses on presenting the methods and techniques that were used to analyse and obtain insights from the contextual data.

3.8 Data analysis

This section presents an explanation of how the data that was collected to answer the first two research subquestions was analysed. The first two subquestions are restated as follows for clarity:

- Subquestion 1: What is the nature of functioning knowledge in an end-user computing service course?
- Subquestion 2: How are computer-based instruction systems used in teaching end-user computing service courses?

The next subsections begin with an explanation of analytical techniques used in qualitative data analysis. This is followed by a discussion of the analytical approach that was applied in this study.

3.8.1 Qualitative data analysis

Ritchie and Spencer (1994:186) explain that qualitative data analysis involves "defining concepts, mapping range and nature of phenomena, creating typologies, finding associations, providing explanations and developing strategies". The analysis of a social phenomenon is explicatory in nature. Hycner (1999) uses the term "explicitation" to imply the exposition of the "constituents of phenomena". The author explains that the term analysis is not preferred in qualitative data analysis as it implies breaking a phenomenon up into its parts. This creates the impression that the whole has been lost as opposed to bringing forth the constituent elements of a phenomenon. Creswell (2013) provides a guide for explicating qualitative research data by advising that such a process involves the following:

- Describing the researcher's own experience with the object or participant under study in order to guard against personal prejudices that may affect data analysis
- Horizontalising the data by listing each relevant individual quote and comparing it to the group
- Grouping the listed relevant topics into units of meaning
- Writing textual descriptions backed by "verbatim quotations" from the research participants
- Writing the structural descriptions

Research data can be viewed in two contexts: a data corpus and a data set. Braun and Clarke (2006) define a data corpus as the entire data set that was collected for a particular research project, while a data set refers to sections of data that are selected for a particular analysis. This study was carried out in the design science research method. Consequently, much of the data was treated in sets that were selected to advance a particular argument.

3.8.2 Analysis of this research

Design science research is done for real-life purposes. This science of the artificial, as described by Simon (1996), focuses on possibilities that the object of design brings about. Design science research focuses on producing utilisable artefacts. Its analytical methods do not only emphasise what it is, but what it can be. The analysis in design science should therefore assist the construction and reconstruction of design artefacts. Using abductive logic, it can be argued that the analytical emphasis of design science research is not on how often a phenomenon occurs, but on the conditions under which the phenomenon occurs.

It is evident from the research aims that the data is ultimately collected for a specific purpose: the design of a framework to promote functioning knowledge. Srivastava and Thomson (2009) explain that research conducted with such predetermined purposes has a priori themes that ultimately find their way into the analytical framework of the data that would have been collected. The authors, however, advise that the researcher needs to remain open to other themes that the data would be generating.

The researcher chose the framework analysis approach to analyse the qualitative data that was collected for this research. The framework analytical technique, among other uses, facilitates a contextual analysis of the nature and form of a phenomenon (Ritchie & Spencer, 1994). It is suitable for research that has specific questions that address a priori themes (Srivastava & Thomson, 2009). It is a flexible analytical approach that balances the depth and breadth of research where specific problems have already been defined (Parkinson et al., 2016).

Framework analysis is a qualitative analytical scheme that keeps the participant's voice and maintains research rigour (Parkinson et al., 2016). The analytical technique allows the researcher to analyse the data using predetermined themes (Srivastava & Thomson, 2009), but to remain open to other characteristics of data that may shape its interpretation (Parkinson et al., 2016). The framework analysis approach was chosen for this research because it allowed the researcher to apply credible research techniques and be responsive to the prescriptive nature of the research aims of design science.

Ritchie and Spencer (1994) explain that framework analysis involves five processes: familiarisation with the data, identifying thematic frames for the data, indexing the data according to the identified themes, creating visual charts based on themes, and mapping and interpreting the data.

3.8.3 The use of a qualitative data analysis tool

A qualitative data software tool – QDA Miner – was used to store the interview transcripts, and to create and manage the themes and categories that were used to extract related information for analysis. Figure 3.9 is a screenshot of QDA Miner that was taken during the coding process of a transcribed interview with one of the end-user computing lecturers.

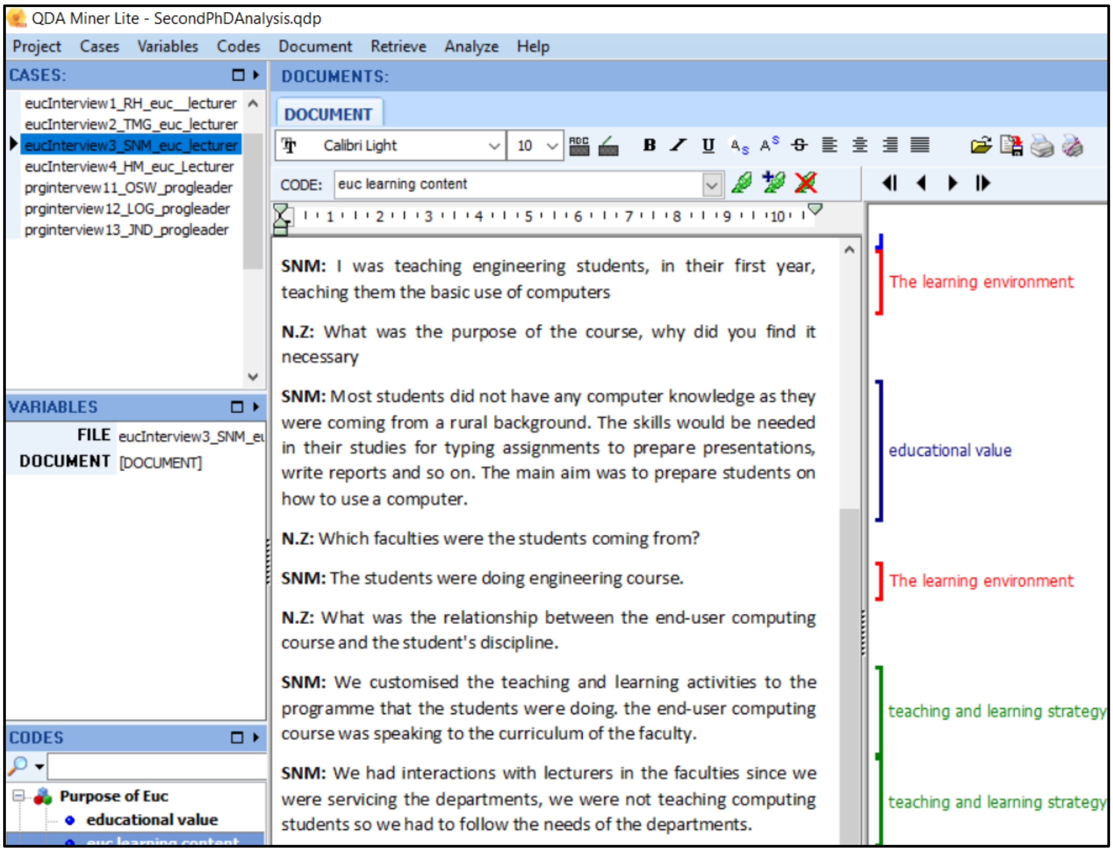


Figure 3.9: QDA software analysis tool

The next subsection describes the analytical processes that were conducted to understand the data.

3.8.4 The analytical process for this study

Qualitative research data was collected for the following two research subquestions:

- Subquestion 1: What is the nature of functioning knowledge in an end-user computing service course?
- Subquestion 2: How are computer-based instruction systems used in teaching end-user computing service courses?

The data for the first research subquestion came from expert interviews with end-user computing lecturers, programme leaders and notes that were taken while reading curriculum documents. The data for the second research subquestion came from the researcher's own experiences, observations of lecturers who use computer-based instruction systems and an analysis of the documentation that was supplied with computer-based instruction systems. The researcher applied the framework analysis processes that are outlined by Ritchie and Spencer (1994) to analyse the qualitative data that was collected as outlined below.

Familiarisation

The researcher read through the interview transcripts, the field notes taken during the lesson visits and the curriculum documents to familiarise himself with the contents of the text (Srivastava & Thomson, 2009). These scripts were loaded as cases into the QDA Miner qualitative analysis software. The researcher created 22 cases to use in the analytical process. The description of the cases is summarised in Table 3.7.

Table 3.7: The collection of cases involved in data analysis{ TA \l "**Table 3.8 the collection of cases involved in data analysis.**" \s "Table 3.8 the collection of cases involved in data analysis." \c 1 **}**

Case description	Number of cases
Interviews with end-user computing lecturers	10 scripts
Interviews with programme leaders	7 scripts
Class visits and observation notes (four class visits)	1 document (script)
End-user computing course outlines	4 course (scripts)

The researcher jotted down interesting issues during this familiarisation process.

Identifying a thematic framework

The framework analysis approach, as has already been alluded to, is useful for research that has a priori or predefined themes. Table 3.8 summarises the key questions that were set up for the interviews with end-user computing lecturers and programme leaders, as well as the analysis of curriculum documents and teaching and learning observations.

Table 3.8: Data sources and the questions that were asked{ TA \l "Table 3.9 Data sources and the questions that were asked" \s "Table 3.9 Data sources and the questions that were asked" \c 1 }

Source	Question
Interviews with end-user computing lecturers	Describe what you consider to be the main focus of your end-user computing service course.
	Explain the knowledge or skills you view as important to an end-user computing student.
	Describe the types of learning activities and assessments that you use in the end-user computing course.
	How can the end-user computing knowledge gained in your course help students in their disciplines and careers?
	Describe the challenges you have faced in facilitating the subject and the strategies you have used to overcome these.
Interviews with programme leaders	Describe the end-user computing knowledge or skills that you think are important to your students.
	In what ways does the knowledge gained in the end-user computing course help your students in their disciplines and careers?
Curriculum documents: learner guides	What are the main aims of the course?
	What are the key teaching and learning activities?
	What are the key assessment activities?
Observations	How is the learning environment configured? What role do computer-based instruction systems play in the learning process?

The researcher scanned through the interview scripts, curriculum documents and the notes that were taken during observations and noted recurring concepts that addressed the nature of the end-user computing service course and the use of computer-based instruction systems. The researcher then created a coding framework in QDA Miner.

The initial coding framework that was generated and illustrated in Figure 3.10 had two categories. The first category focused on the nature of functioning knowledge in an end-user computing course. The common themes in this category were the end-user computing learning content, teaching and learning strategies, and activities, as well as the assessment methods. The second category focused on the use of computer-based instruction systems in the end-user computing service course. The themes that emerged emphasised the organisation of the learning environment, the role and benefits of computer-based instruction systems and the challenges that were faced, as well as how these were overcome.

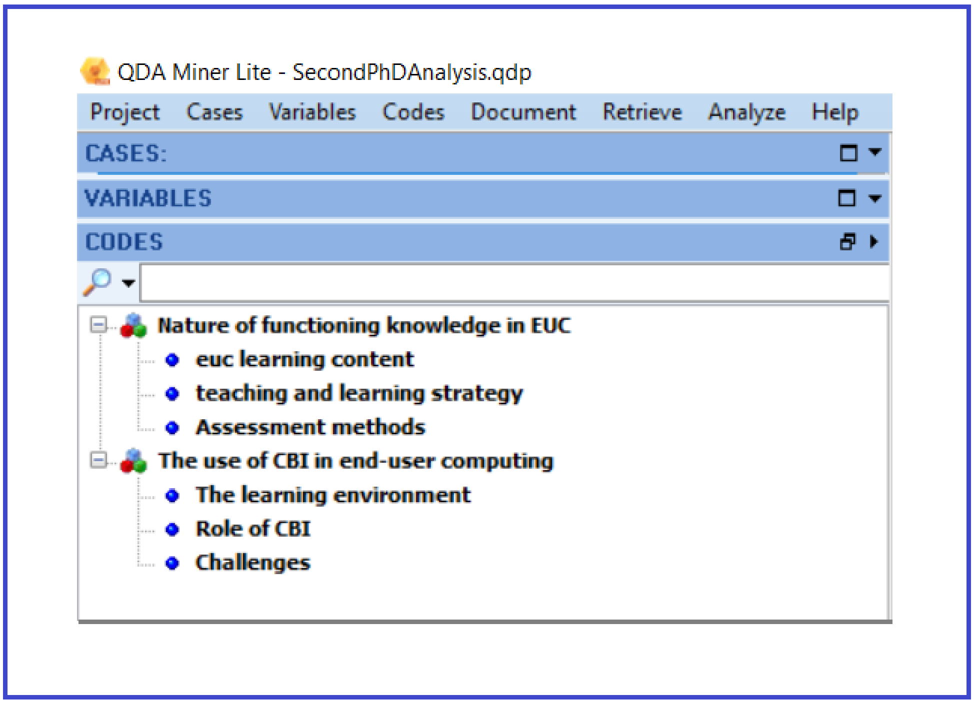


Figure 3.10: Initial themes that were coded in QDA Miner

Parkinson et al. (2016) advise that a thematic framework must allow for expansion and accommodate any new categories that may emerge.

Indexing

Ritchie and Spencer (1994), in Parkinson et al. (2016), indicate that indexing is the process of organising the sections of the transcripts into framework categories. The researcher went through all the scripts and used the QDA Mining tool to identify all the text that could be associated with each of the codes in the coding framework. The text was marked and coded according to its relating theme.

Indexing charting

The charting process involves extracting data from the original source and using the coding scheme or any structure that is suitable for reporting purposes (Srivastava & Thomson, 2009). The researcher used the six themes (codes) and performed a code retrieval in QDA Miner to extract the data for analysis. As illustrated in Figure 3.10, the following codes were used:

1. The end-user computing learning content
2. Teaching and learning strategies
3. Assessment methods
4. The organisation of the learning environment
5. The role of computer-based instruction systems
6. The challenges that are encountered and overcome

Each data set that was extracted based on a thematic category was saved in a spreadsheet file. The file indicated the script (case) from which it was extracted and the text to be analysed. The researcher analysed the data in these spreadsheet files to gain a deeper understanding of the nature of the end-user computing service course and the role of computer-based training. The results and interpretation of this data are presented in Chapter 4.

Interpretation

Srivastava and Thomson (2009:76) indicate that the interpretation of qualitative data in a framework analysis context involves “the analysis of the key characteristics as laid out in the charts”. Chapter 4 presents this detailed interpretation of the qualitative data that was collected to answer the first two subquestions.

The next section presents the ethical considerations that formed part of this study.

3.9 Ethical considerations

The ethical issues relating to this research are outlined in Table 3.9. The general security and confidentiality precautions that were adopted ensured that no data that could lead to the identification of a particular participant, such as their name, surname and insititution, would be recorded or published in a way that identifies them. All research participants’ data and information were stored electronically on a computer that is only accessible to the researcher through a biometric finger scan. The research was conducted in an institutional environment. The researcher obtained approval and informed consent from the institution where seven programme leaders and two end-user computing lecturers participated as informants (see Appendix 8).

Lecturers from other universities participated in their individual capacities, gave informed consent, and signed an agreement document (see Appendix 9). Institutional documents, in the form of curriculum documents and learner guides that are cited in this study, are documents that have already been published and are publicly available on institutional websites and repositories. Special permission and ethical clearance to cite these documents beyond normal and traditional academic referencing were not deemed necessary.

Two end-user computing lecturers, who were observed using SAM, were informally observed over one semester from January 2018 to May 2018. The researcher had been a colleague of the two lecturers for two years, and there was a good rapport between the researcher and the participating instructors. Due to the high ethical risks posed by this exercise because of the close personal and professional relations between them, a special institutional authorisation to observe the two lecturers was requested (see Appendix 8). In addition to the institutional authorisation, the informed consent of the two lecturers was also sought. The lecturers were assured of total confidentiality and that the observations that were being made would only serve an academic purpose and would not be used to judge or assess their performance. The researcher built a good rapport with the two lecturers and avoided writing anything down in their presence.

A summary of the ethical considerations that were made is presented in Table 3.9. The first column indicates likely ethical aspects that could arise. The second column presents areas where potential ethical issues could arise, and the last column presents the steps that were taken to mitigate the perceived ethical risks.

Table 3.9: Ethical risks, considerations and mitigation{ TA \l "Table 3.10 Ethical risks, considerations and mitigation" \s "Table 3.10 Ethical risks, considerations and mitigation" \c 1 }

Aspect	Potential ethical issues	How was it addressed?
Universities will have their computer-based instructional end-user computing courses analysed	Potential exposure of internal teaching processes to public scrutiny	Institutional consent at faculty or departmental level No reference was made to an institution by name in a way that ties particular data sets to it
End-user computing lecturers will be interviewed and observed in the process of teaching	Potential prejudice resulting from expressing an academic opinion that is different from standard institutional practices	Informed consent from the lecturers as individuals No names of lecturers or of their particular universities were revealed
Programme leaders (heads of department)	Potential prejudice resulting from expressing an academic opinion that is different from standard institutional practices	Informed consent from the programme leaders (heads of department) as individuals No names of programme leaders (heads of department) or the university will be mentioned in this study
Analysis of: • Course syllabi or outlines • Learning tasks	Potential exposure of internal teaching processes to public scrutiny	Institutional consent at faculty or departmental level No reference will be made to an institution by name in this study All logos and insignia will be removed from organisational documents
General security	Exposure of participant data to third parties	No data that identifies a particular participant, such as their name, surname or ID, will be collected All research participant data will be stored electronically on a computer that is only accessible to the researcher through a biometric finger scan

The next section concludes this chapter by providing a concluding summary.

3.10 Concluding summary of the research methodology

The methodology of this research is summarised using the conceptualisation of Saunders et al. (2012) of research as an onion (see Figure 3.11).

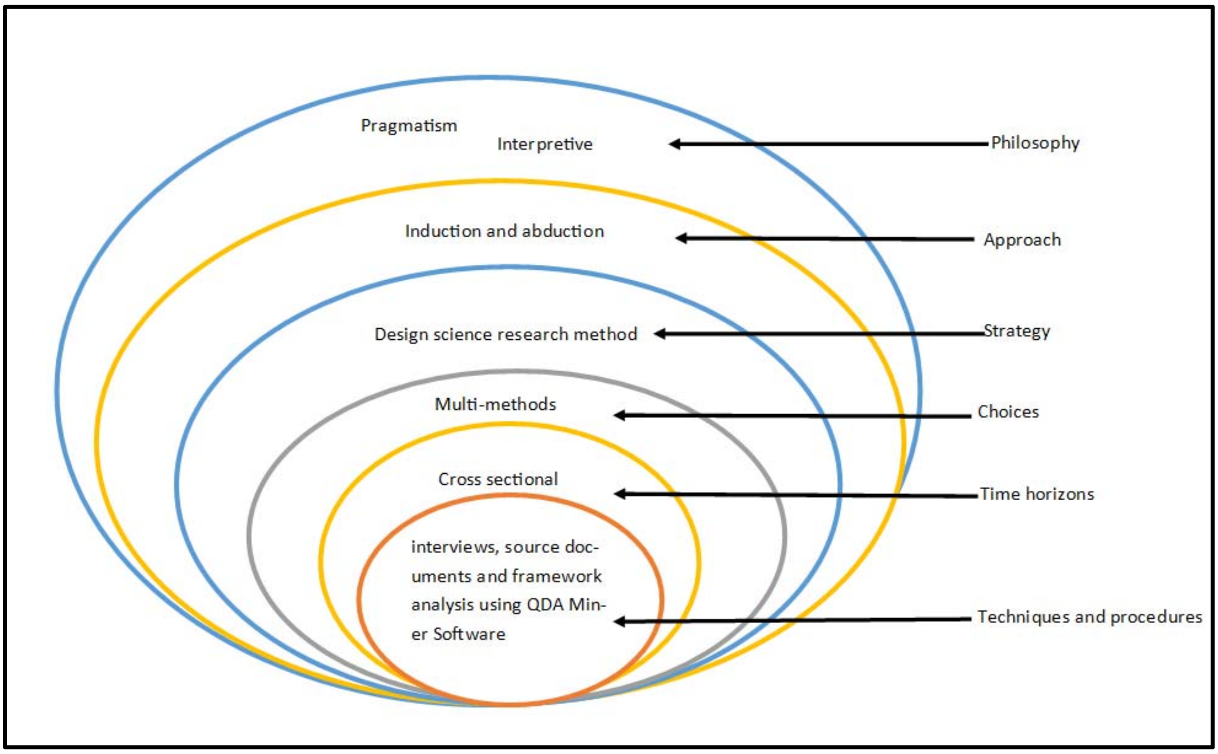


Figure 3.11: An illustration of the approach of this research resembling an onion. Source: Adapted from Saunders et al. (2012)[5]

It is advanced that this research is rooted in the interpretive philosophy. This epistemological position advances that functioning knowledge in the end-user computing course is best understood by interpreting how end-user computing lecturers and programme leaders assign meaning to the phenomenon.

The pragmatist approach was adopted in the problem-solving process. Pragmatism is a philosophical position that advocates the adoption of workable approaches in problem-solving processes. It is put forward that the research problem, which focuses on the promotion of functioning knowledge in an end-user computing service course,

[5] Adapted from Saunders et al. (2012:128)

has practical dimensions. The pragmatic approach enabled the researcher to operate within the realm of what works. Paradigms are philosophical lenses used by researchers. The interpretive paradigm was chosen for this study as it is presumed that reality is brought about by human beings who attach meaning to their observations and experiences. The logical approach to the problem-solving process is both inductive and abductive. Inductive reasoning is applied when data is collected from observations and used to construct a framework for promoting functioning knowledge. Abductive reasoning is applied in the process of building the framework from theory when explanatory accounts are created based on observations and theory. The inductive and abductive approaches become evident in chapters 4 and 5.

The design science research method was used as the research strategy. Stewart (2014) indicates that design science research is a form of action research, or at the very least, its parallel. The design science research method emphasises relevancy and rigour in research processes. The relevancy cycle focuses on building a design artefact that satisfies a business need. Rigour is the application of academic theories, literature and methods to the design science research problem. A process approach to the design science method, as proposed by Kuechler and Vaishnavi (2008), was used as a guiding template. The process emphasises a phase-by-phase research cycle that comprises problem awareness, suggestion, development, evaluation and conclusion in solving the research problem.

Multiple methods were used to collect and analyse the contextual data. Phenomenological interviews were used to collect data that relate to the nature of end-user computing from end-user computing lecturers and programme leaders. Content analysis was used to study the curriculum documents that were used in the course, and ethnographic principles were applied in observing how two lecturers and the researcher used computer-based instruction systems to teach the end-user computing service course. The framework analysis technique was used to understand the qualitative data. It is a qualitative analytical method that is designed for use in explicating data that has a priori themes. A software tool, QDA Miner, was used to store, codify and extract the data for analysis.

The next chapter focuses on explaining the contextual data that was collected. It emphasises the nature of end-user computing courses and exposes how computer-based instruction systems are used in teaching end-user computing courses.

Chapter 4: Functioning knowledge in end-user computing

4.1 Introduction

The main research question is: "How can functioning knowledge be facilitated in a computer-based instruction end-user computing service course". This question frames the research objective, which is to study the use of computer-based instruction in end-user computing courses and recommend a framework for promoting functioning knowledge. The previous chapter proposed the design science approach as the strategic choice that would be used in solving the research problem. Figure 4.1 illustrates the phases of the design science research method that are applied in this research: awareness, suggestion, development, evaluation and conclusion.

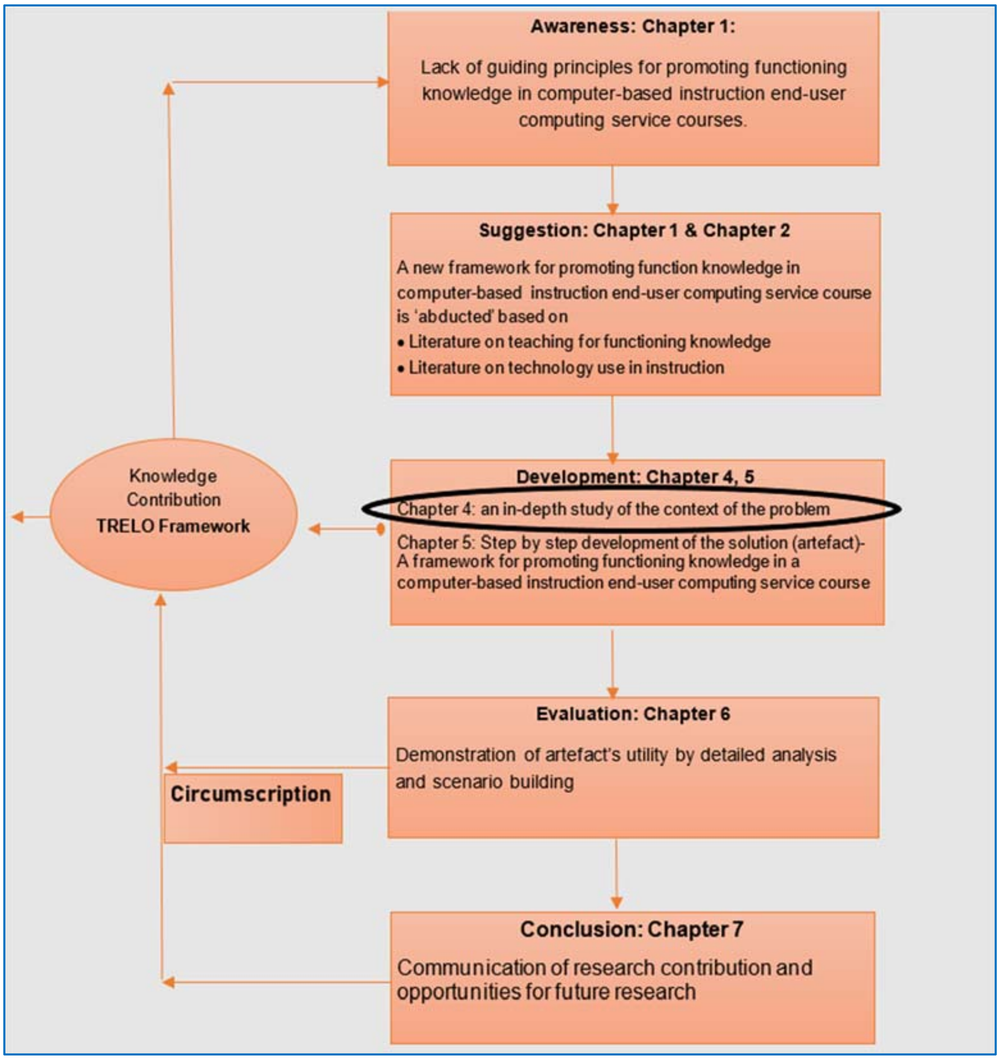


Figure 4.1: Preliminary design and solution development

This chapter, as highlighted in Figure 4.1, focuses on the initial phase of the development stage. This is the collection and understanding of the research problem's contextual data. The first two research subquestions deal with this detailed understanding of the problem's context. The questions are re-stated below for clarity.

- **Subquestion 1:** What is the nature of functioning knowledge in an end-user computing service course?
- **Subquestion 2:** How are computer-based instruction systems used in teaching end-user computing service courses?

Qualitative techniques were used to collect the data that is needed to answer these two subquestions. End-user computing lecturers and programme leaders were interviewed for their insights on the nature of the knowledge that is needed in the end-user computing service course. Sample curriculum documents that are used in the course were also analysed for further insight. The documentation that is supplied with computer-based instruction systems was analysed and it was observed how computer-based instruction systems were used in teaching the course. Finally, the researcher drew insights from his two years of teaching end-user computing courses. QDA Miner was used to store the qualitative data and to code it for easier retrieval and analysis.

The next two sections are dedicated to answering the two research subquestions. Section 4.2 focuses on answering the first subquestion, determining the nature of functioning knowledge in the end-user computing service course. This is followed by an explanation in Section 4.3 of the observations that were made on how computer-based instruction systems are used in end-user service computing courses, thereby answering the second research subquestion. Section 4.4 provides the design recommendations emanating from insights obtained from answering the first two subquestions. In conclusion, Section 4.5 summarises the key concepts that are advanced in this chapter.

4.2 Observations on the nature of end-user computing subject knowledge

This section answers Subquestion 1: "What is the nature of functioning knowledge in an end-user computing service course?"

The researcher interviewed end-user computing lecturers and programme leaders, and perused curriculum documents that are used in the course. Ten end-user computing lecturers and seven programme leaders were interviewed. Four curriculum documents, in the form of course outlines and learner guides, were also analysed. The collected data was loaded into QDA Miner, a qualitative data-handling software, for easier retrieval, inspection and analysis.

4.2.1 The end-user computing learning content

The following key interview questions were used to elicit responses on the nature of functioning knowledge in an end-user computing course:

- Which topics, concepts or areas do you cover in your end-user computing course?
- Describe the knowledge or skills that you think are important to an end-user computing student and the reasons why you think so.
- How can the end-user computing knowledge gained in the end-user computing course help students in their disciplines and careers?
- Describe the teaching, learning and assessment activities that you do to ensure that these end-user computing skills are obtained in your course.

Several responses and varying interpretations regarding the nature of the knowledge in the end-user computing course may be obtained based on the qualitative data that was collected. The researcher also analysed the learning outcomes in the curriculum documents. The analysis is presented based on the three themes that emerged under the category: nature of functioning knowledge. These are end-user computing learning content, teaching and learning strategies used, and assessment methods. The last two themes (teaching and learning strategies used and assessment methods) are presented under one topic for brevity. The section concludes with an analytical argument on the nature of end-user computing.

Knowledge of computer principles

The first theme to emerge was that the end-user computing course focuses on a theoretical understanding of the basic principles of computer systems, especially the basic functions of hardware and software, and the impact of using computer systems.

Participant TMG, an *e*nd-user computing lecturer, explained that her course incorporated information technology networking and communication concepts. The course also covered introductory concepts on emailing, searching for information and using browsers. The theory behind these practical concepts was also covered. The end-user computing course that was designed for a Diploma in Agriculture provided students with opportunities to learn about the hardware and software components of a computer system. They achieved this by defining, describing and explaining theoretical computing concepts such as hardware, software and networking.

Similarly, the course outcomes of an end-user computing course offered to engineering students at a distance learning university expected them to raise critical arguments around the use of ICT tools in societal development, while appreciating the need for ethical behaviour (Unisa, 2018).

Knowledge of using computer systems

The second persistent observation on the nature of knowledge in an end-user computing service course was that students were expected to be able to use a computer. The emphasis of computer usage varied depending on the source or interviewed participant. One of the contexts emphasised the student's ability to operate the computer itself. The following learning outcomes were outlined in an end-user computing course designed for students studying a Diploma in Agriculture:

- Create, edit and enhance standard business documents using MS Word
- Create effective basic MS PowerPoint presentations
- Create spreadsheets, draw charts and carry out calculations using MS Excel.
- Create databases, forms and reports, use filters and carry out basic queries using MS Access

Participant PDP, a programme leader in a Biological Sciences programme, said the following: "We would like our students to have a working knowledge of computers and basic computer programs". A similar sentiment was shared by participant TMD, a programme leader in Development Studies, who indicated that most of the first-year students at his institution lacked the basic computer skills to be functional in a university setup.

Participant JND, a programme leader in an Agricultural Extension programme, highlighted the need for sound computer operation skills by describing that they had to introduce the end-user computing course for students to become familiar with working with MS Word and MS Excel, and for them to make presentations using MS PowerPoint. Participant LOG, a programme leader in Agricultural Sciences, emphasised the importance of spreadsheet processing skills by sharing his expectation. He said: “I expect them to draw graphs if I give them specific data. They should be able to interpret and present the results”.

Participants SNM, DUD and HM, all end-user computing instructors, indicated that they focused on developing basic computer application skills such as MS Word, MS PowerPoint, MS Access and MS Excel because most of the students were from rural backgrounds and did not have any computer knowledge. In their studies they would need to be able to type assignments, prepare presentations and write reports, among other things. In an elementary end-user computing course designed for educators, Musgrave (2017a) outlines that the course, among other objectives, is set to achieve the following:

- Introduce in-service teachers to ICTs and develop their basic skills (word-processing, spreadsheet-processing, internet, email and presentation skills).
- Develop educators’ operational and navigational skills to use the keyboard and the mouse.
- Encourage teachers to use ICTs (MS Word, MS Excel and MS PowerPoint) to improve teaching.

Problem-solving using computer systems

The third observation was a need for problem-solving skills above the mere ability to use a computer. There was a desire for end-user computing students who can solve problems using a computer. Participant RH, an end-user computing instructor, indicated that the end-user computing students had to be able to apply computing knowledge in a farming context. The application could involve the ability to set up a computer spreadsheet of profit and loss accounts, databases of farm assets or PowerPoint presentations of farm budgets.

Participant OSM, a programme leader in a Hospitality Management course, explained that computer application knowledge should be contextualised in a hotel setup. The learners would have to take note of the departments that operate in a hotel setup, and the hotel operations that involve billing, checkouts and customer account reconciliations. He indicated that theory was of little use if it was not linked to industry practices.

Participant LOG, a programme leader in Agricultural Sciences, suggested that the end-user computing course would be of no value if it did not use data, contexts and language that relate to the agricultural discipline. He suggested that the use of discipline-related language, contexts and problems in the end-user computing course “kills two birds with one stone”. The end-user computing programme that was designed for educators spells out that the end-user computing module is not about the technology. Musgrave (2017b) reiterated that computing skills for educators should be about how technology is used innovatively in enhancing the educator’s content and pedagogical skills, and in enriching the teaching and learning process.

The sentiments observed in the previous two paragraphs reinforce the thinking of Brown et al. (1989) and Lave and Wenger (1991) that effective problem-solving has to be tied to the environment and the contexts from which the problem emerges. The thinking that goes into problem-solving should arise from its environmental contexts and not the classroom context that is often artificial. Consequently, Brooks and Brooks (1999) advise that teachers must use raw data, primary sources and physical materials to encourage learners to generate their own understandings from the real-life phenomenon.

Reflective skills

The concept of reflection was heavily emphasised in the end-user computing course designed for educators. Musgrave (2017a; 2017b) outlines that educators should be able to do the following:

- Develop reflective skills on their teaching practices
- Understand the relationship between the content that is taught, the teaching practice and the technology available to enhance learning
- Examine the different ICT tools that can be used in teaching in the classroom

- Share ideas and approaches for the ICT integration with the classroom
- Understand the relationship between the policy, the teacher's role and the integration of technology
- Examine the different ICT deployment models

Similarly, the learning outcomes of an end-user computing course offered to engineering students at a distance university empowered students with the skills to critique information technology use and appreciate ethical issues around technology usage (Unisa, 2018).

Kolb (1984) and Kolb and Kolb (2009) explain the concept of reflection as a process of comparing learning experiences (concrete observations) with existing knowledge. The comparison results in the creation of new ideas about the phenomenon (abstract conceptualism). Lotz-Sisitka and Raven (2009) use the term reflexivity to imply a critical evaluation of one's actions in relation to the changing environment. Pretorius and Ford (2016:24) indicate that reflection or reflective practice aims at growing one's knowledge through self-discovery. The authors explain that reflection occurs both during the moment of practice ("reflection-in-action") or retrospectively ("reflection-on-action").

The next paragraph gives a brief description of the teaching and learning activities that were observed in the end-user computing course.

4.2.2 Teaching, learning and assessment activities

The teaching, learning and assessment activities that were observed in the end-user computing course are explained in the following paragraphs. The information was elicited from the interview questions that were posed, the researcher's reflection on his own facilitation experiences and an analysis of the course documents (learner guides, course outlines and students' manuals) that were used in teaching the course.

A wide range of teaching and learning activities were observed in the end-user computing service course, depending on the learning outcomes that were spelt out. There was, however, a strong sentiment and preference towards practical activities, projects and case studies. Participant TMG, an end-user computing lecturer, indicated that she used groupwork, presentations, research-based activities and learning diaries in her facilitation. She highlighted that traditional written (theoretical) tests were not effective as the course was skills-based to a large extent. The researcher and lecturer ISK largely used practical tasks that were done using software such as word-processing, spreadsheet and presentation packages. Students concluded each learning programme (course) by completing a capstone project that required the application of a wide range of skills that would have been learnt (see Appendix 11 for an example of this task).

Lecturer SNM highlighted that she customised her teaching and learning task sheets to reflect the language, contexts and problems of the students' disciplines. As for advice, programme leaders OSM, TMG and LOG indicated that learning outcomes in the end-user computing course needed to be jointly formulated by including the views of both disciplinary specialists and end-user computing lecturers.

4.2.3 Reflections on the nature of end-user computing knowledge

This section is concluded by presenting an analytical conceptualisation of the nature of knowledge in an end-user computing service course, thereby partially answering the first research subquestion: "What is the nature of functioning knowledge in an end-user computing service course?" This question is partially answered at this stage because perceptions of the nature of knowledge in an end-user computing service course are available. The notion of the nature of functioning knowledge in an end-user computing course will be developed, argued and presented in Chapter 5.

A closer analysis of the insights that arise from the end-user computing service course's learning objectives, the responses from end-user computing lecturers and programme leaders and the researcher's own experience with teaching an end-user computing service course is warranted. In the previous paragraphs, four perceptions were brought forward on the nature of knowledge in the end-user computing course. The first perception, an understanding of the theoretical concepts of computer systems, implies a theoretical understanding of the hardware and software concepts that are involved in the end-user computing course. Thus, there is a need for a theoretical understanding of the basic operation of computer systems.

The second perception is that knowledge in an end-user computing service course involves the practical and demonstrable ability to use and operate a computer. This is the skill to use the hardware and software components of computer systems to solve problems. This problem-solving is not limited to computer operational knowledge, but extends to a third perception: the ability to apply disciplinary knowledge in formulating solutions.

The fourth perception is that end-user computing knowledge involves acts of reflection. In the context of educators, Musgrave (2017a; 2017b) views this reflection as involving, among other things, an understanding of the relationship between the content that is taught, the teaching practice and the technology that is available to enhance learning. Reflection is growing one's knowledge by appraising experiences (Helyer, 2015).

Thus, the knowledge in an end-user computing service course can be construed as emerging from an application of the four kinds of knowledge that are brought forward in this discussion. Figure 4.2 illustrates this conceptualisation, as it becomes apparent that the notion of application is central in the end-user computing service course.

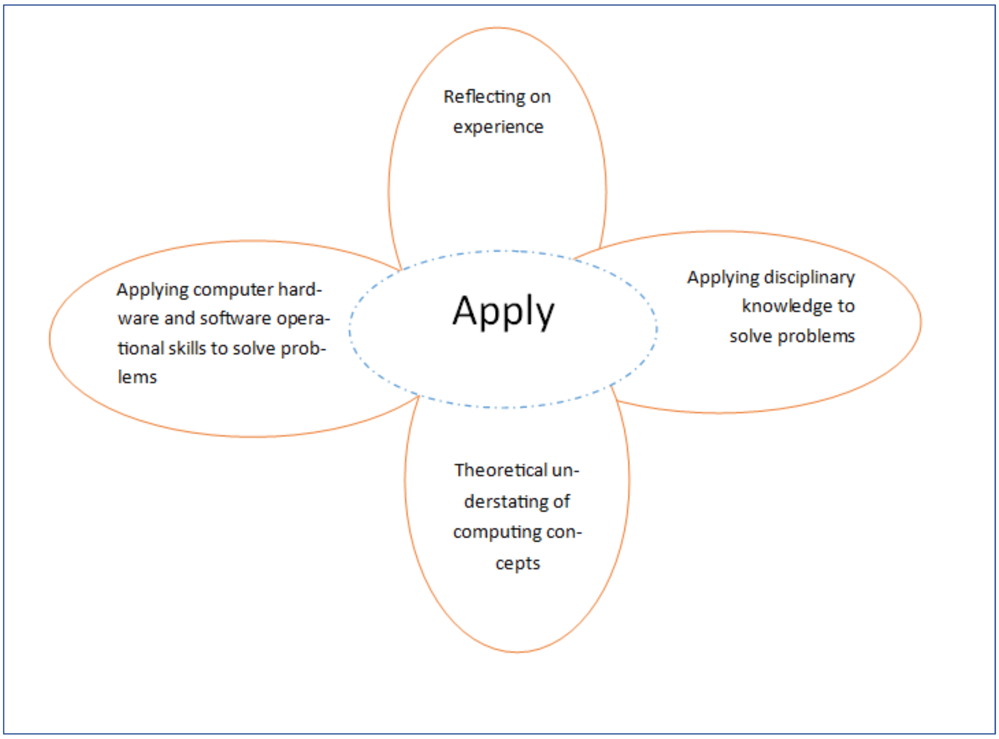


Figure 4.2: The four contexts of knowledge in an end-user computing service course

The conceptualisation of knowledge in an end-user computing service course presented in Figure 4.2 agrees with the way in which Lotz-Sisitka and Raven (2009) define applied competence. Applied competence is seen as a culmination of three intertwined sets of skills: foundational competence, practical competence and reflexive competence. The authors explain that foundational competence is the knowledge and thinking that determines a learner's actions. Practical competence is explained as the ability to choose and perform an action. Reflexive competence, on the other hand, is described as the ability to think about foundational knowledge and the chosen actions in order to adapt to new circumstances or avoid previous mistakes. The theoretical understanding of the computing concepts illustrated in Figure 4.2 has a similar context to foundational competency. It signifies the knowledge and thinking that goes into a student's actions in the subject. The application of computer operation knowledge and disciplinary knowledge in solving problems can similarly be argued to be consistent with practical competence. In this context, learners "show that they can do things" (Lotz-Sisitka & Raven, 2009:316). Finally, what was observed as reflecting on the experience could be aligned with the conceptualisation of Lotz-Sisitka and Raven (2009) with regard to reflexive competence, when learners think about and adapt their knowledge and actions to new circumstances.

The next section describes the operational environment of the end-user computing service.

4.3 Observations on the use of computer-based instruction

This section focuses on answering Subquestion 2: "How are computer-based instruction systems used in teaching end-user computing service courses?"

The observations on how computer-based instruction systems are used in teaching the end-user computing course and the organisation of the learning environment are described. These descriptions are based on the interviews that were conducted with end-user computing instructors, a study of the documentation (videos and manuals) that are supplied with computer-based instruction systems and the researcher's own experiences in teaching the subject. The following interview questions were posed to participants to elicit responses:

- Describe how your learning programme is set up in terms of student numbers, faculties and year levels.

- Which computer-based instruction systems do you use to teach end-user computing?
- What features of computer-based instruction systems do you use to ensure that learners acquire the important knowledge that is useful for their careers and disciplines?
- What features or capabilities would you recommend be incorporated in the computer-based system in order to promote useful knowledge?
- Describe your experience with computer-based instruction systems in teaching the end-user computing service course in terms of its benefits and limitations.

The use of computer-based instruction systems in end-user computing courses is presented under the three themes that emerged. Firstly, the organisation of the learning environment is presented. This is followed by an exposition of how computer-based instruction systems were used in teaching the end-user computing course. Lastly, the challenges that were faced are presented. The section concludes with a critical appraisal of and a reflection on the role of computer-based instruction systems in instruction.

4.3.1 The organisation of the learning environment

The interviews that were conducted with the end-user computing lecturers and the researcher's observations indicate that several learning environment configurations were used to teach the end-user computing service course. These coalesce into four distinct modes. For the purposes of this study, these will be named the face-to-face lab (f2f lab), computer-based training+, open learning and blended learning.

The traditional f2f lab

Figure 4.3 illustrates the f2f lab configuration. Lecturers SNM, TMG and DUD used this configuration in their end-user computing courses. Lecturer SNM used it for engineering students at a university of technology in South Africa.

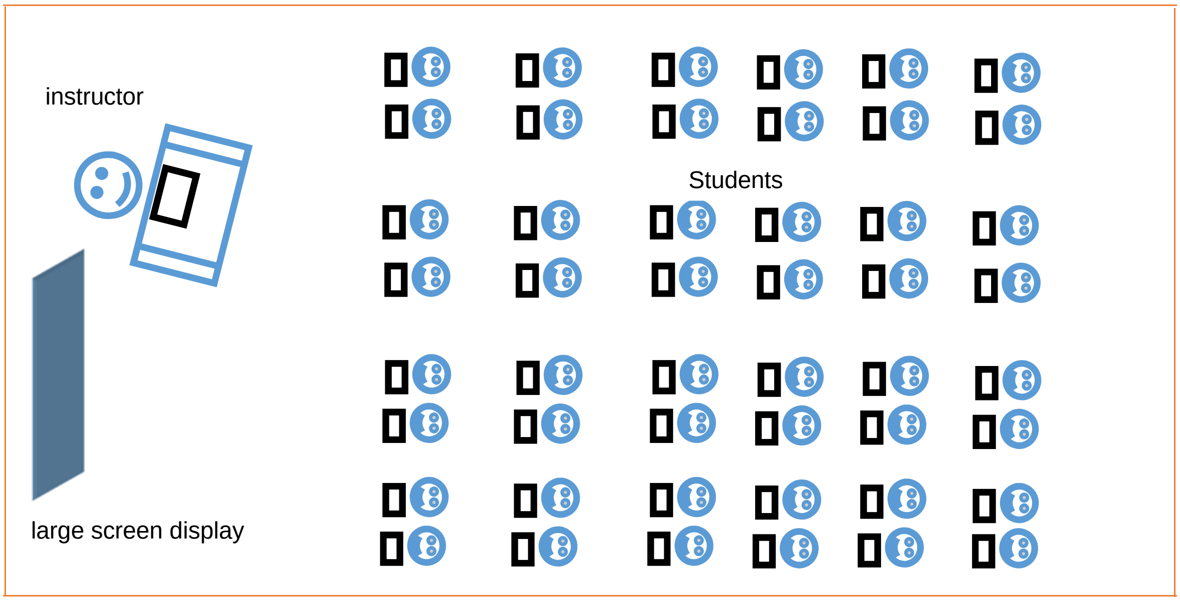


Figure 4.3: The traditional face-to-face lab

Lecturer TMG used a similar setup at a recently established comprehensive university in South Africa, while lecturer DUD used the setup to teach introductory computing skills to members of the community in a community ICT skills programme. The setup typically has not more than 50 computer workstations that are loaded with MS Office suite applications. There is a projector that beams the facilitator's instructions and demonstration. It is physically configured to operate like a traditional classroom.

The computer-based training+

The computer-based training+ (plus) mode is named as such because, in addition to a computer-based training system that offers extensive instruction, a dedicated instructor is also physically available to explain difficult concepts and direct learning. Lecturers TMG, RH, HM, CND and SDL described this learning configuration. Figure 4.4 illustrates the setup in which lectures are conducted in a large computer laboratory with up to 120 computer stations in the cases that were observed. There is an audio system to amplify the instructor's voice, and multiple projectors are used (up to four were observed) to beam the instructor's instructions on different walls. A computer-based instruction system is used to drive the learning process. The system has tutorials, videos and learning tasks for students to follow. The students go through the online teaching and learning material and the facilitator (and maybe two or three teaching assistants) move around the massive laboratory to assist students individually. The lecturer uses projectors when the need for a class-wide demonstration arises. Cengage's SAM computer-based instruction system, which was studied, is available via an online web interface that allows students to access learning resources anywhere, anytime.

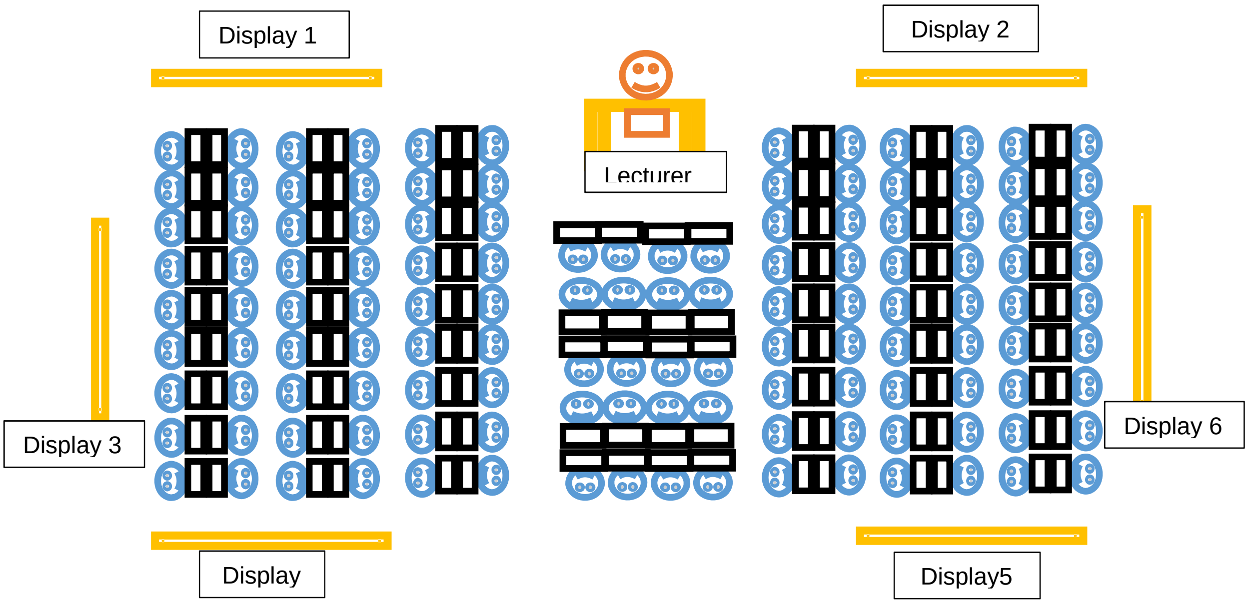


Figure 4.4: The computer-based training+ learning mode

The open learning configuration

Instructor MCH taught at a distance learning institution. She never met her students physically, but used a computer-based instruction system called MyLab IT to train them. MyLab IT has online training material for students. Students follow a selected learning path that is outlined in a course booklet that they receive. Students complete extra assessment activities using actual Microsoft applications and load them for assessment via the university's learning management system. The university has more than 5 000 students enrolled in the end-user computing service course at any time. Instructor MCH was, in fact, one of the many facilitators allocated to provide online support to a group of students allocated to her. Figure 4.5 illustrates how MCH's students were scattered all over South Africa. She could facilitate her course from any part of the world, as long as there was an internet connection.

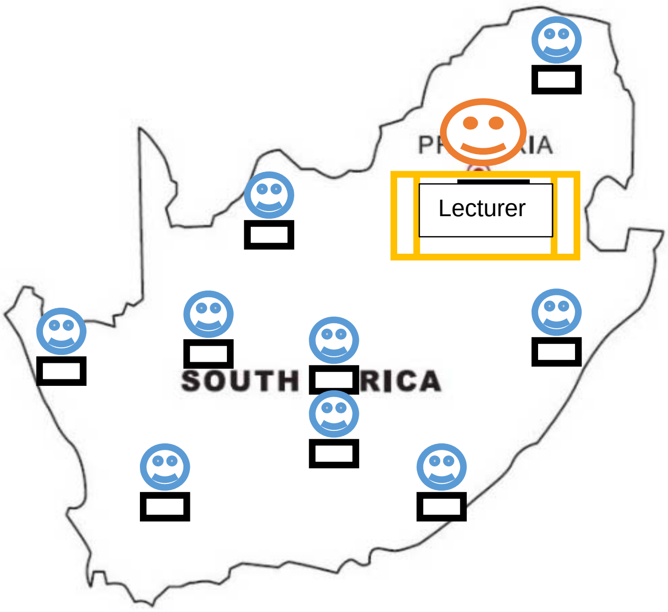


Figure 4.5: Open learning configuration

The blended learning setup

The blended learning modality is used to describe an end-user computing course that was offered to in-service teachers. The course was offered in a “block release” format where instruction was offered partly through contact sessions and partly through correspondence. During contact sessions, instructors went over the learning objectives and milestone activities that covered the essential aspects of the course.

Students did practical and presentation assignment activities individually or in groups under the supervision of instructors. Each module was concluded with an individual capstone project that a student undertook. Capstone projects are extensive research projects that demonstrate a wide range of skills that a student would have been exposed to in a learning programme (Great Schools Partnership, 2016). The completed capstone project would be uploaded onto Blackboard, the university’s learning management system, for assessment. Instructors were available to provide online support via social media platforms such as Google chats, Facebook and WhatsApp between contact sessions. Lecturer ISK and the researcher used this particular system in a course designed for educators.

4.3.2 The use of computer-based instruction systems in the course

The researcher interviewed lecturers who had used computer-based instruction in teaching the end-user computing course to ascertain how they used the system. Participants TMG, RH, HM, CND, SDL and MCH indicated that they had some experience using computer-based instruction systems in facilitating the end-user computing service course. The first five participants (TMG, RH, HM, CND and SDL) had used Cengage's SAM computer-based instruction system. MCH had used Pearson's MyLab IT. The researcher's analysis of the lecturers' responses and a study of the documentation that was supplied with the systems revealed the following insights.

The two systems that were studied (MyLab IT and SAM) simulate Microsoft application programs and provide notes in the form of presentation slides, supporting videos and, in the case of MyLab IT, an electronic textbook. The lecturers create learning paths for students by selecting customised training materials. A path comprises learning activities, projects and examinations that lead to a set of learning outcomes.

Features of computer-based instruction systems

The following features were observed in the use of computer-based instruction systems:

- Training simulations: The students watch a computer video that demonstrates the operations that can be performed using a real Microsoft application. These operations could be copying paragraphs, pasting text, inserting graphs or moving files. The simulated sessions are called "trainings" in Cengage's SAM terminology. The trainings are modelled as a three-step process involving observing, practising and applying. Students watch a short video about a task to observe how it is accomplished. They are then given instruction-led tasks for practice. Finally, they are required to complete the task with limited instruction to establish if they have mastered the task. The assessment tasks are done in the form of online projects and online examinations that the instructors schedule using the computer-based training software.
- The use of real software: Practical project tasks are accomplished in the real software environment. Students download a start file such as an MS Word

document, spreadsheet files or a presentation. They are then given a set of instructions to carry out and implement on the “start file”. The resultant file is uploaded onto the computer-based instruction grading system that compares the student’s actions to a stored correct template. The grading system compares the modified document to the stored template and awards grades based on the degree of similarity.

- Academic monitoring: Instructors can use the systems to track students’ progress through the scheduled tasks that would have been given. Computer-based instruction systems assess the students’ proficiency in a skill by tracking their actions on the computer and giving immediate feedback. The documentation that is supplied with the MyLab IT system indicates that it can report on the time spent on a task, how many attempts were made and the students’ progress towards the outcomes that would have been set (Pearson, 2016).
- Academic administration: Lecturers indicated that computer-based systems are helpful in terms of managing the course administratively. Work, such as the scheduling of tests, handling, submission and return of assignments, and calculating scores, is automated via the system. The SAM system allows instructors to schedule examinations, training sessions, tests and projects for students (Cengage Learning, 2014)
- Twenty-four-hour access to instruction*:* The computer-based instruction systems are available for continuous student practice at any place and at any time for as long as the students have access to the internet. This is a characteristic feature of both SAM and MyLab IT. TMG liked the fact that students had access to learning material before and after lectures, allowing her to focus on explaining concepts during lectures, rather than delivering learning material and content. She added that the systems minimised some challenges that are associated with university learning. These benefits include eliminating the need for a fixed classroom, and when students miss lectures, they can still consult the electronic content and use the learning paths to progress.
- Large repository of practice and assessment tasks: Participant RH, an end-user computing instructor, revealed that the computer-based instruction systems

allow him to give his students extra work using tutorials through video and other interactive material that they can use outside the classroom.

- Communicative role: A practice that was observed in both instances where either SAM or MyLab IT was used is the interfacing of the computer-based instruction system with a communicative tool or LMS such as Moodle, Blackboard, MindTap or Canvas. This allowed instructors to implement educational dialogues through broadcasts, notices, group chats and blogs. In this way, the computer-based instruction system, as a setup, assumed a new communicative role that was beyond mere content delivery.

Challenges associated with computer-based instruction systems

End-user computing instructors raised some challenges that they were experiencing by using computer-based instruction systems. Three of these were student apathy, a lack of the human element and ill-fitting contexts.

In terms of student apathy*,* Participant RH explained that students experienced problems with self-learning when it came to the commitment, the focus and the dedication that is required to be successful. This lack of enthusiasm and failure to go the distance in an online and computer-based instruction course is consistent with the observation of Guerriero (2014) that, on average, only 4% of students who enrol for an online course complete it.

Lecturers TMG, HM and RH indicated that the system lacked a human-teacher element and that students could not be discursive in their assessments. The system grades students' work by examining computer actions such as mouse movements, clicks and document formats. Students can therefore not be evaluated on the basis of explanations and substantiations – a key feature of functioning knowledge. The assessment is limited to a mere comparison of the student's actions on a computer against the pre-recorded steps.

Simin and Haidari (2013) observe both pedagogical and technological challenges associated with computer-based assessments. Pedagogical risks include a lack of supervision that might give rise to plagiarism, a lack of information technology skills that becomes a hindrance to the assessment itself and an overreliance on multiple choice questions that demotivate students.

Participant TMG indicated that Cengage's SAM system that she used provided computing concepts in a context that was set in a foreign, American context. Students could not readily recognise scenarios because they were not relevant to the South African environment. She also regretted the fact that the SAM system she used did not allow lecturers to customise and include their own projects. The MyLab IT system allows instructors to build their own assessment tasks and define how they should be marked.

Reflections on the role of computer-based instruction systems

A critical reflection on the use of computer-based instruction systems is now presented. This reflection provides a substantive response to Subquestion 2: "How are computer-based instruction systems used in teaching end-user computing service courses?" It was observed that computer-based instruction systems provide training simulations, allow the use of real software in practical projects, monitor student progress, have vast repositories of interactive training materials that are accessible anytime, and allow communicative learning dialogues. These observations resonate with the one of Mayes and Fowler (1999) in terms of the functions of courseware.

Firstly, computer-based instruction systems that are used in end-user computing courses have vast repositories of training material. Mayes and Fowler (1999) explain that primary courseware tools support the presentation of concepts and the subject matter. This is crucial during concept formation.

Secondly, computer-based instruction systems allow students to use real software packages, such as word-processing, spreadsheet and database packages, when completing projects. This is identical to the way Mayes and Fowler (1999) describe secondary courseware that is productive and concerned with the tools that support the completion of performance-based tasks and activities. The authors explain that this productive use of software enhances knowledge construction.

Lastly, computer-based instruction systems have communicative tools that support dialogue and knowledge sharing. This is equivalent to the explanation of Mayes and Fowler (1999) of tertiary courseware. Tertiary courseware provides the tools that are used to support dialogue among learners, their peers, teachers and collaborative partners.

It can thus be put forward that, at a conceptual level, the role of a computer-based instruction system in the end-user computing service course is threefold: content delivery, production of work and enhancing educational dialogue through communicative tools.

4.3 Design recommendations

Chapter 1 presented the research problem as a lack of recommendations on how functioning knowledge can be facilitated in a computer-based instruction end-user computing service course. Chapter 2, by focusing on literature, explicated some of the theories that have shaped pedagogy. It was indicated that functioning knowledge is the use of declarative knowledge in the effective performance of tasks. The role of technology, especially computer-based instruction systems, was discussed. This chapter revealed insights on the nature of the end-user computing course based on interviews that were conducted with end-user computer lecturers and programme leaders. In addition, steps were taken to further understand the nature of knowledge in the end-user computing service course. These included an analysis of the contents of the curriculum documents that are used in the course, an assessment of the operational features of two computer-based instruction systems that are used in the course, an observation of computer-based instruction systems in operation and a reflective introspection on the researcher’s own experiences.

The literature review done in Chapter 2 and the observations made in this chapter can thus be used to put forward the design recommendations for a framework that promotes functioning knowledge in an end-user computing service course. The framework would need to consider the following:

- Both declarative and functioning knowledge are crucial in the end-user computing service courses because functioning knowledge is built on declarative knowledge.
- Two application contexts of the knowledge that is acquired in the end-user computing service course were observed: a computer usage approach that focuses on the ability to operate the computer, and an innovative, problem-solving approach in which disciplinary knowledge is primarily used to solve the problem.

- The learning process comprises elements of reflection or reflexivity, which is the ability to think about knowledge and experiences, and to adapt these to new circumstances (Lotz-Sisitka & Raven, 2009).

Chapter 5 converts these recommendations into a framework that can be used to promote functioning knowledge in an end-user computing service course.

4.4 Chapter summary

Chapter 4 brought forward some observations on the nature of the end-user computing course.

The study highlighted that the end-user computing service course involves an understanding of the theoretical concepts of computer hardware and software, as well as reflections on learning experiences. In addition, two application contexts were observed: a “utilisation-like” application context that focuses largely on using the features of the computer software in solving problems, and a problem-solving approach that primarily uses disciplinary knowledge to solve problems. Learning in the end-user computing course also involves growing one’s knowledge by reflecting on experiences and actions. The instructional technology that is used supports three crucial roles in instruction: content delivery, active practice and supporting dialogue.

Four course implementation modalities that are used to teach the course were observed.

The first is a traditional face-to-face laboratory that has a teacher and application software installed on computers in a computer laboratory that would be physically located at an institution.

The second modality is called computer-based training+. This modality has a massive computer lab that has several workstations equipped with computer-based instruction software. Students work at their own pace, but have an on-site instructor to assist with explaining concepts and providing further demonstrations.

The third modality is open learning. It has an instructor using computer-based instruction software systems and online-mediated channels to support geographically dispersed students. Students study from remote places by following a learning path that is presented on the online computer-based instruction system. Online facilitators support students using group chats, emails and blog facilities. These are either built into the system or made available by interfacing the training system with other LMSs.

The last modality is the block release mode or blended mode. Students attend instruction in block sessions with instructors who explain key concepts and provide material and activities that have to be done in between the sessions.

Computer-based instruction systems, the courseware that is used to teach the course, were observed to play three distinct roles. Notes, videos, slides and instructions, loaded into the system, support a content delivery role. Computer-based instruction also plays a productive role by allowing students to work with real software programs to create documents. Finally, these systems play a discursive role by interfacing with the LMSs that enable the establishment of communication platforms where reflective insights may be shared.

Chapter 5: Towards a framework for facilitating functioning knowledge

5.1 Introduction

The main objective of this research was to determine how functioning knowledge can be facilitiated in computer-based instruction end-user computing service courses. This chapter answers Subquestion 3: “What aspects promote functioning knowledge in a computer-based instruction end-user computing course and how can they be organised into a coherent framework?” Chapter 3 explained that this research problem would be solved using the design science approach.

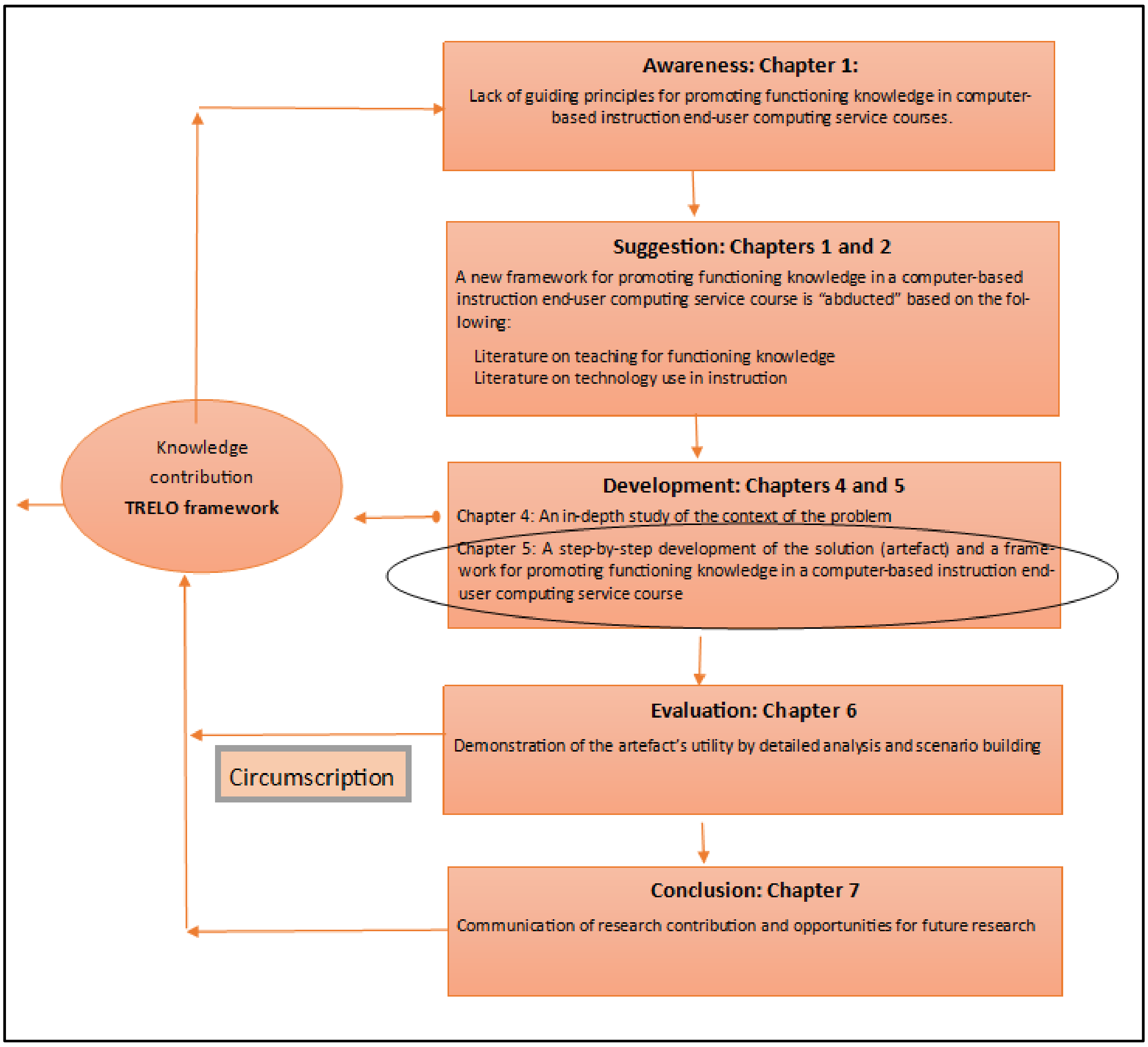


Figure 5.1: The development phase of the design science process

Figure 5.1 illustrates how this chapter, which focuses on the development stage of the design science research method, fits into the overall problem-solving approach. The focus is on presenting a step-by-step process that leads to a solution. Hevner et al. (2004) explain that the design phase is a creative process guided by novelty. This is achieved through examining the problem, inferring information from the available theory and aligning these with the desired outcome. The process embodies abstract ideas that are transformed into tangible and productive artefacts.

Section 5.2 provides background literature and insight into the process of developing a framework. Section 5.3 identifies the key concepts that are necessary for developing a framework to facilitate functioning knowledge in an end-user computing service course and answers the first part of Subquestion 3: "What aspects promote functioning knowledge in a computer-based instruction end-user computing course?"

In Section 5.4, the aspects that define functioning knowledge are aligned into a coherent theoretical structure that is described as the end-user computing knowledge matrix. This theoretical structure is then used as a basis on which a framework for facilitating functioning knowledge in the end-user computing service course is built. Section 5.5 proposes a framework for promoting functioning knowledge in a computer-based instruction end-user computing service course. It is an illustration of how aspects that have been identified as promoting functioning knowledge can be organised into a functional and operable artefact, thereby addressing the second part of the research subquestion: "How can they be organised into a coherent framework?"

5.2 What is a framework?

Verbrugge (2016) describes a framework as a conceptual entity that lies between a model and a method. He explains a model as a simplified and schematic presentation of the state of an existing or future situation. In addition, frameworks contain less detailed structures for realising a goal. They have a higher degree of freedom in their application than models and can contain one or more models. Peffers, Rothenberger, Tuunanen and Vaezi (2012) view a framework as a meta-model. Meta-models comprise the "frames, rules, constraints, models and theories" used to explain and solve a certain class of problems through abstract conceptualisation and minimal semantic content (Génova, 2009:06). On the other hand, a method is more specific, systematic and scientific in its description of the approaches that may be needed to achieve a desired goal.

Botma et al. (2015) explain that developing a conceptual framework involves identifying specific concepts, defining them and linking, integrating and aligning them into the framework. A visual illustration of the process that is applied in this research is presented in Figure 5.2.

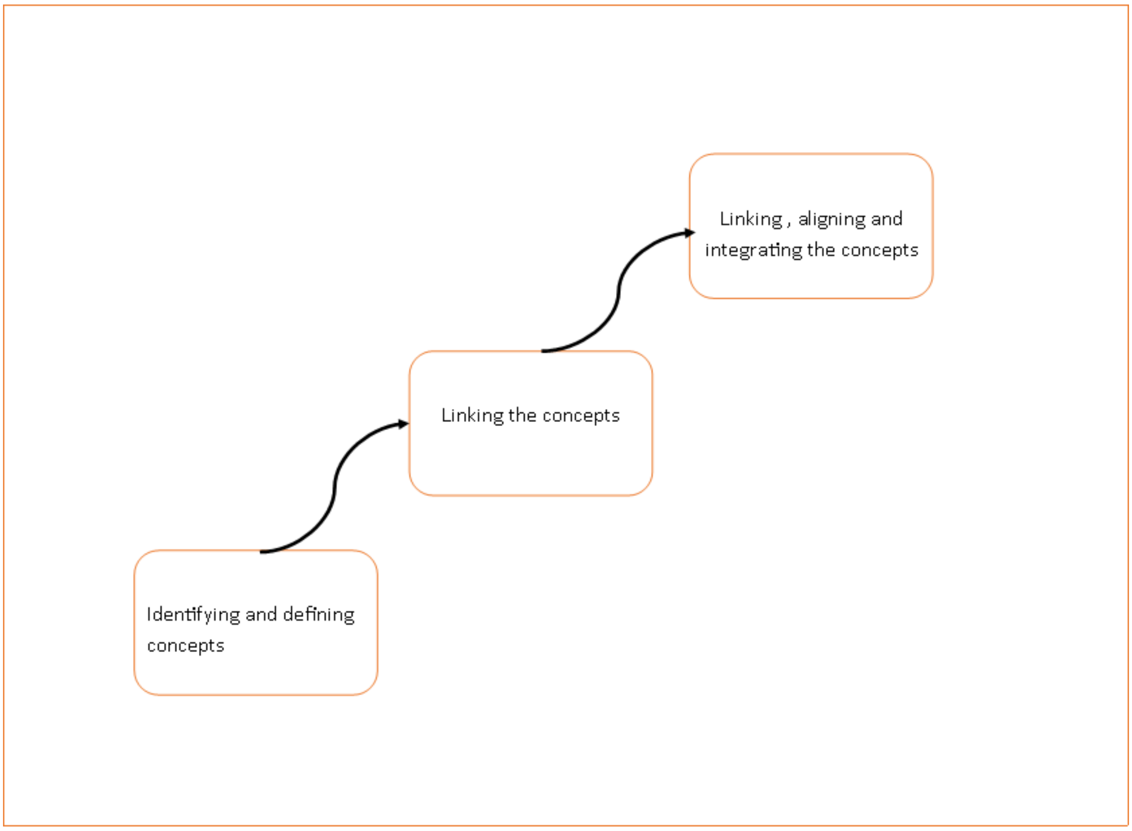


Figure 5.2: The steps followed in developing a framework

The process of developing a framework for facilitating functioning knowledge starts with identifying and defining key concepts that underpin the problem for which a framework is being designed. The concepts are then linked and integrated into a functional, coherent structure by aligning them with the problem that needs to be solved.

5.3 Identification and definition of specific concepts

This section outlines and defines the key concepts that underpin useful and functioning knowledge in an end-user computing service course. These insights are drawn from the literature presented in Chapter 2 and the results of an investigation into the nature of knowledge in the end-user computing service course that is characterised in Chapter 4. The notion of declarative and functioning knowledge is revisited for clarity. After that, a conceptualisation of the character of functioning knowledge in the end-user computing service course is developed by consolidating the definition of functioning knowledge that was highlighted in Chapter 2 and the findings on the nature of knowledge in the end-user computing service course that was presented in Chapter 4. The role of computer-based instruction systems in facilitating functioning knowledge in end-user computing is then suggested.

5.3.1 Declarative and functioning knowledge

It is pertinent to revisit the notions of functioning knowledge and declarative knowledge since this study is about promoting functioning knowledge. Biggs and Tang (2007:72) explain that “declarative, or propositional, knowledge is knowing about things, or knowing what”. They add that such knowledge is explicitly expressible, found in textbooks and taught by instructors. Functioning knowledge, on the other hand, emphasises the performance of a task with understanding. Students need a solid understanding of declarative knowledge for them to be functional. As indicated in the literature review, functioning knowledge is experiential, and involves applying declarative knowledge in solving problems and reflecting on actions.

5.3.2 Functioning knowledge in an end-user computing service course

The character of functioning knowledge in an end-user computing service course is conceivable if the definition of functioning knowledge and the findings presented in Chapter 4 are considered together. Observations into the nature of knowledge in an end-user computing service course, as explained in Chapter 4, indicate that the knowledge in an end-user computing service course comprises four elements. The first involves a theoretical understanding of computing concepts. The second is the application of computing skills in solving problems. The third entails the application of disciplinary knowledge in problem-solving processes and, finally, reflecting on experiences. A further analysis of these concepts is necessary to lay a good foundation for understanding how functioning knowledge in the end-user computing service course could be promoted.

Theoretical concepts: computing and disciplinary knowledge

Chapter 4 mentioned that end-user computing students need a good theoretical understanding of computing concepts. It should also be noted that these students come from disciplines that are not computer related. It is, therefore, logical to propose that end-user computing students need a sound understanding of the theoretical concepts of their respective disciplines to apply disciplinary knowledge in solving problems. These theoretical, disciplinary concepts would naturally be acquired from the various disciplines that the students study. Figure 5.3 is an extension of Figure 4.2 in the previous chapter and is used to illustrate the fact that end-user computing students need a good understanding of their disciplinary knowledge in addition to theoretical computer knowledge.

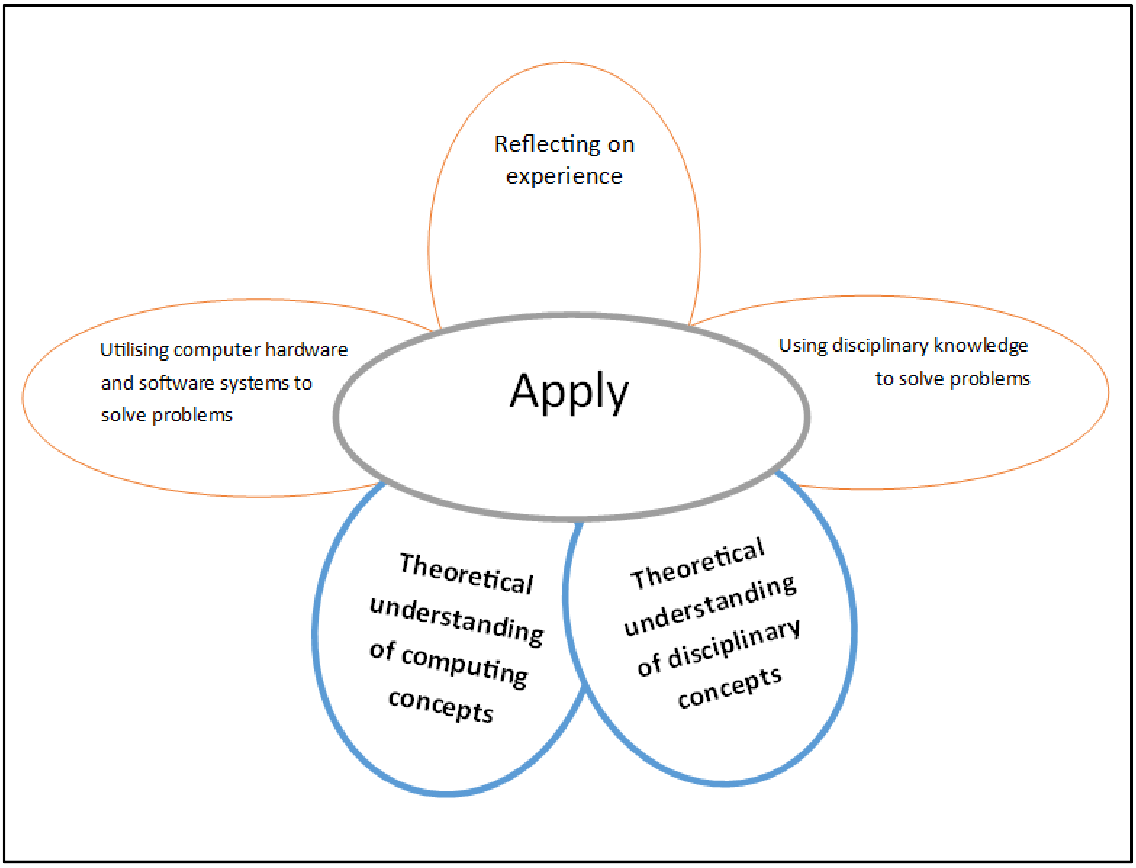


Figure 5.3: The theoretical concepts needed in the end-user computing service course

Application of computing knowledge and disciplinary knowledge

The concept of application was observed as crucial in addition to having a good theoretical understanding of both computing and disciplinary concepts. Two conceptualisations of the notion of application were suggested in Chapter 4. These conceptualisations are highlighted in Figure 5.4. The first application context refers to the utilisation of the computer systems' hardware and software in solving problems. This is much like what was meant by participants LOG, TMG, SM and RH when they indicated that they expected end-user computing students to be able to draw graphs or use spreadsheets to produce graphs. The emphasis, as TMG indicated, is on enabling end-user computing students to use the computer when solving problems. The second context refers to the application of disciplinary knowledge in solving problems. Participant OSM, a programme leader in Hospitality Management, was of the opinion that end-user computing students should be in a position to understand the hotel industry's supply and demand patterns during high and low seasons. After that, they would be expected to "program" these into a computer system that would assist in decision-making.

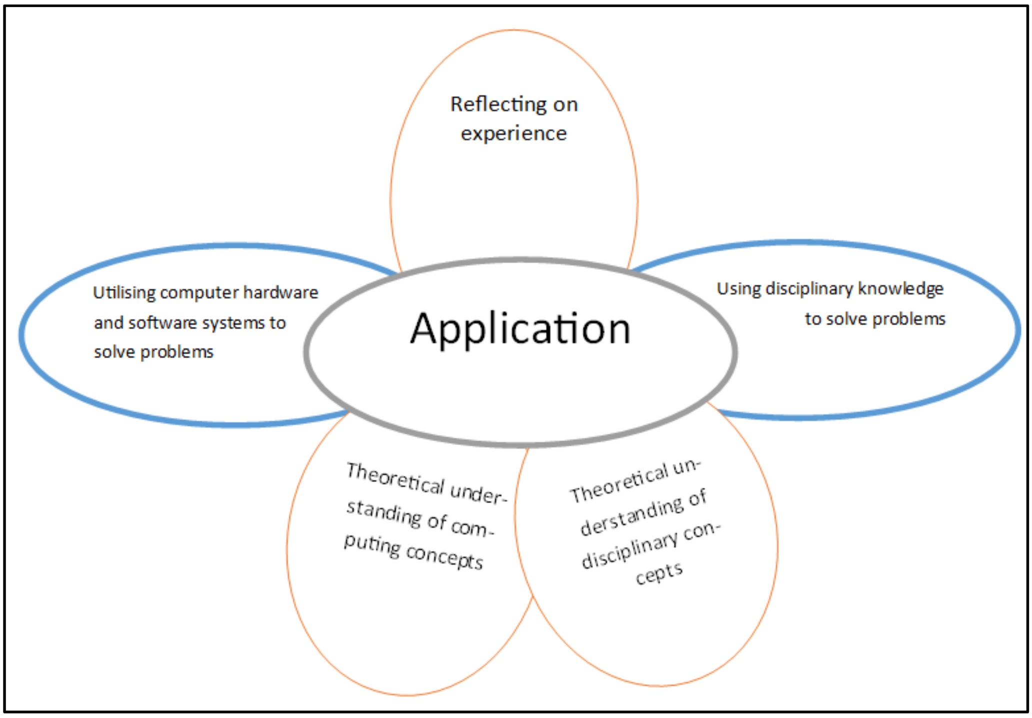


Figure 5.4: The two contexts of application in the end-user computing service course

Figure 5.4 is used to illustrate the fact that the notion of application in an end-user computing service course has two contexts. The conceptualisation of the notion of application advanced above proposes two kinds of skills in the end-user computing service course that are different but important. The first emphasises utility – a desire to have a student who can utilise the features of a computer system and its applications in solving problems. This context is consistent with what Lotz-Sisitka and Raven (2009) call practical competence. This is when learners show that they can do things. The second context emphasises understanding the tenets of the problem itself and then crafting computing solutions that are applicable to the problem. This kind of application uses disciplinary knowledge in building the solution. It can be argued that such an approach has an innovative element of extending disciplinary knowledge in solving problems.

A plausible explanation of this dual conceptualisation of the notion of application is clarified in an argument by Fuller et al. (2007), who indicated that the notion of application, as it relates to practical and applied subjects, is different from the way it is conceived in a traditional academic subject such as English Literature. Niemierko (1990; 2011), instead, explains a taxonomy that places knowledge outcomes in practical subjects at two levels. One level describes the learning outcomes that focus on knowledge, and the second describes the learning outcomes that focus on abilities and skills.

The information in Table 5.1 indicates that the learning outcomes that focus on knowledge emphasise acts of remembering and understanding concepts. On the other hand, learning outcomes that emphasise abilities and skills focus on the application of knowledge. This application is conceived to be of two kinds. The first is an application of the knowledge in familiar or routine contexts. The second is the “problem-solving” kind of application where knowledge is used innovatively to solve unfamiliar problems.

Table 5.1: Niemierko's "ABC" taxonomy of learning objectives

Levels	Categories of learning outcomes
Knowledge	A. Remembering knowledge
	B. Understanding knowledge
Abilities and skills	C. Applying knowledge in typical problem situations
	D. Applying knowledge in unfamiliar problem situations

Source: Fuller et al. (2007:154)

Thus, the explanation of Niemierko (1990; 2011) of the two kinds of skills and abilities[6] seems to explain the two kinds of applications that were observed in knowledge in an end-user computing service course. The skill to utilise the computer's hardware and software systems when solving problems resonates with the explanation of Niemierko (2011) of knowledge application in typical problem situations as demonstrated in participants' statements such as, "I expect them to construct graphs using Excel" and "the main objective of the course is to allow the student to be able to use the computing device in front of them". This approach seemingly emphasises mastering the functionality of the computer artefact as the starting point in solving a problem.

The second context places greater emphasis on understanding the tenets of the problem itself. This is the use of disciplinary knowledge in solving problems. This problem-solving approach resonates well with what Niemierko (2011) points out as the application of knowledge in unfamiliar and dynamic problem situations[7]. It is akin to creating innovative and novel solutions to problems. Disciplinary and practice problems, as observed during interviews with participants, are contextual. This is the knowledge that OSM yearned for when he said that computer application knowledge should be contextualised in a hotel setup and that the learning should take note of the departments that operate in a hotel.

[6] Points C and D in Table 5.1
[7] Point D in Table 5.1

Participant LOG also commented that the end-user computing course would be of no value if it did not use disciplinary (agricultural) data, contexts and language. Musgrave (2017b), in a preamble to an end-user computing programme designed for educators, explicitly states that the computing module is not about the technology. The author explains that computing skills for educators should be about how technology is used innovatively in enhancing the educator's content and pedagogical skills, and enriching the teaching and learning process.

Two terms, “utilisation” and “innovation”, will be used to identify the two kinds of application described above. They emphasise the subtle difference in the way the notion of “application” is conceived in the end-user computing service course. Utilisation is when the student uses practical knowledge to operate a computer such as typing a letter in a word processor, sending an email from a mailing application or setting up columns of marks and creating graphs in a spreadsheet program. Utilisation emphasises the effective operation of the computer artefact. The learner solves the problem by applying the “rules of the computer machine” to solve a problem. The problem is solved according to the standard operating features of the computer and its software. Utilisation is much like what Lotz-Sisitka and Raven (2009) describe as practical competence. Learners show that they can do things.

Innovation, on the other hand, is a different kind of computer application. The end-user computing course is offered to students from disciplines with a major that is not computer sciences (Chapman, 2013). The students encounter problems in their disciplines that need to be solved using a computer. The hypothetical creation of a graph showing the germination percentage of a tonne of seeds per hectare for different crops does not only require being able to create a graph using a spreadsheet program. It also requires an understanding of the mathematical models that are used in crop cultivation and germination. During innovative application, end-user computing students build the solution to a problem on the basis of their disciplinary knowledge. Thus, the innovative application approach brings context, novelty and creativity to the problem-solving process.

It can, therefore, be concluded that the utilisation approach emphasises operating the computer artefact and, in the process, primes understanding the features of software and hardware that makes the computer a problem-solving tool. Innovation, on the other hand, entails using disciplinary knowledge in crafting solutions to problems. Utilisation and innovation are both application contexts of the end-user computing service course that originate from different premises.

Reflecting on experience

The argument presented in the previous paragraphs is extended to include the concept of reflection that was observed as crucial in the end-user computing service course. Musgrave (2017a; 2017b) emphasises that educators should be able to develop reflective skills on their teaching practices, and understand the relationship between the content that is taught, the teaching practice and the technology available to enhance learning. Kolb (1984) and Kolb and Kolb (2009) explain reflection as a process of comparing learning experiences (concrete observations) with existing knowledge to create new ideas (abstract conceptualism). It is a critical evaluation of one’s actions in relation to the changing environment (Lotz-Sisitka & Raven, 2009)

Figure 5.5 proposes the two kinds of reflection that can be construed if the convergent nature of knowledge in end-user computing that has been highlighted thus far is considered. So far, knowledge in end-user computing has been explained as the application of both computing and disciplinary knowledge in solving problems.

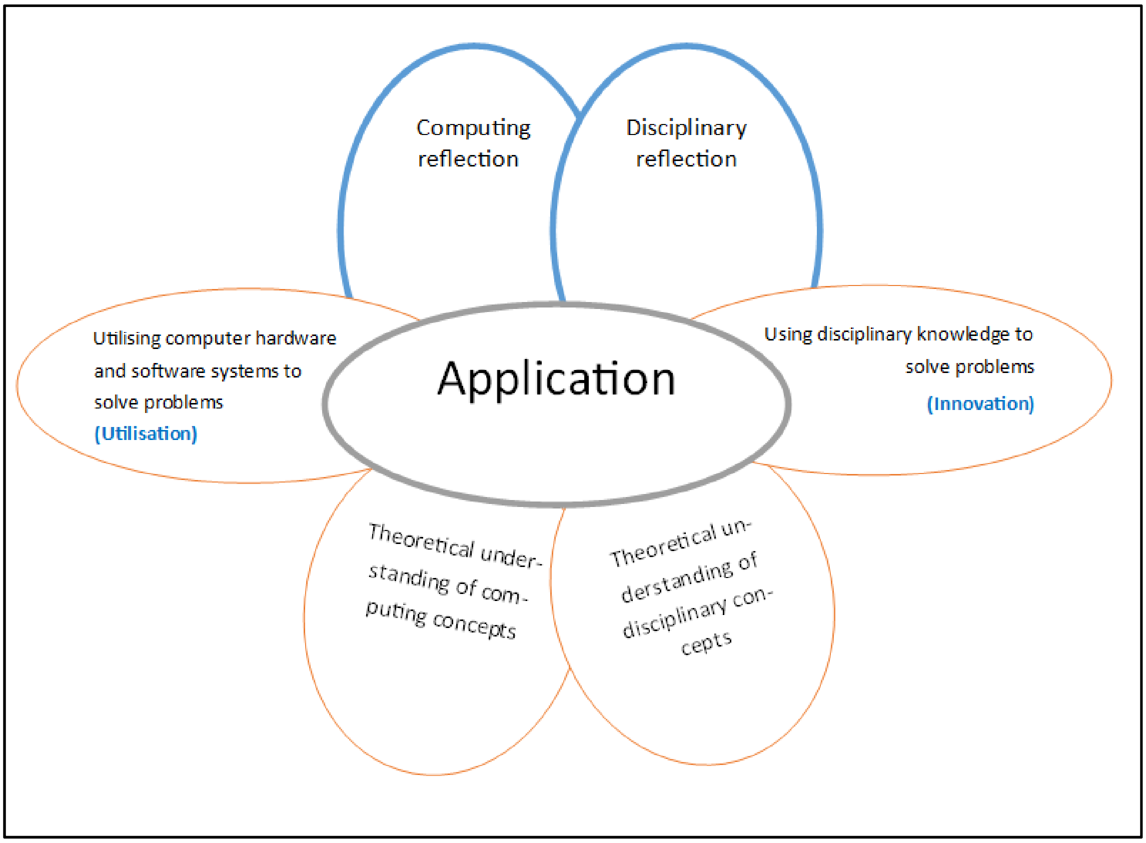


Figure 5.5: The two reflective contexts in the end-user computing service course

Two kinds of reflective processes can be thought of in the context of the dichotomy of knowledge in end-user computing that pits computing concepts on the one hand against disciplinary concepts on the other, as presented in the previous paragraphs. One of these reflective acts would be a computing reflection. This computing reflection focuses on appraising learning experiences based on the knowledge of the computer artefact and its utilisation. A case of such a reflection could be activated when things fail to work. The computing reflection appraises whether the computer artefact was applied correctly in terms of operational procedures and processes. The reflection could also interrogate whether the theoretical computing concepts that the student has mastered are adequate to address the problem. Disciplinary reflection, on the other hand, appraises the way the disciplinary knowledge has been applied in crafting a solution.

5.3.4 The role of actors in the learning environment

Observations on the use of computer-based instruction systems in teaching and learning revealed that the learning environment has three critical role players: the student, the instructor and the computer-based instruction system. The student is central to any instructional effort because it is the end-user computing student who constructs and applies the functioning knowledge. Ertmer and Newby (2013) explain that learners construct knowledge by interacting with the environment. Ashton-Hay (2006) indicates that powerful learning environments promote active learners, who bring and build on their prior experiences. The author contends that effective learning is goal-directed and increases opportunities for learner reflection.

The teacher plays an important role in instruction. Kirschner, Sweller and Clark (2006) stress that direct instruction in learning is important. They argue that the constructivist approach, which is based on minimally guided instruction, is not effective. Gordon (2009), however, refutes such assertions as a misinterpretation of the constructivist teaching approach and suggests that teachers play an active role in constructive learning environments. He suggests a balance between the teacher's "teaching" and the need to allow learners to construct their own understandings. Students and instructors are indispensable in the learning process. Nevertheless, the research question emphasises the role of computer-based instruction systems in promoting functioning knowledge in the end-user computing service course.

The way computer-based instruction systems are used and the learning environments in which such systems function are crucial for determining how functioning knowledge can be facilitated. Ali and Wibowo (2016) highlight that computer-based instruction systems have test banks, practice activities, training and videos that make them excellent sources of declarative computer knowledge. Mayes and Fowler (1999) explain that learning courseware comprises primary software, secondary software and tertiary software. Primary software delivers content that is important to concept formation. Secondary software is productive software, such as software packages, that allows students to construct real documents in support of the constructive and active learning process. Tertiary courseware plays a communicative role that is important for sharing ideas for reflection purposes. A practice that was observed during the study was the interfacing of computer-based instruction systems (SAM, MyLab IT) with LMSs such as Blackboard and Moodle or social media applications. This practice enabled discursive dialogues and exchanges of reflective ideas to be conducted during and after contact sessions.

5.4 Linking the concepts

The previous section highlighted several concepts that were identified as central to the notion of functioning knowledge in an end-user computing service course. It explained how theoretical computing knowledge and disciplinary knowledge formed the basis on which knowledge in an end-user computing service course is built. This knowledge leads to computer utilisation and innovation, which are the two modes of computer application. Computing reflection and disciplinary reflection cap off important knowledge in an end-user computing service course. It was also advanced that the student, the instructor and the computer-based instruction system are the active role players in the instructional environment.

This section proposes a theoretical construct called an end-user computing service course knowledge matrix that will serve as a key building block of the framework for promoting functioning knowledge in the end-user computing service course. This is achieved by identifying linkages among the concepts, integrating them and aligning them.

5.4.1 The convergence of learning experiences

Central to the notion of knowledge in an end-user computing service course is the notion of application. Two forms of application have been identified: utilisation and innovation. These forms stem from the use of computing and disciplinary knowledge and culminate in computing and disciplinary reflections. Figure 5.6 illustrates the integration of relationships. Theoretical computing concepts emphasise an understanding of the computer artefact itself, including a conceptual understanding of its hardware and associated software. Theoretical disciplinary concepts focus on an understanding of specific disciplinary knowledge from fields such as agriculture, hospitality management or commerce. Students learn this in the various university programmes (such as agriculture, commerce, education and accounting) in which they are enrolled.

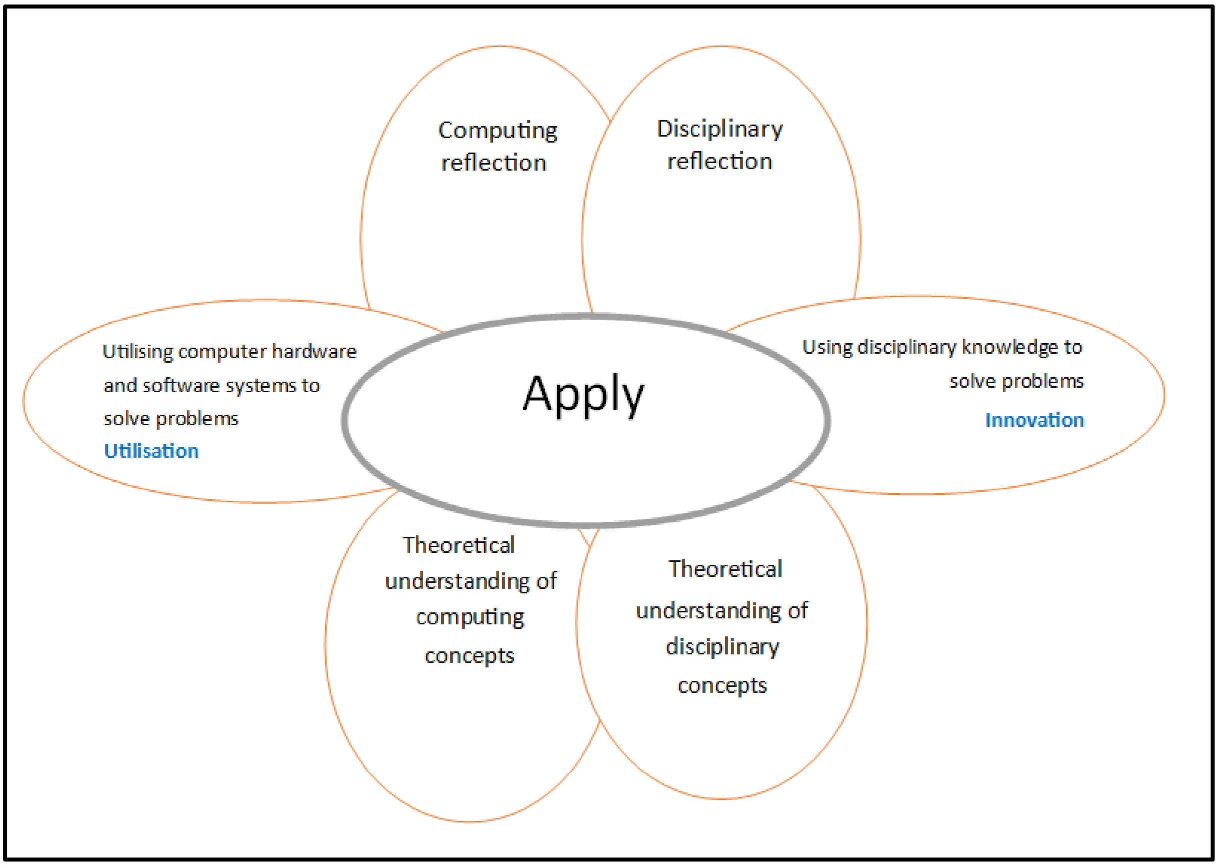


Figure 5.6: The convergence of learning experiences in the end-user computing service course

Two approaches to end-user computing applications emerge from computer knowledge and disciplinary knowledge. The first is utilisation, which is the use of computing principles to solve a problem. The second is innovation, which focuses on the use of disciplinary knowledge from fields such as agriculture, commerce or hospitality management in crafting computing solutions to problems. Reflection is an appraisal of learning experiences against existing knowledge. This reflection can also take two forms in the end-user computing service course: computing reflection and disciplinary reflection. Computing reflection focuses on appraising a student's learning experiences in the context of the computer artefact, including the use of its hardware and associated software. Disciplinary reflection, on the other hand, appraises a student's learning experiences in the context of the specific disciplinary knowledge.

5.4.2 Aligning declarative and functioning knowledge

To understand how knowledge in an end-user computing course, as described in the previous paragraphs, aligns with the notion of functioning knowledge, it is prudent to revisit the definition of Biggs and Tang (2007:72) of declarative and functioning knowledge.

> "Declarative, or propositional, knowledge refers to "knowing about things", or "knowing what" ... It is public knowledge, subject to rules of evidence, that makes it verifiable, replicable and logically consistent. It is what is in libraries and textbooks and is what teachers "declare" in lectures. Functioning knowledge is based on the idea of performances of various kinds underpinned by understanding. This knowledge is within the experience of the learner, who can now put declarative knowledge to work by solving problems" (Biggs and Tang, 2007:72).

Biggs and Tang (2007), using the SOLO model of Biggs and Collins (1982), provide exemplary verbs that may be used to determine the nature of learning outcomes for both declarative and functioning knowledge, which spans from the unistructural level to the extended abstract level. Learning outcomes are "sets of knowledge, skills and/or competencies an individual has acquired and/or can demonstrate after completion of a learning process" (Cedefop, 2014). The verbs are presented in Table 5.2.

Table 5.2: Sample verbs for describing intended learning outcomes { TA \l "**Table 5.2: Declarative and functioning knowledge learning outcomes (Biggs and Tang, 2007)**" \s "Table 5.2: Declarative and functioning knowledge learning outcomes (Biggs and Tang, 2007)" \c 1 **}**

Level	**Structure**	**Declarative knowledge**	**Functioning knowledge**
Surface	Unistructural	Memorise, identify and recite	Count, match and order
	Multistructural	Describe and classify	Compute and illustrate

Level	Structure	Declarative knowledge	Functioning knowledge
Deep-level	Relational	Compare, contrast, explain, argue and analyse	Apply, construct, translate, solve near the problem, predict within the same domain
	Extended abstract	Theorise, hypothesise and generalise	Reflect, improve, invent, create, solve unseen problems and predict to unknown domain

Source: Biggs & Tang (2007)

The information presented in Table 5.2 has a very similar context to the observations that were made regarding the nature of knowledge in the end-user computing course. Figure 5.7 attempts a crude but graphic illustration of this argument. A theoretical divide, represented by a dotted line, is made between the two learning levels that denote declarative knowledge and functioning knowledge. Declarative knowledge is seen as focusing on knowing of or about things. The declarative knowledge verbs that are presented in Table 5.2 (memorise, recite, compare, argue and theorise) resonate with a theoretical understanding of the concepts as illustrated in Figure 5.7. It is advanced that an understanding of theoretical computing and disciplinary concepts involves knowing about things by memorising, describing, comparing and hypothesising phenomena. Such acts of knowing, therefore, lie in the realm of declarative knowledge.

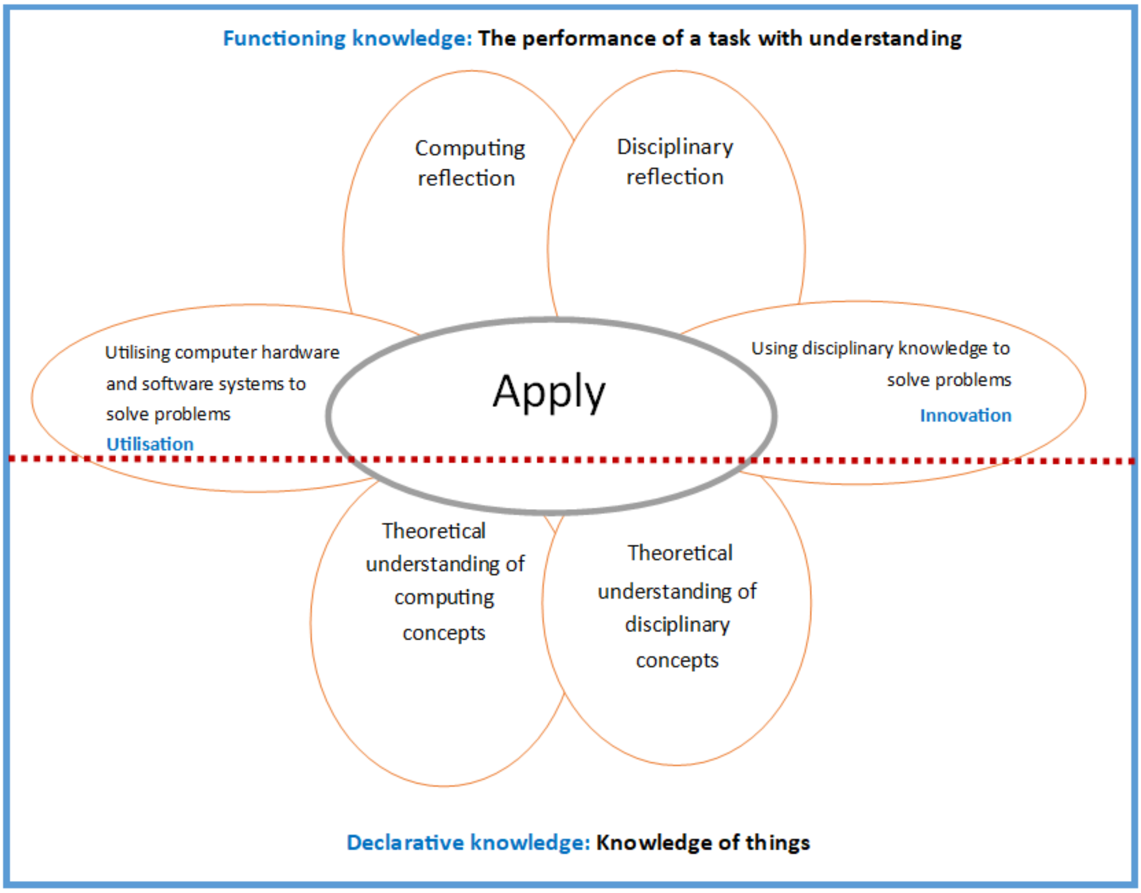


Figure 5.7: Declarative and functioning knowledge in the end-user computing service course

On the other hand, functioning knowledge, such as the performance of a task, seems to resonate with the utilisation of computer systems, the innovative application of disciplinary knowledge in solving problems and reflections on knowledge use. Students utilise the computer to count and solve problems practically. They also apply disciplinary knowledge to construct, translate and solve problems. Reflection is seen as the kind of appraisal (thinking about) that leads to improvements, inventions and predictions. These four acts of knowing (utilisation, the innovative application of disciplinary knowledge, computing reflection and disciplinary reflection) thus lie on the functioning knowledge side. They demonstrate the performance of a task with understanding.

5.4.3 Integrating the concepts

The alignment that is made in Figure 5.7 leads to six "kinds of" knowledge that can be thought of as constituting knowledge in the end-user computing service course. These are declarative computer knowledge, declarative disciplinary knowledge, computer utilisation knowledge, disciplinary innovation, computing reflection and disciplinary reflection. Figure 5.8 assists in explaining these terms. For reference purposes, it will be called the end-user computing service course knowledge matrix.

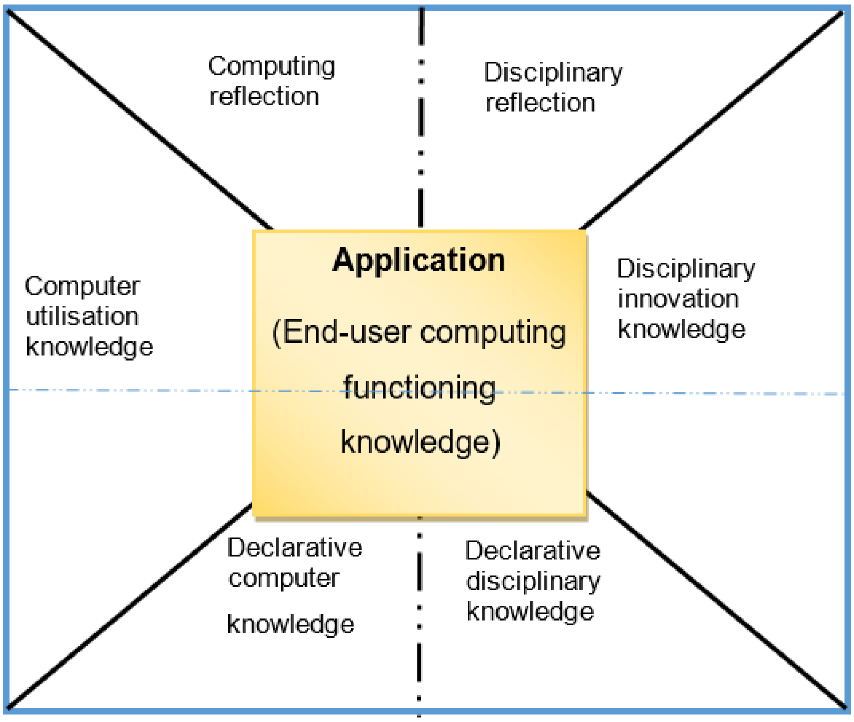


Figure 5.8: The end-user computing service course knowledge matrix

The confluence of theoretical computer concepts and the concept of declarative knowledge gives rise to declarative computer knowledge. Declarative knowledge, as has already been explained, indicates "knowing about" something; it is "know what". The kind of knowledge that is conceived in this convergence inclines towards understanding the computer itself, its functionality and the aspects that make it useful as a tool for solving problems. The focus of learning processes is on understanding or showing that the learner "knows about" the computer. It is more theoretical in its expression, as expressed by Biggs and Tang (2007) that declarative knowledge is realised in the use of verbs such as memorise, identify, recite, describe, classify compare, contrast, explain, argue, analyse, theorise, hypothesise and generalise. It agrees with what TMG, an end-user computing lecturer, indicated by saying that they covered computing concepts, such as explaining what a computer is and understanding the hardware and software aspects of a computer system, which comprises the communication aspect of information technology.

Declarative disciplinary knowledge would be realised at the confluence of theoretical disciplinary concepts and the concept of declarative knowledge. It is similar to declarative computer knowledge. This knowledge is accumulated and taught in the learners' specific disciplines. It is knowing about disciplinary subject content, such as germination theory in agriculture, demand and supply principles in economics or pedagogical techniques in education. Its significance in the context of the end-user computing service course is that disciplinary knowledge is the bedrock on which disciplinary innovation is built since end-user computing students are drawn from disciplines that are not computer sciences. Students need to have a concrete encounter with the disciplinary knowledge to be effective innovators. These specialised disciplines expose them to concrete experiences and problem contexts that they will bring to the end-user computing service course.

Computer utilisation knowledge is functioning knowledge that emphasises the practical utilisation of the computer artefact. The students would have had a concrete encounter with the computer artefact itself and would be ready for what Kolb (1984) describes as active experimentation. They achieve this by performing practical actions such as trying out spreadsheet formulae, typing word-processing documents or sending emails. Computer utilisation knowledge was discernible in respondents' statements such as "students must know how to type, search for information on the internet, print a document, send an email or create a pie chart using a spreadsheet". The driving knowledge base during utilisation is knowledge of the computer artefact. The performance outcomes are practical and demonstrate action as expressed in the following verbs by Biggs and Tang (2007): compute, illustrate, apply, construct, translate and solve.

Disciplinary innovation knowledge focuses on adapting and extending disciplinary knowledge to solve problems. The learner constructs, invents and generates computing solutions to problems by drawing from their disciplinary knowledge. Students would have had a concrete experience of disciplinary contexts and would actively experiment with this knowledge to create computer-based solutions. This is similar to what OSM, a programme leader in hospitality management, requested by suggesting that students should be able to "tell" the computer that this is a high or a low season and set up solutions that assist in decision-making. The performance outcomes when teaching disciplinary innovation knowledge emphasises the use of disciplinary knowledge in solving problems. The key verbs of Biggs and Tang (2007), such as improve, invent, create, solve and predict, would be consistent with this innovative use of disciplinary knowledge.

Computing reflection is a reflective process that enhances and deepens end-user computing functioning knowledge. It is an appraisal of encounters with both declarative computer knowledge and computer utilisation knowledge. The end-user computing student encounters new theoretical concepts in computing and uses these concepts to update their understanding and form new conceptualisations. The same applies when they utilise this knowledge through active experimentation. Disciplinary reflection is similar to computing reflection. This process, however, focuses on the use of disciplinary knowledge. Concrete experience of disciplinary knowledge in fields such as agriculture, hospitality management and biology create new understandings. These understandings support the innovative problem-solving process. Disciplinary reflection thus becomes an appraisal of the problem-solving process in which disciplinary knowledge was used as the point of referral.

5.4.4 A close look at the end-user computing service course knowledge matrix

So far, the term '"type" or "kind" has been used to describe the various aspects that are associated with knowledge in the end-user computing service course. It would be tempting to conclude that knowledge in the end-user computing course can easily be portioned into neat and easily identifiable categories. This would be slightly misleading in the context of this thesis. Illeris (2017) advises that the totality of a learning experience must be maintained to ensure that the process remains coherent. Santos et al. (2017) argue that the fragmentation of curricula into disciplines is a mere consequence of overspecialisation. The various notions of knowledge in an end-user computing service course that were developed in the previous discussion were graphically illustrated as a cohesive theoretical structure that brings forth the interconnectedness of knowledge in Figure 5.8.

It is essential to explain the paradox that arises from the position that has been advanced to describe knowledge in an end-user computing service course as an integrated phenomenon on the one hand, while at the same time trying to dissect it into its various constituent parts, as denoted by terms like declarative computing and disciplinary knowledge. Cook and Brown (1999) use the term "forms of knowledge" when describing different aspects of knowledge. The use of the phrase “forms of knowledge” by Cook and Brown (1999) suggests that knowledge is a singular phenomenon that can take different shapes. A more appropriate conceptualisation of the end-user computing service course knowledge matrix would be to view it as an integrated knowledge construct of six dimensions. The phrase “learning orientations” (knowledge orientations) is thus crafted in this study to advance the argument that knowledge in an end-user computing service course is understood to be an all-encompassing phenomenon that has multiple facets. Each knowledge facet or learning orientation emphasises particular knowledge aspects. Learning efforts are thus oriented towards some kind of knowledge outcomes. It is therefore sustainable to think of an end-user computing service course learning activity as *“*oriented*”* towards declarative computing knowledge, computer utilisation, disciplinary innovation, computing reflection or disciplinary reflection. Instances of these learning orientations are presented in Chapter 6.

Conceiving functioning knowledge in the end-user computing service course in multiple forms or dimensions, as proposed in the previous paragraphs, is sustainable. It was argued in Chapter 2, by drawing on the works of Nonaka (1994) and Cook and Brown (1999), that there are different ways to perceive knowledge. Three proposals regarding knowledge were put forward. Knowledge could be seen as a thing that can be possessed. It could be actions, as well as processes that underwrite those actions. Using the proposal, it can be argued that declarative computer knowledge and disciplinary knowledge could be conceived as belonging to that epistemology of possession.

Consequently, a student can be seen as possessing declarative knowledge. The epistemology of practice views knowledge in the context of action by focusing on what is done with the possessed knowledge, such as when a student uses declarative computer knowledge and disciplinary knowledge to create a computer program. Computer utilisation knowledge and disciplinary innovative knowledge could thus be associated with the epistemology of practice that Cook and Brown (1999) describe as knowledge used in action (know-how). Computing and disciplinary reflection are acts or series of actions that create knowledge. They are cognitive processes that lead to new insights or knowledge. Thus, reflection is an example of conceiving knowledge as a process.

It is important to reiterate that the attempt to bring to the fore the constituent knowledge dimensions that characterise knowledge in an end-user computing service course is not about promoting disparate teaching of the subject by emphasising the different dimensions. The aim is to promote what the Brazilian Ministry of Education explained in Santos et al. (2017) that learning, especially interdisciplinary learning, should not dilute the disciplines, but rather maintain their individuality by acknowledging the multiple factors that shape knowledge. These individual learning orientations only present an opportunity for learning to be focused and directed towards specific outcomes.

5.5 Towards a framework for promoting functioning knowledge

The previous section identified various constituent components of functioning knowledge in the end-user computing service course. This section focuses on answering the second part of Subquestion 3: "How can these be organised into a coherent framework?" Emphasis is put on illustrating how the identified concepts can be organised into a coherent functional structure – a framework for facilitating functioning knowledge in computer-based instruction in an end-user computing service course.

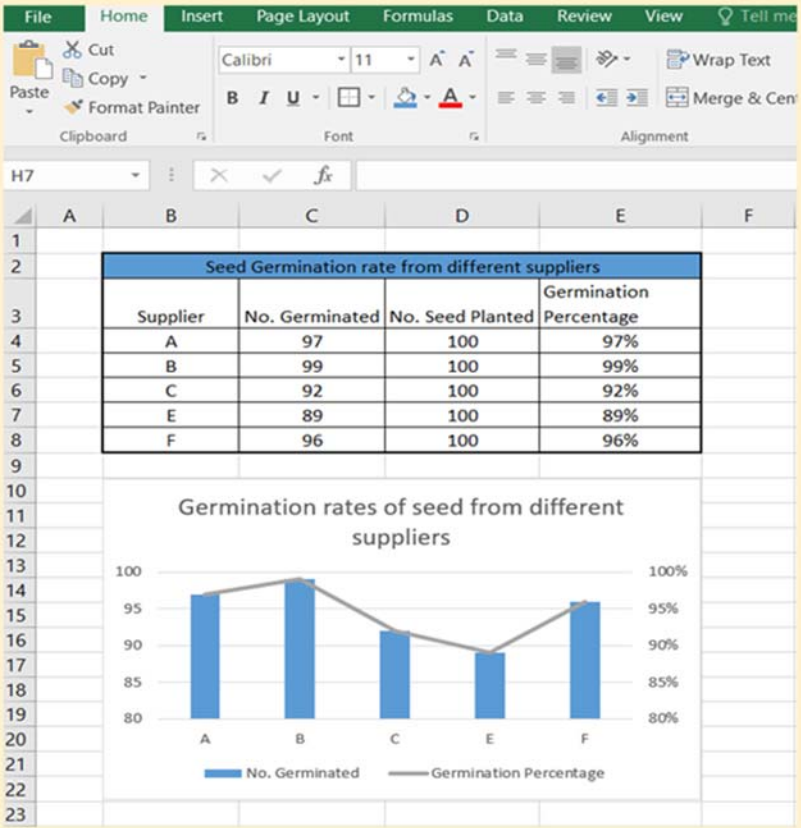
The section begins by illustrating the nature of learning activities that characterise each learning orientation in the end-user computing service course knowledge matrix developed in the previous section. This is followed by a presentation of a made-up learning scenario that shows how functioning knowledge in an end-user computing service course can be facilitated using the end-user computing knowledge matrix as a guiding template. Finally, the role of computer-based instruction systems, as guided by insights drawn from literature, is incorporated and a framework for facilitating functioning knowledge in computer-based instruction in an end-user computing service course is proposed.

5.5.1 Understanding the individual learning orientations

End-user computing service course learning activities that lead to functioning knowledge must ideally explore all dimensions of the end-user computing service course knowledge matrix. The end-user computing service course knowledge matrix has six learning orientations: declarative computer knowledge, declarative disciplinary knowledge, computer utilisation knowledge, disciplinary innovation knowledge, computing reflection and disciplinary reflection. Teaching and learning circumstances may, however, dictate that the knowledge dimensions (learning orientations) should be explored separately. A spreadsheet activity that focuses on analysing the germination potential of rice seed from different suppliers is used to explain each of the learning orientations that are included in the end-user computing service course knowledge matrix. This activity is presented in Figure 5.9 in the form of a scenario.

Learning Scenario: Seed Germination Success

Crop Science students will use a spreadsheet program to analyse the germination percentage of a certain variety of rice seed from different growers. A germination test ascertains the number of seeds that are alive in any sample calculated as a percentage of the number of seeds that germinated out of the total that have been planted (Saupe, 2009 ; Gummert, 2010). This period that is used for this calculation is from the 5th day to the 10th day (Gummert, 2010).



The first column in the spreadsheet shows the seed supplier, the next column indicates the number of seeds that germinated from a total that is indicated in the third column. The last column presents germination percentage figures for each sample supplied. A graph depicting the germination statistics is also created.

Figure 5.9: A learning activity that depicts various learning orientations

Declarative computer knowledge focuses on knowing about computers and their hardware and software features. All learning activities that focus on understanding the aspects of the computer system or features of a particular software could be seen as being oriented towards declarative computer knowledge. Declarative knowledge, as noted earlier, manifests in verbs like memorise, identify, recite, describe, classify compare, contrast, explain, argue, analyse, theorise, hypothesise and generalise. Declarative computer knowledge learning activities could focus on explaining the syntax of the function that is used in the spreadsheet or explaining the charting tools that are available for use in the spreadsheet program*.*

Declarative disciplinary knowledge is similar to declarative computer knowledge, albeit that it is focused on agricultural crop science knowledge.

The mathematical formula that is used to calculate germination percentages:

Germination percentage (GP) = number of seeds germinated/total number of seeds planted * 100

would be a classic example of the disciplinary knowledge that goes into the solution.

Computer utilisation knowledge involves the active use of and experimentation with declarative computer knowledge. The focus is on the ability to use the computer system correctly. Practical actions such as typing figures into a spreadsheet, typing functions or constructing a chart using the spreadsheet tools should be seen as orientating the learning process towards computer utilisation knowledge.

Disciplinary innovative knowledge involves adapting and extending disciplinary concepts into computerised solutions. The ability to model seed germination data into an informative spreadsheet and chart by the knowledge of the agricultural discipline is disciplinary innovation. Finally, both computing reflection knowledge and disciplinary reflection knowledge speak to the ability to appraise one’s actions and learn from the experience. Students may start to consider whether the chart that was used, among the many in a spreadsheet program, could be the best tool to present such information. That would be computing reflection. Disciplinary innovation knowledge may involve students considering whether the results are consistent with other varieties of seeds from the same suppliers. In such a case, vital insights like rating each supplier can be conceived.

Figure 5.10 is used to illustrate how each of the learning activities described in the previous paragraphs is mapped on the end-user computing knowledge matrix. To summarise, activities that focus on knowing about the computer system, such as understanding the syntax of a spreadsheet function, denote declarative computer knowledge. Facts and knowledge from disciplines, such as the formula used to calculate germination percentages, is declarative disciplinary knowledge. The active and practical operation of the computer system when constructing the spreadsheet solution involves computer utilisation knowledge. The use of seed germination data to model germination patterns and provide an informative solution exemplifies disciplinary innovation knowledge use. The students could try to establish, through further experiments, whether the seed germination graph is typical of other crops from the same suppliers. This would be a disciplinary reflection that extends knowledge to new contexts. During a computing reflection activity, the students could consider alternative ways to model the seed germination patterns.

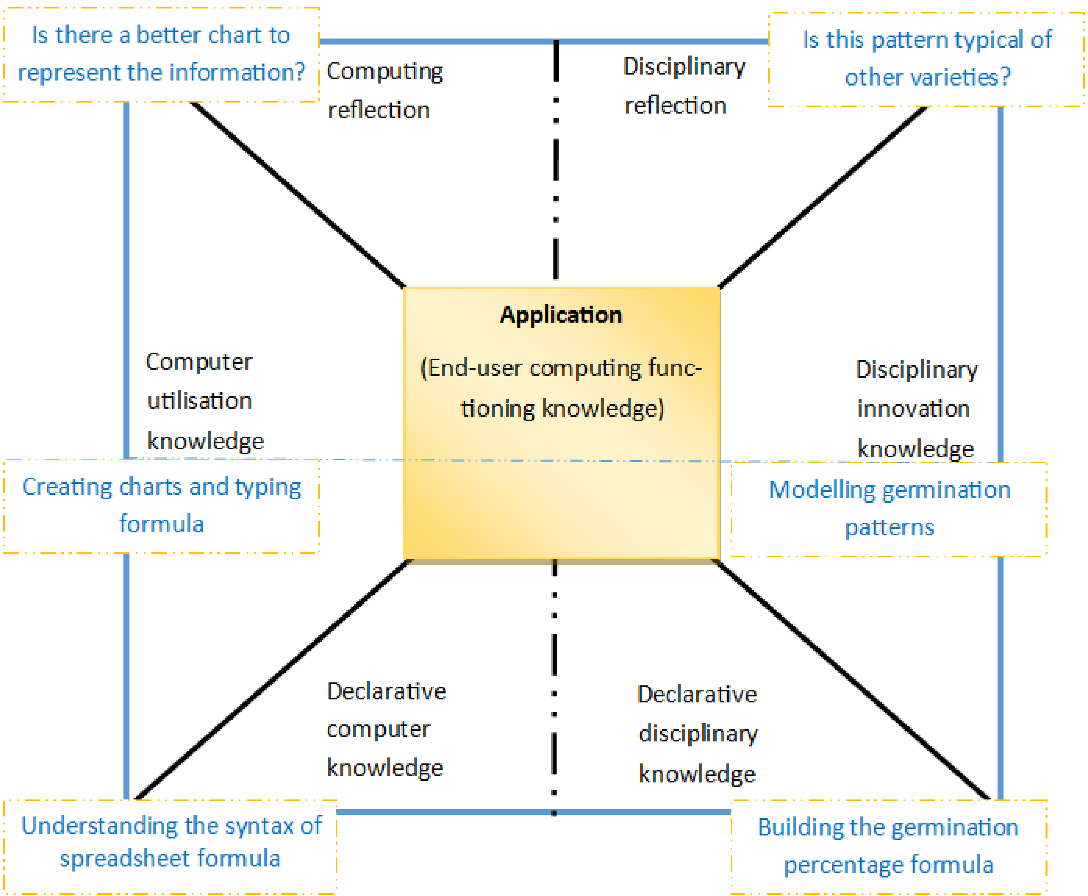


Figure 5.10: Understanding the learning orientations separately

5.5.2 A learning process that leads to functioning knowledge

It was explained in the previous paragraphs how learning activities in the end-user computing service course could be of a certain learning orientation, depending on the particular knowledge in end-user computing that was emphasised. In this subsection, the achievement of functioning knowledge in an end-user computing learning activity is illustrated by following a learning path that touches on all facets of the end-user computing knowledge matrix. Achieving functioning knowledge involves exploring all the dimensions of knowledge in an end-user computing service course, following a centralised learning theme. Figure 5.11 proposes a plausible pathway to achieve this functioning knowledge.

The following explanation builds on the illustrations made in the previous paragraphs regarding agricultural students who study crop production. The learning process, as illustrated in Figure 5.11, could start by ascertaining the declarative disciplinary knowledge principles that underpin the learning activity, such as establishing the concept of seed germination percentage, why it is important and how it is calculated. This enacts an authentic learning environment in the end-user computing service course learning activity. Herrington, Reeves and Oliver (2014) advise that authentic environments empower students with knowledge that is readily transferable to the working contexts.

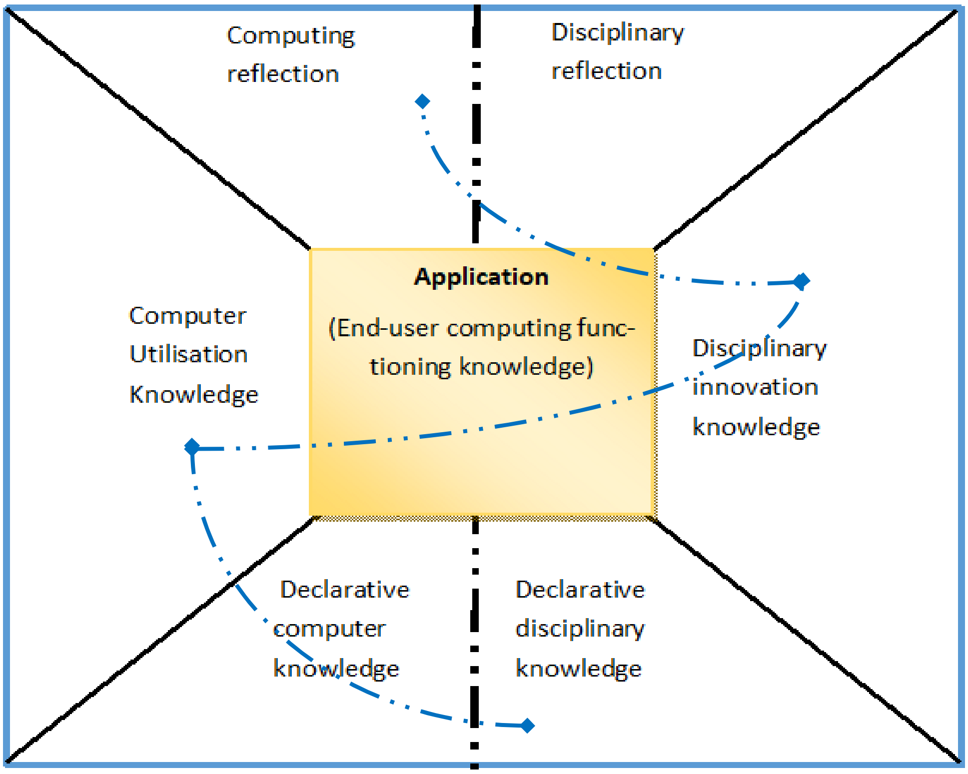


Figure 5.11: A plausible pathway to functioning knowledge in an end-user computing service course

The learning activity could then proceed to an explanation of the spreadsheet functions and formulae that are needed to perform the calculations and the spreadsheet tools that can be used to create graphic presentations such as pie charts. This will be declarative computer knowledge. Students would then actively experiment with and utilise spreadsheet tools to construct and practice on worksheets and graphs. This is necessary to enhance their computer utilisation knowledge. Disciplinary innovation knowledge would be used to incorporate spreadsheet formulae and charts into informative spreadsheets that illustrate germination successes for each supplier's sample. Disciplinary reflection uses disciplinary knowledge to appraise the learning encounter. Students could reflect on the resultant spreadsheet figures or charts and ascertain whether they are consistent with expectations. Computing reflection would be an appraisal of the learning encounter based on students' computing knowledge, such as considering whether a pie chart, bar chart or histogram would have been the best option to present the graph.

5.5.3 Incorporating computer-based instruction systems

The initial paragraphs showed three critical actors in end-user computing instruction: the student, the instructor and the computer-based instruction system. The research objective is to establish a framework for facilitating functioning knowledge in a computer-based instruction end-user computing service course. The roles of instructor and student are critical, but, as computer-based instruction systems begin to take an active and central role in instruction, it is put forward that the activities of both the student and the instructor become profoundly shaped by what these systems afford. The framework that is suggested in the next paragraphs focuses on the role of computer-based instruction systems. The actions of instructors and students are still critical in the teaching and learning processes, but these will be left for further research in the interest of the clarity and brevity of this research.

5.5.4 A framework for facilitating functioning knowledge

A framework for facilitating functioning knowledge in a computer-based instruction service course is conceivable if insights from the literature on computer-based instruction systems and the concepts proposed in the end-user computing knowledge matrix are carefully put together. Figure 5.12 illustrates the three concepts that underpin the framework: the six learning orientations that constitute the end-user computing service course knowledge matrix, the role of technology in instruction, especially computer-based instruction systems and the explorations in the end-user computing knowledge matrix that emphasise the desired learning outcomes. The explorations in the end-user computing knowledge matrix denote instructional planning and strategies that may be crafted to achieve a set of particular learning objectives. It is advised that these explorations need to touch on all six learning orientations of the end-user computing knowledge matrix for functioning knowledge to be achieved.

The conceptualisations of Mayes and Fowler (1999) in terms of the role of courseware in instruction provide a guide on the role that computer-based instruction systems play in support of the explorations in the end-user computing service course knowledge matrix. According to Mayes and Fowler (1999), instructional technology plays three crucial roles in learning support: content delivery, production and discussion.

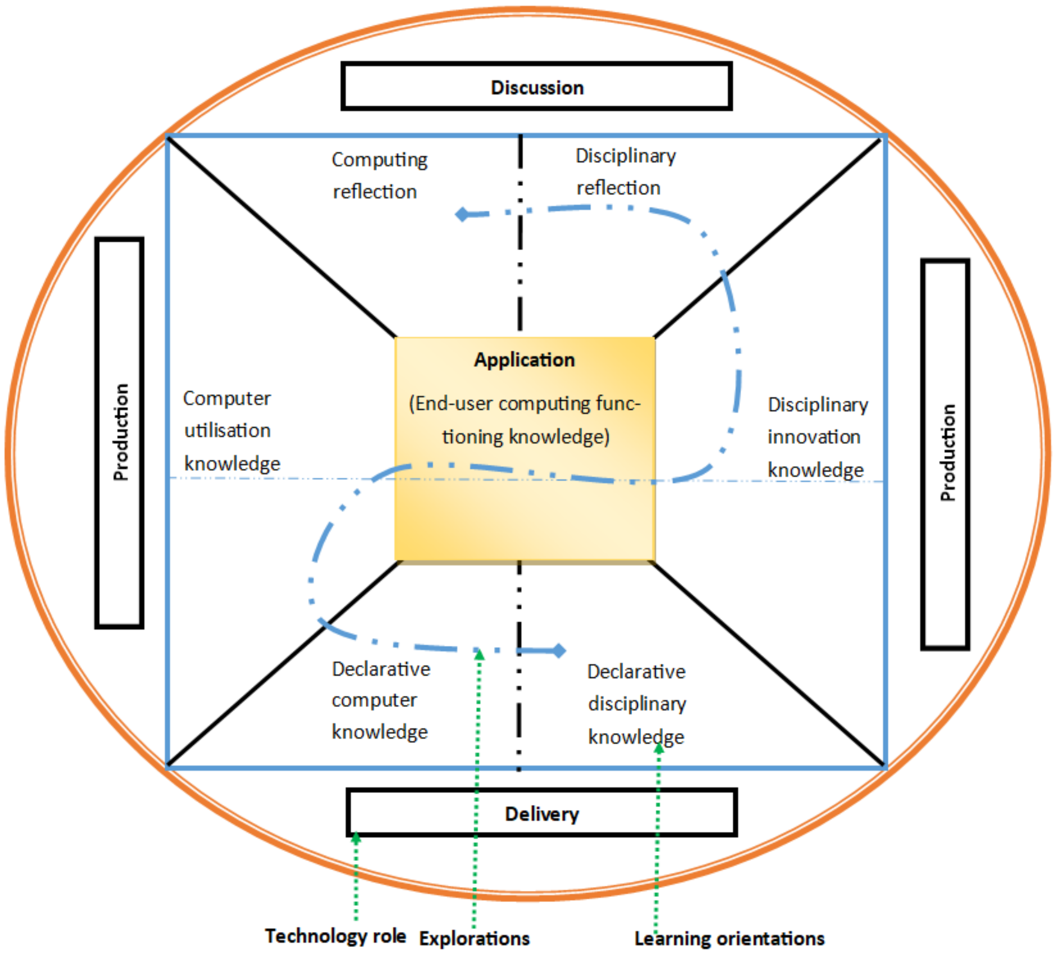


Figure 5.12: A framework for promoting functioning knowledge in an end-user computing service course

Primary courseware plays a content delivery role. Computer-based instruction systems like SAM and MyLab IT have notes, slides, videos and interactive training sessions that effectively deliver content support to promote concept formation. Likewise, Laurillard (2002) observes that narrative and interactive instructional media, such as video and web resources, support attentive, investigative and explorative learning. Thus, declarative computer knowledge and disciplinary knowledge can be effectively provided using computer-based instruction systems, as such content is explicitly expressible.

Secondary software supports productive activities such as the creation of documents and spreadsheets. Computer-based systems have built-in projects and case-based activities that use real software packages. Learning activities become active and productive and, in the process, encourage what Mayes and Fowler (1999) describe as constructive learning. Students learn by doing through constructing documents such as spreadsheets, emails and presentations. Clinch (2005) views such productive and adaptive use of technology as good for learning activities that involve expression, experimentation, practice and articulation. Computer utilisation knowledge and disciplinary innovation knowledge involve the practical application of computing and the innovative use of disciplinary knowledge to create computerised solutions to problems. Such knowledge can be facilitated and enhanced through the use of productive software that is accessible via the computer-based instruction system. In such circumstances, students use real software to construct real documents.

Tertiary software supports communication and enables discursive dialogues. A practice that was observed during the study was the interfacing of computer-based instruction systems with LMSs, such as Moodle and Blackboard, especially to support learning dialogues. Facilitators would send learning instructions and set up discussion forums. Such communicative platforms support discussions and debates (Clinch, 2005). Mayes and Fowler (1999) explain that such communicative platforms enable dialogue and encourage reflective thoughts to be shared with peers and instructors. This discursive use of computer-based instruction systems, therefore, promotes and supports the sharing of disciplinary and computing reflection.

The framework that is illustrated in Figure 5.12 is thus referred to as the TRELO (**T**echnology **R**ole in **E**xploring **L**earning **O**rientations) framework**.** This proposed framework for promoting functioning knowledge in an end-user computing service course comprises the following:

- Understanding the role that technology (computer-instruction systems) plays in enabling particular forms of learning activities during instruction **– Technology role**
- Defining the explorations in the end-user computing service course knowledge matrix that lead to particular learning outcomes – **Explorations.**
- Emphasising the six learning orientations that constitute functioning knowledge in the end-user computing service course **- Learning orientations**

5.5.5 Discussion of the knowledge matrix

It is pertinent to conclude by providing some perspective on the discussion and arguments that have been presented thus far and re-emphasising that learning is an integrated phenomenon and that the illustrations presented above are neither absolute nor exhaustive.

The knowledge matrix is only a piece of the larger puzzle

The end-user computing service course knowledge matrix should not be viewed as encompassing all the knowledge that an end-user computing student experiences. An example is given of the declarative disciplinary knowledge. Students learn about germination percentages in agriculture. They learn about hotel occupation rates in hospitality management or diminishing returns on investment and depreciation in accounting. This is crucial declarative disciplinary knowledge in the end-user computing service course, but is not all the knowledge there is to learn. Those aspects that are necessary for growing students' knowledge in the end-user computing service course are emphasised, as highlighted by Biggs and Tang (2007), who state that functioning knowledge and deeper understanding are built on solid declarative knowledge.

Navigating the knowledge matrix is flexible

The pathway presented in the previous discussion is not absolute. The end-user computing knowledge matrix can be adapted to begin in any segment, depending on the context. This means that learning processes may even start with a reflective process that questions certain preconceptions and then go on to build the necessary declarative knowledge and finally conclude with a computer utilisation or innovative disciplinary activity. It is also important to indicate that learning is a cyclic and never-ending process. Using the example presented in the preceding paragraph, reflection updates declarative knowledge and the learning process starts again once there are new insights that question current knowledge.

Learning is an integrated phenomenon

It should also be noted that the forms of knowledge or learning orientations advanced in the previous discussion should not be conceptualised as mutually exclusive or fractural. This is to say that when learning actions that make use of declarative knowledge or computer utilisation are undertaken, other actions of knowledge use and creation such as reflection do not cease to operate. The connectedness of cognition indicates that learning, knowledge creation or knowing is an integrated phenomenon.

The learning orientations presented in the end-user computing knowledge matrix are put forward as the barest threads that hold the notion of knowledge in end-user computing functioning together. This study, however, deliberately accentuates and presents these learning orientations separately as a feasible mechanism by which the course could be taught.

The primacy of application

The proposed end-user computing knowledge matrix does not emphasise the traditional approach to instruction, as shaped by Bloom's taxonomy. In Bloom's taxonomy, cognitive learning outcomes are treated hierarchically. The application of knowledge is seen as a cognitive effort somewhere in between a continuum that begins with understanding and ends with synthesis and evaluation (Anderson & Krathwohl, 2001). The end-user computing knowledge matrix approaches prime application of knowledge, as recommended by Fuller et al. (2007). The application of knowledge is seen as the epitome of functioning knowledge in the end-user computing service course. Fuller et al. (2007) argue that Bloom's taxonomy cannot be universal across different learning specialisations. Using computer programming and English literature courses as examples, the authors explain that literature emphasises critique, while computer programming emphasises the production of artefacts. They propose that application, in computer sciences, should be treated as the ultimate measure of understanding. Application, rather than being a lower-level skill below synthesising, as indicated in Bloom's taxonomy, is actually the highest and most desired performance outcome in applied subjects.

In the context of this study, it is therefore advanced that the notion of application in the end-user computing service course should not be treated on the same continuum of understanding, application and synthesis as proposed in Bloom's taxonomy. It is the sum total of the six learning orientations in the end-user computing service course knowledge matrix.

5.6 Conclusion

The framework for facilitating functioning knowledge developed in this chapter proposes that knowledge in end-user computing service courses focuses on application. There are two implied application contexts: a computer operation application and a disciplinary innovation application context. The computer use application – utilisation – focuses on using computer operation knowledge to solve problems. The disciplinary application – innovation – focuses on applying disciplinary knowledge to solve problems. Reflection is an appraisal of the problem-solving processes, thereby creating new insights and questioning existing assumptions. Computing reflection focuses on appraising the learning experiences related to computer artefacts and their utilisation. The disciplinary reflection appraises the way disciplinary knowledge is applied in crafting a solution.

The framework for promoting functioning knowledge in an end-user computing course explicates three roles for computer-based instruction systems in support of learning. The technology plays a content delivery, productive and communicative role. Content delivery supports concept formation. Productive software use enables active experimentation with software and the creation of real documents and solutions. Discursive platforms support communication and dialogue, which are critical for sharing ideas and reflective thoughts. The next chapter focuses on demonstrating the TRELO framework's utility by presenting instances and use-case scenarios that illustrate how the framework can be used during instruction to promote functioning knowledge in an end-user computing service course.

Chapter 6: Evaluation of the framework

6.1 Introduction

This chapter focuses on answering Subquestion 4: "How applicable is the proposed framework in promoting functioning knowledge in a computer-based instruction end-user computing service course?" The research question is typical of design science artefact evaluation. Figure 6.1 illustrates how such an evaluation fits into the overall design science strategy that is adopted in this study.

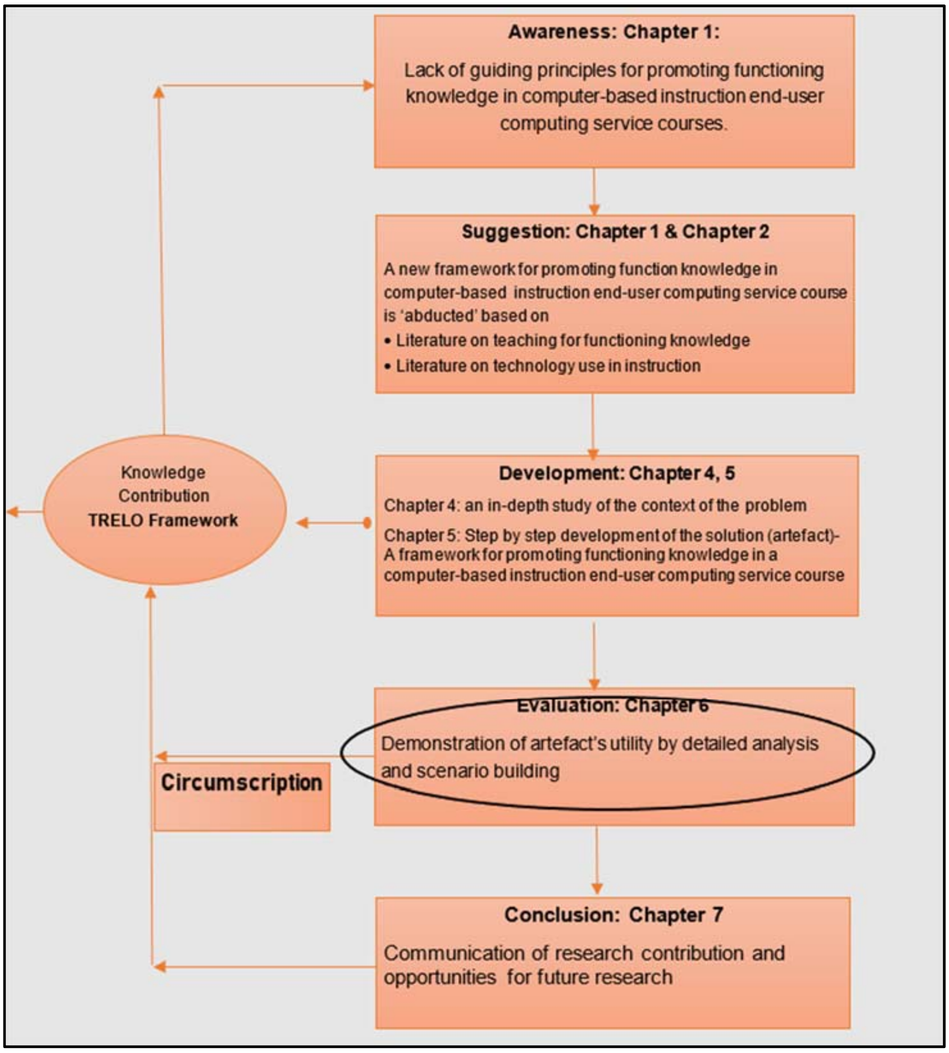


Figure 6.1: The design science research evaluation process

Section 6.2 presents a brief review of literature pertaining to design science evaluation. The section focuses on explaining what design science evaluation is, what is evaluated and methods that are used for the evaluation. Evaluation considerations for the TRELO framework are made where it is stated that arguments, explanations and scenarios are more appropriate modes of evaluating the TRELO framework. Experiments and other interventionist evaluation strategies are seen to pose both credibility and ethical risks.

Section 6.3 presents the evaluative options selected for the TRELO framework that was proposed in Chapter 5. Two broad contexts are proposed. The first is the artefact's utility and the second is its fit into conventional teaching and learning practices. Section 6.4 provides a concluding summary of this chapter.

6.2 Design science evaluation

A brief literature review on design science evaluation is presented in this section by exploring what design science evaluation entails. This is done by discussing what is evaluated when the evaluation should be done and how it should be done. Evaluation considerations for this study are also explored, and recommendations are made based on what is considered to be the most appropriate evaluation strategy for the TRELO framework.

6.2.1 Design science research evaluation literature

Evaluation is a crucial aspect of design science research (Venable, Pries-Heje, & Baskerville, 2016). Venable et al. (2016) explain that the evaluation focuses on the artefact, its output and the theory it generates. An evaluation demonstrates the utility and efficacy of the design science artefact (Hevner et al., 2004). Pries-Heje et al. (2008) present an evaluative framework for design science research that proposes three operational questions that need to be asked: What is evaluated? When is the evaluation done? How is the evaluation carried out? In a follow-up paper, Venable et al. (2016) also include the "why" aspect of design science research evaluation.

The "what" of design science evaluation is a choice that is made about which of the many outputs of design science research artefacts to evaluate. These could be algorithms, constructs, frameworks, instantiations, methods and models (Peffers et al., 2012). The "when" of design science evaluation is a timing issue. The timing has two extreme points on a continuum: *ex ante* and *ex post* (Venable et al., 2016). An *ex* *ante* evaluation is done prior to the design. It is a “predictive evaluation that is performed in order to estimate and evaluate the impact of future situations” (Stefanou, 2001:206). The *ex ante* evaluation is done before the design and construction of artefacts to ascertain the value of a design effort or to decide on the most valuable option among competing alternatives (Venable et al., 2016). The *ex post* evaluation is done after an artefact has been acquired, constructed, designed or implemented to ascertain the extent to which it lives up to its claims (Klecun & Cornford, 2005).

Hevner et al. (2004) describe five evaluation strategies for design artefacts that could be used to guide how design science evaluation should be undertaken: observational, descriptive, analytical, experimental and testing strategies. The observational strategy uses case studies and field studies to implement the artefact in a real-life situation and notes its effect. The descriptive approach uses informed arguments and scenarios by drawing from literature and building convincing arguments on the artefact’s plausibility. Scenarios are illustrative cases that are constructed to help explicate the artefact’s plausibility. The analytical evaluation takes the form of either a static analysis or an architectural analysis. The static analytical approach evaluates the artefact for static structural qualities such as comprehensibility and complexity. Architectural analysis appraises the artefact for its fit into conventional practices. In a similar fashion to descriptive evaluation, analytical analysis ensures that the claims made about the artefact’s usefulness can be compared to existing knowledge foundations. Experimental and testing evaluation methods involve setting up controlled or simulated environments where the artefact is tested.

Peffers et al. (2012) observe the variety in the outputs of design science efforts. They argue that each design science artefact has suitable evaluation methods. The authors mention six types of design science artefacts in information systems: algorithms, constructs, frameworks, instantiations, methods and models. They propose eight evaluation methods that are used for these artefacts: logical arguments, expert evaluations, technical experiments, subject-based experiments, prototypes, action research, case studies and illustrative scenarios. The authors indicate that the most common method for evaluating frameworks is the illustrative scenario where the artefact is applied in made-up or real situations to demonstrate its plausibility and utility.

6.2.2 Evaluation considerations for this research

Identifying what to evaluate in this research is not difficult because a framework for facilitating functioning knowledge in a computer-based instruction end-user computing service course is proposed and offered for evaluation. Choosing when to evaluate requires some consideration. Stefanou (2001) and Venable et al. (2016) agree that the purpose of the *ex ante* evaluation that is done before an artefact is constructed or designed is to limit the costs associated with poor choices and to avoid pursuing less optimal options. If it is to be pursued, this line of thinking portrays a benign assumption that several options exist and that the potential outcomes of each choice, in terms of costs and benefit, can be ascertained or estimated from the onset.

The design research problem, as it is framed in this thesis, presents a slightly different context to what Stefanou (2001) and Venable et al. (2016) may have perceived when they explained the reasons for an *ex ante* evaluation. The research question “How can functioning knowledge be facilitated in a computer-based instruction end-user computing course?” shows that the emphasis has shifted from a choice of one among many to a pursuit of one probable solution. Prefixing the research question with the phrase “how can” has the effect of emphasising the design science research process as opposed to creating a solution from a premise where none is presumed to exist. Once this new or novel solution is claimed to have been found or created, a greater burden is placed on proving what Hevner et al. (2004) described as its utility, efficacy and fit in conventional practices. This reasoning persuaded the researcher to place greater emphasis on the *ex post* evaluation. This evaluation was done after the TRELO framework had been constructed to ascertain the extent to which it lives up to its claims. The following paragraph explains how this evaluation was conducted.

Peffers et al. (2012) observed illustrative scenarios as the most common approach used in evaluating frameworks. Scenarios are illustrative cases that were constructed to help explain the plausibility of artefacts (Hevner et al., 2004). Illustrative scenarios on how the TRELO framework can be used to promote functioning knowledge in a computer-based instruction end-user computing course are presented in the next section. The observational, experimental testing or other forms of evaluation, such as experiments, simulation, executing and testing that would have involved disruptive interventions were not considered for ethical reasons. These forms of evaluation were seen as posing ethical risks that are associated with privileging (or academically burdening) one set of students over others. In addition, there were reasonable assumptions that the observed changes would not have been wholly attributed to the artefact, as other variables, such as the facilitator, the learner's ability and motivation, could also affect the results. This would have posed an additional challenge of setting up the credible controls that such experimental evaluation designs require. The researcher operated on the premise that there is sufficient published pedagogic literature that could be used to illustrate the efficacy of the framework without resorting to empirical evaluative approaches.

6.3 Evaluating the TRELO framework

It is pertinent to revisit the definition of a framework before attempting its evaluation. Verbrugge (2016) explains that frameworks "contain structures or systems for the realisation of a defined result or goal". He adds that frameworks are less detailed and, accordingly, have a higher degree of freedom in their use. Peffers et al. (2012) view frameworks as meta-models. Meta-models comprise frames, rules and constraints that are used to explain and solve particular types of problems by abstract conceptualisation and involve very little semantics (Génova, 2009).

The two broad contexts for evaluating the TRELO framework, namely, its utility and fit into conventional practices are elaborated in this section. Two categories are presented for each context. The utility context demonstrates that the framework is a useful artefact that can be used to classify learning activities in the course and that the framework is an operable artefact that can be used to build comprehensive learning processes that lead to functioning knowledge. In the second context, the TRELO framework is presented as an academic toolkit that is compatible with current higher education instructional methodologies such as the flipped classroom and blended learning. It is also argued that the TRELO framework fits in with two established and highly regarded pedagogical approaches for defining learning outcomes: Bloom's taxonomy and the SOLO framework.

The contexts implied in the previous paragraph lead to four propositions that are advanced to guide the TRELO framework's evaluation:

1. The TRELO framework is useful and operable, and can be used to classify and understand learning activities in the end-user computing service course. This is achieved by demonstrating that the learning objectives and learning activities of the end-user computing service course belong to one or more of the learning orientations of the end-user computing service course knowledge matrix. To achieve this, learning tasks are drawn from real university end-user computing service courses. They are then explained and classified in the context of the TRELO framework's six learning orientations.

2. The TRELO framework can be used as a template for facilitating functioning knowledge in a computer-based instruction end-user computing service course. A purposefully designed learning activity is presented to demonstrate how the TRELO framework could be used to enact learning programmes that lead to functioning knowledge.

3. The TRELO framework is compatible with current higher education instructional methodologies. This is an architectural analysis that is done to demonstrate that the TRELO framework fits into conventional practices in higher education. The flipped classroom, open learning and blended learning instructional approaches are selected for this demonstration.

4. The TRELO framework fits in with well-established conventions on expressing educational learning outcomes. Two established methods for describing educational learning outcomes are selected for illustration: Bloom's taxonomy and the SOLO taxonomy.

The next subsections present the four evaluative options selected for the TRELO framework.

6.3.1 TRELO framework as a classifying framework for learning activities

This subsection illustrates how the TRELO framework could be used to classify and explain teaching and learning activities in the end-user computing service course. Some end-user computing learning scenarios or sessions are identified for illustration. It is then explained how each of these learning activities could be interpreted in the context of the TRELO framework. Two questions are crafted to operationalise this kind of evaluation: What is the learning orientation? What could be the role of the computer-based instruction system?

It is posited that learning activities in an end-user computing service course denote one or more of the six facets of the end-user computing service course knowledge matrix: declarative computer knowledge, declarative disciplinary knowledge, computer utilisation, disciplinary innovation, computing reflection and disciplinary reflection. The role of technology indicates the optimal way a computer-based instruction system may be used in a given setup. Clinch (2005) elaborates on the work of Laurillard (1993; 2002) on balancing media in instruction, and explains that learning media could be used in five different forms: narrative, interactive, communicative, adaptive and productive. The author illustrates that each media form supports a different learning experience. Narrative media support knowledge transmission; interactive media support investigative and exploratory learning; communicative media support discussions and debates; and adaptive media support experiments, simulations and practical activities. Productive media allow students to be expressive and articulate by producing real works such as essays and models.

Six illustrative cases that demonstrate the utility of the TRELO framework as a classifying and analytical tool for learning activities in end-user computing service course are presented in this subsection. The first five illustrative cases present learning scenarios that typify each of the TRELO framework's learning orientations. The last is a demonstration of how capstone projects – a popular mode of assessment in the end-user computing service course – could be a short cut for promoting functioning knowledge in the end-user computing course if it is well constructed.

Declarative computer knowledge

Declarative computer knowledge focuses on knowing about the computer. Figure 6.2 is an adaptation of a learning activity by Musgrave (2018:15) that has been designed for trainee educators at a South African university. The activity is used to illustrate the notion of declarative computer knowledge. The course is offered at the South African NQF Level 5. The scenario is used to illustrate the nature and form of declarative computer knowledge as conceived in the end-user computing service course knowledge matrix.

Topic: Email Basics

The activity learning outcomes

By the end of this unit, you should be able to

-set up your email account, create, send, and reply to an email

-follow the correct netiquette when creating an email

-send an email with an attachment

-manage an email account using folders

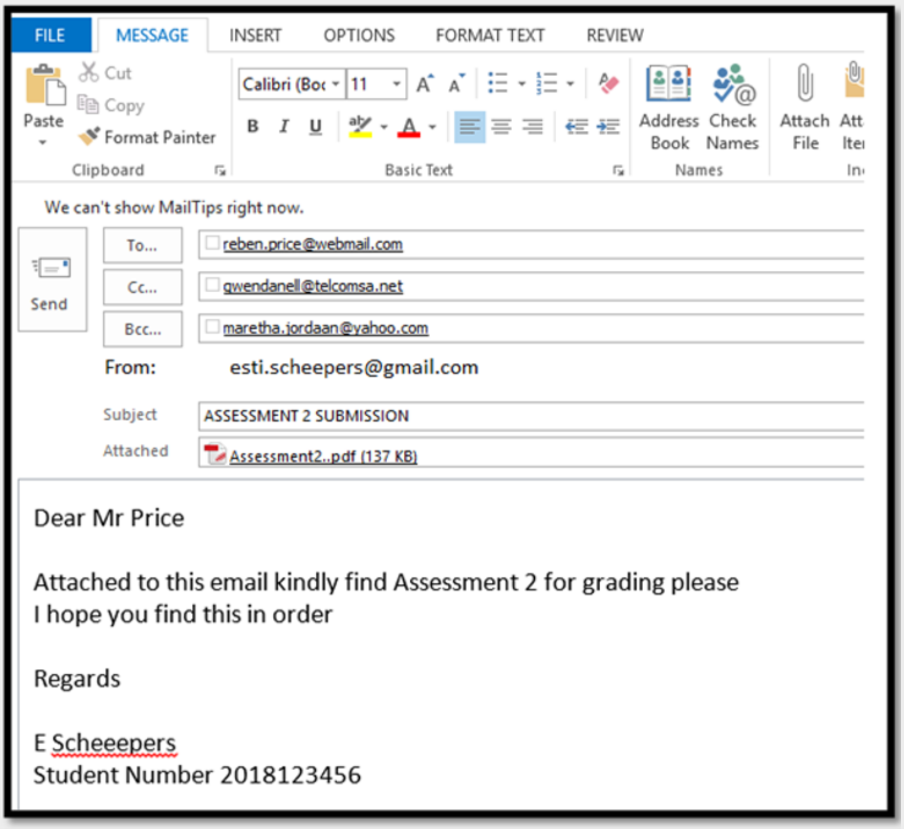
-consider one's digital footprint when sending emails

Learning activities

Students watch a video explaining the features of the emailing software and how emails are created.

Task Instructions

Study the screenshot of an email and answer the questions below.



Questions

1. Who was the sender of the sender of the email? Write down the email address of the sender.
2. The email was *cc /d* to gwendnell@telcomsa.net. What does it mean if an email is *cc /d* cc/d?
3. The email was *bcc /d* to maretha.jordaan@yahoo.com. Why was the message *bcc /d* to the recipient?
4. The email does not follow correct email netiquette. What, do you think, is wrong in the body of the email?
5. Explain what an email attachment is.
6. What is the size of the document attached to the email?
7. Why is the attached document in pdf format and not MS Word format?

Figure 6.2: Learning declarative computer knowledge

The two operational questions are posed in the next paragraph to indicate the classifying properties of the TRELO framework.

What is the learning orientation?

The learning activity presented in Figure 6.2 roughly has three sections: the learning objectives, some student activities and questions to be attempted by students. It can be observed that the learning outcomes (objectives) specify declarative computer knowledge, computer utilisation knowledge and computing reflection. The instructor specifies that students must be able to set up their own email account, manage their account using folders, and send an email. These actions emphasise utilising the computer system. The last objective in which the student is expected to consider their digital footprint denotes computing reflection because the consideration is an appraisal of the implications of the use of computer systems.

The task questions, however, indicate a learning process that is oriented towards declarative computer knowledge, especially if the assessment questions are taken into consideration. The assessor focused on evaluating the conceptual aspects of the emailing process. The questions put forward emphasise evaluating the student's understanding of the emailing process, the software that is used and its associated features. The concepts of the email sender, receiver, attachment, cc and bcc are declarative computer knowledge concepts that can be read in textbooks, explained by the instructor and documented. The following assessment questions from the scenario focus on evaluating whether the student understands the principles of the emailing concept and the aspects that make it useful in solving communication problems:

- The email does not obey email etiquette. What do you think is wrong in the body of the email?
- Explain what an email attachment is.
- What is the size of the document attached to the email?
- Why is the attached document in pdf format and not in MS Word format?

It is similar to teaching an apprentice carpenter the principle of driving in a nail by explaining that the blunt side of a hammer is used to drive in a nail while the claw side is used to pull out the nail. The assessment questions emphasise understanding the principles of computer emailing and would, therefore, be consistent with what is put forward in this thesis as declarative computer knowledge.

What could be the role of the computer-based instruction system?

It is possible to link the role of the computer-based instruction system to one of the three roles defined in the TRELO framework: the content delivery, productive and discursive roles. The instructor "preps" the students by directing them to a video source in the scenario presented in Figure 6.2. Computer-based instruction systems were found to be excellent in content delivery by supplying online notes, instructional videos and reading lists (Vincent, 2015). Computer-based instruction system could, thus, play an effective content delivery role in setups where declarative knowledge is predominant. Systems such as SAM have built-in videos that illustrate and explain to the learner how to carry out activities. The technology is used in a manner that supports concept building during content delivery (Mayes & Fowler, 1999). Clinch (2005) explains that the use of media in narrative and interactive fashions promotes attention to concepts.

The notion of declarative disciplinary knowledge is explored in the next paragraphs.

Declarative disciplinary knowledge

Declarative disciplinary knowledge in fields such as hospitality management, agriculture and commerce is taught in courses that are in the disciplines in which the students would have registered. This study observed that most end-user computing lecturers were computer science experts who focused on teaching computing skills. Disciplinary knowledge is crucial in end-user computing service courses as it forms the basis on which functioning knowledge is built. Although declarative disciplinary knowledge is not taught in the end-user computing service course, it serves as a crucial base for functioning knowledge. The constructivist learning theory also indicates that learners bring their own understandings and toolkits to the learning situation. Learning is thus cumulative (Biggs, 2003). Participants OSM and TMD, programme leaders in courses in hospitality management and development studies respectively, reiterated the importance of disciplinary knowledge in the end-user computing service courses. OSM indicated that end-user computing skills for hospitality management students needed to be contextualised to a hotel situation. He insisted that hospitality management students needed to appreciate the role of computer systems in managing interrelated hotel operations such as reservations management, billing and checking out. In the previous chapter, the following seed germination percentage formula

Germination percentage (GP) = number of seeds germinated/total number of seeds planted * 100

was cited as a classic example of the disciplinary knowledge that goes into creating an informative spreadsheet on the germination rates of a variety of seeds from different suppliers. The two classifying questions are thus posed to illustrate how such disciplinary knowledge can be classified in the context of the TRELO framework, as well as the role of instructional technology.

What is the learning orientation?

An understanding of the agricultural principles and calculations involved in seed germination is declarative disciplinary knowledge. Such principles can be clearly defined and well-articulated in written, audio, graphic and visual media.

What could be the role of computer-based instruction systems?

The typical end-user computing instructor that was interviewed was a computer scientist with no formal tertiary training in disciplines such as agriculture, hospitality management or life sciences. This is a massive setback for promoting functioning knowledge in the end-user computing service course as such disciplinary knowledge is crucial for promoting functioning knowledge. Brooks and Brooks (1999) encourage constructivist teachers to use raw data and primary sources, along with manipulative, interactive and physical material to encourage learners to generate their own abstractions and understandings from real-life phenomena. Computer-based instruction systems are excellent for content delivery and could be interfaced with LMSs such as Blackboard or Moodle to make videos and reading material available that create context-specific learning tasks to generate real-life examples. In the previous example of a seed germination spreadsheet learning activity, an end-user computing instructor could upload a plant germination video to bring real-life disciplinary contexts to the activity. In that way, the end-user computing student has a visual, real-life example of the purpose and importance of understanding the activity.

Computer utilisation knowledge

The learning task presented in Figure 6.3 is used to illustrate and classify a learning activity that typifies the notion of computer utilisation knowledge. It is adapted from an end-user computing course that Musgrave (2018:50) designed for trainee educators. The course is offered at the South African NQF Level 5.

Learning Theme: Processing Students Marks

Learning outcomes of the learning activity

At the end of the unit you will be able to

-create, edit and format worksheets in MS Excel

-understand the basic functions and formulas in Excel

-Insert graphs (called charts) and

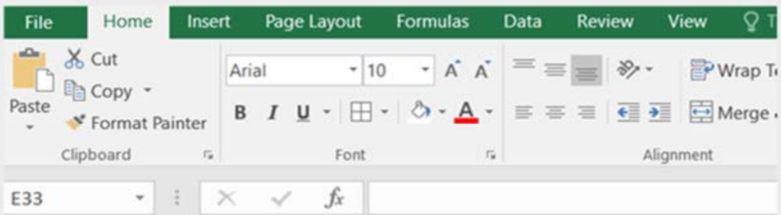
-filter data in a spreadsheet

Student Learning Activity

The trainee teachers (students) are requested complete a spreadsheet that indicate performance of their learners based on a set of marks obtained in tests.

Task Instructions

Open the spreadsheet Mark sheet and complete it by carrying out the instructions below



	A	B	C	D	E	F	G	H	I
1	**SUNRISE SCHOOL**								
2	**Natural Sciences Grade 7**								
3				**/30**	**/20**	**/50**	**/100**	**/150**	**%**
4		**Surname**	**Name**	**Test 1**	**Test 2**	**Test total**	**Exam**	**Total**	**TOTAL**
5	1	Botha	Gwendolene	22	13		71		
6	2	Nell	Patricia	15	15		53		
7	3	Brink	Isle	23	17		69		
8	4	Owen	Mavis	26	14		69		
9	5	Uys	Lerato	25	13		73		
10	6	Mathabela	Cindy	16	12		64		
11	7	Gareeb	Kananelo	28	20		59		
12	8	Dlamini	Dino	30	15		85		
13	9	Rossouw	Teboho	30	16		68		
14	10	Goosen	Lucky	18	14		65		
15	11	Jordaan	Suzie	21	15		66		
16	12	Brittz	Thersia	28	18		46		
17	13	Mofokeng	Tebogo	20	11		78		
18	14	Makwela	Dikeledi	25	19		89		
19	15	Duma	Bokang	16	12		64		
20	16	Lewis	Joyce	23	17		69		
21	17	Gumede	Itumeleng	18	14		65		
22	18	Marincowitz	Ann	28	20		59		
23	19	Mashalane	Violet	25	16		78		
24	20	Roos	Ruben	14	10		52		
25		**Class average**							
26		**Highest mark**							
27		**Lowest mark**							

1. Change the size of the heading in row 1 to 18pt
2. Fill the range A1:I1 with any blue colour
3. Merge and centre the cell range A2:I2.
4. Change the orientation of all column headings in row 4 to 90 degrees
5. Use a formula to calculate the test total of Gwendolene Botha in cell F5. The test total is the sum of Test1 and Test2. Use the fill tool to copy the formulae into the cells F6:F22 below.

[activity continued]

1. Work in cell H9. Calculate the total mark out of 150 by adding the total mark out of 50 to the exam mark out of 100.
2. Use a function in cell D25 to calculate the average the Test 1 marks.
3. Use a function in cell E26 and calculate the highest mark achieved for test 2.
4. Calculate in cell F27 the lowest mark out of 50. Use a function.
5. In cell I24, calculate the marks of Ruben Roos in %
6. Use conditional formatting in column G. Fill all cells containing a mark below 80 with a red colour.
7. Create a chart (use the chart that Excel recommends) that will display the names of the learners in column C and the exam marks in column.
8. Provide the chart with a title: Exam Marks
9. Sort the entire spreadsheet according to the total marks of the learners in column I from high to low (z-a).
10. Apply filters to row 4 to make it easy to look up the mark.
11. Border the cell range A1:I27
12. Did you save the marksheet as Excel_YourStudentNumber?

Figure 6.3: A lesson that focuses on computer utilisation

The two classifying questions are explored below.

What is the learning orientation?

The learning activity presented in Figure 6.3 is aimed at facilitating computer utilisation knowledge. Computer utilisation, as has already been explained, is the active use of and experimentation with hardware devices and the software features of a computer system. Students do activities such as typing on the keyboard, changing the text to bold and trying out different spreadsheet formulae. The learning outcomes, such as that students should be able to create, edit and format worksheets in MS Excel, insert graphs (called charts) and filter data in a spreadsheet, emphasise developing the skill of using (operating) a computer. This is epitomised in the following instruction: “Use a formula to calculate the test total of Gwendolene Botha in cell F5. The test total is the sum of Test 1 and Test 2. Use the fill tool to copy the formulae into the cells F6:F22 below” (see Figure 6.3).

The fact that the assessor provided the students with the spreadsheet formula that is needed to complete the task indicates that the focus is not on developing the student’s mathematical understanding of the calculations that are involved. The focus of the assessment question suggests a desire to ascertain the student’s ability to use the spreadsheet application. Another example of a strong orientation towards computer utilisation is evident in assessment question 10 where the assessor instructed the learners to apply filters so that it would be easier to look up a mark. The assessor gives the students the reason for having filters, and is interested in finding out if the learners can use a computer application to implement these. It is evident from this example that the learning orientation has shifted from understanding the principle of a filter (declarative computer knowledge) to the practical implementation of a filter in a spreadsheet program. This is similar to giving an apprentice carpenter a hammer and requesting him to drive a nail into a plank of wood. The focus would not be on understanding the properties of nails or hammering tools, but on developing the skill that is needed to drive the nail in accurately.

What could be the role of computer-based instruction systems?

A computer-based instruction system could still perform a content delivery role as was explained in the declarative computer knowledge learning orientation. Videos and demonstrations could still be made available to act as reference material. A more active and productive role is, however, envisaged. Computer-based instruction systems like SAM and MyLAB IT have projects and tasks that are done using real software products such as word processors, spreadsheets and presentations in addition to content delivery. Learning activities, such as the one provided in Figure 6.3, could be set up as part of a computer-based instruction project in a learning path. Students would download the spreadsheet start-up file and complete it. The finished file can then be uploaded and automatically graded using the grading conditions set by the instructor. This is the secondary and productive use of courseware that Mayes and Fowler (1999) indicated as providing the tools that support constructive learning. This is much the same as what Clinch (2005) explained as the productive use of learning media that allows students to express themselves through real works such as essays. Thus, the computer-based instruction system plays a productive role by enabling students to do such projects using real software. This productive use of courseware is extended in the next paragraphs where the role of computer-based instruction systems in supporting innovative disciplinary knowledge is demonstrated.

Disciplinary innovation knowledge

Disciplinary innovation is a different kind of end-user computing knowledge application. The knowledge that drives the problem-solving process is not only underwritten by computing skills as is the case with computer utilisation. During disciplinary innovation, disciplinary knowledge is used as the founding block in the problem-solving process. The following example is adapted from a post that was posted on MrExcel.com (2007) (see Appendix 10). The researcher adapted and redesigned the problem to be a learning activity for first-year commerce students at a university in South Africa. The learning activity is used to demonstrate how disciplinary innovation knowledge can be realised in an end-user computing service course.

Lesson Theme: Diminishing returns on advertising expenditure

Learning outcomes

By the end of this activity students be able to: -

1. Model straight-line graphs of returns on advertising expenditure using a spreadsheet.
2. Model non-linear or diminishing returns on adverting expenditure using a spreadsheet

The problem

A sales analyst is interested in illustrating the relationship between advertising costs and the revenue that is generated from selling a certain product (X). A market research on the product indicated that every rand spend on advertising generates a certain volume of sales. In a linear relationship, the relationship between advertising expenditure and sales revenue is expected to be a straight line. For example, if every Rand spend generate 95c then spending R500 delivers R475. This would be 95c for every Rand that is spent. Likewise, spending R7500 on advertising delivers R7125 worth of sales that would still be 95c per 1 Rand spent.

The market research revealed that the relationship is non-linear. In reality, increased expenditure on advertising returns less money than before - each Rand spend at higher levels delivers less than 95c, say 85c instead. It is an established fact that, for the product in question, the initial level of advertising expenditure delivers 95c per rand but then declines exponentially as advertising spending rises.

The Task

Use a spreadsheet to Illustrate the differences in returns on advertise between a straight line relationship and an exponential decline. The initial advertising expenditure is set R500.

The Solution

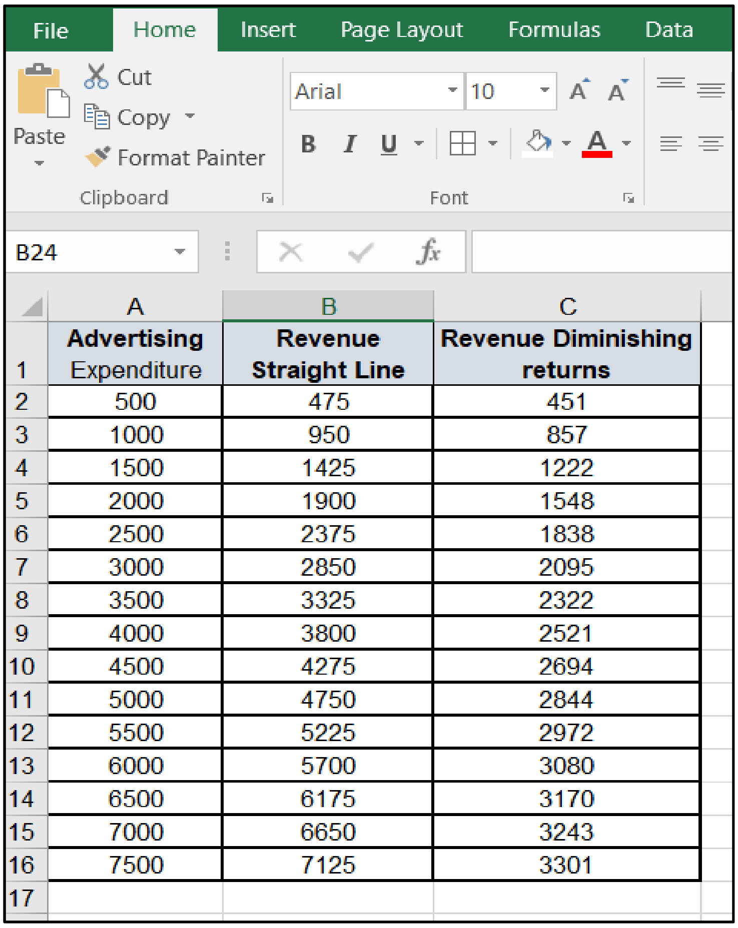
1. Put the advertising expenditure data in column A.
2. The revenue based on a straight line is computed in column B. This is done by typing in the formula = A2* 0,95 in cell B2 and copying it down.
3. To model the exponential decline in returns, the following formula is typed in cell C2, =0.95^(ROW()-1)*A2 and copied down.
4. A Scatter (XY) graph based on all the three columns is then created.
5. The graph gives two lines, one models revenue based on a straight line and the other (curved) illustrates revenue based on the diminishing returns principle.

Source: The ideas for this task were obtained and adapted from https://www.mrexcel.com/forum/excel-questions/292520-formula-create-sales-curve-displaying-dimishing-returns.html.

Figure 6.4: A disciplinary innovation problem

Figure 6.4 describes a problem that has a vast and deep disciplinary context. The problem and its solution have been simplified to avoid going into the deep economic principles that are involved and are beyond the scope of this study.

The solution to the problem is modelled and presented in figures 6.5 and 6.6. Figure 6.5 shows the spreadsheet figures that were used to create the graphs presented in Figure 6.6. The spreadsheet (Figure 6.5) shows the results of two formulae that were used in columns B and C to model the expected returns on advertising when the concepts of a straight-line return and an exponential decline on returns are modelled respectively. The revenue based on a straight line is computed in Column B. This was done by typing the formula = A2* 0.95 in cell B2 and copying it down to the rest of the cells B3 to B16. The formula = 0.95^ (ROW ()-1) *A2 was typed in cell C2 to model the exponential decline in advertising returns. The formula was then copied down to cells C3 to C16.



	A	B	C
1	Advertising Expenditure	Revenue Straight Line	Revenue Diminishing returns
2	500	475	451
3	1000	950	857
4	1500	1425	1222
5	2000	1900	1548
6	2500	2375	1838
7	3000	2850	2095
8	3500	3325	2322
9	4000	3800	2521
10	4500	4275	2694
11	5000	4750	2844
12	5500	5225	2972
13	6000	5700	3080
14	6500	6175	3170
15	7000	6650	3243
16	7500	7125	3301
17			

Figure 6.5: The spreadsheet solution

The data in Figure 6.5 was then used to model the two graphs presented in Figure 6.6 that show the differences in advertising returns between the two ways of calculating sales returns on advertising.

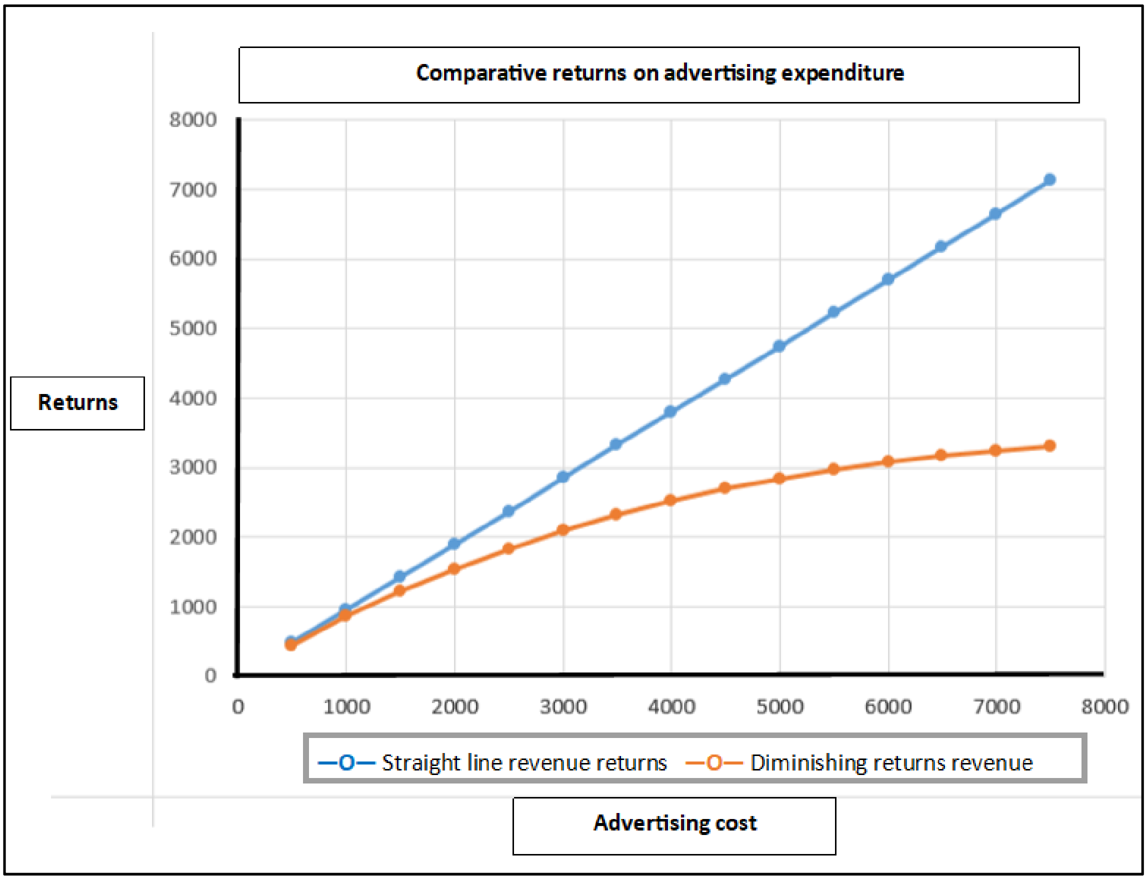


Figure 6.6: The graphic solution

The two classifying questions are applied to the problem that is presented in Figure 6.4 and to its solutions that are provided in figures 6.5 and 6.6 to illustrate the nature and form of disciplinary innovation knowledge in the end-user computing service course and the role of computer-based instruction systems.

What is the learning orientation?

The learning orientation presented in the scenario above is typical of what this study calls disciplinary innovation. The problem that is presented has a substantial disciplinary context. Economics and commerce students will realise that the problem presented above has its roots in the economic principle of diminishing returns. This concept is well-documented declarative disciplinary knowledge that they encounter in their economics courses or modules. The students do not solve this problem using expert computing knowledge only, but by using their understanding of economic principles as well. The knowledge that is needed to formulate the exponential decline formula that generates the diminishing returns curve is learnt in economics. Once this formula has been ascertained, the student uses declarative computer knowledge and computer utilisation knowledge to construct the graphs.

What could be the role of the computer-based instruction system?

The computer-based instruction system plays a similar role as discussed in the previous illustration that focused on the computer utilisation learning orientation. Computer-based instruction systems can be used to support content delivery and productive learning. Declarative disciplinary knowledge, such as how to construct exponential curves, could be made available through videos and demonstrations that the instructor could load on the computer-based instruction system. The video and other source materials could also be loaded on an LMS, such as Moodle, that easily interfaces with computer-based instruction systems such as SAM and MyLab IT that are used in teaching end-user computing courses. This has the effect of enacting a learning experience that is closer to reality and almost authentic. The projects that are done in actual productive software, such as word processors, spreadsheets and presentations, allow instructors to build their own tasks that enable students to create innovative solutions. The problem presented above could be loaded as a computer-based instruction project with an initial start-up file. Students would then download it, complete it and upload the solution for grading. The computer-based instruction would thus be supporting constructive engagement and productive learning.

A reflective learning moment

Passarelli and Kolb (2012:3) explain that learning involves action and continuous reflection. People make better choices and improve their effectiveness through reflection (Rogers, 2001). Reflection grows knowledge and self-discovery through evaluations of actions and activities (Pretorius & Ford, 2016). The previous example on the exponential decline of advertising returns is extended and used as a case for igniting reflective learning in the end-user computing service course. Figure 6.7 is used for illustration.

Learning theme: Constructing and interpreting graphs

Learning outcomes

1. Students should be able to use a spreadsheet program to construct graphs indicating returns on advertising expenditure.
2. Students should be able to provide insightful comments on graphs depicting return on advertising expenditure.

Task instructions

1. Study the graph depicting returns on advertising expenditure for a particular product and comment on your observations.

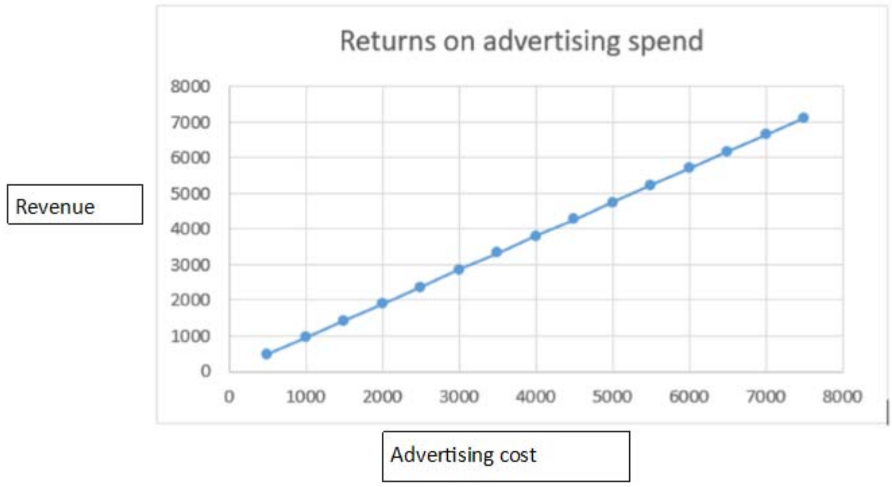


Figure 6.7: A revenue chart used to spark reflection

The learning activity presented in Figure 6.7 is used as an example of an activity that would trigger both disciplinary and computing reflection. Economics students are provided (or would have constructed) a straight-line graph that shows the returns on advertising costs of a particular product. They are then asked to comment on the results. This comment would involve interpreting the graph in terms of what it is and what else they know. They think back and forth, appraising what they see against what they already know. A capable economics student would realise that there is something wrong with this graph or not typical about it. Their declarative disciplinary knowledge would have prepared them to expect a curved line instead of a straight line. This creates a conflict as Passarelli and Kolb (2012) explain. They stated that learning is a conflict-driven process that involves actions on the one hand, and thinking and feeling on the other. The two possible kinds of reflection that could result from the process are computing and disciplinary reflection.

Thus, the two evaluative questions are posed to illustrate how this learning activity leads to both computing and disciplinary reflection and clarifies the role of computer-based instruction systems in the learning process.

What is the learning orientation?

A computing reflection occurs whenever students appraise their declarative computing or computer utilisation knowledge. The learning activity illustrated in Figure 6.7, where the data yields an unexpected graph, provides moments for computing reflection. A plausible starting point would be for the end-user computing students to revisit the data, formula and the procedures they used to create the graph. They should then ascertain whether they applied the concepts correctly. If they do not find a plausible explanation for the anomaly, it could be a moment for disciplinary reflection.

Disciplinary reflection occurs whenever the student thinks about the problem in a disciplinary context. The graph presented in Figure 6.7 is not typical of what an economics student would expect. The students revisit the data that they would have used to solve the problem and examine the way they formulated the solution to establish if there are any inconsistencies. Another option would be to revisit their declarative disciplinary knowledge or conduct further reading on advertising returns theory to establish if there is an explanation for the unexpected findings.

It is important to stress that computing and disciplinary reflection are not only limited to appraisals of learning experiences as described above. They extend to include the application of new insights to new problems and contexts.

What could be the role of the computer-based instruction system?

It was observed in this study that computer-based instruction systems were used to support communication by interfacing with communicative LMSs such as Blackboard, Moodle and MindTap. Learners and instructors were provided with a platform to share experiences and compare ideas. Lin, Hmelo, Kinzer and Secules (1999) write that learning technologies are essential for reflection because they make problem-solving and thinking processes visible. They direct students to important learning activities and make experts' thinking processes available for comparison through dialogue in forums. Thus, learning the technology is important in enacting learning dialogues that afford opportunities for sharing, explaining and justifying ideas that would have been formulated (Mercer, Hennessy, & Warwick, 2017). The computer-based instruction system plays a communicative role in support of discussions that are crucial for reflection.

Capstone projects

The examples presented in the previous subsections demonstrated how selected learning activities could be analysed and classified in the context of the TRELO framework's learning orientations. This section analyses case studies, problem-based learning and capstone projects, which are common assessment and learning activities in the end-user computing service course. It is advanced that such learning activities readily provide a comprehensive pathway to achieving functioning knowledge because they make it easier to construct learning activities in such a way that the problem-solving process touches on all six aspects of the end-user computing service course knowledge matrix.

The example provided in Figure 6.8 is an end-user computing capstone project that Musgrave (2017b:38–40)[8] designed for trainee teachers at a university in South Africa. The task has been adapted and reworded for brevity; the full task description is provided as Appendix 11. This summative assessment attempts to capture all six of the TRELO framework's learning orientations. It is also important to note that the task is rooted in authentic learning contexts as the trainee teachers were required to apply knowledge in a real-life working environment.

[8] The researcher admininstered this activity in one of the end-user computing lectures that he conducted for trainee educators.

The Summative Assignment Task

Selected Course learning objectives

<u>At the end of this unit, you will be able to</u>

Investigate and implement the different models of ICT deployment at schools;

Reflect on the benefits and challenges of using computer labs;

Identify the best placement for a computer or laptop in your class;

Explain (list) at least 3 tips when planning to take your class to the school's computer lab; and

Reflect and explain the benefits and challenges of using laptops.

<u>Task scenario</u>

The time has come to return to your school, inspired to implement the ideas you have been working on. The implementation of your ideas and the submission of evidence will contribute to 70% of your final mark for this module. In this assignment, you will analyse what technology is available at your school and then prepare a presentation for your school governing body.

Step 1.1: Investigate the ICT resources available at your school and how they are currently used.

Step 1.2: Comment on the successful or unsuccessful use of the ICT resources at your school.

Step 1.3: Prepare a presentation for your School Governing Body. In the presentation, highlight the resources that are available and their potential use. Your ideas should be contextualised to the school you teach at.

Figure 6.8: A capstone project on ICT usage in schools

The analytical and classification questions are posed to help understand the learning task in the context of the TRELO framework.

What is the learning orientation?

It is advanced that the activity presented in Figure 6.8 is tightly woven around all learning orientations. Declarative computer knowledge is realised when the students investigate the ICT resources that are available at their school and how they are currently used as required in Step 1.1 of the task. The students must use their declarative computer knowledge to correctly identify and describe the use of devices such as printers, laptops, iPads, networking servers and webcams. On the other hand, declarative disciplinary knowledge provides a background understanding of how the ICT resources are used. For example, teachers would realise that when more than one learner works on a single tablet, they would be using the groupwork learning method. They would also understand that a teacher who uses presentation slides projected onto a screen and spends most of their time talking through the slides is using the lecture method. Trainee teachers would use their computer utilisation knowledge to prepare a presentation for the School Governing Body (SGB) as required in Step 1.3 of the task. Disciplinary innovation, as the active use of disciplinary knowledge in creating effective computing solutions, is useful for the creation of informative presentations. Trainee teachers may include disciplinary jargon, such as the teacher-to-pupil ratio to make their presentation more informative. These terms have their roots in the teaching and learning discipline.

Reflection is invoked when students provide insights on the impact of technology use in their teaching, especially when they comment on the success or failures of technology use in response to the question that is posed in Step 1.2 of the task: "Comment on the successful or unsuccessful use of the ICT resources at your school". Computing reflection is used to examine the way available technology is used and ascertaining successes and failure. Their knowledge of pedagogy and technology use in teaching helps trainee teachers appreciate whether devices such as tablets, smartboards, audio, visual and educational software are being utilised optimally. This would be disciplinary reflection.

What could be the role of computer-based instruction systems?

The capstone project presented in Figure 6.8 offers the potential for the computer-based instruction systems to be used in all three conceived roles: content delivery, productive and discursive roles.

In the content delivery role, trainee teachers who were involved in this course were taught in a block-release format. Much of the learning materials, such as CDs, videos, textbooks and reading materials, that were used were hand-delivered to learners during contact sessions. A computer-based instruction system that is interfaced to an LMS, such as Moodle, can also be used to deliver these learning materials.

In the productive role, the presentation for SGB members was constructed in MS PowerPoint. This task can be set up as a MyLab IT project file that can be downloaded, worked on and uploaded for grading. The limitation is that the grader looks for specific formats and not content. Instructors must manually mark this task for context.

In the discursive role, the computer-based instruction systems can be interfaced with an LMS to facilitate chats and the sharing of insights with peers and instructors.

6.3.2 A complete lesson that leads to functioning knowledge

The previous subsections illustrated how the TRELO framework could be used as a classifying tool that shows how different learning activities could be understood in the context of the various learning orientations of the end-user computing course knowledge matrix. The role of computer-based instruction systems in each of the learning activities was suggested. It was also illustrated how a well-designed capstone project could represent an effective learning process that leads to functioning knowledge. This subsection offers a demonstration of how the TRELO framework could be used as a template for achieving functioning knowledge in an end-user computing learning activity.

The learning activity is designed in a three-stage format that involves the TRELO framework’s six learning orientations. The use of stages or phases in planning a learning process is well accepted in pedagogical practices. As an example, the framework of Laurillard (1993) comprises the discursive, interactive, adaptive and reflective processes that show how students move from the specifics of experience to the generalisations of knowing. Mayes and Fowler (1999) also use a three-stage learning model to illustrate how learning begins at a concept development level, moves to knowledge construction and concludes with dialogue.

The presentation of a learning activity that leads to functioning knowledge based on the TRELO framework is modelled as a phased learning process that explores all six learning orientations of the TRELO framework’s knowledge matrix. In addition, the three-stage learning framework of Mayes and Fowler (1999) that comprises conceptualisation, construction and dialogue is used to guide the learning activity’s flow. Figure 6.9 is an illustration of how this learning process (activity) unfolds from declarative knowledge concepts to reflection in a process that explores all six of the TRELO framework's learning orientations. The role of instructional technology (computer-based instruction systems) is indicated as content delivery, production and discussion.

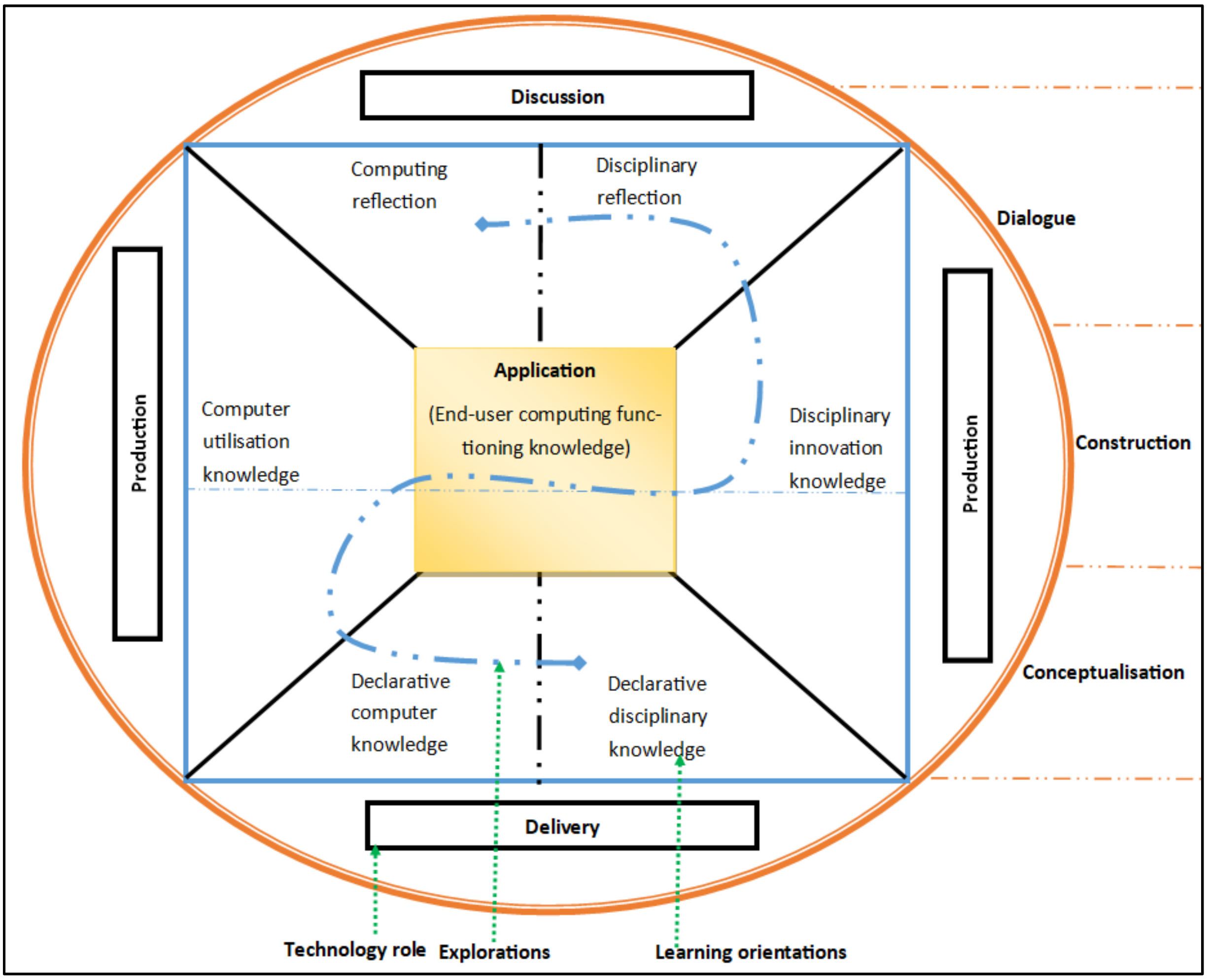


Figure 6.9: A learning programme designed for functioning knowledge

The proposed learning activity for facilitating functioning knowledge explores all six learning orientations of the TRELO framework, as illustrated in Figure 6.9. The first phase of this lesson is designed to mimic the conceptualisation stage of Mayes and Fowler (1999). This initial interaction between the student and the facilitator exposes the learner to new concepts (Bati et al., 2014). It involves understanding the declarative disciplinary concepts that are involved in solving the problem so that the learning experience is rooted in authentic disciplinary contexts and an understanding of the declarative computer knowledge that is needed to solve the problem. After that, the lesson progresses to a constructive stage where learners use concepts and combine them to accomplish tasks (Bati et al., 2014). In the proposed learning activity, students apply computer utilisation knowledge and innovative disciplinary knowledge to actively engage with the computer artefact to construct solutions to problems. Finally, the learning activity concludes with a discursive dialogue where conversations, insights and reflections are exchanged. Hadjerrouit (2008) explains that the dialogue stage is accomplished through conversing, reflecting and extending concepts to new settings.

Planning the functioning knowledge lesson

The learning activity is an extension of the seed germination task that was presented in Chapter 5. It is designed for end-user computing students from the agricultural faculty who are studying plant physiology. In this activity, the students use a spreadsheet program to analyse the results of an investigation of the effect of temperature on the germination of wheat seeds. Appendix 12 is a snippet from GrainSA's website. It indicates that the germination and success rate of wheat seeds is optimal at temperatures between 12 °C and 25 °C. Sub-optimal temperatures lead to slow germination processes and lower germination percentages. As part of the activity, the end-user computing instructor obtains data that shows seed germination figures for seeds that were planted and observed for 10 days under different temperature conditions[9]. The seeds came from the same bag. The students created a spreadsheet that showed the germination figures of the two germination data sets. They calculated germination percentages and reflected on the process.

As has already been advanced, the success of a learning process that leads to functioning knowledge depends on the learning outcomes that explore all six of the TRELO framework's learning orientations. Figure 6.10 presents plausible learning outcomes of a learning activity that lead to functioning knowledge. The learning outcomes touch on all six learning orientations of the end-user computing service course knowledge matrix.

[9] Hypothetical figures are used in this activity to emphasise aspects that pertain to this study.

Lesson Theme: The effect of temperature on wheat seed germination success

The Possible Learning outcomes leading to functioning knowledge

Declarative disciplinary knowledge learning outcomes

1. Students should be able to define/explain the concepts of germination percentage.
2. Calculate the seed germination percentage and rate

Declarative computer knowledge learning outcomes

1. Students should be able to identify/describe/name the spreadsheet functions that are used to perform the following mathematical operations in a spreadsheet (addition, multiplication, subtraction, division and percentages.
2. Students should be able to name/describe/identify the charts that are available in a spreadsheet programme.

Computer utilisation performance outcomes

1. The student should be able to use spreadsheet functions to perform mathematical calculations such as addition and finding percentages in a spreadsheet programme.
2. Use spreadsheet data to create charts (pie, bar, cumulative, histogram, scatter, XY)

Disciplinary innovation performance outcomes

1. Students should be able to use spreadsheet functions to calculate seed germination rates and percentages.
2. Students should be able to use spreadsheets charts to analyse germination patterns.

Computing reflection learning outcomes

1. Students should be able to comment on the appropriateness of the bar chart as a data presentation tool for seed germination statistics.
2. Students should be able to suggest alternative data presentation tools for seed germination.

Disciplinary reflection learning outcomes

1. Students should be able to comment on the impact of temperature on seed germination.
2. Students should be able to evaluate and provide insightful comments on the methods used to determine seed germination percentages

Figure 6.10: Learning outcomes that lead to functioning knowledge

Stage 1: Conceptualisation stage

The conceptualisation stage exposes learners to new concepts (Mayes & Fowler, 1999). Biggs and Tang (2007) advance that problem-based learning and authentic contexts should be built into the learning situation from the onset. They argue that the premise on which functioning knowledge is built is an authentic problem or an authentic learning environment. This authentic learning environment is similar to what Participant OSM, a programme leader in Hospitality Management studies, meant when he said that all end-user computing learning should be contextualised to a hotel situation. The end-user computing instructor may assign or direct the students to a prepared reading (such as Appendix 12) to create an awareness of the theory behind seed germination.

An even better approach would be to request the students to find wheat seeds, divide them into two sets, and plant one set under certain temperature conditions and the other set under different temperature conditions. They would then note how many germinate from each set after two, three or four days. This first stage serves the significant role of rooting the learning process in a real-life experience. It also activates existing knowledge that Botma et al. (2015) see as crucial in fostering understanding. It is conceivable that agriculture students could be familiar with seed germination. The end-user computing instructor would then ascertain that the students are familiar with the concept of germination percentage or how it is calculated.

The learning activity could then move on to the acquisition of the declarative computer knowledge that relates to the learning theme. This stage is similar in context to what Botma et al. (2015) express as engaging with new information or what Kolb and Kolb (2009) indicate to be the concrete learning experience. Students would be introduced to new phenomena or concepts. The learning objectives of declarative computer knowledge are expressed as follows: Students should be able to identify, name or describe the functions that are used to calculate percentages in a spreadsheet program. The aim is to acquire explicit knowledge regarding the theoretical concepts of the computer artefact. In this example, the concepts are the spreadsheet functions that are available in a spreadsheet for use in calculating germination percentages.

Stage 2: Construction stage

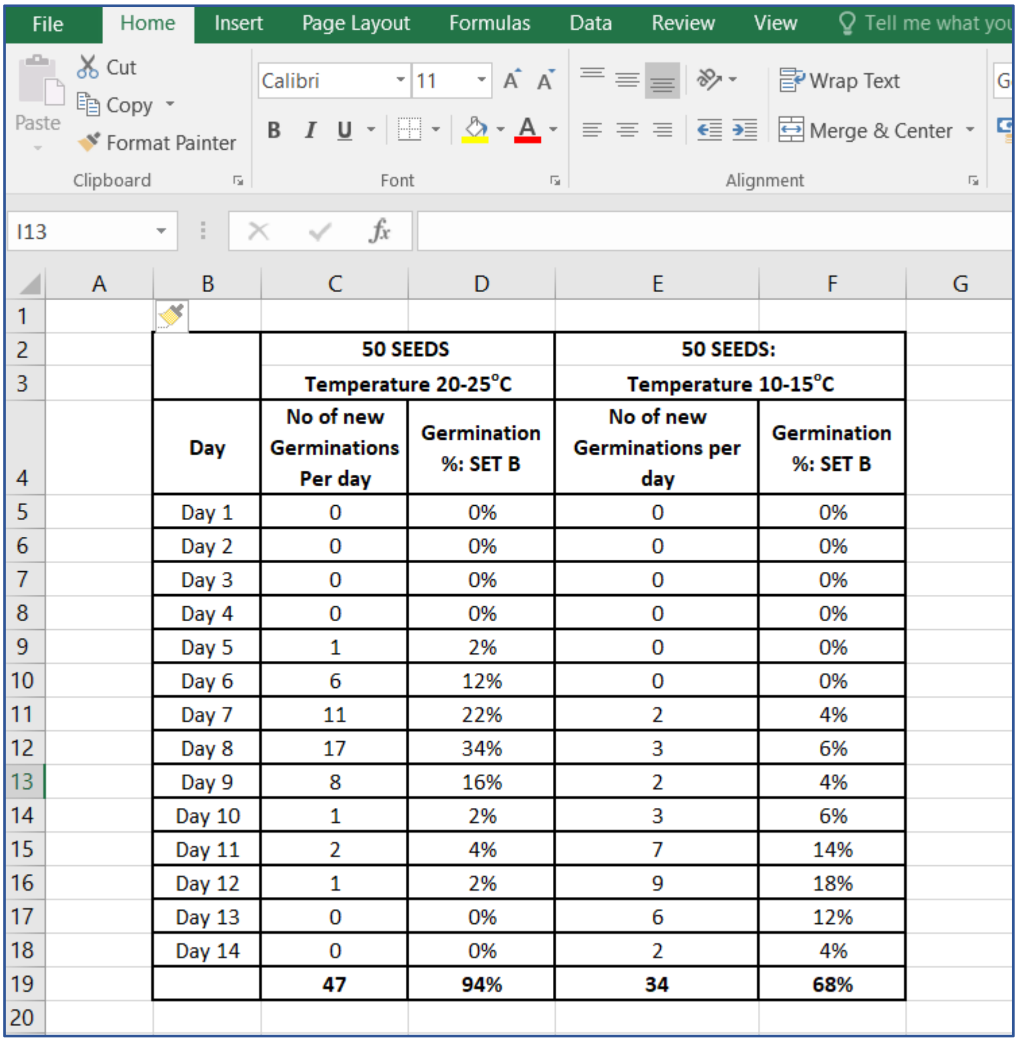
At this stage, the students would have been exposed to declarative computer knowledge and applicable disciplinary knowledge. They would be in a position to understand what germination percentage entails and the formula needed to calculate it. They would also know of the spreadsheet functions available for performing calculations and the type of charts that can be created. Their task would be to construct a solution. The first aspect of this construction is what is termed computer utilisation in this study. The focus is on making the students learn how to utilise the computer. They learn how to use the spreadsheet formula correctly and apply the correct syntax. The computer utilisation performance objectives focus on operating computer artefacts. The use of the phrase “performance objectives” at this stage is deliberate to emphasise the physical action that is contemplated during the problem-solving process.

The performance objectives are as follows:

- The student should be able to use a spreadsheet program to perform mathematical operations such as addition, subtraction and calculating percentages.
- The student should be able to create graphs in a spreadsheet.

The second aspect of this construction is applying disciplinary knowledge in solving the problem. The learner successfully constructs the formulae that are needed to calculate the germination percentage, such as the number of germinating seeds divided by the total number of seeds planted multiplied by 100, using declarative disciplinary knowledge. Computer utilisation knowledge is used to type the formula accurately and with the correct syntax.

Figure 6.11 indicates a plausible spreadsheet solution that is constructed for two sets of identical seeds planted under different conditions.



Day	50 SEEDS Temperature 20-25°C No of new Germinations Per day	Germination %: SET B	50 SEEDS: Temperature 10-15°C No of new Germinations per day	Germination %: SET B
Day 1	0	0%	0	0%
Day 2	0	0%	0	0%
Day 3	0	0%	0	0%
Day 4	0	0%	0	0%
Day 5	1	2%	0	0%
Day 6	6	12%	0	0%
Day 7	11	22%	2	4%
Day 8	17	34%	3	6%
Day 9	8	16%	2	4%
Day 10	1	2%	3	6%
Day 11	2	4%	7	14%
Day 12	1	2%	9	18%
Day 13	0	0%	6	12%
Day 14	0	0%	2	4%
	47	**94%**	**34**	**68%**

Figure 6.11: Seed germination under different temperature conditions

The students may use their computer utilisation knowledge to construct a graph that shows the number and percentage of seeds that were germinating after each day as illustrated in Figure 6.12.

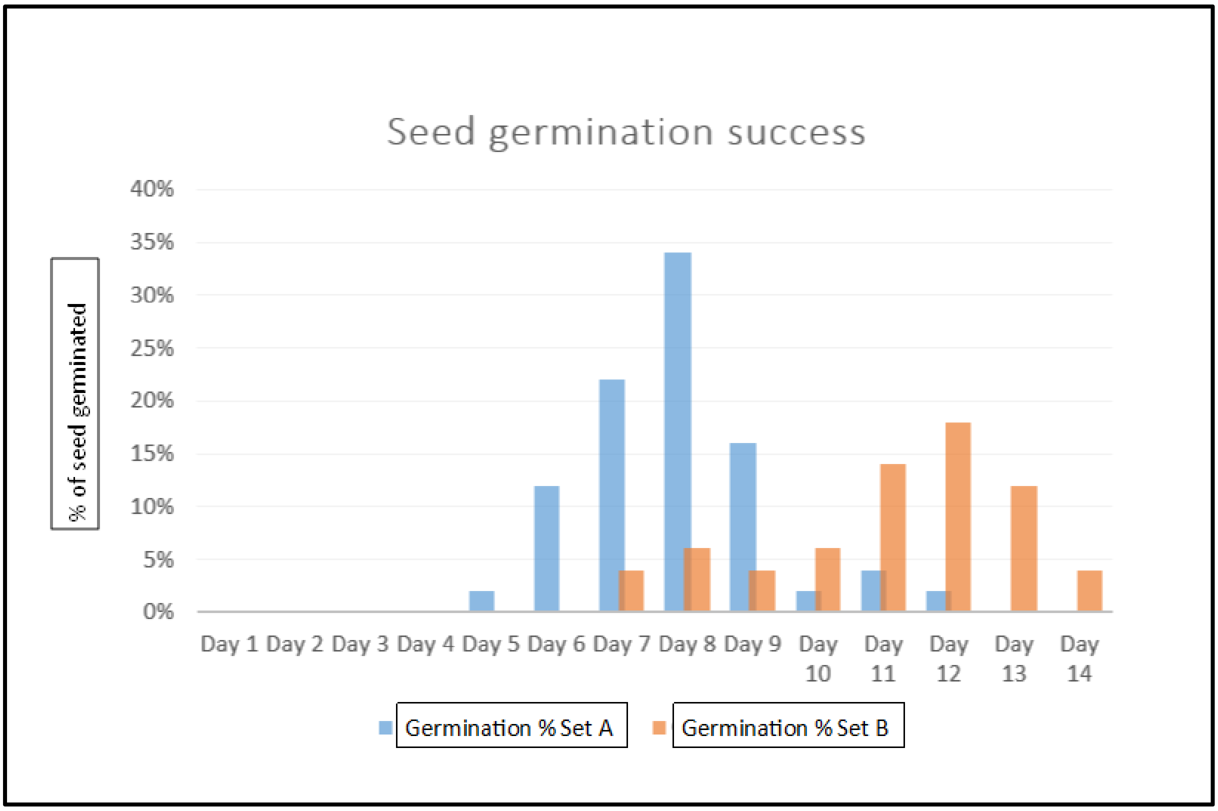


Figure 6.12: A chart showing seeds germination under two different conditions

Figures 6.11 and 6.12 illustrate what students may achieve after successfully using both computer utilisation and disciplinary innovation knowledge to construct the spreadsheet and graph. They would have used computer utilisation knowledge to set up the spreadsheet, type the formulae, use the correct syntax and construct the chart accurately. They would also have applied the agricultural disciplinary knowledge to calculate the germination percentage correctly. Disciplinary innovation knowledge is evident in the way the solution is built and arrived at. An agricultural student would realise that they need to compare the germination percentage daily for a reasonable duration like 14 days to make a fair assessment of seed germination. This reasonableness is deeply tied to their knowledge of the agriculture discipline and not computing.

Stage 3: Dialogue

The dialogue stage offers an opportunity for sharing insights and reflections. The possibilities for reflection are endless. Reflection has been discussed in previous sections as focusing on evaluating and appraising one's actions. The performance outcome that requires students to comment on the appropriateness of the bar chart as a data presentation tool indicates a computing reflection process. Students could think of the merits of other plausible options such as a pie chart here. Another plausible outcome would be a cumulative germination percentage chart showing the total percentage of seeds that would have germinated after seven, eight and nine days, for example. The performance outcome that requires students to comment on the impact of temperature on seed germination indicates a disciplinary reflection process. The information presented in the spreadsheet and chart seems to suggest that low temperatures delay germination and affect the number of seeds that germinate. Students may start to wonder whether this pattern is applicable in other crop varieties such as maize. They may also question whether the differences could be as a result of other uncontrolled variables such as humidity and sunlight.

The two classifying questions are posed to complete the analysis.

What is the learning orientation?

The learning objectives explore all six facets of the end-user computing knowledge service course knowledge matrix: the declarative disciplinary and computing knowledge, computer utilisation and disciplinary innovation knowledge, and computing and disciplinary reflection.

What is the role of the computer-based instruction system?

As discussed, the computer-based instruction systems play content delivery, productive and discursive roles. They could be used to deliver declarative computer knowledge by making training videos and specifically designed learning paths that are available and that demonstrate how to perform calculations and create charts in a spreadsheet.

The declarative disciplinary knowledge such as the formula used in calculating germination percentages, however, has to come from the students' main disciplines. A study on the computer-based instruction system SAM reveals that it has preloaded cases and projects that are not tailor-made to particular learning contexts. Therefore, the end-user computing instructor has to bring forth this "context" into the facilitation of the end-user computing service course to enact an authentic learning environment.

A possibility is to interface the computer-based instruction system with LMSs such as Blackboard or Moodle to allow the delivery of customised learning resources.

During the construction stage, the students craft solutions to the problem. Computer-based instruction systems have project-like tasks that allow students to work with real software. These would be useful when students apply their disciplinary innovation computer knowledge to create a spreadsheet and charts. Other systems like MyLab IT also allow instructors to introduce their own customised, practical tasks that can be designed to suit the learning objectives. Finally, the dialogue phase can focus on reflection that would involve thinking about, evaluating and sharing experiences. SAM did not have the functionality for sharing or creating student discussion groups. This limitation was overcome by interfacing the system with LMSs that have chatting and collaborative facilities. Students can share their experiences and compare notes during the reflection processes.

6.3.3 The TRELO framework fits into conventional practice

The interviews that were conducted with end-user computing lecturers showed that four kinds of teaching approaches were common. The first was face-to-face instruction in a smaller computer lab of about 30 to 50 computers. The second was a large setup that had a large computer centre and one main instructor, some technical assistants and more than 120 workstations. Multiple projectors were used for display. The third option was a blended learning format where students had intermittent contact sessions with instructors and were given reading material in between. The contact sessions were used for discussion and for going over difficult assignments. The last was an open learning approach where the students were given access to online resources and textbooks with the instructors providing instructional support online.

Hevner et al. (2004) describe design evaluation as proof of an artefact’s utility, efficacy and fit in conventional practices. The previous subsections focused on demonstrating what the TRELO framework can accomplish. The demonstrations could be construed as an illustration of the artefact’s utility. This subsection focuses on illustrating how the TRELO frameworks fit into conventional instructional practices. It is a demonstration of how the proposed framework, as a pedagogical artefact, stands among its peers. Two contexts are selected for this kind of demonstration. The first is an illustration that the TRELO framework is consistent with current instructional methodologies in higher education. Three methodologies – the flipped classroom instructional methodology, the blended learning approach and the open learning methodology – are used for the demonstration. The second context is an illustration that the TRELO framework aligns with accepted approaches used for describing educational learning outcomes Two such approaches are chosen: Bloom's taxonomy and the SOLO approach.

The TRELO framework and the flipped classroom instructional methodology

The hallmark of the flipped classroom methodology is that students do preparatory work at home or before the lecture and use their contact time with the instructor to solve problems and share insights with others. Students go through preparatory work such as watching a video or reading an article before class and then use the class time to work on problems, advance their knowledge and collaborate with others (Tucker, 2012).

The flipped classroom approach can be implemented in the context of the TRELO framework and still ensure that functioning knowledge is achieved in an end-user computing service course. Students are given prepared reading at home. This could be in the form of source text, video or simulation texts. Computer-based instruction systems, such as SAM, have preloaded videos, demonstrations, practice tasks and activities for the students to get the preparatory declarative computer knowledge and declarative disciplinary knowledge. The computer-based instruction system plays a content delivery role in this context. During lectures, the instructors use the time for students to solve problems and do reflection. Students have the opportunity to use productive software and solve problems under the teacher's guidance. This enhances their computer utilisation knowledge and disciplinary innovation knowledge, as they would be working on real software and real problems. A platform for sharing reflective thoughts can be initiated through discursive forums that can easily be set up on learning management software.

The TRELO and blended learning instructional methodology

The current conceptualisation of blended learning, as described by Christensen et al (2013), depicts a learning process in which students partly experience instruction in a supervised brick-and-mortar environment and partly through online channels. A similar approach to the one described in the flipped classroom methodology could also be applicable in the blended learning context. The computer-based instruction systems could be used to deliver the bulk of the declarative computer knowledge and disciplinary knowledge to the students for prior reading and practice. Such content is similarly made available for revision and referencing after lectures. Students and facilitators would then focus on productive tasks such as completing assessments using actual software and sharing insights during contact sessions.

TRELO and the open learning methodology

Open learning provides distance learning without physical instructor support. An open learning instructor who was interviewed in this study indicated that students were given access to course material and instructor support online. The same configuration for the flipped classroom described in the previous section could be used for the open learning methodology with minor modification to account for the lack of instructor support. The computer-based instruction system would be used to deliver videos, resources, instructions and learning paths that cater for the declarative computer knowledge and declarative disciplinary knowledge. Online instructors could then prepare projects, tasks and assignments that involve the actual use of productive software, such as word processing, spreadsheet and presentation software, to develop the computer utilisation and disciplinary innovation knowledge. After that, students and instructors can engage in dialogue via discursive forums to share their reflections. The computer-based instruction system would still play a content delivery role that supports conceptualisation. Its productive role enables constructive learning and the communicative role supports learning.

The TRELO framework's compatibility with Bloom's taxonomy

Bloom's revised taxonomy, as outlined by Anderson and Krathwohl (2001), views cognitive knowledge as a hierarchy of six levels. The taxonomy indicates remembering as requiring the least cognitive effort. This is followed by understanding, application, analysis and evaluation, and ends with creation. Bloom's original taxonomy similarly had six cognitive levels. Knowledge and comprehension indicated lower-level cognitive skills, while application, analysis, synthesis and evaluation indicated higher-level thinking skills (Stanny, 2016). It is possible to align the TRELO framework's six learning orientations (knowledge matrix) to the formulations of Bloom's taxonomy.

Figure 6.13 is used to illustrate how the TRELO framework can be aligned with the arguments presented in Bloom's original taxonomy.

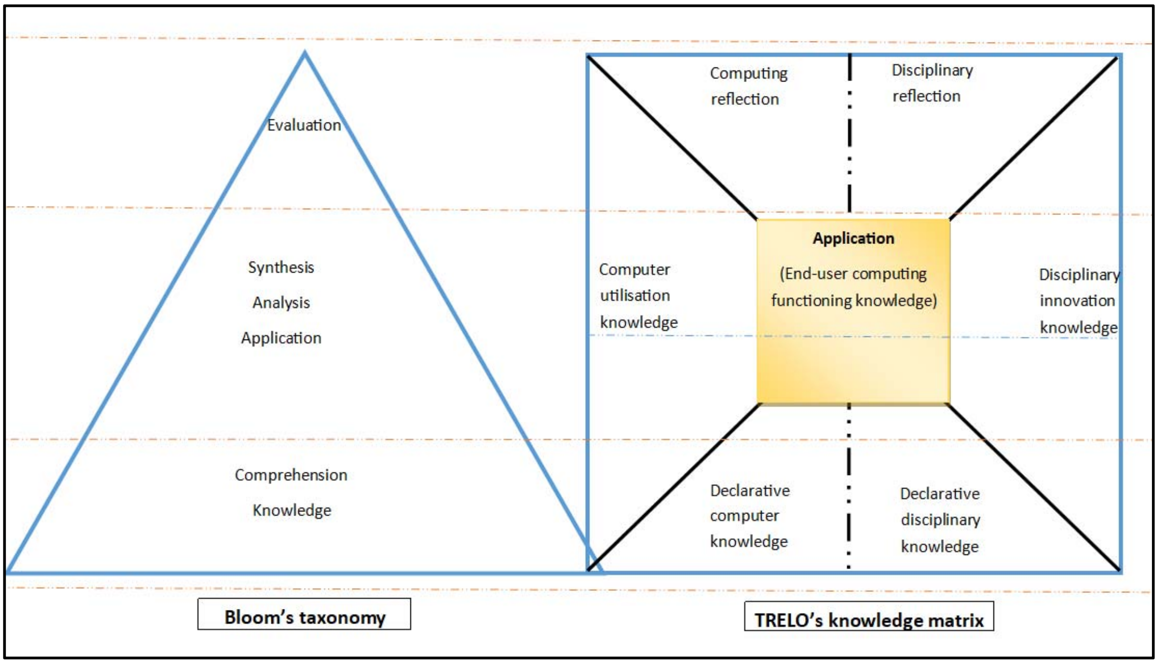


Figure 6.13: Aligning the TRELO framework with Bloom's taxonomy

Bloom et al. (1956) explain knowledge and comprehension as follows:

- Knowledge: "involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or setting" (Bloom et al., 1956:201)
- Comprehension: "a type of understanding or apprehension such that the individual knows what is being communicated and can make use of the material or idea being communicated" (Bloom et al., 1956:205)

The comprehension and knowledge cognitive levels could be associated with the declarative computer knowledge and declarative disciplinary knowledge in the TRELO framework. The learning efforts, as has already been discussed, are directed towards knowing about and remembering declarative facts. These would be computing or disciplinary facts.

Knowledge and comprehension support the next cognitive operations in Bloom's taxonomy: application, analysis and synthesis.

- Application: “The use of abstractions in particular and concrete situations” (Bloom et al., 1956:205)
- Analysis: “The breakdown of communication into its constituent elements or parts such that the relative hierarchy of ideas is made clear and/or the relations between the ideas expressed are made explicit” (Bloom et al., 1956:205)
- Synthesis: “The putting together of elements and parts so as to form a whole. This involves the process of working with pieces, parts, elements, etc., and arranging and combining them in such a way as to constitute a pattern or structure not clearly there before” (Bloom et al., 1956:206).

The application, analysis and synthesis cognitive levels in Bloom’s taxonomy could be likened to the utilisation of the computer artefact and the innovative use of disciplinary knowledge in the end-user computing service course problem-solving process. When students apply their declarative computer knowledge and disciplinary knowledge through utilisation and innovation in constructing solutions, it can be argued that they are breaking down a problem into its constituent parts (Bloom’s analysis). The ideas are made explicit in form of the tangible objects produced (e.g. a document). Utilisation of the computer artefact and the innovative use of disciplinary knowledge, therefore, transform abstract ideas into concrete objects (Bloom’s application).

Similarly, when students construct, for example, a payroll in a spreadsheet, it could be likened to Bloom’s synthesis cognitive level because learners could be said to be “working with pieces, parts, elements, etc., and arranging and combining them in such a way as to constitute a pattern or structure not clearly there before” (Bloom et al., 1956:206) (Bloom’s synthesis). The computing and disciplinary reflection in the TRELO framework would equate to Bloom’s evaluation cognitive level. It could be argued that computing and disciplinary reflection are similar to making “judgements about the value of material and methods for given purposes… the extent to which material and methods satisfy criteria” (Bloom et al., 1956:207).

Computer-based instruction systems would play a content delivery role to support declarative knowledge acquisition during the comprehension and knowledge cognitive levels. Productive software, such as spreadsheets, support practical application (application analysis and synthesis). Finally, discursive forums enable students and instructors to share reflective thoughts during the cognitive evaluation level.

The TRELO framework's compatibility with the SOLO taxonomy

Learning, as observed by Biggs and Collins (1982), operates at five levels: prestructural, unistructural, multistructural, relational and extended abstract. It is seen as a gradual process of acquiring knowledge in which the three lower levels (prestructural, unistructural and multistructural) increase the quantity of what is known. The relational and extended abstract levels indicate the quality of what is known. A proposal is made in this study that it is possible to align the TRELO framework with the core principles of the SOLO framework will be presented in the following paragraphs.

Ivanitskaya et al. (2002) use the structural model of Biggs and Collins (1982) to illustrate how interdisciplinary learning outcomes can be formulated at a unistructural level through the extended abstract level. The authors advance that, at the unistructural level, learning is unidisciplinary, as the learner focuses on a single discipline. The multistructural level sees the learner acquiring knowledge from different disciplines, but the knowledge is not integrated. The relational level shows the integration of knowledge from many disciplines around a central theme, which leads to some critical thinking. The extended abstract level is reached when the learner acquires an interpretive knowledge structure that integrates theories, tools, paradigms and concepts from multiple disciplines. The extended abstract level leads to critical interdisciplinary thinking, metacognitive skills, highly advanced epistemological beliefs and the transfer of interdisciplinary knowledge. Figure 6.14 is used to illustrate how the TRELO framework can be aligned with the application of Ivanitskaya et al. (2002) of the SOLO taxonomy in an interdisciplinary context.

Declarative computer knowledge and declarative disciplinary knowledge could be conceived as operating at the unistructural level of the interdisciplinary learning environment perceived by Ivanitskaya et al. (2002). This is because learning would be focusing on a single aspect of either declarative computer knowledge or declarative disciplinary knowledge. The multistructural level is achieved when the learner acquires more declarative facts in the discipline or across the discipline without a proper integrative structure. An example is when they understand more spreadsheet formulae and spreadsheet features or more facts about their specific disciplines, such as germination percentages and soil types in agriculture.

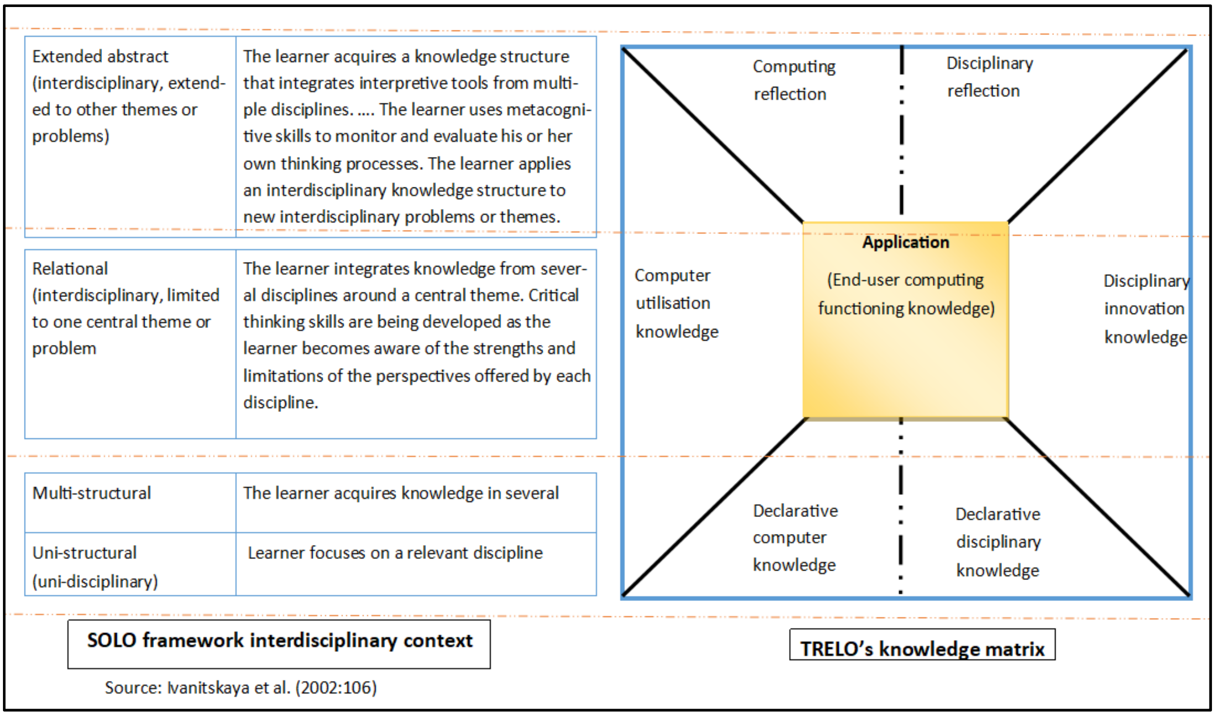


Figure 6.14 Aligning the TRELO framework to the SOLO taxonomy

Computer utilisation and disciplinary innovation can be argued to be similar to the relational level of understanding in the interdisciplinary context perceived by Ivanitskaya et al. (2002). This is because the learner uses both computing knowledge (utilisation) and disciplinary knowledge (innovation) to solve problems. By combining computer knowledge and disciplinary knowledge to solve problems, learners begin to think across both disciplines. Ivanitskaya et al. (2002:106) indicate that relational thinking in an interdisciplinary learning environment leads to “interdisciplinary content thinking (declarative and procedural knowledge), critical thinking skills, some metacognitive skills and advanced epistemological beliefs”.

Computing reflection and disciplinary reflection in the TRELO framework represents thinking about, considering and judging how a problem was solved. This level of operation could be associated with an extended abstract level in the SOLO taxonomy. Ivanitskaya et al. (2002:106) write that, at the extended abstract level, a student exhibits “metacognitive skills to monitor and evaluate his or her own thinking processes. The learner applies an interdisciplinary knowledge structure to new interdisciplinary problems or themes”. This is similar to the explanation of Santos et al. (2017) that the students’ thoughts, actions and reflections become seamless as they develop a holistic level of understanding that breaks the bounds of disciplines.

6.4 Summary

The aim of a design science evaluation is to demonstrate that the design artefact stands its own among its peers by fitting into the landscape it was designed for (Gill & Hevner, 2013). The TRELO framework for facilitating functioning knowledge in end-user computing was evaluated in this chapter through the use of illustrative scenarios and analytical arguments.

The first scenario was a demonstration of learning instances of each of the six learning orientations that constitute functioning knowledge. The second example demonstrated how capstone projects that are modelled according to the dictates of the TRELO framework could be used as a quicker pathway to functioning knowledge in the end-user computing service course. The third demonstration illustrated how functioning knowledge could be achieved in an end-user computing learning activity designed for agricultural students studying crop sciences. It was also illustrated how the framework is compatible with current higher education instructional methodologies such as the flipped classroom methodology, blended learning and open learning approaches. Finally, the evaluation concluded by illustrating how the TRELO framework fits in with the accepted conventions on setting educational learning outcomes. The TRELO framework is compatible with two popular taxonomies: Bloom’s taxonomy and the SOLO taxonomy that are used for describing educational learning outcomes.

This research findings, insights, contributions, recommendation and conclusions are presented in the next and final chapter.

Chapter 7: Conclusion

7.1 Introduction

Paltridge and Starfield (2007) explain that the concluding chapter of a thesis summarises the study. They differentiate a summary from a conclusion when they write: "summaries are a statement of what the student found out; conclusions are a statement of the significance" (Paltridge & Starfield, 2007:151). Figure 7.1 illustrates how this concluding chapter fits into the overall design science strategy that was adopted for this study.

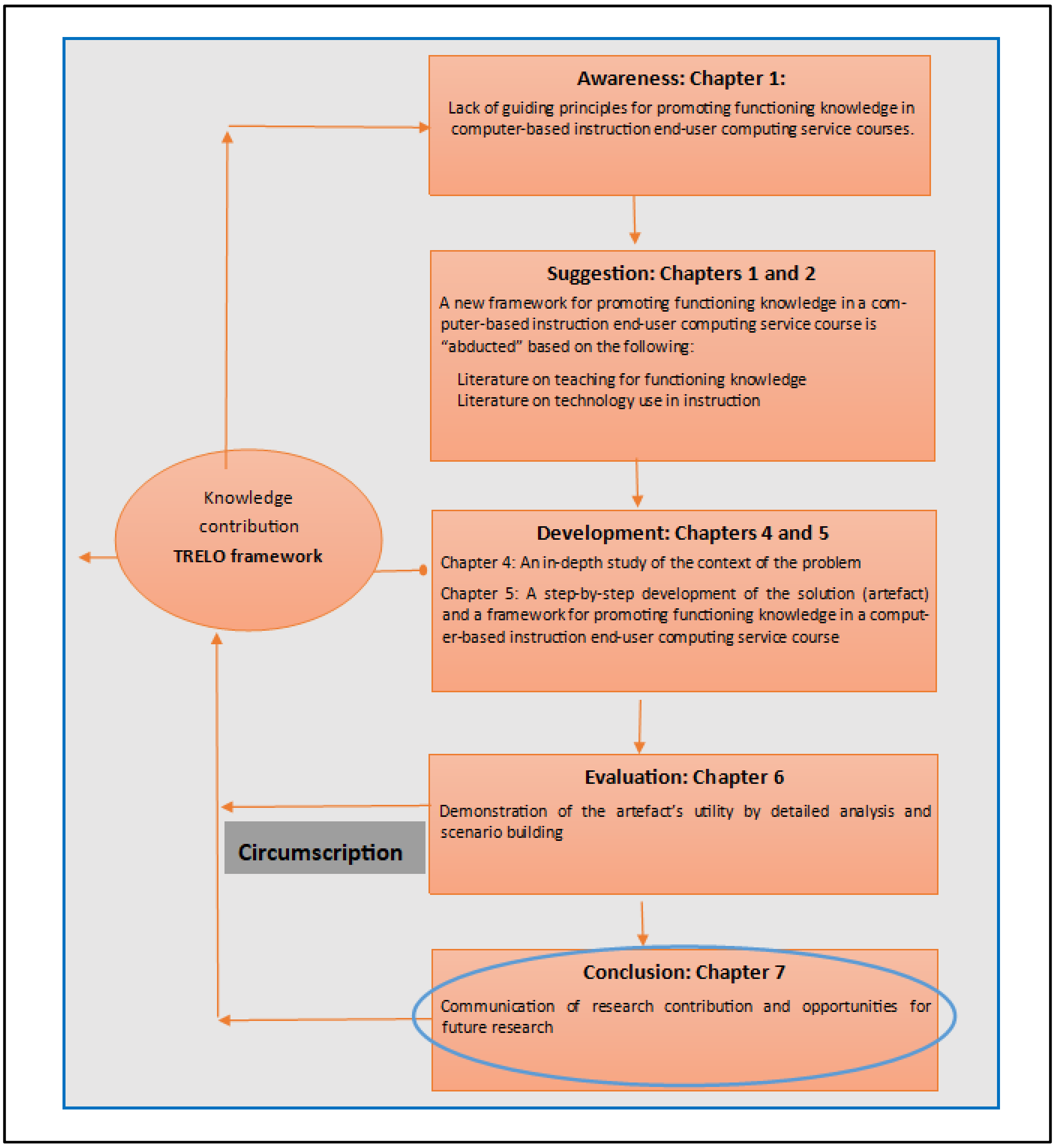


Figure 7.1: The conclusion of a design science process

The conclusion of a design science research effort is not a grand finale, but a communication of the insights that were obtained and an opportunity to point to areas that need further effort (Vaishnavi & Kuechler, 2012). Section 7.2 provides a summary of how the entire study was conducted in order to achieve the research objectives and answer the research questions. Section 7.3 focuses on explaining this research study's finding in terms of the research problem and the theory of design. Section 7.4 presents the contributions that this study makes to computer education literature with a special emphasis on the use of instructional technology. Finally, Section 7.5 presents the implications of this study for the teaching and learning of the end-user computing service course and Section 7.6 explores opportunities for future research.

7.2 Summary of the study

This study was motivated by the need to promote functioning knowledge in end-user computing service courses where computer-based instruction systems are predominantly used as the main medium of instruction. Concerned academics and preliminary literature highlighted a shortcoming in the design of commonly used computer-based instruction systems in terms of promoting functioning knowledge. A study of the use of computer-based instruction systems in teaching end-user computing service courses was then undertaken, and a framework for promoting functioning knowledge was recommended. The following paragraphs summarise the research objectives and how they were addressed.

7.2.1 How were the research objectives achieved?

Four sub-objectives, as outlined below, were designed to realise the main objective.

The nature of the end-user computing course

The first sub-objective was to understand the nature of functioning knowledge in computer-based instruction end-user computing service courses in order to gain the insights that are necessary to promote functioning knowledge. This was done by interviewing end-user computing lecturers and programme leaders. Programme leaders are defined as the academic leaders from faculties and programmes from which end-user computing students are drawn. The researcher also studied the material that was used to teach the subject, observed the actions of two colleagues who were teaching the course and drew on insights obtained from facilitating the course. It was observed that the essence of the end-user computing service course is the application. The notion of application in the end-user computing course has a dual context. The first context denotes artefact utilisation. This is the use of computing knowledge to successfully operate the computer system, its hardware and associated software to solve problems. The second context in the innovative use of disciplinary knowledge is crafting a computerised solution. The end-user computing service course knowledge also comprises elements of reflection. A computing reflection appraises problem-solving processes and solutions in terms of the computer-related knowledge that has been applied. Likewise, a disciplinary reflection appraises problem-solving processes in terms of the disciplinary knowledge used.

The use of computer-based instruction systems

The second sub-objective studied the use of computer-based instruction systems in teaching end-user computing courses in order to gain the insights that are necessary to promote functioning knowledge. This was achieved by asking participating lecturers to describe the learning setup at the institutions for which they worked. The researcher considered the setup of the teaching and learning environment at the institutions at which he had worked. Insights from Laurillard (2002) and Mayes and Fowler (1999) and observations made during the study indicated that computer-based instruction systems, such as SAM and MyLab IT, have three contexts to which they can effectively be applied in a learning environment. The systems have large repositories of video, training material and online demonstrations to support a content delivery role. This content delivery role supports concept formation during learning. The systems also have projects that use real software tools such as word processors, spreadsheets and desktop publishers. These tools can be used in productive learning when students produce real documents. In addition, the computer-based instruction systems have the facilities to integrate communicative tools. These communication platforms support learning dialogues and discussions that are crucial for sharing reflections and insights.

Promoting functioning knowledge

The third sub-objective focused on identifying the aspects that promote functioning knowledge in a computer-based instruction end-user computing service course and organising them into a conceptual framework for promoting functioning knowledge.

This was done by intuitively creating an end-user computing service course knowledge matrix that focuses on functioning knowledge principles on the one hand and the observations that were made during a study of the end-user computing course on the other. The result was six learning orientations that characterise the nature of functioning knowledge in an end-user computing service course: declarative computer knowledge, declarative disciplinary knowledge, computer utilisation knowledge, disciplinary innovation knowledge, computing reflection and disciplinary reflection.

Declarative computing knowledge focuses on knowing about the computer as an artefact. Declarative disciplinary knowledge focuses on the knowledge obtained from specific disciplines such as agriculture, commerce or hospitality management. These two types of knowledge contribute to computer utilisation knowledge and disciplinary innovation. Computer utilisation knowledge is the know-how that is required to utilise the computer artefact and its associated software in solving problems. Disciplinary innovation is the use of disciplinary knowledge to craft context-specific computer solutions to problems. Computing reflection focuses on appraising how problems are solved in the context of computing tools, methods and processes. On the other hand, disciplinary reflection focuses on thinking about the problem and its solution in light of the disciplinary knowledge that is available.

The next step was to ascertain the role of computer-based instruction systems to support instruction and promote functioning knowledge.

It was indicated that promoting functioning knowledge in an end-user computing course involves creating learning environments that explore the six learning orientations and using computer-based instruction systems to support particular aspects of this exploration. The systems play a content delivery role through the provision of notes, slides, video and revision material that support the conceptualisation of declarative computer and disciplinary knowledge. In addition, computer-based instruction systems play a productive role in which real application software, such as word processors and spreadsheets, are used to create and produce documents and projects that are uploaded for assessment. Using courseware in that context supports constructive learning. Finally, the systems have discursive interfaces for enacting dialogues and discussions. Such dialogues promote the exchange of insights and reflective thoughts.

The utility of the TRELO framework

The fourth and last research sub-objective focused on illustrating how the conceptual framework that had been identified could be applied to facilitate functioning knowledge in a computer-based instruction end-user computing service course. It was demonstrated that the proposed artefact had both utility and consistency in relation to conventional practices. This was done through arguments and illustrative scenarios. The first demonstration was an illustration of how the TRELO framework could be used to guide learning in each of the six learning orientations. The second scenario illustrated how an end-user computing learning process that explores all six learning orientations could be conceived to result in functioning knowledge. The role of computer-based instruction systems in supporting the learning process was explained. The third illustration showed how capstone projects in end-user computing courses could be used as a short cut for setting up assessments that cover all six learning orientations in an authentic learning environment. The last illustration focused on how the TRELO framework could be aligned with two widely used taxonomies: Bloom’s taxonomy and the SOLO taxonomy, for defining educational learning outcomes.

The next subsection illustrates how the design science research method was used to accomplish the research objectives discussed in the previous paragraphs.

7.2.2 How the problem-solving process evolved

The design science research method was used to operationalise this research, and the document is presented in a format that depicts phases of the design science research process. Circumscription[10] processes and moments of reflection, however, resulted in a spiral and iterative problem-solving process. Spiral approaches to artefact development, together with incremental refinement, have had considerable use in information systems development (Satzinger, Jackson, & Burd, 2016). The five phases of the design science research process stated by Kuechler and Vaishnavi (2008), awareness of the problem, suggestion, development, evaluation and conclusion, used a template for the problem-solving process. Figure 7.2 is used to illustrate how this problem-solving process unfolded in a cyclic fashion. It should be studied together with Table 7.1, which provides an explanatory key to the figure. Terminology from other

[10] Circumscription is depicted in design science research as the process or act of learning through construction, especially the lessons that are learnt when things do not happen as expected.

design science authorities such as Takeda et al. (1990), Hevner et al. (2004), Peffers et al. (2007) and Kuechler and Vaishnavi (2012) is also incorporated into Figure 7.2 and its interpretation. It is important to note that although Kuechler and Vaishnavi (2008) described the first phase as an awareness of the problem, Figure 7.2 illustrates the phase as involving both an awareness of the problem and its definition. Similarly, the third phase is described as incorporating both the design and development of the solution as opposed to describing it as development only. The last phase that Kuechler and Vaishnavi (2008) indicate as a conclusion is described as communication in this research. This term is perceived to be more applicable to academic research efforts. This phase communicates the connection of the research and its contributions to theory. Kuechler and Vaishnavi (2012) concede that the design science research conclusion is not a grand finale, but, instead, a communication of the tentative solutions, insights obtained and their implications for future design.

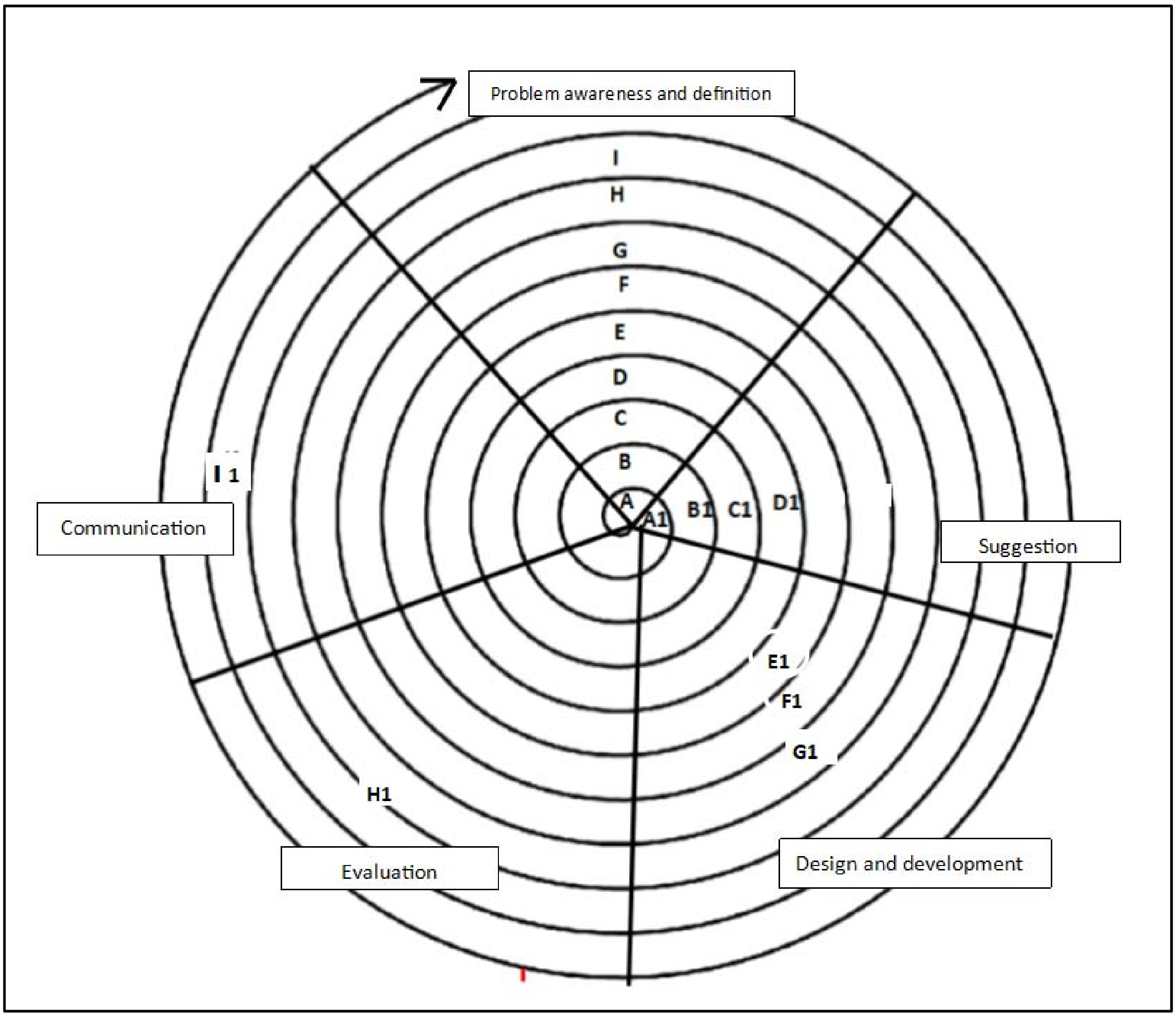


Figure 7.2: How the problem-solving process unfolded

Table 7.1: An explanatory key to Figure 7.2{ TA \l "Table 7.1: An explanatory Key to Figure 7-2" \s "Table 7.1: An explanatory Key to Figure 7-2" \c 1 }

Key	Description	Phase
A	What are the signs (symptoms of a problem)?	Problem definition
A1	Dissatisfaction with the quality of the end-user computing graduate	Suggestion
B	Where does the problem lie?	Problem definition
B1	A lack of functioning knowledge in computer-based instruction environments (content and mode of instruction)	Suggestion
C	What is the solution?	Problem definition
C1	Guidelines (a framework) for promoting functioning knowledge in a computer-based instruction service course	Suggestion
D	What are the current shortcomings of current technology-use frameworks?	Problem definition
D1	Current literature on technology use and functioning knowledge is not course specific.	Suggestion
E	What is the nature of functioning knowledge and how do students learn functioning knowledge in an end-user computing service course?	Problem definition
E1	Functioning knowledge is the performance of a task with understanding. Learning is active construction. It is participative and reflective. Learning functioning knowledge in the end-user computing service course involves understanding declarative facts, applying them and reflecting on actions.	Suggestion
E2	Solutions presented in E1 serve as design recommendations.	Preliminary design
F	What is the role of computer-based instruction systems in instruction?	Problem definition
F1	The computer-based instruction role includes content delivery, productive use and is discursive.	Suggestion
F2	Solutions provided in F1 serve as design recommendations.	Preliminary design
G	How do I create a framework for promoting functioning knowledge?	Problem definition
G1	Incorporating the six learning orientations and using computer-based instruction systems to support each learning orientation differently.	Design and development
H	How can the framework be evaluated and proved worthy?	Problem definition
H1	Demonstrations of the artefact's utility and illustration of how the framework fits into its landscape.	Evaluation
I	What are the lessons learnt? (New insights on all aspects of the design science research.)	Problem definition
I1	Conclusions and communication. Insights on the design process. Recommendations for practitioners.	Communication and conclusion

Key	Description	Phase
	Opportunities for future research.	

It is important to note that the cyclic nature of the research process was characterised by “revisiting” the problem definition after each operation. This is an indication that each design science action helped the researcher to know and understand more about the problem that was being solved.

From problem awareness to problem definition

Hevner et al. (2004) point out that design science research focuses on the real problems that affect practice. The letter **A** in Figure 7.2 and in Table 7.1 signifies a point in time that initiated the problem-solving process that resulted from disappointment in the attributes of the end-user computing service course graduate. This dissatisfaction could be associated with the initial stages of the problem-awareness phase in the design science research process. At Stage **A1**, it was conjectured that the course, as offered at a particular institution, was not equipping students with computing skills that are crucial to make them functional in their disciplines. Vaishnavi and Kuechler (2007) explain that a design science research suggestion is informed by prior knowledge of related issues and “thought experiments” that explore the feasibility of each option.

A brief introspection, indicated as Point **B** in Figure 7.2 and in Table 7.1, considered the possible sources of the problem. Questions such as “could it be the content, the method of instruction, poor teaching, or a lack of resources?” were asked. Hevner et al. (2004) highlight that peoples’ actions, organisational processes and the technology used in organisations create problems that need solving. The introspection led to Point **B1** in Figure 7.2, where a realisation and a suggestion was made that functioning knowledge is lacking in computer-based instruction environments. This realisation indicated that the problem had to do with both the nature of the knowledge that is realised in the course and the mode of instruction. It is important to note that this realisation represented a transition from being aware of a problem to understanding its nature. At this point, the problem could be understood and led to this research’s main question: “How can functioning knowledge be facilitated in a computer-based instruction end-user computing service course? This is indicated as point **C.** Once the problem could be formally defined in the form of a research question, the required solution could be stated. This is indicated by point **C1**, where the solution was suggested in the form of guidelines for promoting functioning knowledge in a computer-based instruction end-user computing service course.

The researcher had to evaluate the prevailing literature and artefacts to establish whether a solution already existed (point **D**). It was observed that, although literature on functioning knowledge and technology use in pedagogy was prevalent[11], none gave direction to the promotion of functioning knowledge in a computer-based instruction end-user computing service course (point **D1**).

This research's main finding during the awareness stage, in terms of design science thinking, is what would be referred to as the triple transition. The first six points indicate three critical transitions in the early stages of the design science research. Pair **A** and **A1** indicates problem awareness; pair B and B1 indicates problem definition; and the last pair, **C** and **C1**, signifies solution identification. A discussion of these triple transitions will be presented in detail in the next section on research findings. It is also important to note that this problem awareness stage informs forthcoming stages, hence the illustration of the process as circular and spiral in nature (see Figure 7.2).

Suggestions and design insights

Vigorous and determined efforts to realise the solution started once the solution was identified. This is indicated as points **E, E1** and **E2** as well as **F, F1** and **F2** in Figure 7.2. Two points (**E** and **F**) mirror this study's first two subquestions[12]. The search for the solution involved two aspects: a much more intensive literature review and an empirical study of the way the course is taught. The literature review sought to gain a deeper understanding of the principles of sound pedagogy, and the nature of functioning knowledge and insights into the role of technology in instruction with a special emphasis on computer-based instruction. The empirical study sought to understand how experts such as lecturers and programme leaders view the nature of functioning knowledge in the end-user computing service course, how the course is taught and how computer-based instruction technology was used. The empirical study

[11] The following were considered: teaching for functional knowledge of Biggs and Tang (2007), the TPACK model, the three-stage model of Mayes and Fowler (1999), the conversational model of Laurillard (1993) and Rod Sims's Design Alchemy model.
[12] Sub-question 1: What is the nature of functioning knowledge in an end-user computing service course?
Sub-question *2:* How are computer-based instruction systems used in teaching end-user computing service courses?

was qualitative and involved interviewing end-user computing service course instructors and academic leaders from the programmes from which end-user computing students are drawn. It also involved observing instructors teaching the course, studying curriculum documents, understanding the way computer-based instruction systems, such as SAM and MyLab IT, were used and reflecting on their own experiences.

Points **E1** and **F1** represent revelations from the literature review and the empirical studies that answered this study's first two subquestions. It was reviewed that knowledge acquisition involves active mental construction; it is participative and reflective. Functioning knowledge in the end-user computing service course comprises at least six types of knowledge: declarative computer knowledge, declarative disciplinary knowledge, computer utilisation, disciplinary innovation, computing reflection and disciplinary reflection. The first two focus on understanding declarative facts; the second two focus on applying the facts; while the last two involve reflecting on actions. Insights from literature and discussions with end-user computing lecturers revealed that the role of computer-based instruction systems in end-user computing service course training is threefold. Computer-based instruction systems deliver content, allow the productive use of real software and support discussions. Points **E2** and **F2** signify the transition from the suggestion phase to preliminary design stages where insights drawn from literature reviews and qualitative studies served as the basis for conceiving the framework. This transition was not once-off. It involved movements back and forth the suggestion phases and the design stages, hence the inclusion of **E1** and **F1** in the suggestion phase and **E2** and **F2** in the preliminary design stages.

Design and development

Points **G** represent moments of creating the TRELO framework as guided by Subquestion 3*:* "What aspects promote functioning knowledge in a computer-based instruction end-user computing course and how can they be organised into a coherent framework?" Point **G1** indicates the answer to this third research subquestion, where it emerged that a framework for promoting functioning knowledge in the end-user computing service course entailed incorporating the six learning orientations that constitute the end-user computing service course knowledge matrix and using computer-based instruction systems to support each learning orientation differently. Computer-based instruction systems could play a content delivery role when the focus is on concept formation that involves declarative computer knowledge and declarative disciplinary knowledge. The systems could enable productive learning when students use real software and apply computer utilisation knowledge and innovative disciplinary knowledge to produce actual computer products that represent a solution to a problem. These could be informative emails or payrolls done on a spreadsheet program. Finally, the systems could facilitate dialogue and communication amongst students and instructors when sharing insights and reflections.

Artefact evaluation

Point **H** in Figure 7.2 and Table 7.1 represents the point when the TRELO framework was evaluated. The evaluation is informed and shaped by Subquestion 4: "How applicable is the framework identified in Subquestion 3 in promoting functioning knowledge in a computer-based instruction end-user computing service course? Various evaluative options were considered based on design science research literature on artefact evaluation. Point **H1** represents the two key evaluative contexts, based on the recommendations of Hevner et al. (2004) that were chosen. The first was a demonstration that the TRELO framework is a useful and operable artefact for promoting functioning knowledge. This was done by presenting scenarios and learning contexts where the utility of the framework could be ascertained. The second evaluation approach considered the framework's compatibility with renowned practices in pedagogy. It was illustrated that the TRELO framework is compatible with prevailing and accepted higher education instructional methods such as the flipped classroom, open learning and blended learning. It was also illustrated that the framework is consistent with two well-accepted notions on specifying educational learning outcomes: Bloom's taxonomy and the SOLO taxonomy.

Communication

Point **I** in Figure 7.2 and Table 7.1 represents the conclusion of this particular instance of the research process. Kuechler and Vaishnavi (2012) advise that the design science research conclusion is not a grand finale, but a communication of the tentative solutions, the insights obtained and their implications for future design. Point **I1** represents an indication of how these insights affect all the stages of the design science research process. The insights are communicated in Section 7.3.

7.3 Conclusion

This section communicates what Paltridge and Starfield (2007) call the statements of significance of the research in the form of the insights that were obtained from the research study and its contribution to design science theory. Recommendations for the practice of pedagogy, its implications and limitations, as well as opportunities for future research, are made.

The study was conducted in the realm of design science theory and was carried out in an iterative fashion. The solution was grown organically while considering the phased approach that is characteristic of traditional design science research theory. Two contexts will be considered for each of the findings in this section. The first highlights the implications for design science research theory, thereby indicating the contribution that this research makes to design science thinking. The triple transition in the initial stages of design science research is put forward as one such contribution. The second aspect is the contributions that this study makes to practice, thereby emphasising the utility or relevancy dimensions of the research. The TRELO framework and the notion of the end-user computing knowledge matrix are put forward as pedagogical artefacts that are helpful to practitioners (educators). Thus, this research has both rigour and relevance.

7.3.1 Contributions to design science

The triple transition in the early stages of design science research

Three distinct transitions in the problem awareness and definition stage were observed in this study. Firstly, a problem was realised in the end-user computing service course when programme leaders, the researcher and fellow end-user computing instructors began to question the end-user computing graduate's competence. Secondly, a preliminary scan of related literature and considerations of the researcher's prior knowledge led to the realisation that the problem had something to do with the nature of the knowledge that is imparted in the course and the indiscriminate use of computer-based instruction systems as a means of instruction. Finally, a recommendation was made that the design of guidelines, in the form of a framework, could promote functional knowledge.

There is consensus in most design science literature that the initial stages of a design science research process are ignited by awareness of a practice-related problem that needs solving or improving (Hevner et al., 2004; Kuechler & Vaishnavi, 2012). Peffers et al. (2008) indicate that the awareness stage is an appreciation of a situation that motivates a better and alternative way of doing things. What is less visible in design science literature is the lesson for design science researchers that is implied in the triple transition in the initial phases of problem awareness and definition as described in the preceding paragraph. Design science researchers should be capable of distinguishing among observing the symptoms of a practice problem, defining the problem and prescribing its solution. Symptoms make the problem visible and observable; the definition indicates the source of the problem, while the prescription states the solution.

The moment programme leaders and the researcher start doubting the quality of the instruction offered to students is the moment when the symptoms of a problem are observed. A simple example of Johnny who is always late for work is used to clarify this illustration. The statement "Johnny is always late for work" is an observation of the symptoms of a problem. On the other hand, the observation that there is no bus that leaves Johnny's home early enough for him to be at work on time defines a problem. This second observation, made after some consideration, locates the source of the problem. Finally, a suggestion or determination that Johnny needs a company vehicle (or any other means of transport) for him to make it to work on time represents a solution to the problem.

Symptoms are the first signs of a practice problem. These are evident through mere observation and experience, as in the case of programme leaders and instructors raising their concerns regarding the competencies of end-user computing graduates. The definition of the problem comes after some kind of an investigation, as took place in the case of the preliminary literature, which identified the problem as a lack of functioning knowledge in a computer-based instruction end-user computing service course. This led to the recommendation of a solution in the form of a framework for promoting functioning knowledge. It is important to note that not all design science research problem-solving approaches need to undergo the proposed triple transition. Gill and Hevner (2013) write of problem-space maturity, implying that in instances where a problem is well known and developed, it is possible to start the problem-solving processes with later stages such as recommending a solution.

7.3.2 Contributions to pedagogy

Hevner et al. (2004) highlight the fact that artefacts, as instances of design science efforts, must have real-life usefulness for practitioners in the field. The next paragraphs explore contributions and insights that this research makes to pedagogy.

The end-user computing knowledge matrix

The TRELO framework proposes that functioning knowledge in a computer-based instruction end-user computing service course is achieved through the considered use of computer-based instruction systems in support of the acquisition of six kinds of learning orientations that contribute to end-user computing service course knowledge. The TRELO framework integrates the work of Biggs and Tang (2007) on quality teaching in higher education and observations from a study of the nature of an end-user computing service course to put forward six learning orientations that characterise the course. The work of Laurillard (2002) and Mayes and Fowler (1999) on the role of technology in instruction is used to illustrate how instructional technologies such as computer-based instruction systems can be used to support learning activities that promote functioning knowledge. The framework demonstrates how learning objectives and processes in a computer-based instruction service course can be designed to achieve functioning knowledge. It is, thus, an additional toolkit for educational practitioners.

Interdisciplinary boundary navigation

The study on the nature of the end-user computing service course revealed that the notion of the application has a dual context. End-user computing knowledge was seen as the use of computer skills in solving problems and the innovative use of disciplinary knowledge in crafting computerised knowledge. This observation contributes to the literature on interdisciplinary learning. Akkerman and Bakker (2011) explain that the traditional interdisciplinary approach is to find the pedagogical benefits of exploring the "third space" that lies between the boundaries of disciplines. They indicate that, although literature on pedagogical boundary objects is abundant, there is little to explain how such boundary crossing can be implemented.

Repko, Szostak and Buchberger (2013) highlight the fact that very little pedagogical literature is available to challenge students to integrate multiple sources and methods for solving problems. The TRELO framework could be construed as one such boundary navigation object that is designed to facilitate interdisciplinary learning between the computer discipline and other disciplines such as agriculture. The framework proposes that the nature of functioning knowledge in the end-user computing service course requires a strong disciplinary focus on both computer knowledge and disciplinary knowledge. Learning in the end-user computing course should navigate and touch on all six facets that constitute the end-user computing course knowledge matrix.

7.3.3 From multidisciplines to interdisciplines

Van den Besselaar and Heimeriks (2001) explain that the issue of interdisciplinary learning is crucial to pedagogy, but has the challenge of a complex definition. The interdisciplinary learning process implores the integration of knowledge from more than one discipline over a common learning theme or topic (Holley, 2017). Three concepts – intradisciplinary, multidisciplinary and interdisciplinary –, are often cited in interdisciplinary studies and can be illustrated using the TRELO framework as a reference. McPeek and Morthland (2013:619) define these three terms as follows:

- Intra-disciplinary: Being or occurring within the scope of a scholarly or academic discipline or profession
- Multidisciplinary: Knowledge associated with more than one existing academic discipline or profession
- Interdisciplinary: New knowledge extensions that exist between or beyond existing academic disciplines or professions

Firstly, declarative computer knowledge and declarative disciplinary knowledge could be closely associated with intradisciplinary learning. Learning at this level is still confined to a particular specialised discipline and profession. Secondly, computer utilisation and disciplinary innovation knowledge indicate a multidisciplinary approach. The two demonstrate the active use of computer and disciplinary knowledge to solve problems that are more often across the disciplines. The student begins to merge knowledge from the discipline of computing and agriculture, hospitality management or commerce, for example, to come up with solutions. Finally, computing and disciplinary reflection create a platform for interdisciplinary learning when students reflect on their actions and extend their insights to contexts that are within and beyond the confines of each discipline.

7.4 Implications

The insights and observations raised in this research have practical implications in the teaching and learning of the end-user computing service course.

7.4.1 End-user computing can be a fulcrum of disciplinary innovation

The end-user computing service course has the potential to be at the centre of interdisciplinary innovation instead of being one of the supplementary courses that students complete in order to be proficient with using computers. Innovative learning that spurs disciplinary knowledge can actually originate in the end-user computing service course. The seed germination activity that was used to illustrate how end-user computing students could acquire functioning knowledge when learning spreadsheet processing skills can be expanded to spur further investigation in the agriculture course. Students could start to explore whether their observations are only applicable to wheat species or whether they can be applied to other grass species as well, such as maize, barley and corn. They could also start investigating whether these observations can be attributed to temperature variations or to other variables that were not investigated, such as humidity or pathogens in the soil.

7.4.2 The skills of end-user computing instructors

The study revealed a need for joint course development by cross-disciplinary experts in the end-user computing course. Computer scientists and disciplinary specialists in other fields such as agriculture and science need to be involved in the design of the end-user computing curriculum. This will ensure that learning activities and tasks are rooted in the appropriate disciplinary contexts. The study showed that the implications of this observation are that the end-user computing instructor has to be an interdisciplinary expert as opposed to a computer scientist. An interdisciplinary specialist would be capable of navigating the cross-boundary territory that comprises computer utilisation on the one hand and disciplinary knowledge on the other.

7.4.3 The role of the end-user computing instructor

The study revealed that, in as much as computer-based instruction systems provide empowering tools, the role of the instructor is still paramount in the construction of functioning knowledge. The systems have repositories of resources that can make content available that supports declarative knowledge and guides students to learn how to perform computer operations. The two systems that were analysed, SAM and MyLab IT, included general problems, tasks and cases that were not crafted to reflect the students' authentic contexts. The end-user computing instructor's role in enacting the authentic learning environment to ensure functioning knowledge thus becomes indispensable.

7.4.4 The importance of scaffolding

Scaffolding is an instructional practice that encourages guided and structured learning processes (Hammond & Gibbons, 2001). The TRELO framework proposes that functioning knowledge in the end-user computing service course is achieved through learning outcomes that navigate and touch on all six orientations. Instructional design and teaching activities in the end-user computing service course need to have built-in scaffolds that enable navigation for functioning knowledge to be possible.

7.5 Limitations and opportunities for future research

This section considers the limitations of this research and points out some areas that would merit further investigation as a result of the insights obtained in this study.

7.5.1 Limitations

Frameworks are mere guidelines and not prescriptions for solutions

The TRELO framework that was developed and presented in this study should be evaluated in the context of frameworks. Frameworks are, by their very nature, generalised guidelines that require refinement. Instructors in end-user computing courses would still need to be competent educators who can design learning activities within the guidelines of the framework. Instructors would still be required to design specific teaching and learning strategies that suit different contexts and variables such as the technology that is available, students' prior knowledge, and their institutional and curriculum-related requirements. The framework on its own does not guarantee functioning knowledge in the end-user computing service course. It is like a tool that only serves its purpose when placed in the right hands.

Challenges of instructional technology

The framework is conceived on the basis of ideal instructors and students. There is an inherent assumption that students will read their work and go through the learning material that is available to them. There is also an assumption that exploring the six learning orientations flows smoothly from declarative knowledge to reflective thinking. The framework does not account for the challenges that come with instructional technology, such as learner apathy towards e-learning and technophobia (Madiope & Govender, 2015).

7.5.2 Opportunities for future research

A need for empirical evaluation

The framework is demonstrated using illustrative scenarios. These demonstrations are backed by well-publicised literature, but there is no empirical evidence on the practical implications of adopting the framework. Further research could extend some of the sample lessons and ideas that are presented in the framework and implement them to note the practical implications of adopting the framework.

Extendibility to similar courses

The cases that are used in this study are computer-based examples. Several university courses are conceived in the context of service modules, such as applied statistics and business communication. The research could be widened to observe if the concept of the six learning orientations could be applicable to other courses that reference more than one discipline.

7.6 Concluding summary

The research question posed at the beginning of the study asked how functioning knowledge can be facilitated in a computer-based instruction end-user computing service course. The study affirmed that functioning knowledge in a computer-based instruction service course can be promoted by exploring the six learning orientations that characterise the computing service course. Computer-based instruction systems can be used to support the learning process by providing learning content that supports concept formation during learning. The systems could also be used to facilitate constructive learning when students use productive software such as spreadsheets, databases and word-processing software to solve problems. Finally, computer-based instruction systems can be configured to support discursive dialogues that are important for reflection.

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Chapter 8: Appendices

Appendix 1:

Structured interview questions with end-user computing lecturers

Interview protocol

1. Introduce myself as a PhD candidate from the University of Pretoria and reveal ethical clearance letter.
2. Brief the participant on purpose of the interview and assure him or her of confidentiality.
3. Inform the participant that the interview is recorded.
4. Ask the participant to turn down the interview if he or she is uncomfortable.
5. Assure the participant that he or she may refuse to participate at any stage.
6. Ask the participant to sign the consent form.

Interview stage	Key questions
Introduction • Collect basic information about the participant and their experience • Understand the teaching and learning environment	1. How long have you been teaching end-user computing? 2. Describe your qualifications, academic and teaching. 3. How long have you been using computer-based instruction to teach end-user computing? 4. Which topics, concepts or areas do you cover in your end-user computing course? 5. Describe how your learning programme is set up in terms of student numbers, their faculties and year levels. 6. Which computer-based instruction systems do you use to teach end-user computing? 7. Describe the crucial learning activities and assessments that you use in the course.
Mid-stage • A focused discussion on how computer-based instruction is used in teaching end-user computing	1. Describe the knowledge or skills that you think is important to an end-user computing student and the reasons you think that way. 2. How does end-user computing knowledge gained in your course help the students in their disciplines and careers? 3. Describe the teaching and learning activities that you do to ensure that these skills are obtained during your course. 4. What features of computer-based instruction system do you use to ensure that learners acquire the vital knowledge that is useful for their careers and disciplines?

Interview stage	Key questions
	5. Describe your experience with computer-based instruction in teaching end-user computing in terms of its benefits and limitations. 6. What features or capabilities would you recommend be incorporated in the computer-based system in order to promote useful knowledge?
Closing stage • Thank the participant and request for further referrals	Do you know of any other instructors who would be interested in participating in this research?

Sample transcribed interview transcript

Structured interview with an end-user computing lecturer

CODES: NZ = Researcher; RH = Interview participant

NZ:	So good afternoon, thank you for agreeing to this interview, in which we are trying to gather information and your experience with the end-user computing subject. I will be asking you questions, and you are free to say no to any question or add more information. I will be recording the interview with your consent, of course. Your name will not appear anywhere in this research, it will be edited out, and no one will be able to trace your answers to you.
NZ.	In the first section of this discussion, I am interested in your qualifications and how long you have been teaching the subject (end-user computing).
RH:	*I have been teaching it for 5 years.*
NZ:	Excellent, you are quite experienced to be answering my questions, and your qualifications, academic and teaching-wise?
RH:	*Academic I have a degree, BSC degree.*
N.Z:	Do you have any experience in teaching the subject using computer-based training?
RH:	*Yes, Yes, I do. I use, eem, what is it called SAM from Cengage, it is meant to assist and help students learn.*
N.Z	Alright we will be coming back to that later. For now, can you please describe for me how your academic programme is set up, how many students, you have typically per session and overall.
RH:	*Ok, ee the environment is such that it is dictated by the number of resources we have. Usually we are using a class of 44, a class that could accommodate 44 students with 44 PCs. For the past three years we have been limited by the number of spaces available to an average of 40 students per session using the interactive kind of learning where in students are participating directly with the PC as you teach.*

NZ: So 44 per session and as an institution, what figure do you have as a total number for end-user computing.

RH: I would say an approximate number of 380 students. We usually have 250 students for national diploma in agriculture, around 120 for the Bsc Agric and B Agric what's the other filed, I forgot the other fields but in total in total there are almost 300 to 400 hundred.

NZ: Ok That quite a substantial number and significant number, … now tell me at what level do you teach end-user computing, first year, second year, third, fourth year?

RH: I only teach 1st years, the purpose of teaching first years is to introduce them to electronic learning and electronic management of school work and also for them to be able to know how to cope with technology since everything in the university is presented technologically.

NZ: You mentioned that you have a Learning technological systems (SAMS) that you use, do how do you use it.

RH: It is able to give them extra work, tutorials through video and other interactive materials that they can use outside the classroom. It has a substantial number of resources that are able to help. However, the only challenge with the computer-based test (CBT) is that it requires self-learning which most of our students are not acquainted with. From their matric level they are usually (know) used to contacts sessions with the teacher, when it comes to self-learning it's a bit difficult for them. I have realised that if you give up everything and to the system to assist them, the performance is very very poor. They still require a teacher much more than the system itself, yet those who are able to learn through the system tend to do much better and to be more equipped as opposed to those who solely rely on the system, but now electronic learning is something that they are not used to.

NZ: Ok, Ok, I just what to unbundle that one a little bit, let's talk about something that you mentioned about students being not experienced enough or not being used to electronic learning, can you explain that little bit further?

RH: It is a very very big factor because the idea behind CBT's is actually to allow students to be able to improve and learn on their own which is I could say out of the 100% of the system, the main object which is 70% is for students self-learn which they don't do they only use 30% part of it where they submit work and write tests and other things. They compromise the entire 70%, which is meant to help them in learning, so it is a limiting and it is quite difficult to have a solution for it. However, surprisingly, when it comes to social issues, they become they are excellent when it comes to doing school work there is something different, there is a missing link there. If we would be able to take the interest that they have for social issues electronically and they have the same kind of interest in learning electronically then we would be able to go far. We have to establish why the lack of interest in learning. They need interaction from the lecturer so that they will be able to ask specific questions which may not be answered *by the system. They also need the system because it allows them to learn outside the classroom*

NZ: Right: So now I want to ask you something that has to do with the actual system itself, let's take away the commitment, let's take away the self-directedness or the passion to learn or self-learn and (look) focus on the design of the system that you use, SAM. What do you think are its limiting aspects, to the subject itself (end-user computing)?

RH: Honestly speaking: The Skills assessment manager (SAM) has got no limiting factors. What I have learnt is that the limitation comes from the type of candidates you have. The SAMS itself the way it has been designed looks like a thorough research has been made because it covers all aspects of teaching and learning. It makes it easy for the lecturer to teach, it makes easy for students to learn, it is comprehensive, there is nothing miss in it, the only challenge as I have said is electronic learning. The challenge exists in our candidates and not in necessarily on the system itself. We do have quite a few number of our students who are able to use it very effectively. They do very well which is also a problem for us, because those who get to master it too much, you know its is a system and it can easily give you 100%, but if I was marking manually, I could try and penalise for spelling and other things. The problem with the system is that once it is mastered it works against the system in the university in the sense that you get to see very good marks.

NZ: Ok now you said if they mastered the system. Could they be a difference between mastering the system like you said and mastering the subject knowledge of end-user computing.

RH: If I were to say in terms of ratios, in terms of mastering the system against mastering the content, there would be a ratio of 5 is to 3. The program itself has got its own short comings. Comprehensive and complete as it is, it lacks that human element such as reading an essay from a student as an example so in most cases when I talk about mastering it, you know, you only click to an answer, you select, you match, there is no way where a student has to write a paragraph and then it is scrutinised and marked, so that part of learning has to come from the lecturer. So, if we were to entirely depend on the system for everything and overlook normal teaching, those are the kind of problems we could have, because it cannot, in terms of assessment it is limited to certain degree. They can't discuss, they can't explain, also they cannot, substantiate their answers, they just click the correct answer, that's it. So, I could say it limits.

NZ: Ok, right, sorry to take you back gain, what would you then see as the role of the system and the role of the lecturer in such a setup. You said we have a very comprehensive system and you acknowledged its strengths and you mentioned that it lacks that human element and normally universities have lecturers in place, what then would be the role of the lecturer and the role of the system in such a setup.

RH:, The lecturer has got his own role which the system cannot take care of. There are things that a lecturer can do that the system cannot do and things the system can do that a lecturer cannot do. The two complement *one another. So, it would be a good idea to have the approach from both sides. The system in terms of managing the subject is excellent, in terms of doing administrative work such as scheduling of tests assessments also calculating scores and so on, yet the other part wherein the students have to demonstrate their understanding of the concept can only come from the lecturer. Yes, the system may teach them how to do certain things because it is very interactive, they are concepts which require explanation and an understanding as opposed to using an app.*

NZ: Umm, that excellent, I think we have talked extensively on and about the system. Let's now go back to an aspect that I am interested in. At the beginning you said the subject is taught so that students would be able to managed their learning. I am assuming that these learners are coming from different faculties. And they are not computing students, if may assume that.

RH: Right

NZ: So, how then do you make sure that the end-user computing knowledge that they get is relevant to their studies.

RH: Ok the basic existence of end-user computing is first and for most help students to be able to manage their work electronically and to do whatever they do, whether in their field, whether it's something else that requires an overall management you know of their enrolment in the university that is what the system does. It is very-very much specific to their field. All of them it doesn't matter where they come from, because at some point all these fields requires, I will give an example of an assignment, an assignment has to be typed, it has to be printed, it has to be prepared using a computer, so it is programme independent. It works for all programmes. Yet again not only does it assist in managing the electronic work, the computer subject itself helps in their thinking. When we teach end-user computing we teach things like binary numbering, the way a compute operates in some cases it sounds to be irrelevant to the students. But if you make them understand how a computer works and how it thinks (operates) in a way it makes them adapt easily to any new technologies that they make come across. When it comes to subject specific or programme specific for instance agriculture students you create something like an invoice for them and you ask them about items from a farm and you put them in the invoice, you put prices you make the system calculate through excel which makes, it ends up looking as if now you are teaching agric and that is how they sort of merge and they become very relevant. Because although we are using a computer to calculate prices, we are calculating prices of things from the farm, each comes from the students themselves. You ask them how do you do this in agriculture and they explain to you and you show them how they should be able to use the system to yield the outcome.

NZ: And how effective is the computer-based system in teaching that kind of knowledge you are talking about, such as creating invoice.

RH: Not very effective, I must say, its moderate, because the core-concepts honestly speaking have nothing to do with the programme. It is a small fraction of situations where you have to use examples of their fields, *anyway you the instructor does not or may not have knowledge of some of the programme so you teach it generically, so when it comes to giving of an example and making of scenarios of real-life situation you confine yourself to their programmes. The information that you have about the programme doesn't come from you as a lecturer... instead it comes from them and you show them how you take the information into the system and how it gets processed and how you get results. So, it is a very small fraction. What is a big fraction is how to use technology for effective learning and studying and also managing one's life.*

NZ: Alright, OK, and maybe my last question as we are edging towards the end. If you were to think of features that you would want incorporated into the learning technology (SAM) what would come to your mind?

RH OK Before, I talk about the CBT, lets talk about the subject itself. You know the way in which technology is advancing day after day, its almost impossible to catch-up, but the subject itself needs to be structured in such a way that it should be able to help pupils to cope with change because there is too much change in technology. We may need to incorporate the use of mobile, currently we call it end-user computing. We are so much, computing should be inclusive of mobiles and other things that are able to process data. But if you look at our curriculum and our books, they are more focused on the physical computer, they are not so much focused on the working of mobiles and how to effectively use mobiles, the different kinds of setups that you have in mobiles and the desktop version. We are so much concerned about the desktop and now most of the work that we do these days to be honest is not necessarily done through the desktop but is done through mobile. So, we need to enhance the understanding of mobiles, how they work. Their effectiveness is not emphasised enough in the subject itself. I have checked several textbooks and their emphasis is on the desktop, laptop, they don't emphasis on the tablet you know. Another example, I would give an example on the operating system, they are more concerned on the windows, environment. In mobiles we have got android, we have got the iOS from apple and so on. Those technologies need to be learnt, all of them. They need to be included into the course itself and that obviously has to affect the CBT itself. Because CBT itself is Windows based so it kinds of limits people from exploring other available technologies which can even do better. As it is the CBT it much more limited to Windows.

NZ: Alright, let's go back to right now, what skills do you think are important to an end-user computing student, when you are teaching the students, when they walk out of the course, what would you say are the key critical skills that you think are important, that they should master.

RH: Because they are so many of them, I can be direct to say this should be skills

NZ: But you can just mention in general

RH: They should be able to produce results. They should be able to process information and produce some desired results. Yah, It could be in a form of printing out, or processing some kind of information, but the ultimate goal is *that they should be successful in getting the kind of information that they want. It comes in many forms and it is very difficult to say this skill is not critical and this skill is critical. They need to be complete. They may not be strong in all areas but they should be in a position where they are able to make a computer process information and give the desired output.*

NZ: And what sort of activities should be focusing on as universities so that we produce these results you are talking about, such as the ability to process information and for them to be complete.

RH: As a university what we should look at, we must not give the responsibility of learning to the end-user computing. It should be something which is done across the board. All programmes must somehow make sure that they support the use of technology by introducing customised software for particular programmes so that students can learn so many things the end-user computing task is very limited because it will show you how to do things generically but specialised software are only found in those programmes so introduce them, so if it AutoCAD in the engineering programme so introduce it. If it is farming what, what from agriculture introduce it. I have learnt that as a university we are not strong in that. We do not have and we do not support electronic learning that much. Maybe it can be attributed to skills empowerment for staff as well, because I have learnt that most of our staff are also challenged, when it comes to technology. But you go to other universities you realised that, end-user computing, out 100% of computer learning it only constitutes 60%. The rest of the other 40% comes from other programmes. They are shown AutoCAD, they are shown drawing software they are shown weather forecasting software which we are lacking here. In fact I even saw mathematics software, which I think for our mathematics literacy can be very helpful and also help the students enhance, perhaps we need to empower our staff on that so that they can be able to empower students as well.

NZ: Now, I think we have covered what I wanted to discuss in one way or the other in as much as the questions did not come exactly from what I had here but at least we discussed around the issues that I was interested in. Thank you so much**.**

Appendix 2:

Structured interview questions with programme leaders

Interview protocol

1. Introduce myself as a PhD candidate from the University of Pretoria and reveal ethical clearance letter.
2. Brief the participant on purpose of the interview and assure him or her of confidentiality.
3. Inform the participant that the interview is recorded.
4. Ask the participant to turn down the interview if he or she is uncomfortable.
5. Assure the participant that he or she may refuse to participate at any stage.
6. Ask the participant to sign the consent form.

The interview schedule

Interview stage	Key questions
Introduction: Collect basic information about the participant and their experience Understand the teaching and learning environment	1. What is your highest academic qualification? 2. How long have you been leading your programme? 3. How many students do end-user computing in your programme? 4. At what stage (s) is the end-user computing programme offered?
Mid-stage A focused discussion on the end-user computing programme	1. Which end-user computing knowledge/skills do you think are important to your students and why? 2. Which aspects of the current end-user computing programme, at your institution, would you recommend be changed. 3. How do you see the end-user computing knowledge gained in the end-user computing course helping the students in their disciplines and careers?
Closing stage Thank the participant and request for further referrals	1. Would you know of any other programme leader from another institution who would be whose comments would be valuable to this research?

Sample interview transcript

Interview transcript with programme leader **Codes: NZ = Researcher; LG = Interview participant**

NZ: *Thank you for agreeing to be interviewed for this research, in which we I am trying to find out your experiences and perspectives on the subject of end-user computing and the first questions I will be asking you are just general. Like just getting to know you and your qualifications and the role you play in your institution. So what is your highest qualification academically?*

LG: *I have got a Master's degree in Crop Science, Agriculture, that is my area of specialisation. I am a lecturer as well as a programme leader for the Bachelor of Science in Agriculture programme.*

NZ: *In summary, what is involved in programme leadership?*

LG: *Programme leadership basically, and literally means taking care of the programme. It is more like a baby. Whatever that baby needs you make sure that it is well provided in terms of the resources, the lecturers that are needed and need to be allocated to the modules be it first year and up to fourth year. Currently we are ending in third year and we haven't reached third year. So literary is the long and short of programme leadership.*

NZ: *Right and then I gather that have students who do end-user computing from your programme. How many students are we looking at? From the programme that you lead?*

LG*:* *They only do it in the first year, it is offered as a fundamental module, and others are core modules, so it and numerical literacy are the fundamental modules. The irony of it is that it is offered in the second semester, I feel it should be offered in the second semester, because you need to ground your students in those because you expect your students to type assignments and now we have migrated to e-learning and those competences are computer-based concepts. So if you now put it into the second semester, it doesn't serve the purpose it is intended to serve as early as I would want it to serve in the programme.*

NZ: *Which purpose then do you think is not served by not doing it in the first semester, as my understanding is that you already have expectations of the programme? What are those expectations?*

LG: *Of course. I have dialogues with students and they gave me this impression that probably where it is situated is probably the wrong place. I was teaching them one module and in that module I expected them to do their assignments that should have been typed for instance. So typing, that just basic tying became a challenge because I encountered students who were seeing a computer for the very first time in their lives if you understand. But I had to query if some had smartphones and I said you cannot realistically say this is your first time to encounter a computer. A laptop yes I agreed but you know a smartphone is a mini computer. So if you can type on Whatsapp you should be able to type. So that was one but not all have smartphones anyway. So that was the first challenge that I realised that typing is just an issue. It also means then use of*

MS Word would be an issue. It also means MS Excel is a problem because I expect them to draw graphs if I give them certain data. I expect them to construct graphs on excel. They should be able to interpret and present results. And you can only do those in a computer. In the olden days, yes you could draw them on a graph paper but now everything we literary and practically do on the computer.

NZ: *and did you find those skills lacking before they had end-user computing?*

LG: *Definitely.*

NZ: *An I presume you have also taught students who have done end-user computing,*

LG: *Um huu (Yes)*

***NZ**: Did you find out that these skills had improved, they could do things better? Was there any difference?*

LG: *I haven't gone to the level where I can literally…. You know that is research and of course teaching involves research.*

NZ: *But your experience, because you said at one point you taught students who were struggling and you said you teach students who are in first year, second year and third year? You teach across the curriculum, right? And your second-year students, by assumption would have done the course? and then your observation, of students who would have done end-user computing, did you see an improvement, was there …*

LG: *There was a little bit of an improvement, to be honest, but again to be honest but again you see they have used it as a yard stick. If you look at, like I have told you, they were migration from faculty V drive where we were storing information, it was more like a server where we store, everything that we need our students to access, materials and so forth. Electronically. We moved to Moodle, which is now and e-learning platform. There was a bit of resistance. You get a sort of mismatch, perhaps my feel is that the end-user computing itself has not yet stepped up., or they missed that opportunity. Perhaps learning how to use Moodle should have been incorporated into the end-user computing programme. It is my expectation that students should have been taught how to manage (use) the e-learning platform. It is my expectation towards end-user computing. And I cannot say they have these skills on board because we implemented it quite late. That like last year second semester that is when we went to Moodle. And with end-user computing there were issues of computer resources. So sometimes we had to shift the groups or shift it to first semester. But you then get students trying to use it as an excuse., that the teacher did not teach and now I have the burden to try and teach Moodle. I even assess it and that application on how to effectively use it. Then on top of it then tech module content through it. It then eats up my time of what I should be specialising in and focusing on. Because now I have to spend time going back to what I thought, what I expect end-user computing to address.*

NZ: *OK, we are going to come back to that. I just want to go back to the, in you opening statement you were speaking of the expectation of being able to type, using graphs, and things like that. SO did that improve in the second year after they had done their end-user computing do you see and improvement in that regard.*

LG: *The challenge I have, without me rushing to conclusion is that had there been this dialogue and the implementer and the programme leadership, because the implementers (should) get their direction from me. They normally, most of them, even I had a lecturer who called me for numerical and academic literacy on how we should structure it. Are still going to separate it, are we going to test and examine in differently, but in terms of the content I expect, we have already ironed it out.*

NZ: *You bring something exciting, I am actually interested, when you bring the dimension of the implementers having to talk to you. Obviously you have got a feeling that there are things that are omitted, that you would probably want to see. and I would be happy to sort of discuss around those issues but maybe in terms of concepts that we think or maybe approaches like that. What would you probably, why would you be interested in having dialogue with end-user computing lecturers, teachers or implementer.*

LG: *Because they need to be conversant with the literacies that we expect our students to attain. Disciplinary literacies. Now this is an outside disciplinary literacy itself but it applies in our literacies. So if you work (end-user computing lecturer) in isolation there is always going to be that disharmony because you will be implementing your literacies, generic literacies and you may omit, not incorporate certain elements or values that we want that are actually pertinent to our discipline.*

NZ: *Such as??*

LG: *Now for instance, I do not know what sort of graphics or data that they are dealing with, and how they are applying it. The thing is, I am not sure what is happening there. That is the first challenge, because why I do not have a learner guide from the, even if I may have a learner guide from the end-user computing most of it is done on the computer. So evidence of what the learner is doing or experiencing end there. {Disturbance}. When I wanted to do a results analysis for example, I could not do because they told me that no one failed basically. The students are always given multiple opportunities. But what I do not know is what those multiple opportunities entail and how applicable are they across my module. Now I have got all these modules that I have from plant to stock and whatever, how applicable are these supporting modules (end-user computing) have because these skills are not in isolation. They are there to be applied, that is my expectation. They should find use or empower the student to actually perform in those other modules that are core to the discipline since these are fundamental modules. I do not know if you get my point.*

NZ: *Yes I get it. I am trying to follow your argument. It is exciting. You bring very exciting aspects here. So in general you say if they have done end-user computing or when they are doing end-user computing, if I get you well, you are saying. You really want to have an input into what they are doing so that it can in aligning and applying what they are learning.*

LG: *Yes. Actually what you are saying now is constructive alignment. That alignment, you see it is of no value (end-user computing) if it is not aligned to enable the student to perform better in the programme. If I put it well. It becomes of no value to the programme, even though it is valuable itself to have but to the programme, specific programme then it is on no value of it is not aligned to the needs of the programme. And that dialogue is not happening.*

NZ:	*And I get it that by that dialogue you are interested in shaping the learning outcomes, the assessments and the output of the (end-user computing) programme.*
LG:	*ummm, exactly. What to include, what not to include and what not to focus on. There are certain things that we may really not be interested in and there are certain things that I feel may be very relevant to cut across. We need to consider all the modules that they are going to have, you understand.*
NZ:	*and these experiences, are tied to your experience as a programme leader in this (Bsc Agriculture programme.)*
LG:	*For instance you see with numerical and academic literacy, I am just giving you an example, because I have had dialogues with those lecturers. eee. we do not have statistics in our agriculture and I said to them include statistics, but statistical applications relating to agriculture. I didn't want them to talk of statistics of HIV and whatever community or cholera outbreaks or thing like that. I want examples that are disciplinary related. Then once you now include the disciplinary language, you bring in data and information that is disciplinary. So learners are also learning disciplinary language using the application that they need to learn. So you are killing two birds with one stone. But if you just make it general it will serve that general purpose.*
NZ:	*So is it your experience that the students are struggling to bring the general that is offered to the specific application in your discipline.*
LG:	*They bring it but if falls short it does not match the demands of the discipline itself, because you will be operating outside the demands of the discipline itself and you are using a different language and now you come in here all of a sudden it becomes Afrikaans. (Laughter)*
NZ:	*Alright that is quite exciting. I just want to focus on something else but that is closely related. I am glad that you have answered most of my question through the discussion that we have been having. Have you ever had an experience with an institution that uses computer-based training to teach students end-user computing? What have been your experiences?*
LG:	*With computer-based instruction?*
NZ	*Yes, computer-based instruction and the products thereof.*
LG:	*umm, I am not sure, now if you are talking of the software, here is gap that I have personally. First of all I need to be familiar with computer-based instruction. Are you talking in terms of, is it a software that is*
***NZ**:*	*It is a simulation software that is used to train students on how to use MS Word PowerPoint and things like that.*
LG.	*But now you see things with this software is that it is designed elsewhere. Perhaps, how to arrange data or maybe how to...can you give an example.*
NZ:	*No it is fine, we can leave that question it is not relevant maybe you probably had a comment or experiences with computer-based training software but it is something that you do not have direct experiences with. I can always ask that are working with it. Ok my first question was how many end-user computing students you have let's say at first-year level.*

***LG**: We are talking about, because it is compulsory, we are talking about 150, last year 120 and in 2016 it was 50.*

***NZ:** And then when you said it was a first-year course or you wanted it in the first semester. Do you see this subject as something that is needed in again or once they have done their end-user computing they should be fine throughout the rest their career in your faculty?*

***LG:** I think it's a subject that has been overlooked s our lives are now dependant on the computer.*

***NZ:** OK*

***LG:** One needs to appreciate that how much of it we are using. That is the first question. I look at the word that I am using, I do not think I am fully utilising it as much as I should be. If we continually had, even, us as staff not just including students. Because (if) you empower the student and the staff member is left out, that equation does not balance. You still have a blind man leading another one. (Laughter). That is why you fond with the Moodle it has been difficult to other lecturers, because they could not, are not yet conversant with the Moodle platform itself. They have not really pitched up to where they are expected to be and then they are expected to bring student on board because they were trained and the trainer said we have trained you and now train the student. The student will blame the lecturer because the lecturer did not train if you understand. So it then falls on also to computers to say computer end-users where do you chip in. This is where we needed you most (laughter). It doesn't end there. There are module now look at, we have introduced Geography 202. It is now an elective up to fourth year level and is a combination of physical geography and human geography. And in that physical geography there are computer applications that they are going to use, GIS now these are computer-based applications. GIS basically, if we are going there gradually. I mean GIS has got so many disciplinary applications. In any applied subject you can apply it. Just like computers.*

***NZ:** I just what to find out from you. What was the need to introduce GIS another module called AgGIS that focuses on computers, when you already have an end-user computing course. What was the justification? What was the need? What prompted you to want to do Ag GIS.*

***LG:** Ok it is part of the learning outcomes in that geography module. That geography module has a component of GIS and physical geography attached to it as GIS. Because remember geography, we all learn geography that it is about different places on the planet. No to get there we used physical maps. Now we are moving to electronic maps. That are provided in AgGIS.*

***NZ:** You are saying this is not covered in you end-user computing course.*

***LG:** I doubt. And if it was covered this dialogue should have happened first for it to happen. Because on what bases are they covering it. That is my question. So that is why I am saying that alignment comes into question. between service modules and the core modules. Are they singing the SAM song, the same chorus and*

***NZ:** And would it be a feasible thing to structure your AgGIS as part end-user computing for Agriculture student.*

LG: *I do not think it is impossible. I think it is very possible. And in fact it sits well there. Once you agree in your end-user, you are even teaching them on how to make use of certain application of computer skills and relevant software. Relevant software applications to agriculture. And it is not only AgGIS we are talking about.*

NZ: *The others?, I am interested.*

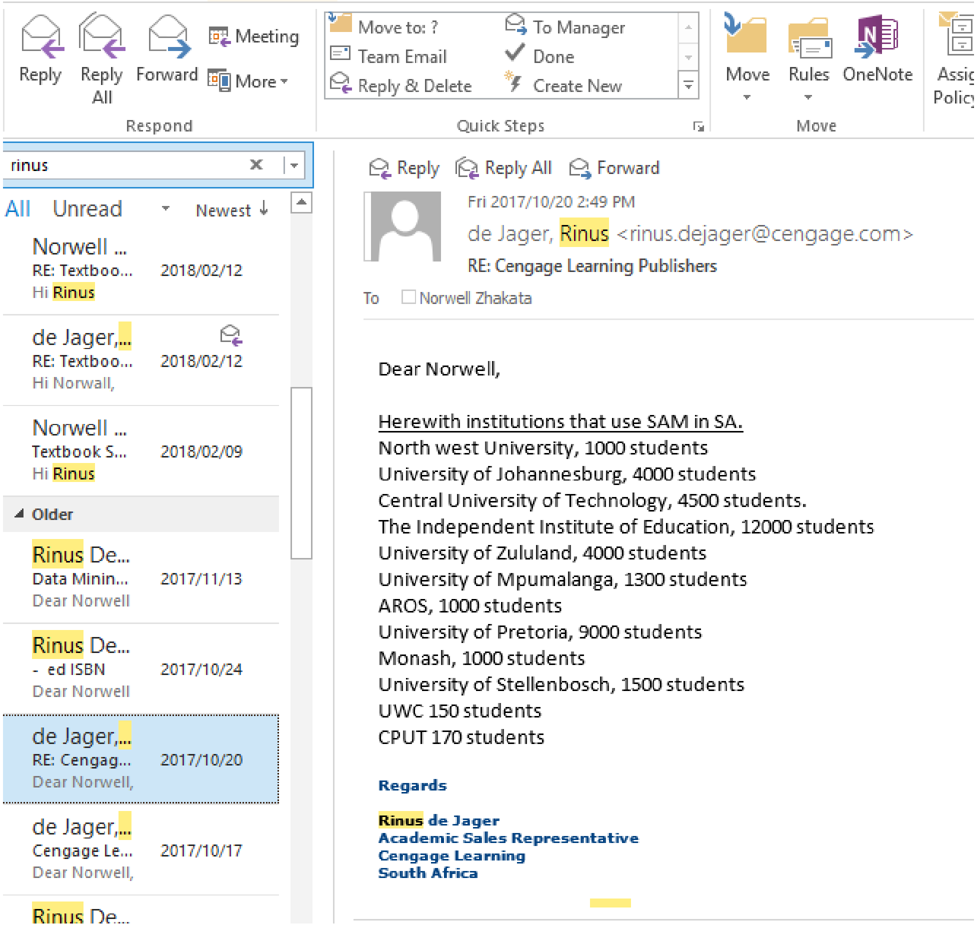
LG: *There are others like farm management software, that we might not even, but because you incorporated those as part of teaching end-user computing. And when a student comes and is now faced with AgGIS or anything. It is no longer Africans. They are now applying the language.*

NZ: *Thank you so much for the interview and your insight. Lastly would you know anyone in the programme or in similar position like yours? Who will be interested in this discussion or add value.*

{*Recording stopped*}

Appendix 3:

Higher education institutions that use Cengage's SAM


Fri 2017/10/20 2:49 PM
de Jager, Rinus <rinus.dejager@cengage.com>
RE: Cengage Learning Publishers
To Norwell Zhakata

Dear Norwell,

Herewith institutions that use SAM in SA.
North west University, 1000 students
University of Johannesburg, 4000 students
Central University of Technology, 4500 students.
The Independent Institute of Education, 12000 students
University of Zululand, 4000 students
University of Mpumalanga, 1300 students
AROS, 1000 students
University of Pretoria, 9000 students
Monash, 1000 students
University of Stellenbosch, 1500 students
UWC 150 students
CPUT 170 students

Regards

Rinus de Jager
Academic Sales Representative
Cengage Learning
South Africa

Appendix 4:

Approval letter – research proposal

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Department of Informatics
Faculty of Engineering, Built Environment and Information Technology
Pretoria 0002 Republic of South Africa
Tel (012) 420-6321 Fax (012) 362-5287
http://www.up.ac.za

25 October 2017

To whom it may concern

Research proposal approved: Mr N Zhakata

Mr N Zhakata (Student nr 15263984) is registered for a PhD (IT) at the University of Pretoria. He is doing her research under my supervision, Prof Helene Gelderblom.

I herewith confirm that Mr Zhakata's research proposal has been approved. He may continue with the planning of his data collection, as well as his ethics application.

Kindest regards

Prof H Gelderblom
Supervisor
012 420 3798
Helene.gelderblom@up.ac.za

Appendix 5:

Title registration

Our ref.: 15263984
Contact person: Ms NN Bahula
Tel: +27 12 420 5279
E-mail: nellie.bahula@up.ac.za

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Denkleiers • Leading Minds • Dikgopolo tša Dihlalefi

FACULTY OF ECONOMIC AND MANAGEMENT SCIENCES
STUDENT ADMINISTRATION

24 Nov 2017

Mr N Zhakata

Dear Mr Zhakata,

SUBJECT:THESIS

I have pleasure in informing you that the following subject has been approved:

SUBJECT: A framework for facilitating functioning knowledge in a computer based instruction end-user computing service course

EBW08/06
EBW11/07
Attached please find a checklist (**EBW 08/06**) and Notice to Submit (**EBW 11/07**).

Your enrolment as a student must be renewed annually until you have complied with all the requirements for the degree, preferably during the official period of enrolment but before **28 February**. You will only be entitled to the guidance of your supervisor if annual proof of registration can be submitted.

Kind regards

NN Bahula

For Prof E Loots
DEAN

Appendix 6:

Ethical clearance University of Pretoria

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering, Built Environment and Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie / Lefapha la Boetšenere, Tikologo ya Kago le Theknolotši ya Tshedimošo

Reference number: EBIT/128/2017 6 December 2017

Mr N Zhakata
Department of Informatics
University of Pretoria
Pretoria
0028

Dear Mr Zhakata

FACULTY COMMITTEE FOR RESEARCH ETHICS AND INTEGRITY

Your recent application to the EBIT Research Ethics Committee refers.

Approval is granted for the application with reference number that appears above.

1. This means that the research project entitled "A framework for facilitating functioning knowledge in a computer based instruction end-user computing service course" has been approved as submitted. It is important to note what approval implies. This is expanded on in the points that follow.
2. This approval does not imply that the researcher, student or lecturer is relieved of any accountability in terms of the Code of Ethics for Scholarly Activities of the University of Pretoria, or the Policy and Procedures for Responsible Research of the University of Pretoria. These documents are available on the website of the EBIT Research Ethics Committee.
3. If action is taken beyond the approved application, approval is withdrawn automatically.
4. According to the regulations, any relevant problem arising from the study or research methodology as well as any amendments or changes, must be brought to the attention of the EBIT Research Ethics Office.
5. The Committee must be notified on completion of the project.

The Committee wishes you every success with the research project.

Prof JJ Hanekom
Chair: Faculty Committee for Research Ethics and Integrity
FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

Appendix 7:

Approval to interview lecturers: University of Pretoria

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering, Built Environment and Information Technology
Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie / Lefapha la Boetšenere, Tikologo ya Kago le Theknolotši ya Tshedimošo

24 October 2017

Prof Helene Gelderblom
Department of Informatics

Re: Approval for Ethical Clearance: PhD Student Mr N Zhakata – Interview UP lecturers and students involved in AIM Courses

Reference is made to the above heading.

I am pleased to inform you that ethical clearance has been granted based on the abovementioned study.

The validitity of the ethical clearance is effective until February 2018.

Prof JHP Eloff
Deputy Dean: Research and Postgraduate Studies

Prof Jan Eloff
Deputy Dean: Research and Postgraduate Studies
University of Pretoria, Engineering 1, 6.8.1
Private Bag X20
Hatfield 0028, South Africa
Tel. +27 (0)12 420 3798
Email: jan.eloff@up.ac.za

Faculty of Engineering, Built Environment and Information Technology
Department of Mechanical and Aeronautical Engineering
Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie
Departement Meganiese en Lugvaartkundinge Ingenieurswese
Lefapha la Boetšenere, Tikologo ya Kago le Theknolotši ya Tshedimošo
Kgoro ya Boentšenere bja Semotšhene le Aeronathikale

Appendix 8:

Ethical clearance to conduct research: University of Mpumalanga

UNIVERSITY OF MPUMALANGA

Creating opportunities

Private Bag X11283, Mbombela, 1200
Cnr R40 White River Road & D725, 013 002 0001, www.ump.ac.za

Thursday, September 21, 2017

LETTER OF CLEARANCE FROM UNIVERSITY OF MPUMALANGA RESEARCH DIRECTORATE

This letter is to confirm that the PhD student Norwell Zhakata, studying at University of Pretoria, is granted permission to conduct a research titled:

> A framework for facilitating functioning knowledge in a computer based instruction end-user computing service course.

I hereby confirm that I am aware the study involves:-

- interviewing end-user computing lecturers, programmer leaders and students .
- end-user computing learning sessions and analysing the features of the computer based training system.
- as well as examining end-user computing curriculum documents such as course outlines and assessments.

Mr Zhakata is granted permission to carry out this study under the following conditions.

1. Sensitive information be shared with UMP Management.
2. A copy of the Thesis be shared with UMP Library.
3. Ethical principles be upheld.

Yours faithfully

Professor Phindile Lukhele-Olorunju
Director Research Management
Email: P.Lukheleolorunju@ump.ac.za
Tel: 013 002 0230

Appendix 9:

Sample consent letters

u15263984

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Department : Economic and Management Sciences

LETTER OF INTRODUCTION AND INFORMED CONSENT FOR PARTICIPATION IN ACADEMIC RESEARCH

Title Of The Study:

A framework for facilitating functioning knowledge in a computer based instruction end-user computing service course.

Researcher:
Norwell Zhakata
noelzhakata@gmail.com (+27722234254)

You are cordially invited to participate in an academic research study due to your experience and knowledge in the research area, namely ***end-user computing***. You must read, understand and sign this document *before* participating in this study. If you are less than 17 years we will also ask your parents parent/legal guardian to give consent in addition to yours.

- **Purpose of the study**: The purpose of the study is to study the use of computer based instruction in teaching end-user computing courses and recommend a framework for promoting functioning knowledge. The results of the study may be published in an academic journal. You will be provided with a summary of our findings on request. Your name will NOT be used in the final publication.

- **Duration of the study**: The study will be conducted over a period of one year and its projected date of completion is 31 December 2018.
- **Research procedures**: The study is based on an observation of teaching practices in computer based instruction end-user computing courses and information supplied in structured interviews.
- **What is expected of you**: You will be asked to describe your experience of using a computer based instruction to teach/ learn/supervise the end-user computing course.
- **Your rights**: Your participation in this study is very important. You may, however, choose not to participate and you may also stop participating at any time without stating any reasons and without any negative consequences. You, as participant, may contact the researcher at any time in order to clarify any issues pertaining to this research. The respondent as well as the researcher must each keep a copy of this signed document.
- **Confidentiality**: All information will be treated as treated as confidential and securely kept. Your name will not be recorded and the organisation you work for will be kept anonymous. The raw data such as questionnaires and interview recording will be stored on a secure computer, only accessible to the researcher through a biometric scan. The relevant data will be destroyed, should you choose to withdraw.

WRITTEN INFORMED CONSENT

I hereby confirm that I have been informed about the nature of this research.
I understand that I may, at any stage, without prejudice, withdraw my consent and participation in the research. I have had sufficient opportunity to ask questions.

Respondent: ____________________

Researcher: ____________________

Date: ____________________

Contact number of the Researcher:

____

VERBAL INFORMED CONSENT *(Only applicable if respondent cannot write)*

I, the researcher, have read and have explained fully to the respondent, named

____________________________________ and his/her relatives, the letter of introduction. The respondent indicated that he/she understands that he/she will be free to withdraw at any time.

Respondent: ____________________

Researcher: ____________________

Witness: ____________________

Date: ____________________

Appendix 10:

Source – The returns on advertising cost

https://www.mrexcel.com/forum/excel-questions/292520-formula-create-sales-curve-displaying-dimishing-returns.html

MrExcel.com
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Forum > Question Forums > Excel Questions > Formula to create sales curve displaying dimishing returns

Become a **Registered Member** (free) to remove the ad that appears in the top post.

Click **here** to reset your password. You MUST have a valid e-mail address so that you may receive the instructions to complete the reset.

If this is your first visit, be sure to check out the **Board FAQ** by clicking the link above.
You may have to **register** before you can post: click the register link above to proceed.
To start viewing messages, select the forum that you want to visit from the selection below.

Excellor_From_London
Board Regular
Join Date: Aug 2007
Location: London
Posts: 50
Post Thanks / Like
Mentioned: 0 Post(s)
Tagged: 0 Thread(s)

Formula to create sales curve displaying dimishing returns

Hi,

Hope someone can help with this, probably more of a math question but I want to implement this in excel.

I'm doing some analysis looking at the relationship between advertising and sales. In the example below, every pound you spend on advertising generates 95 pence. This relationship is linear and therefore constant over time, so when you plot the data below between the two series you a get a straight line.

So in the example below, spending 500 pounds delivers 475 pounds - that's 95 pence per pound spent, spending 7500 pounds delivers 7125 pounds of sales, still 95 pence per pound spent.

However in reality the relationship is is likely to be non-linear, for example after the same amount of advertising will return less pounds than before - each pound spent at higher levels should be delivering less than 95p, say 85 pence instead.

So really I want to create a non-linear relationship between the variables and so plot a non-linear/concave curve instead of a straight one. Does anyone know a formula I can use to do this. Note I don't want to add a non-linear curve to the actual data below, instead I want to recreate the series/data so that as your adversting spening goes up, sales respond at a slower rate than before and eventually you reach a point of saturation so that you almost have a straight line at that range.

My starting point would be to assume that each pound spent at teh initial level of advertising deliver 95 pence but then gradually declines as advertising spending keeps rising.

I hope someone can help.

Thanks,

Fellow Excellor

Spend (X) Return (Y)
500 475
1000 950
1500 1425
2000 1900
2500 2375
3000 2850
3500 3325
4000 3800
4500 4275
5000 4750
5500 5225
6000 5700
6500 6175
7000 6650
7500 7125

0 0

Dec 6th, 2007, 04:51 PM

RalphA
Board Regular
Join Date: May 2003
Location: Katy, Texas
Posts: 3,829
Post Thanks / Like
Mentioned: 0 Post(s)
Tagged: 0 Thread(s)

Here's one solution.
Using the same values in you Spend (X) column, and assuming that is column A, then, leave your present data in column B, and, in C2, enter:
=0.95^(ROW()-1)*A2
and copy down.
Plot all three columns, selecting the Scatter(XY) graph. The resulting two curves are just what you want!

Appendix 11:

Capstone project by Musgrave (2017b:38-40)

Summative Assignment

The time has come to return to your school, inspired to implement the ideas you have been working on. The implementation of your ideas and the submission of evidence will contribute to 70% of your final mark for this module.

In this module, you have investigated the different implementation models of ICT that schools use. You have also considered how this relates to your own school and classroom situation. In this assignment, you will analyse what is available at your school and then complete a plan to integrate these resources in the teaching activities you plan. You will provide graphical evidence that you have implemented what you have planned and then reflect on how it changed your teaching success.

Part 1: This part will be in the form of a PowerPoint presentation.

Step 1.1: Investigate the ICT resources available at your school and how it is currently used by considering the following:

Teachers have access to a computer/laptop/s at the school.
Teachers use the computer/s available at the school.
Teachers have access to a printer at the school.
Teachers have access to the internet at the school.
The number of computers at my school that learners can use.
The number of working computers available to learners to use.
Our school has a computer lab.
If yes, there are….. number of computers in the computer lab.
The computer laboratory is currently used as follows.
Suggestions for using the computer laboratory better.
If no, how could our school benefit from a computer lab?

Teachers at my have access to computers/laptops in their classrooms.
If yes, there are … number of computers/laptops in the classrooms.
The computers/laptops are currently used as follows.
Suggestions for using the computers/laptops better.
If no, how could our school benefit from giving teachers access to computers/laptops in their classes?
Other ICT resources available at my school.
Other ICT resources available in my classroom.
Learners have access to computers/laptops at the school.
Examples of how the learners currently use the technology available.

Step 1.2: Take pictures of the available resources and how it is currently used or not used.

Step 1.3: Consider the successful or unsuccessful use of the ICT resources at your school.

Step 1.4: Prepare a presentation for your School Governing Body (SGB). In the presentation, highlight the resources that are available and their potential use. You may use some of the information in the module for your presentation, but all ideas should be contextualised to the school you teach at.

Step 1.5: Complete the presentation with ideas of how you would like to use learning technologies in your teaching in the future.

Part 2: This part can be created using any presentation program of your choice.

Step 2.1: Consider a lesson you plan to teach in the next month.

Step 2.2: Use the list you completed in Part 1 to analyse what technology you have access to when teaching this lesson. Consider your class and the setting. Is it just one computer and data projector? Is it a computer room with limited space for off-computer working? Are you dealing with laptops or hand-held computers?

Step 2.3: Taking ideas formulated during the module, plan how the technology can be used to teach this lesson. Mention how the learners will use the technology and how you as a teacher will use the technology. Consider the role of ICT to achieve any of the following:

Characteristic	Teacher use	Learner use
Multiple perspectives		
Learner-directed goals		
Teachers as coaches		
Metacognition		
Learner control		
Real-world activities and contexts		
Knowledge construction		
Sharing knowledge		
Reference to what learners know already		
Problem-solving		
Explicit thinking about errors and misconceptions		
Exploration		
Peer-group learning		
Alternative viewpoints offered		
Scaffolding		
Assessment for learning		
Primary sources of data		

Step 2.4: Implement your lesson and collect evidence of how you and/or your students have used the technology to achieve any of the above.

Step 2.5: Pretend it is three months from now. Following the module, you have decided to embrace the available technology at your school, you presented your presentation to the SGB and you implemented the lesson as planned in steps 2.1 to 2.4.

Your school principal is so impressed that he or she wants to enter you in for the National Teacher Awards in the teaching with technology category. As part of your entry, you need to present evidence of how you have used the technology that you have available at your school and the impact it has had on the learners in your class.

Prepare a presentation in any program of your choice that illustrates to the judges of the National Teachers Awards why they should consider you for the award for teaching with technology. Your presentation should prove to the judges that you have implemented the technology based on sound judgement. End your presentation with a personal reflection of the value of ICT and how it supports you in your role as teacher.

The assignment should be submitted by

____

You have two options to submit your assignment:

(1) Save all documents on a DVD. Clearly mark your DVD and hand it to your centre coordinator no later than ____

(2) Alternatively, email your assignment to ______________________________ with both documents attached.

Question and answer:

Must the lesson really be implemented?

Yes. You need to provide evidence (photos) of the lesson being implemented.

What if I create the lesson idea but do not implement it?

You can then present your lesson idea only, but will lose marks as indicated on the rubric.

What should be saved on the DVD or email I send to my presenter?

- *The presentation prepared for the SGB.*
- *A presentation to the National Teachers Award Judges that includes evidence of at least one technology tool being used by either you or your learners.*

Appendix 12:

Source: factors affecting wheat germination

http://www.grainsa.co.za/factors-affecting-wheat-seed-germination

GRAIN SA
GRAAN SA

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You are here: / Home / Publications / Article / Factors affecting wheat seed germination

Factors affecting wheat seed germination

Temperature

Soil temperature plays a significant role in the rate at which germination proceeds. Although germination may occur between 4 °C and 37 °C, optimal temperatures range from 12 °C to 25 °C. The rate of water absorption or imbibition, the diffusion of respiratory gases and the rate of chemical reactions involved in the metabolism of the seed are all affected by temperature.

Species-specific seed often have a temperature range within which it will germinate, and it will not do so above or below this range. Suboptimal temperatures lead to lower success rates and longer germination periods. Higher temperatures will, up to certain limits, increase the rate of germination. Once the limit is reached, further increases in temperature will reduce or prevent germination. High temperatures reduce enzyme efficiency and eventually a temperature is reached at which cellular protein is denatured and the seed is killed.