UNISA university of south africa

TEACHING PROBLEM-SOLVING SKILLS IN A DISTANCE EDUCATION PROGRAMME USING A BLENDED-LEARNING APPROACH

by

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I declare that

"TEACHING PROBLEM-SOLVING SKILLS IN A DISTANCE EDUCATION PROGRAMME USING A BLENDED-LEARNING APPROACH"

is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I have not previously submitted this work, or part of it, for examination at UNISA for another qualification or at any other higher education institution.

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SIGNATURE
(G. J. Rampho)

DATE

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Summary

This study investigated the effect of a blended-learning approach in the learning of problem-solving skills in a first-level distance education physics module. A problem-solving type of instruction with explicit teaching of a problem-solving strategy was implemented in the module, which was presented through correspondence, online using an in-house learning management system as well as two face-to-face discussion classes. The study used the *ex post facto* research design with stratified sampling to investigate the possible cause-effect relationship between the blended-learning approach and the problem-solving performance. The number of problems attempted, the mean frequency of using strategy in problem solving and the achievement marks of the three strata were compared using inferential statistics. The finding of the study indicated that the blended-learning approach had no statistically significant effect in the learning of problem-solving skills in a distance education module.

Keywords : Educational technology, Distance education, Learning management system, Blended learning, Correspondence education, Online learning, Problem solving, Problem-solving skills, Problem-solving strategy.

Contents

Chapter 1

Introduction

1.1 Introduction

This chapter outlines the background and context of the study undertaken. The research questions and limitations of the study are indicated and introductory remarks on the literature surveyed, the research methodology followed and data collection procedures are highlighted. The validity and reliability of the research design, the data collection instrument and the data are discussed. The chapter is concluded with a list of concepts involved in the study. The next section outlines the background to the study.

1.2 The background and context of the study

Many tertiary education institutions make use of course management systems and learning management systems to facilitate the development and delivery of courses. Such systems have the capacity to integrate a wide range of pedagogical and course administration tools (Coates, James, & Baldwin, 2005). The use of technology in the delivery of distance education is not avoidable (Moore & Kearsley, 2005). Apart from the reliance on technology for the delivery of courses, distance education institutions need to keep up with contemporary trends in education practices (Kinuthia & Dagada, 2008), not only to prepare students for the information-based economy, but also to compete favourably with traditional on-campus educational institutions for students. However, the effective use of technology, in general, in the delivery of distance education, in particular, requires careful consideration of pedagogical theories and affordances of technologies involved (P. Mishra & Koehler, 2006). Moreover, in the light of challenges faced by developing countries (Gulati, 2008; Jhurree, 2005; Kinuthia & Dagada, 2008), education institutions servicing such countries, like the University of South Africa (UNISA), require analytical investigations into the use of technology in the delivery of courses.

Distance education is a unique form of education (Peters, 2004) requiring unique pedagogical practices and institutional organization. The unique relationship between distance education and technology has resulted in distance education needing to keep transforming in parallel with developments in technology (Peters, 2010). The impact of such developments on the delivery of distance education requires constant evaluation. Sener (2004) proposes that investigations related to practices in education of this type should be conducted within distance education for such investigations to be relevant to it. However, there are very few true studies dedicated to technology use and pedagogy related to distance education (Phipps & Merisotis, 1999; Sener, 2004). Therefore, investigations into factors, technologies and pedagogical methodologies, that may increase success rates in entry-level science modules, are necessary. The present study focuses on first-level physics modules. However, the findings of the study may be applicable to other distance education physics modules as well as mathematics and chemistry modules. The research problem and motivation are discussed in the next section.

1.3 Research problem and significance

Figure 1.1 illustrates the success rate pattern in one of the UNISA first-level physics theory modules in the past seven semesters. This success rate is low and is representative of performance problems in many science programmes (A. Mishra, Vijayshri, & Garg, 2009). Many such programmes have a common aim of teaching problem-solving skills to science students (Maloney, 2011), in addition to science concepts and methodologies. As a result, learning activities and assessment instruments in most science programmes are dominated by problem solving tasks (Bonham, Deardorff, & Beichner, 2003). This study explores possible effective ways of teaching problem-solving skills in a distance education physics course. Research (Hull, Kuo, Gupta, & Elby, 2013; Selçuk, Çalişkan, & Erol, 2008) has

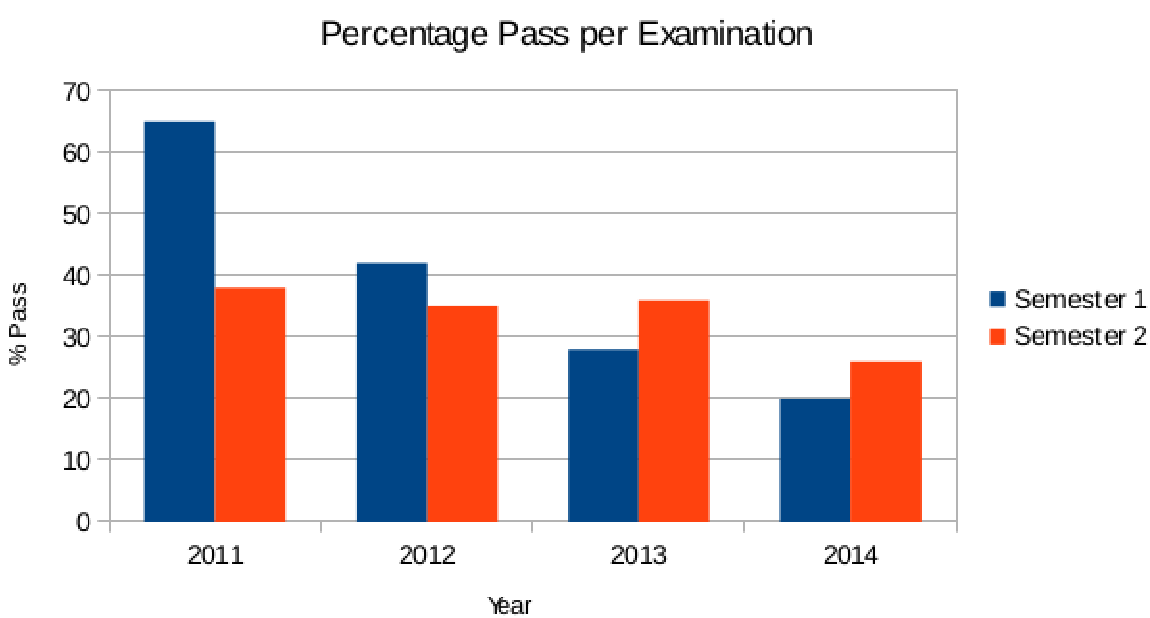


Figure 1.1: Pass rate for the first-level physics module Mechanics in the previous six semesters.

shown that explicit teaching of problem-solving skills in science courses is likely to increase success rates in the courses. The study is conducted on an actual distance education module delivery. Many investigations involving the teaching and learning of problem-solving skills are focused mainly on the traditional face-to-face education while many of the studies are conducted under ideal experimental settings (Gök & Silay, 2010; Selçuk et al., 2008).

The main module materials in a distance education physics course are published textbooks and tutorial letters. A physics textbook that would support independent learning would offer a summary of fundamental physics concepts, laws and principles as well as many worked-out examples. Tutorial letters are compiled by lecturers and focus mainly on module information and feedback on formative assessment. This distance teaching approach relies heavily on the maturity of the students for its success. At entry-level many of the physics students may lack problem-solving skills required for success in physics modules. Therefore, teaching such skills to entry-level physics students may improve success rates in the modules. However, the teaching and learning is mediated through technology.

A typical first-generation distance education delivery mode is correspondence where print technologies as well as postal services are used for communication, whereas a typical third-generation distance education delivery mode involves correspondence and Web-based tools (Bates & Poole, 2003). Various combinations of synchronous and asynchronous learning interactions have been shown to be very effective in the delivery of distance education (Garrison & Kanuka, 2004). Synchronous learning interactions include face-to-face, video- and audio-conferencing interactions while asynchronous learning interactions include online discussions as well as electronic mail and postal mail interactions (Garrison & Kanuka, 2004). An emphasis on an appropriate combination of student-support interventions into an effective learning environment for the teaching and learning of a distance education is likely to improve the success rate in distance education courses. However, several studies on the effect of technology on learning outcomes (Clark, 1983; Russell, 2001) indicate that technology and media have no statistically significant effect on the attainment of learning outcomes. The present study investigates whether the choice of technology in the delivery of physics modules at UNISA has any effect in the learning outcomes of physics. The next section discusses the research questions.

This study compares the effectiveness of combinations of three presentation modes of a distance education module. The three presentation modes relate to the past (correspondence) and current (online) distance education delivery. The comparison is done within the realm of distance education. The study also reflects on the effectiveness of current practices in distance education delivery. Therefore, the study is a true open and distance education investigation, the results of which may directly distance education practices, such as teaching quality and effectiveness as well as institutional transformations (Sener, 2004).

1.4 The research question and limitations

The aim of this study is to determine the effects of using a blended-learning approach in the learning of problem-solving skills in distance education physics modules. In this study "blended-learning approach" refers to some combination of correspondence, online and face-to-face learning interactions. It is understood that such interactions will involve the use of some technology, at the very least, information and communication technology. The study assumes, as reported in a number of other studies (Gök & Silay, 2010; Hull et al., 2013; Selçuk et al., 2008), that direct and explicit teaching of a problem-solving strategy will increase the use of the strategy, problem-solving performance and achievement of students. The research question addressed in this study is:

1. How do the components of a blended-learning approach affect the learning of problem-solving skills in a distance education physics module?

To address this question the following sub-questions were addressed:

1. Is there any significant difference in the problem-solving performances between students who use a blended-learning approach and those who do not use a blended-learning approach in a distance education physics module?

2. Is there any significant difference in the mean frequency of problem-solving strategy use between students who use a blended-learning approach and those who do not use a blended-learning approach in a distance education physics module?

3. Is there any significant difference in the achievement marks between students who use a blended-learning approach and those who do not use a blended-learning approach in a distance education physics module?

Therefore, the objective of the study is to identify components of a blended-learning environment that could increase problem-solving performance in a distance education module. The hypotheses to be tested are:

H_1 : In a distance education module, students using a blended-learning approach will perform better at problem solving than students not using a blended-learning approach.

H_2 : In a distance education module, students using a blended-learning approach will more frequently use strategy when solving problems than students not using a blended-learning approach.

H_3 : In a distance education module, students using a blended-learning approach will obtain higher achievement marks than students not using a blended-learning approach.

This research is a small-scale investigation of possible effective ways of blending learning environments in distance education, here after DE, for technologically and socio-economically challenged populations. The study focuses on one DE module with the possibility of undertaking a much larger research study focusing on several modules of a programme. This research is exploratory and its conclusions are, therefore, tentative. In the next section a summary of the literature reviewed for this study is given

1.5 Literature review

This study investigates the effect of a blended learning approach in learning problem-solving skills in a DE module. Therefore, literature on distance education, blended learning and problem solving is reviewed in the following three subsections.

1.5.1 Problem solving

One of the aims of science is to teach problem-solving skills (Docktor, 2009). Many researchers agree that the explicit teaching of problem-solving strategies in a subject will help improve the problem-solving skills of the students (K. Heller & Heller, 2010). These researchers argue that improved problem-solving skills lead to improved academic achievement. Hull et al. (2013) give a comprehensive summary of the research consensus on characteristics of an effective problem-solving strategy.

The ability to solve problems requires a certain level of creativity that cannot be reduced to a procedure (Bolton & Ross, 1997). However, there are some characteristics of an experienced problem solver that can be acquired, mainly through practice, by an inexperienced problem solver to improve their problem-solving skills (Docktor, 2009). There is a consensus among researchers (Hull et al., 2013) that an efficient problem-solving process involves the use of strategy. In general, the problem-solving process begins with extracting useful information from the problem statement and illustrating the problem situation using diagrams. Then, applicable principles and laws are identified to set a stage for logical mathematical procedures followed to obtain the answer. Finally the answer is assessed for acceptability (P. Heller, Keith, & Anderson, 1992).

Although there are different approaches to and strategies for solving physics problems, almost all of the approaches reflect a common problem-solving skill-set. An expert problem solver demonstrates these skills during a problem-solving process. These problem-solving skills are applicable in, and therefore transferable to, many fields (Larkin & Reif, 1979). However, these skills are difficult to acquire without assistance (Bolton & Ross, 1997). There are several instructional approaches that can be used to teach problem-solving in physics. The more common instructional approach is the cooperative group instruction (K. Heller & Heller, 2010), where students learn in structured groups. The approach requires the organization of well structured groups of students and well managed problem-solving sessions. Other instructional approaches are the problem-based learning (Capon & Kuhn, 2004) and the example-problem approach (Paas & van Gog, 2006). The case-based reasoning (Mateycik, Jonassen, & Rebello, 2009) or example-problem instructional approach (Sweller & Cooper, 1985) use worked-out examples to emphasize subject matter and fundamental concepts. In this approach students can learn individually or in a group from structured worked-out examples (Lin & Singh, 2011; Mateycik et al., 2009).

1.5.2 Distance education

DE can be defined as the "teaching and planned learning in which the teaching normally occurs in a different place from the learning, requiring communication through technologies as well as special institutional organization" (Moore & Kearsley, 2005, p. 2). In the beginning DE was delivered through correspondence where communication was mainly through print technology and postal services (Peters, 2010). Currently DE is delivered through information and communication technologies that are Web-based. The dependence of the delivery of DE on technology has resulted in the evolution of DE along with developments in technology (Garrison & Cleveland-Innes, 2010). DE focuses on providing education to individuals at a separate geographical location from the provider institution. Therefore, quality courses still need to be designed, presented and managed by the institutions, and technology is still used to present course material to learners.

Since the birth of DE a number of educational theories have been developed to help clearly define and explain it as a unique form of education i.e. not an extension of the traditional classroom education. Some of the earlier theories of DE are the *industrialization theory* of Otto Peters (Peters, 2010), the *theory of transactional distance* advanced by Borje Holmberg (Holmberg, 2008) and the *theory of andragogy* developed by Malcolm Knowls (Knowls, 1980). DE methodologies and practices continue to evolve and develop as a result of developing societal, psychological, cultural and technological changes. Some of the more recent DE theories are *heutagogy*, *constructivism* and *connectivism* (Holmberg, 2008). Some of the theories and practices of DE are discussed in the next two subsections.

1.5.3 Blended learning

There are several DE theories that guide its practice (Holmberg, 2008, chap. 4). Most of these theories emphasize the use of non-formal conversational dialogue in interactions with students. The empathy approach advocates for a simulated conversation or dialogue in presenting instructional materials as well as communications with students. The transactional presence approach seeks to reduce the feeling of isolation usually experienced by DE students. The tutorial-in-print approach mimics the one-on-one conversational presentation that simulates interaction of the teacher with individual students. A DE teacher is expected to be able to successfully implement all these measures in teaching with technology at a distance.

Many higher education institutions, including UNISA, use learning management systems for the delivery of courses. Such systems support different multimedia and collaborative platforms that allow for an effective learning environment. The designing of learning activities that incorporate authentic learning experiences often requires the thoughtful use of different multimedia resources and educational technologies. The effective use of these resources can be more convenient and cost-effective, yet challenging, in the case of science subjects such as physics in distance education. The challenge results from the majority of learning activities in science requiring experiments and involving demonstrations of abstract concepts. However, developments in technologies and pedagogies related to DE have made it easier to effectively use technology and multimedia tools in teaching and learning through DE. The World Wide Web provides instructional designers with access to educational repositories of a variety of educational resources that can be used and reused. Moreover, different frameworks (Bates & Poole, 2003; Krauss & Ally, 2005; Leacock & Nesbit, 2007) have been designed to guide the selection and appropriate use of technology and multimedia tools for educational purposes.

There are several definitions of the term *blended learning*, depending on what is to be blended and who is to do the blending (Anderson, 2003; Bates & Poole, 2003; Garrison & Kanuka, 2004; Vaughan, 2010). A more inclusive definition is offered by Garrison and Kanuka (2004) who refer to blended learning as the combination of synchronous and asynchronous learning activities or modalities to create a flexible and supportive learning environment. Here synchronous learning activities include audio- and video-conferencing, face-to-face classroom activities and one-to-one consultation. Asynchronous activities include online discussions, electronic mail and postal mail communications. Peters (1998) discusses various aspects of distance education, including possible course presentation modes. A DE course can be presented through combinations of correspondence, online and face-to-face learning activities. These combinations can be viewed as various degrees of blending technologies and pedagogies applicable to each component.

The implementation of a blended learning approach is not expected to be without challenges (Vaughan, 2010). Many of the challenges associated with the use of technology in education are summarized by the SECTIONS framework discussed by Bates and Poole (2003). The framework is designed to evaluate the level of appropriateness and usefulness of a given technology when used for educational purposes. Traditionally, DE courses rely on correspondence for communication and delivery of course material and are managed through learning management systems. Based on the SECTIONS framework the use of a learning management system raises concern over issues of reliability, costs and access, especially in the context of a developing country like South Africa. These limitations arise because of the low quality of technical support provided by the institution, low technological competency of the target students and additional cost to students of internet access. In the case of a correspondence DE course the SECTIONS framework highlights issues of reliability and speed that result from the inherently slow nature of postal services. For UNISA students, UNISA regional centres across the country, and in some African countries, can be used to access computer facilities, internet access and tutor support. However, issues of proximity, which affects access, still remain.

1.6 Research method

The present study investigated the effects of using a blended-learning approach in the learning of problem-solving skills in a single-mode DE environment. The research instruments were researcher-designed domain-referenced tests that also formed an integral part of the official assessment plan of the module. These tests were chosen as data collection instruments since the same tests were used to determine achievement in the module. In the next two subsections the research design and target population are discussed.

1.6.1 Research design

There are several types of research methodologies associated with quantitative research. A detailed discussion of these can be found in (Creswell, 2012). The more common research designs are the case study, laboratory experiment, survey and *ex post facto* design. In experimental research subjects are studied under controlled conditions where there are at least two variables that are compared (Campbell & Stanley, 1963). In such a design the cause-effect relationships between the variables are studied where one variable changes and another is observed. An *ex post facto* design is normally used to investigate correlation relationships between variables. However, in such a design there is no control over all the dependent variables (Cohen, Manion, & Morrison, 2007). The present study is one involving delivery of DE. It is not possible to control all the dependent variables involved, while attempting any such control is impractical and would be unethical. It is also not possible to randomly assign subjects to groups. Therefore, the *ex post facto* research design was used for this study.

In this study *blended learning* was the treatment variable, with the treatment levels described as *mild*, *moderate* and *full* based on the combinations of learning modes used. Using only correspondence was considered no blending while using online and face-to-face were considered full blending. These levels of blended learning interactions resulted in four possible subgroups of students as indicated in Table 1.1. The number of problems solved, the achievement marks and strategy use in problem-solving tasks were treated as the response variables.

1.6.2 Population and sampling

A population is the total number of elements or subjects in a group that have similar characteristics (McMillan, 1996). The target population for this study was all the students registered for the first-level physics module Mechanics. It is not always possible to study the whole population. Therefore, a small number of subjects from the population that are representative of the population is usually studied and the result generalized to the whole population. This small number of the population is called a *sample* of the population. There are several permitted procedures for selecting a sample from a population for the results to be valid. These procedures, which include simple random sampling, stratified sampling and purposive sampling, are discussed by (Creswell, 2012). In *stratified sampling* the population is first divided into several homogeneous subgroups before randomly sampling each subgroup (Cohen et al., 2007). Since the target population was divided into groups that use a particular mode of learning, the stratified sampling technique was used in selecting the sample for this study. The sample was stratified according to correspondence, online and face-to-face learning.

All the students were invited to: (i) complete learning activities in the study guide, (ii) participate in the online learning activities and (iii) attend at least one scheduled face-to-face class for the module. The following three presentation modes were used for the module:

- *Correspondence*: This was the usual tuition mode at UNISA that all the students experience. It involved sending the course material (study guide and tutorial letters) to students and using postal services, electronic mail and telephone for communication.
- *Online*: This was conducted through the myUnisa learning management system. Participation in the online interactions requires access to internet facilities such as information and communication technologies. Students could access such facilities at regional centers.
- *Face-to-face*: Two face-to-face classes were held at a single geographical location, each for one day. All students were invited to participate in the face-to-face discussion class.

Table 1.1 shows that four subgroups of students are anticipated, based on whether the students participated in the online and attend one face-to-face class or not. Group 1 comprises the students who use only correspondence in the study of course materials while Group 2 consists of the students who use online resources in addition to correspondence in the study of course materials. Group 3 comprises those who attend a face-to-face class in addition to using correspondence in the study of course materials. Group 4 constituted by the students who use online resources and attend a face-to-face class in addition to using correspondence in the study of course materials. The collection and analysis of data is indicated in the next subsection.

Table 1.1: Possible subgroups of the sample.

Group	Correspondence	Online	Face-to-face
1	Yes	No	No
2	Yes	Yes	No
3	Yes	No	Yes
4	Yes	Yes	Yes

1.6.3 Data collection and analysis

This study is a quantitative research study that requires collection of quantitative data to answer the research questions. The research data were obtained using, as mentioned, researcher-designed criterion-referenced tests with closed problems as test items. The problems were testing the knowledge and understanding of physics concepts at various levels of Bloom's taxonomy of learning objectives (Krathwohl, 2002). Primary and secondary data were collected to answer the research questions. The former data consisted of: (i) solutions to the formative practice problems, (ii) the number of problems solved, (iii) the frequency of strategy use in solving problems as well as (iv) the achievement marks in the formative assignment and the summative examination. Secondary data consisted of: (i) participation in the correspondence, online and face-to-face learning activities and (ii) the achievement marks for the formative assignment and the summative examination.

Primary data were obtained from solutions to the formative practice problems, formative assignment problems as well as summative examination problems. Quantitative primary data were descriptive, while inferential statistics of the data were calculated. Secondary data for the study were obtained from the sources indicated in Table 1.2. The next section deals with the validity and reliability of the data and the data-collection instruments.

1.7 Validity and reliability

Validity in research refers to the demonstration that the treatment caused the observed effect, and the extent to which the findings can be generalized (Cohen et

Table 1.2: Relevant secondary data to be collected and the sources of the data.

Data	**Source**
myUnisa participation	myUnisa
Face-to-face participation	Face-to-face attendance register
Correspondence participation	E-mails, records of telephone and postal communications from tutors
Formative/Summative assessment	Assignment/Examination departments

al., 2007). The validity of the data is threatened by errors introduced through, among other factors, *sampling bias, experimental mortality, instrumentation* and *instrument reactivity* (Campbell & Stanley, 1963). Some of the measures that minimize threats to the validity of the results are randomizing the sampling, keeping the treatment period reasonably short and natural as well as using standard data-collection instruments (Creswell, 2012). *Reliability* in research refers to the consistency of the treatments in producing the same response at other times or from different experimental groups (Creswell, 2012). The main types of reliability in quantitative research are *stability, equivalence* and *internal consistency.*

Several measures were taken to ensure the validity and the reliability of the instruments and results. The problems were selected from a test-bank used in previous official formative and summative assessment tests in the module. In addition, a test consisting of problems with deep similarity characteristics to the problems in the assessment tests was given to students registered for the module in the previous semester. This helped improve the clarity and comprehensibility of the problems in the tests. The same rubric used to assess solutions to the formative practice problems was used to assess solutions to problems in the formative and summative assessment tests. The problems in the tests were moderated by an internal physics expert. The student solutions to the tests were marked by an external marker and the marked solutions were moderated by two internal physics experts. The inter-rater ratio was also calculated. Ethical considerations are discussed in the next section.

1.8 Ethical considerations

Research is considered sensitive when it poses potential physical and/or emotional harm to the researchers, participants and their communities (Creswell, 2012). Research that involves animals, people or classified information is usually sensitive. Such research would, among other factors, cause physical or emotional pain, intrude into private spaces, address content that is emotionally challenging and/or result in consequences (positive or negative) for researchers and participants (Cohen et al., 2007). Many organizations have established research ethics policies to guide, and ethics bodies to supervise, ethical practices in research. Standard practice is that all research needs to be sanctioned based on its ethics policy by the institution hosting the research. All ethical policy requirements were followed in this study.

Permission to conduct this study was granted by the College of Education Research Ethics Committee. An ethics clearance certificate was awarded (see Appendix A). Participants in this research were students registered for the first-level Mechanics physics module at UNISA. Permission to use UNISA students, staff or data in this study was granted by the UNISA Senate Research and Innovation and Higher Degrees Committee. Primary data collected relate only to the learning activities in the course. Permission to use the data was requested from all the students. Participants were required to complete and sign an informed consent form. Participation was voluntary and there was no expectation to provide reasons for not participating. Participation in the study could be withdrawn at any time without reprisal. Confidentiality and anonymity were upheld. Key terms are defined in the next section.

1.9 Definition of terms

Blended learning	:	"the combination of synchronous and asynchronous learning activities or modalities to create a flexible and supportive learning environment" (Garrison & Kanuka, 2004).
Distance education	:	"teaching and planned learning in which the teaching normally occurs in a different place from the learning, requiring communication through technologies as well as special institutional organization" (Moore & Kearsley, 2005).
Learning management system	:	"an integrated computer system" (Coates et al., 2005).
Problem	:	you have a problem "when you want something and do not know immediately what series of actions you can perform to get it" (Docktor & Heller, 2009).
Problem solving	:	"a search for some action appropriate to attain a clearly conceived, but not immediately attainable" (Docktor & Heller, 2009).
Synchronous interactions	:	interactions taking place at the same time.
Technology affordance	:	"the advantages and disadvantages which emerge from the uses and misuses of a particular technology" (Swan, 2010).

1.10 Dissertation overview

Chapter 1: Introduction

Outline of the background and context of the study. Research questions and research limitations. Summaries of the literature surveyed, research methodology and data collection procedures.

Chapter 2: Conceptual framework

Reviewed literature. Problem-solving skills. Teaching and evaluating problem-solving skills in physics. Definition of blended learning. Challenges of the use of technology in distance education.

Chapter 3: Research method

Research design. Population and sampling. Data collection procedures.

Chapter 4: Results and discussions

Presentation of the results. Discussion and analysis of the results.

Chapter 5: Conclusions

Reflections on the research questions, hypotheses and findings of the study. Implications of the results.

1.11 Conclusion

This chapter has outlined the aim of this study as well as the research questions addressed. The research method considered and data collection procedures for the study have been indicated, and the validity and reliability of the data considered. The chapter concluded with reflections on ethical considerations in the study. In the next chapter, the review of literature on the concepts of distance education, problem solving and a blended learning approach is presented.

Chapter 2

Conceptual framework

2.1 Introduction

This study involves the teaching of problem-solving skills in a distance education (DE) module. Hence, this chapter explains the concepts of problem solving, DE and the blended-learning environments in DE based on the literature. The concepts are then contextualized to the DE practices at the University of South Africa. In the next section the teaching, learning and assessment of problem solving are discussed.

2.2 Problem solving

As indicated in Chapter 1, one of the aims of learning science is to acquire problem-solving skills (Docktor, 2009). This explains why most assessment instruments in science involve problem solving tasks (Bonham et al., 2003). Many researchers indicate that the explicit teaching of problem-solving strategies in the teaching of a subject will help improve the problem-solving skills of the students (K. Heller & Heller, 2010; Hull et al., 2013). These researchers argue that improved problem-solving skills lead to improved academic achievement. Hull et al. (2013) give a comprehensive summary of the research consensus on characteristics of an effective problem-solving strategy. An example of a standard problem-solving strategy is

Table 2.1: The problem-solving strategy of P. Heller et al. (1992).

Step	Action
1. **Visualize the problem**	• draw sketches that illustrate the problem situation • identify known quantities, unknown quantities and constraints • identify the physics concepts and principles appropriate for the problem situation
2. **Describe the problem in physics terms**	• use appropriate physics principles to construct relevant diagrams for each object • represent each relevant quantity (known and unknown) with a symbol
3. **Plan a solution**	• express the identified physics concepts and principles in equation form • apply the identified physics concepts and principles to each object or situation • incorporate the specified constraints in the equations • express the unknown quantity in terms of only the known quantities
4. **Execute the plan**	• use correct mathematical rules and procedures to express the unknown quantity in terms of the known quantities • substitute the given values of the known quantities to determine the value of the unknown quantity
5. **Check and evaluate**	• check if the solution is complete • check if the sign and units of the answer are correct • check if the magnitude of the answer is reasonable

shown in Table 2.1.

The ability to solve problems requires a certain level of creativity that cannot be reduced to a procedure (Bolton & Ross, 1997). However, there are some characteristics of an experienced or “expert” problem solver that can be acquired, mainly through practice, by an inexperienced or a “novice” problem solver to improve their problem-solving skills (Docktor, 2009). An efficient problem-solving process involves a strategy like the one outlined in Table 2.1. In general, the problem-solving process begins with extracting useful information from the problem statement and illustrating the problem situation using diagrams. Then, applicable principles and laws are identified to set a stage for logical mathematical procedures followed to obtain the answer. Finally the answer is assessed for acceptability. This problem-solving strategy highlights some of the important problem-solving skills.

Although there are different approaches to and strategies for solving physics problems, almost all of the approaches reflect a common problem-solving skill-set, as noted previously. According to Bolton and Ross (1997), an effective problem solver is able to

- extract useful information given explicitly or implicitly;
- identify applicable laws and principle and related variables;
- apply correct basic mathematical procedures; and
- make appropriate assumptions and estimates.

An expert problem solver demonstrates these skills during a problem-solving process. These problem-solving skills are applicable in, and therefore transferable to, many fields (Larkin & Reif, 1979). However, these skills are difficult to acquire without assistance (Bolton & Ross, 1997). In the following two subsections the teaching of problem-solving skills and the measuring of problem-solving ability are discussed.

2.2.1 Teaching problem solving skills

There are several instructional approaches that can be used to teach problem-solving in physics. The more common instructional approach is the cooperative group instruction (K. Heller & Heller, 2010), where students learn in structured groups. The approach requires the organization of well structured groups of students and well managed problem-solving sessions. This approach is based on the social-constructivists' view of knowledge construction which asserts that knowledge construction is a social activity (Anderson & Dron, 2011). The approach was shown to be effective in a traditional face-to-face classroom setting (K. Heller & Heller, 2010; P. Heller et al., 1992).

Other instructional approaches are the problem-based learning (Capon & Kuhn, 2004) and the example-problem approach (Paas & van Gog, 2006). The case-based reasoning (Mateycik et al., 2009) or example-problem instructional approach (Sweller & Cooper, 1985) use worked-out examples to emphasize subject matter and fundamental concepts. In this approach students can learn individually or in a group from structured worked-out examples (Lin & Singh, 2011; Mateycik et al., 2009). The approach is based on the cognitive load theory (Moreno, 2006) that asserts that cognitive tasks with less than seven elements that need to be processed simultaneously by the human brain can be successfully learned. Worked-out examples reduce the content to be learned into smaller "chunks" (Paas & van Gog, 2006). The problem-based learning instruction uses real-life problems to stimulate learners' knowledge construction (Capon & Kuhn, 2004). Usually learners work collaboratively in small groups to solve a given problem. The approach promotes active learning and is based on the assertion that authentic learning is situated.

A problem-solving instructional approach that can be implemented in a DE course should be implementable in all modes of course delivery in DE. The approach should allow for a direct teaching of a prescribed problem-solving strategy, modelling of the strategy in all problem-solving activities (Bolton & Ross, 1997) and provide a problem-solving format to guide students in such tasks (P. Heller et al., 1992). The approach should also emphasize the learning of the subject concepts before engaging in problem solving activities. The worked-out examples can then be used to illustrate principles and laws of the subject. Instructive worked-out examples emphasize fundamental principles and laws of the subject, minimize the use of non-fundamental formulae (Bolton & Ross, 1997) and contain explanations of the rationale behind solution steps (Paas & van Gog, 2006). Although many of the instructional approaches have proved successful, their implementation in DE courses presents different challenges. However, the worked-out example approach can be implemented in the correspondence, online and face-to-face settings and allows for feedback corrective measures in all the modes. It is this approach that was used in this study.

2.2.2 Evaluating problem-solving skills

Problem-solving skills are often displayed in the process of solving problems. However, the skills may not be explicitly observable in the solution itself. To assess such skills requires a reliable and valid instrument that can evaluate the quality as well as the correctness of the problem solutions (P. Heller et al., 1992). Such an instrument is vital for generating objective and consistent feedback that is independent of time and independent of the observer or the observed (Cohen et al., 2007). The availability of such an instrument also assists in the selection of test items for domain-referenced assessment tests. It can be argued that the instrument helps align the teaching and the learning and the assessment of the subject matter.

Adopting a problem-solving strategy (e.g. Table 2.1) in the teaching of a subject provides a platform to formulate a transparent assessment rubric for evaluating written solutions to problems. The written solution rubric of P. Heller et al. (1992), shown in Appendix C, has been widely researched and accordingly modified over the years (Docktor, 2009; Hull et al., 2013). The rubric divides the problem-solving process into five categories and provides a grading mechanism for each. The categories are *useful description*, *physics approach*, *specific application of physics*, *mathematical procedures* and *logical progression* (Docktor & Heller, 2009). All the categories are weighted equally with each graded according to its appropriateness and completeness, considering if the category is necessary for solving the problem. The rubric can be used to evaluate problem-solving performance, strategy use in solving problems as well as academic achievement.

Problem-solving performance is also affected by the level of difficulty of the problem, in addition to the level of expertise of the problem solver. The difficulty level of a problem for a particular group of students can be established, after administering the problem, by the number of students who attempt to solve it (Cohen et al., 2007). However, characteristic factors of a problem have been identified (P. Heller et al., 1992; Maloney, 2011) that can be used to determine the difficulty level of a problem in advance. The factors are given in Table 2.2 along with the problem difficulty rating. Based on these factors, a problem is considered not difficult to solve if it has a difficulty rating of 3 or less and considered difficult if it has a difficulty rating of 4 or higher.

The solution rubric of P. Heller et al. (1992) was adopted in this study to

Table 2.2: Factors used to determine the difficulty level of a problem (P. Heller et al., 1992).

Characteristic	**Difficulty rating = 0**	**Difficulty rating = 1**
Problem context	familiar context	unfamiliar context
Problem cues	explicit cues for applicable principles given	no cues given
Given information	only needed information given	more than needed information given, assumption or estimations required
Number of approaches	only one applicable approach	more than one possible approach
Explicitness of question	target variables specified	target variables not specified
Memory load	five or fewer equations to be solved	more than five equations to be solved

assess solutions to problems from the formative and summative assessment tests. The rubric is in line with the assessment policy of UNISA and is consistent with best practice in teaching. Only problems of difficulty level between 2 and 4 were chosen for the domain-referenced researcher-designed tests. The tests are shown in Appendix B. The concepts of DE and related practices at UNISA are discussed in the next section.

2.3 Distance education

DE can be defined as the "teaching and planned learning in which the teaching normally occurs in a different place from the learning, requiring communication through technologies as well as special institutional organization" (Moore & Kearsley, 2005, p. 2). This definition highlights the importance of technology in the delivery of DE. At its infancy DE was delivered, as mentioned, through correspondence where communication was mainly through print technology and postal services (Peters, 2010). The dependence of the delivery of DE on technology has resulted in the evolution over the years of DE along with developments in educational as well as information and communication technologies (Garrison & Cleveland-Innes, 2010).

Since the birth of DE a number of educational theories have been developed to help clearly define and explain it as a unique form of education i.e. not an extension of the traditional classroom education. Some of the earlier theories of DE are the *industrialization theory* of Otto Peters (Peters, 2010), the *theory of transactional distance* advanced by Borje Holmberg (Holmberg, 2008) and the *theory of andragogy* developed by Malcolm Knowls (Knowls, 1980). DE methodologies and practices continue to evolve and develop as a result of developing societal, psychological, cultural and technological changes. Some of the more recent DE theories are *heutagogy*, *constructivism* and *connectivism* (Holmberg, 2008). Some of the theories and practices of DE are discussed in the next two subsections.

2.3.1 Distance education practices

Developments in information and communication technologies have challenged many theories and practices in DE. As a result, new theories are continuously constructed based on the new and emerging technologies in its delivery (Peters, 2004, p. 34). However, the basic models are still the same. DE focuses on providing education to individuals at a separate geographical location from the provider institution. Therefore, quality courses still need to be designed, presented and managed by the institutions, and technology is still used to present course material to learners.

Many institutions, such as the Open University of the United Kingdom, employ the team approach in the design of their courses (Haughey, 2010). A group of experts in different affected fields work together as a team to design a course. Academics collaborate with instructional designers to plan and design the content and optimal presentation of a course. The academics work on the content while the technologists work on the best ways of presenting the content. The experts may come from different institutions. The team approach is an example of rationalization of responsibilities and is a characteristic of industrialization (Peters, 2010, p. 15). The Open University courses are also designed and presented as open courses, which means, among others, that the learner determines the pace of learning. This is the application, to some extent, of the theory of andragogy.

UNISA also advocates for a team approach in the development of its courses and strives for the delivery of open courseware (UNISA, 2014). However, UNISA courses still have fixed schedules, like registration and assessment dates. The production and delivery of the course material to learners at UNISA is done by different non-academic departments. An economy-of-scale is realized by the mass distribution of course material. Many DE institutions employ this mechanism in a time-line and production-line manner (Peters, 2004). This form of course material production and delivery is also characteristic of the industrialization theory of Peters (1998).

2.3.2 Teaching at a distance

As indicated, there are several DE theories that guide the practice of it (Holmberg, 2008, chap. 4). Most of these theories emphasize the use of non-formal conversational dialogue in interactions with students. The empathy approach advocates for a simulated conversation or dialogue in presenting instructional materials as well as communications with students. The transactional presence approach seeks to reduce the feeling of isolation usually experienced by DE students. The tutorial-in-print approach mimics the one-on-one conversational presentation that simulates interaction of the teacher with individual students. A DE teacher is expected to be able to successfully implement all these measures in teaching with technology at a distance.

Many higher education institutions, including UNISA, use learning management systems for the delivery of courses. Such systems support different multimedia and collaborative platforms that allow for an effective learning environment. The designing of learning activities that incorporate authentic learning experiences often requires the thoughtful use of different multimedia resources and educational technologies. The effective use of these resources can be more convenient and cost-effective, yet challenging, in the case of science subjects such as physics in DE. The challenge results from the majority of learning activities in science requiring experiments and involving demonstrations of abstract concepts. However, developments in technologies and pedagogies related to DE have made it easier to effectively use technology and multimedia tools in teaching and learning through DE. The World Wide Web provides instructional designers with access to educational repositories of a variety of educational resources that can be used and reused. Moreover, different frameworks (Bates & Poole, 2003; Krauss & Ally, 2005; Leacock & Nesbit, 2007) have been designed to guide the selection and appropriate use of technology and multimedia tools for educational purposes.

According to Anderson (2003) an effective learning environment supports student-content interactions, student-teacher interactions and student-student interactions. The extent to which each of the interactions is emphasized for establishing a meaningful learning experience is determined by the instructional approach adopted. The required emphasis on each of the interactions can be guided by the Community of Inquiry (CoI) framework (Garrison & Anderson, 2003) illustrated in Figure 2.1. According to this framework an instructional activity will lead to meaningful educational experiences if it maintains appropriate levels of cognitive presence, social presence and teaching presence. In a DE setting these components of the CoI framework have to be implemented through the appropriate use of technology.

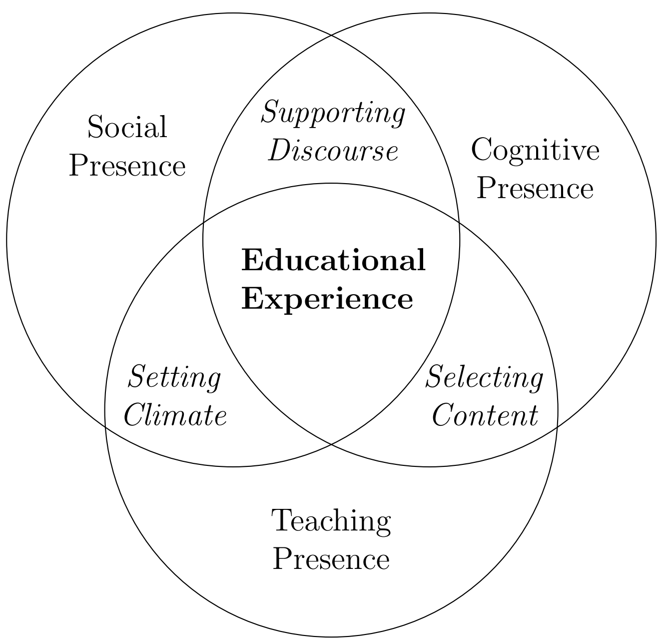


Figure 2.1: Community of Inquiry framework (Garrison & Anderson, 2003).

As mentioned earlier, many tertiary education institutions, including UNISA, make use of course management systems and learning management systems to facilitate the development and delivery of courses. Such systems have the capacity to integrate a wide range of pedagogical and course administration tools (Coates et al., 2005). Technological affordances of these systems include synchronous and asynchronous communication, content development and delivery, and assessment. The effective and efficient use of technology, in general, in the delivery of DE, in particular, is guided by pedagogical theories that relate subject-matter content to technology. This is well illustrated by the Technological Pedagogical Content Knowledge (TPCK) framework (P. Mishra & Koehler, 2006), Figure 2.2, outlines

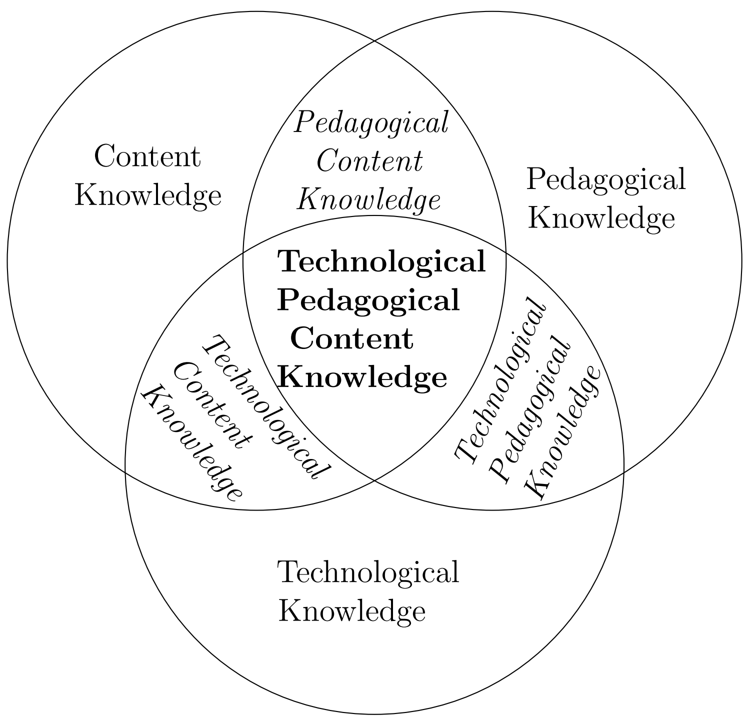


Figure 2.2: Technological Pedagogical Content Knowledge framework (P. Mishra & Koehler, 2006).

the usefulness of understanding the relationships among and affordances of technology, pedagogy and content knowledge for effective teaching with technology.

In this study the TPCK framework was used to contextualize the teaching of problem-solving skills in a DE physics module. The components of the framework were identified as follows:

Content	:	problem-solving skills, physics concepts
Pedagogy	:	problem-solving instruction, community of inquiry, connectivism, constructivism
Technology	:	print-based, learning management system, information and communication, classroom

The content delivered in the module includes concepts, principles and laws of mechanics as well as problem-solving skills. As required by the TPACK framework, the module is facilitated by an expert in physics with expert knowledge of mechanics and such skills. The minimum technology requirements in each presentation mode of the module are shown in Table 2.3 along with the perceived levels of the components of the CoI framework. In this case print-based technologies relate to the textbooks, tutorial letters and written assessment tasks (Peters, 2010). The module facilitator is a qualified educator with more than ten years of experience in higher and DE practices. It can, therefore, be argued that this facilitator has adequate knowledge of the content, pedagogy and technologies involved in the presentation of the module. The differing levels of the components of the CoI framework in the learning modes may lead to differing levels of learning achievement in the modes. The next section outlines how these three components can be combined to create a blended-learning environment in the delivery of courses at UNISA.

Table 2.3: The levels of the components of the CoI in relation to the learning modes and the technologies involved in the present study.

Learning Mode	**Technology used**	**CoI Presence**
Correspondence	Print-based, Information and Communication	- Social : Low - Cognitive : Low - Teaching : Low
Online	Print-based, Learning Management System	- Social : Moderate - Cognitive : Moderate - Teaching : Moderate
Face-to-face	Print-based, Classroom devices	- Social : High - Cognitive : High - Teaching : High

2.4 Blended learning

Implementing a blended learning approach in DE requires the combination of traditional correspondence, online and face-to-face classroom technologies and pedagogies to varying degrees. A clear guideline on what to combine and how to combine and to what extent would be helpful in creating effective learning environments. However, discussions on the correct definition of a blended learning environment are still going on (Graham, 2005). According to the TPCK framework, the creation of a meaningful learning environment involving technology is the result of sufficient knowledge of the relationships among and the affordances of technology, the pedagogy and the content.

There are several definitions of the term *blended learning*, as mentioned. Some of the definitions are limited to the traditional classroom teaching and learning

(Anderson, 2003). Bates and Poole (2003, p. 41) view blended learning as the use of a combination of different learning strategies and approaches. Vaughan (2010) argue that blended learning is the integration of best features of two or more learning strategies or modalities to promote active, flexible and self-directed learning. As noted, Garrison and Kanuka (2004) helpfully refer to blended learning as the combination of synchronous and asynchronous learning activities or modalities to create a flexible and supportive learning environment. Here synchronous learning activities include audio- and video-conferencing, face-to-face classroom activities and one-to-one consultation. Asynchronous activities include online discussions, electronic mail and postal mail communications.

Peters (1998) discusses various aspects of DE, including possible course presen-

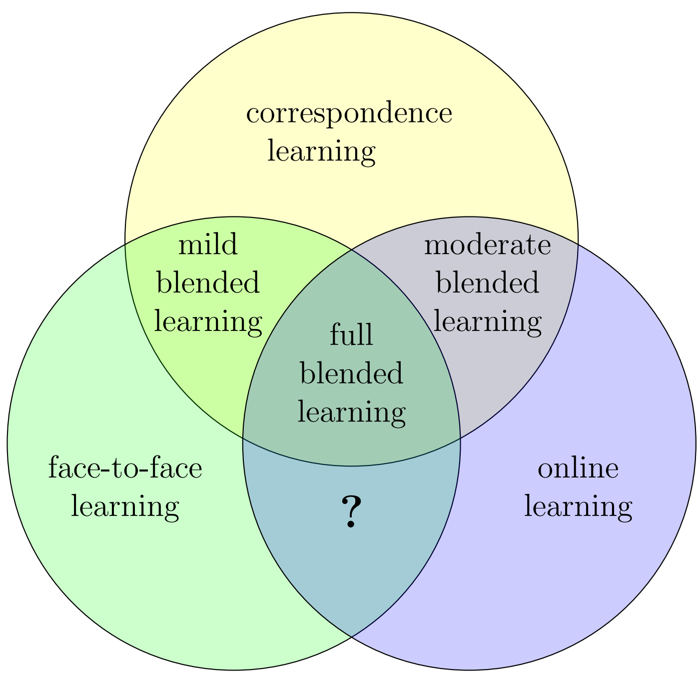


Figure 2.3: Possible learning approaches in a distance education environment.

tation modes. Different possible combinations of such course presentation modes are illustrated in Figure 2.3. These combinations can be viewed as various degrees of blending technologies and pedagogies applicable to each component. It was indicated earlier that effective blending of the course presentation modes require careful consideration of pedagogical strengths and weaknesses of the various technologies. The implementation of a blended learning approach is not expected to be without challenges (Vaughan, 2010). However, is was discovered that the success of the implementation depends on (Stacey & Gerbic, 2008; Vaughan, 2010) (i) the institutional needs and readiness in terms of technical support, (ii) teacher motivation in terms of development programs, (iii) student maturity and expectation in relation to time management and technology competencies, and (iv) pedagogical bases of various technologies involved in relation to content and context.

Research has shown that courses that employ blended learning have relatively higher success rates than traditional classroom and fully online courses (Graham & Allan, 2005; Vaughan, 2010, p. 169). The results of these studies also indicate that the quality of the learning through blended learning is also higher. These results support the prediction of Peters (1998) that distance teaching and learning with blended educational technologies would establish an enabling learning environment. However, the effective use of technology in the delivery of education in developing countries is likely to be faced with challenges (Gulati, 2008; Jhurree, 2005; Kinuthia & Dagada, 2008). Some of the challenges of blended learning are discussed in the next subsection.

2.4.1 Challenges of technology use in education

The quality of an education course is determined by a number of factors, like *media utilization, presentation strategy, learning activities, assessment* and *feedback*

(Moore & Kearsley, 2005). At the beginning of online education, online courses were presented through text-based computer-mediated (Caplan & Graham, 2008) materials restricted to learning management systems. However, because of developments in DE pedagogies and Internet technology, the delivery of distance and online courses is able to harness Internet capabilities for effective teaching and learning (Veletsianos, 2010). Different multimedia resources and repositories, like Discovering Physics (Bolton & Ross, 1997) and Mastering Physics (Knight, 2013), are now accessible either through the Internet or recorded digital devices (Gonen & Basaran, 2008). The main instructional materials in a traditional correspondence DE course are textbooks and study guides. These course materials may be augmented with a pacer and instructional material to guide students. Since different physics textbooks adhere to different problem-solving strategies (Halliday, Resnick, & Walker, 2011; Knight, 2013), the instructional material would address the difference between the prescribed problem-solving strategy and the one adopted in the prescribed textbook.

Many of the challenges associated with the use of technology in education are summarized by the SECTIONS framework developed by Bates and Poole (2003). This is designed to evaluate the level of appropriateness and usefulness of a given technology when used for educational purposes. Traditionally, DE courses rely on correspondence for communication and delivery of course material and are managed through learning management systems. Based on the SECTIONS framework the use of a learning management system raises concern over issues of reliability, costs and access, especially in the context of a developing country like South Africa. These limitations arise because of the low quality of technical support provided by the institution, low technological competency of the target students and additional cost to students of internet access. In the case of a correspondence DE course the SECTIONS framework highlights issues of reliability and speed, that result from the inherently slow nature of postal services. For UNISA students, UNISA regional centres across the country, and in some African countries, can be used to access computer facilities, internet access and tutor support. However, issues of proximity, which affects access, still remain.

2.5 Conclusion

In this chapter the concepts of problem solving and DE have been outlined based on the literature. Problem-solving skills and problem-solving assessment have been discussed. Developments in DE and the dependence of such development on technology were described. In the next chapter the research method of the study is described.

Chapter 3

Research method

3.1 Introduction

This chapter outlines the research method followed in the study. The research design of the study is explained and the target population as well as the sampling procedure used are described. The data collection procedure and data collection instruments are also discussed. The validity and reliability of the instruments and data are explained. The design of the study is discussed in the next section.

3.2 Research design

There are several types of research methods associated with quantitative research. A detailed discussion of these can be found in a standard textbook, such as (Creswell, 2012). The more common research designs are the case study, laboratory experiment, survey and *ex post facto*. In experimental research subjects are studied under controlled conditions where there are at least two variables that are compared (Campbell & Stanley, 1963; Cohen et al., 2007). In such a design the cause-effect relationships between the variables are studied where one variable changes and another is observed. An *ex post facto* design is normally used to investigate correlational relationships between variables. However, in such a design there is no control over all the dependent variables (Creswell, 2012). The present study is one involving delivery of DE. It is not possible to control all the dependent variables involved and attempting any such control is impractical and would be unethical. It is also not possible to randomly assign subjects to groups. Therefore, the *ex post facto* research design was used for this study.

In this study *blended learning* was the treatment variable, with the treatment levels described as *mild*, *moderate* and *full* based on the combinations of learning modes used. Using only correspondence was considered no blending while using online and face-to-face were considered full blending. The number of problems solved, the achievement marks and strategy used in problem-solving tasks were treated as the response variables. A problem-solving instruction was implemented in a first-level distance education physics module with the objective of teaching problem-solving skills to students taking the module. The population of students taking the module automatically divided into two groups, students who used such an approach and students who did not use a blended-learning approach in the learning of problem-solving skills in the module. The study compared the physics achievement of the final formative and summative assessment tests for the two groups, assuming that the problem-solving instruction was effective in transferring problem-solving skills in a traditional face-to-face classroom setting (P. Heller et al., 1992).

The design of the study was based on the presentation modes of the module. As indicated above, the module was presented through print-based correspondence, text-based online and face-to-face classes as follows:

- **Correspondence**: This was the traditional tuition mode at UNISA. In this learning mode tuition takes place through sending (receiving) the module material (study guide and tutorial letters) to (from) the university using postal services, e-mail and telephone.

- **Online**: The myUnisa LMS was used for the online presentation of the module material (study guide and tutorial letters). Weekly online module discussions were scheduled on the discussion forum. Participation in the online interactions required access to computer and internet facilities, which could be accessed at the university regional centers.

- **Face-to-face**: Two face-to-face discussion classes in the semester were scheduled for the module, and the students were informed of the date, time and venue at least one month before the class. The classes were held at different regional centres in the Gauteng Province. Module material related to the first two module units was treated during each class. The class focused on problem-solving and students were working individually during the problem-solving activity.

All students registered for the module were invited to participate in the module through all the three modes of the module presentation.

The presentation of the module supported synchronous and asynchronous learning interactions through face-to-face, online and correspondence. The learning interactions relevant to this study were identified as

Interaction 1: *asynchronous* through *correspondence* interactions.

Interaction 2: *asynchronous* through *correspondence* and *online* interactions.

Interaction 3: *synchronous* and *asynchronous* through *face-to-face* and *online* interactions.

Interaction 4: *synchronous* and *asynchronous* through *face-to-face* and *correspondence* interactions.

Interaction 5: *synchronous* and *asynchronous* through *face-to-face* and *online* and *correspondence* interactions.

All these learning interactions represent varying degrees of blended learning modes. The correspondence and online modes can individually be considered blended learning to some extent (Peters, 2010) since there are possibilities of additional synchronous interactions through audio- and video-conferencing or in-personal consultations. A face-to-face class in DE is not considered an independent presentation mode but a student-support mechanism (Moore & Kearsley, 2005; Peters, 1998). Learning interaction 3 is included in Learning interaction 5 for DE modules.

Table 3.1: Treatment levels and coding of the blended-learning approach.

Code	**Level**	**Description**
0	No blending	Correspondence only
1	Mild blending	Correspondence and face-to-face
2	Moderate blending	Correspondence and online
3	Full blending	Correspondence and face-to-face and online

In this study *blended learning* was the treatment variable with the treatment levels described as *mild*, *moderate* and *full*. The coding and description of the treatment levels are summarized in Table 3.1. These levels of blended learning interactions result in four possible subgroups of students. The students' achievement marks, frequency of strategy used and problem-solving performance in the module were the response variables. The hypothesis of this study, as noted, was that DE students using moderate or full blended-learning approaches learn effectively and perform better in problem-solving assessment tasks than students using no blended-learning approaches. In the next section the data collection procedure is described.

3.3 Data collection procedure

The data collection procedure for this study is based on the actual presentation of the module. The teaching of problem-solving skills followed the general guidelines for skills training. These include; the (i) direct explanation of the prescribed problem-solving strategy, (ii) the modelling of the strategy through worked-out examples, (iii) offering opportunity for independent practice of the strategy through formative practice problems and (iv) giving immediate feedback (Selçuk et al., 2008). The module considered for this study was a DE semester module: the calculus-based first-level physics Mechanics module. It was presented through correspondence as well as online using the myUnisa LMS. Two face-to-face classes were organized as a learner-support measure. The module was divided into four learning units with each unit scheduled to be treated over three weeks. Online presentation followed the schedule shown in Table 3.2. Students relying on the correspondence mode were advised to adhere to the same schedule for pacing.

For each module unit students were required to first study the summary of the mechanics concepts, laws and principles covered. Three worked-out examples and three formative exercise problems were assigned for each module unit. The format of the solutions of the worked-out examples was consistent with the prescribed problem-solving strategy and the solution rubric. The summaries of the mechanics concepts, laws and principles were discussed with the instructor, or tutor. However,

Table 3.2: Module learning units discussion modes and schedule.

	Traditional	**Asynchronous**	**Synchronous**
Unit 1	Correspondence	Online (week 1 - week 3)	
Unit 2	Correspondence	Online (week 4 - week 6)	Face-to-face one day (week 6)
Assignment 1	Formative assessment		
Unit 3	Correspondence	Online (week 7 - week 9)	Face-to-face one day (week 9)
Assignment 2	Formative assessment		
Unit 4	Correspondence	Online (week 10 - week 12)	
Examination	Summative assessment		

the solutions to the exercise problems were constructed by the students without assistance. This procedure was referred to as the problem-solving instruction in this study (Hoffman, 1997). The example and exercise problems were chosen to be of difficulty rating 3 or less (explained in Section 3.6).

A study guide, in the form of a tutorial letter, containing an outline of the problem-solving instruction was made available to students at the beginning of the semester. The study guide contained the following information:

- an outline of the prescribed problem solving strategy,
- the solution assessment rubric,
- worked-out examples of three problems per learning unit,

- three exercise problems per learning unit for students to solve, and
- a tentative study schedule or pacer for the module; see Table 3.2.

The study guide was compiled following the tutorial-in-print approach in an informal conversational tone (Holmberg, 2008).

In all the three modes students were required to go through the problem-solving instruction. The problem-solving instructional approach involved: (i) studying the concepts, laws and principles, (ii) studying the worked-out examples, and (iii) solving the exercise problems. Then, the students were to

- complete learning activities in the study guide and submit solutions to the formative test problems to the instructor for feedback,
- participate in the online learning activities and submit solutions to the formative test problems to the instructor for feedback, and
- attend at least one face-to-face class, participate in the problem-solving activities and submit solutions to the formative test problems to the instructor for feedback.

The problems were to be treated (solved and solution submitted for feedback) one at a time, starting with Problem 1 of Learning Unit 1. The solution rubric shown in Appendix C, which reinforced the prescribed problem-solving strategy, was used for providing feedback on the submitted solutions. Problem 2 was to be treated only after feedback for Problem 1 was received. This instructional approach incorporated the "feedback-corrective procedures" and "parallel formative assessment" which are characteristics of the *mastery learning* approach (Bloom, 1984). The next section focuses on the population and sampling for the study.

3.4 Target population and sampling

A population is the total number of elements or subjects in a group that have similar characteristics of interest to a researcher (Creswell, 2012). The target population comprised all the students registered for the first-level mechanics physics module. The module was primarily registered for, as part of a qualification pursued for career purposes. The target student population consisted of males and females with ages between 18 years and 50 years, the majority of whom resided in South African, Africa. Some of the students were employed in various economic sectors while others were not employed. However, the target population was treated as a homogeneous group. All the students were familiar with information and communication technologies (computer, cellphone) and had used instant-messaging and e-mail services. Also, one of the admission requirements to the module was a pass in the Physical Science and English subjects at Grade 12 level. Therefore, the students were familiar with DE technologies and were proficient in the language used in the module presentation. However, the students were used to face-to-face teaching, which differed from the distance teaching and learning in this module.

As indicated, it is not always possible to study the whole population. Therefore, a small number of subjects from the population that are representative of it are usually studied and the result generalized to the whole population. This small number is called a *sample* of the population (Creswell, 2012). There are several permitted procedures of selecting a sample from a population for results to be valid. These, which include simple random sampling, stratified sampling and purposive sampling, are discussed by (Cohen et al., 2007). In *simple random sampling* subjects are randomly selected from the population with an equal probability of being selected while in *stratified sampling* the population is first divided into several homogeneous subgroups before sampling each subgroup. In *purposive sampling* the researcher selects the sample based on the researcher's expected feedback from the subjects (Cohen et al., 2007). Since the target population is divided into groups that use a particular mode of learning, the stratified sampling technique was used in selecting the sample for this study.

As mentioned, all the students registered for the module were invited to participate in the module by taking part in the online module activities as well as attending the face-to-face class of the module, in addition to the traditional correspondence tuition. Three main subgroups of students in the module were identified based on whether they participated in the online part and/or face-to-face class of the module. As a result, a stratified random sampling technique (Creswell, 2012) was used to identify groups of students, depending on the additional participation mode in the learning activities of the module. The strata and the subject selection in the strata are illustrated in Figure 3.1. Since few students were anticipated to participate in the face-to-face class as well as the online part of the module, for reasons indicated in the previous chapter, all the participants in these learning modes were considered for the study. However, a simple random sampling technique was used to select a proportional number of students using the correspondence learning mode only. Data collection instrumentation is discussed in the next section.

3.5 Data collection instruments

The data collection instruments for this study were researcher-designed criterion-referenced tests with closed problems as test items (see Appendix B). The problems tested the knowledge and understanding of physics concepts at various levels of

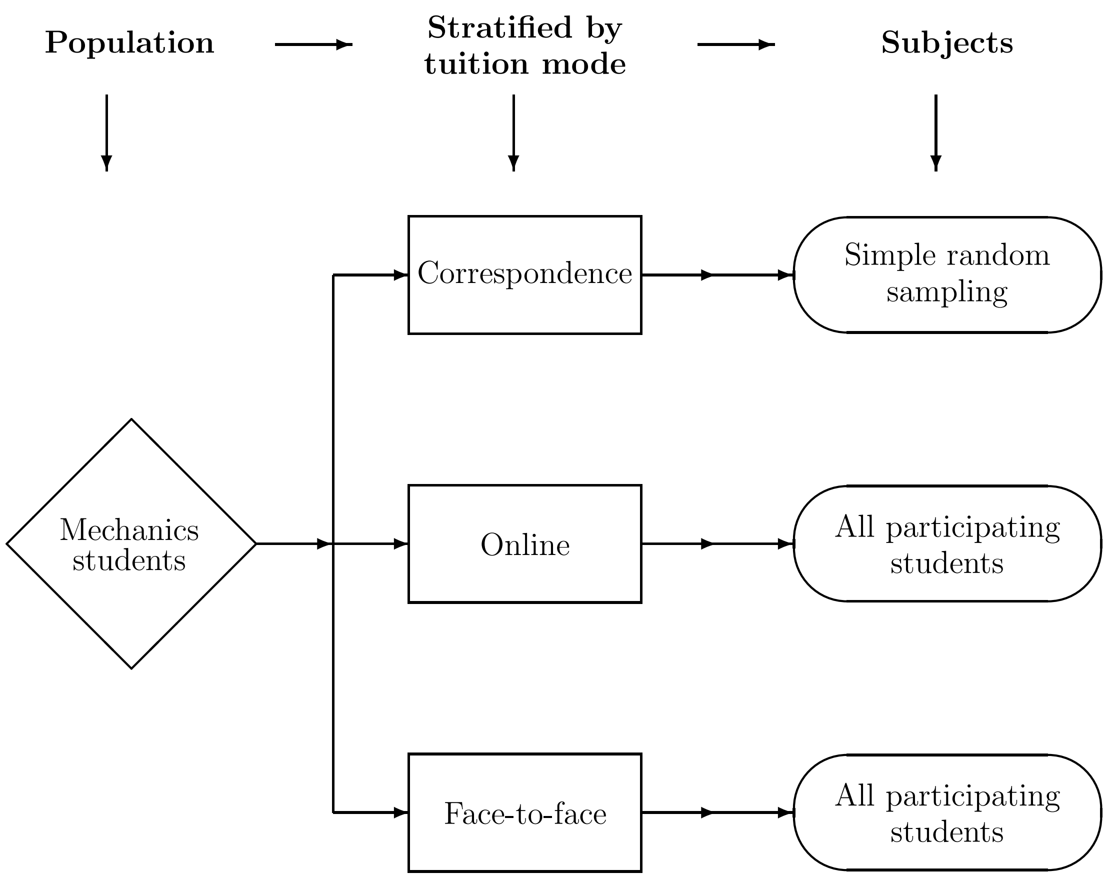


Figure 3.1: Illustration of the sampling of the target population for this study based on tuition mode.

Bloom's taxonomy of learning objectives (Krathwohl, 2002). The problem-solving activity in this study consisted of three sets of problems: worked-out examples, formative practice problems, and formative assessment ones. All the problems in the formative tests were end-of-chapter problems taken from standard mechanics textbooks (see Appendix B). The problems in the formative practice set were taken from that by Halliday, Resnick, and Walker (2001) whereas those in the formative assignment and the summative examination were taken from the textbook by Knight (2013). The former textbook was previously prescribed while the latter is currently prescribed for this module. The formative practice problems were used to guide the learning of problem-solving skills while the formative and summative tests are used to assess the achieved level of problem-solving skills. The concepts of validity and reliability are discussed in the next section.

3.6 Validity and reliability

Validity in experimental research, as mentioned, refers to the demonstration that the experimental treatment caused the observed effect, and the extent to which the experimental findings can be generalized (Creswell, 2012). The validity of experimental data is threatened by errors introduced through, among other factors, *sampling bias, experimental mortality, instrumentation* and *instrument reactivity* (Campbell & Stanley, 1963). As explained by Cohen et al. (2007):

- Sampling bias results when subjects are selected differently or when a complete class is used as an experimental or control group.
- Experimental mortality occurs when the experiment is too long and experiment subjects drop out of the experiment.
- A data-collection instrument that was not appropriately prepared and was not well tested is not reliable.
- Instrument reactivity refers to the context (the psychological effect and physical conditions) of the implementation of the instrument on the subjects.

Some of the measures that minimize threats to validity of experimental results are randomizing the sampling, keeping the experimentation period short and natural, as well as standardizing the data-collection instrument (Cohen et al., 2007).

The data collection instruments for this study were the formative assignment and a summative end-of-semester examination. Several measures were taken, as noted earlier, to ensure validity and the reliability of the instruments and results. The problems were selected from a test-bank used in previous official formative and summative assessment tests in the module. In addition, a test consisting of problems with deep similarity characteristics to the problems in the assessment tests was given to students registered for the module in the previous semester. This helped improve the clarity and comprehensibility of the problems in the tests. The same rubric used to assess solutions to the formative practice problems was used to assess solutions to problems in the formative and summative assessment tests. The test problems were moderated by an internal physics expert. The students' solutions were marked by an external marker and the marked solutions were moderated by two internal physics expert. The inter-rater ratio was also calculated.

Reliability in experimental research refers to the consistency of the experimental treatments in producing the same response at other times or from different experimental groups (Creswell, 2012). The main types of reliability in quantitative research are *stability, equivalence* and *internal consistency.* Stability of the data-collection instrument is achieved when similar results are produced at different times and with similar samples, while equivalence is achieved when equivalent instruments or different observers generate similar results. A measure of the equivalence in test results is the inter-observer ratio R (Cohen et al., 2007),

$$R = \frac{Number\ of\ actual\ agreements}{Number\ of\ possible\ agreements}\,.$$

An inter-observer ratio of $R = 1.00$ denotes perfect agreement between observers.

The use of formal formative and summative assessment tests scores as data for testing treatment effect in educational research is generally discouraged (Black, 2000; Campbell & Stanley, 1963; Moody & Sindre, 2003). This is owing to not only the possible diminished reliability and validity of such tests as research instrument (Black, 2000; Phipps & Merisotis, 1999), but also to possible sample-integrity degradation (history) (Moody & Sindre, 2003). Sample integrity cannot be assured in experimental designs that require prolonged treatments (Creswell, 2012). However, because of the unique experimental setting of the study (single-mode distance learning), and sampling procedure employed, the sample-strata integrity is less threatened by diffusion in time.

3.7 Conclusion

In this chapter the design of the study and methods of collecting data as well as data collection instruments have been explained and justified. The target population and sampling were described. The reliability and validity of the instruments and data were considered. In the next chapter the results of the study are presented and analyzed.

Chapter 4

Results and discussions

4.1 Introduction

In this chapter student participation in the module and the sample size are discussed. Primary and secondary data for the study are presented and analyzed. The composition of the sample is first explained in the next section before the data is given.

4.2 The sample size

Records from the student management system show that there was a total of 240 active students registered for the module in the semester considered. However, the sample was drawn from the population of students who participated in the face-to-face and online learning activities of the module, as well as those who submitted solutions to the second formative assignment and sat for the summative examination. Records from the assignment management system show that a total of 179 students submitted a response to the second formative assignment. Most of these students also sat for the summative examination.

4.2.1 Face-to-face

Two four-hour-long face-to-face classes were scheduled for the module and, as indicated previously, the students were informed of the date, time and venue one month before the class. Both classes were held at UNISA regional centres in the Gauteng Province, one month apart. All students were invited to attend at least one of the face-to-face discussion classes. Out of all the students registered for the module, only 13 students attended the first class, 13 attended the second class with 6 students attending both classes. Students worked individually during the problem-solving activity. Feedback was given for the solutions to practice problems and copies of the students' solutions were kept for further analysis.

Based on the records kept by the module instructor, a total of 19 students attended the face-to-face discussion classes. It was noted that attending a class required students to travel to the class venue. Therefore, limitations related to proximity and socio-economic factors, in addition to other reasons, may have prohibited some students from attending the classes (Jhurree, 2005). All but two of the 19 students submitted solutions to the second formative assignment while two others did not sit for the summative examination. Using the outlined selection criterion, only 15 students were selected for the face-to-face group.

4.2.2 Online

The myUnisa LMS was used for the online presentation of the module material (study guide, tutorial letters, etc). Weekly online module discussions were held on the discussion forum. Also, regular announcements inviting students to participate in the discussions and the problem-solving exercise were posted on myUnisa. The myUnisa site statistics show that the discussion forum, drop box and learning units tools were extensively used by students. However, the relevant data for this study were the students' responses to the set learning tasks, which were the discussions on the forum and the solutions to the formative practice problems. The solutions to the formative practice problems were to be sent to the instructor through e-mail, the postal system or drop box, for assessment and feedback. Based on the site statistics for these two tasks, only 16 students contributed in the online discussions and submitted solutions to some of the practice problems through drop box and e-mail.

Based on the statistics from the myUnisa LMS site, the students were active only for Unit 1 and Unit 2 discussions. A total of 19 students participated in the online discussion forum and submitted solutions to some of the formative practice problems. Participation in the online interactions required students to access computer and internet facilities, for instance at the university regional centres. However, limitations related to proximity to such centres and socio-economic factors as well as student competency with the technologies (Bates & Poole, 2003) may have prohibited other students from participating. All but two of the 19 students submitted solutions to the second formative assignment. Therefore, only 17 students were considered for the online group.

4.2.3 Correspondence

It will be recalled that correspondence tuition involves sending (receiving) module material (study guide, tutorial letters, etc) to (from) students using mainly the postal system and e-mail for communication (Peters, 2010). Occasionally, telephone and in-person consultations are used for communication and feedback. According to the record kept by the instructor only 16 students used e-mail for discussion and submitted solutions to the formative assignment. Only 2 students used in-person consultation for discussion.

The solutions to the formative practice problems were to be sent to the instructor through the postal system or e-mail. However, communication through the former was expected to be delayed by the nature of such a system (Peters, 1998). There was also an industrial action in the postal system of South Africa from the second month of the semester (August) that continued until the semester summative examination was written (Post Office of South Africa [SAPO], 19 August 2014). This industrial action affected the speedy delivery of assignments and feedback from/to students. Only students who submitted solutions to the second formative assignment and did not attend a face-to-face class nor participate in the online learning activities were considered for the correspondence group. There were 127 such students.

A summary of the number of subjects in each group is given in Table 4.1. In this table N_i represents the initial number of active subjects, N_f the final number of legitimate subjects as explained above, and N_S the number of subjects sampled. N_i for the correspondence group is determined by subtracting the N_i for the face-to-face and online groups from the population number. The lowest N_f of the

Table 4.1: The number of active subjects in correspondence, face-to-face and online groups. N_S is the final group size.

Groups	$\mathbf{N_i}$	$\mathbf{N_f}$	$\mathbf{N_S}$
Correspondence	157	127	15
Face-to-face	19	15	15
Online	19	17	15

three groups is 15, which is for the face-to-face group. This number was set as the sample size for all the groups. As a result, a systematic sampling technique (Cohen et al., 2007) was used to select 15 subjects for the correspondence group from a randomly organized list of all the corresponding students. A simple random sampling technique was used to exclude two subjects for the online group from a randomly organized list of subjects in the group. Therefore, the final simple size was 45 students. No matching of the subjects in the groups (Creswell, 2012, p. 298) was done as this would have shrunk an already small sample.

4.3 Data collection

All the necessary ethics permissions were obtained before data collection started. Primary and secondary data were collected to answer the research questions posed. The primary data consisted of: (i) the solutions to formative practice problems, (ii) the number of problems attempted in the problem-based formative and summative assessment tests, (iii) the frequency of strategy use when solving problems and (iv) the academic achievement marks of the formative and summative assessment tests. The secondary data comprised: (i) statistical data relating to participation in online learning activities, correspondence communications and (ii) the mark for the module determined from the combinations of the achievement marks of the two formative assignments and the summative examination. The primary and secondary data are presented in the following two subsections

4.3.1 Primary data

The formative assignment and the summative examination were marked by external experts who had no knowledge of the experiment. The marks for the second formative assignments as well as the number of problems N_P with complete solutions are given in Table 4.2 for the three groups. The data is listed in descending

Table 4.2: The number of problems with complete solutions N_P and the formative assignment mark S_F for the three groups.

Subj. Code	**Correspond**	
	N_P	S_F
C1	10	100
C2	10	93
C3	10	92
C4	10	63
C5	10	51
C6	10	43
C7	10	38
C8	9	78
C9	9	58
C10	8	77
C11	8	74
C12	7	55
C13	6	56
C14	5	33
C15	2	18

Subj. Code	**Face-to-face**	
	N_P	S_F
F1	10	92
F2	10	91
F3	10	86
F4	10	74
F5	10	73
F6	10	45
F7	10	45
F8	9	67
F9	9	55
F10	9	51
F11	8	47
F12	7	35
F13	6	34
F14	6	32
F15	4	17

Subj. Code	**Online**	
	N_P	S_F
L1	10	100
L2	10	95
L3	10	95
L4	10	91
L5	10	87
L6	10	86
L7	10	74
L8	10	73
L9	10	68
L10	10	53
L11	10	15
L12	9	78
L13	8	49
L14	7	66
L15	6	58

order of the value of N_P and the assignment mark S_F. The subject codes (Cx, Fx, Lx) correspond to the label of the group where $x = 1, 2, 3, \ldots, 15$. Table 4.3 shows the mark S_S for the summative examination, the number of problems with complete solutions, as well as the frequency of strategy use N_{SU} in the solved problems. After moderation of the summative examination, a sample of 31 examination scripts (worksheets) was randomly selected for remarking as well as for counting the number of problems with complete solutions carried out by a physics expert. The inter-rater ratios were determined by the relation (Cohen et al., 2007)

$$R = \frac{number\ of\ actual\ agreements}{number\ of\ possible\ agreements}\,.$$

The inter-rater scores for the examination mark and the number of problems with complete solutions are found to be $R_S = 0.68$ and $R_{N_P} = 0.65$, respectively. These scores qualify the rater agreements as good (Gwet, 2010) and, therefore, acceptable for rater reliability.

In the study conducted by P. Heller et al. (1992) students were given limited time to complete the formative assignment and unlimited time to complete the summative examination. In the present study students were given unlimited time to complete the formative assignment and limited time to complete the summative examination. It should, however, be noted that the concept of "unlimited time" in the context of distance education differs from that of the P. Heller et al. (1992) experiment. As in the studies by P. Heller et al. (1992) and by Selçuk et al. (2008) the number of attempted problems and completed solutions was used to assess the quality of the students' formative and summative solutions. A complete but incorrect solution is likely to contain more information about the problem-solving strategy used than a partially correct but incomplete solution. This is the reason why incomplete solutions were not considered as useful data in this study. In the case of the summative examination 30 worksheets were selected randomly from a randomly organized set of 246 worksheets for analysis by two physics experts.

Table 4.3: The number of problems with complete solutions N_P, the frequency of strategy use N_{SU} and the summative examination mark S_S for the three groups.

Subj. Code	**Correspondence**			**Face-to-face**			**Online**		
	N_P	N_{SU}	S_S	N_P	N_{SU}	S_S	N_P	N_{SU}	S_S
1	7	1	28	5	5	23	5	2	35
2	8	1	42	7	3	64	7	2	39
3	9	1	47	6	3	58	10	10	86
4	4	2	26	8	3	38	4	1	25
5	8	1	51	7	4	52	7	7	67
6	10	3	40	6	2	21	6	3	58
7	9	0	59	8	3	29	8	2	40
8	8	1	55	7	3	39	7	1	22
9	7	3	47	7	4	39	7	7	40
10	8	1	46	8	5	52	7	3	42
11	9	9	79	6	4	28	8	3	57
12	4	2	14	5	2	43	5	1	43
13	5	2	23	6	3	30	1	0	15
14	4	0	55	5	3	33	8	5	55
15	4	1	42	3	3	21	5	1	38

4.3.2 Secondary data

The official grading system at UNISA uses percentages for marks. The final mark for the module is obtained from 20% of the formative assessment mark and 80% of the summative examination mark. The final module mark was obtained from records provided by the examination department. Other secondary quantitative data concerning students' activities in the module during the semester include communication with the instructor (tutors), attendance of the face-to-face class as well as using myUnisa for learning activities. Statistical data concerning students' participation in the online learning activities on myUnisa were obtained from the myUnisa site statistics. Data concerning students' participation in the face-to-face class as well as telephone and in-person discussions were obtained from records kept by the instructor. The data presented is analyzed in the next section.

4.4 Data analysis

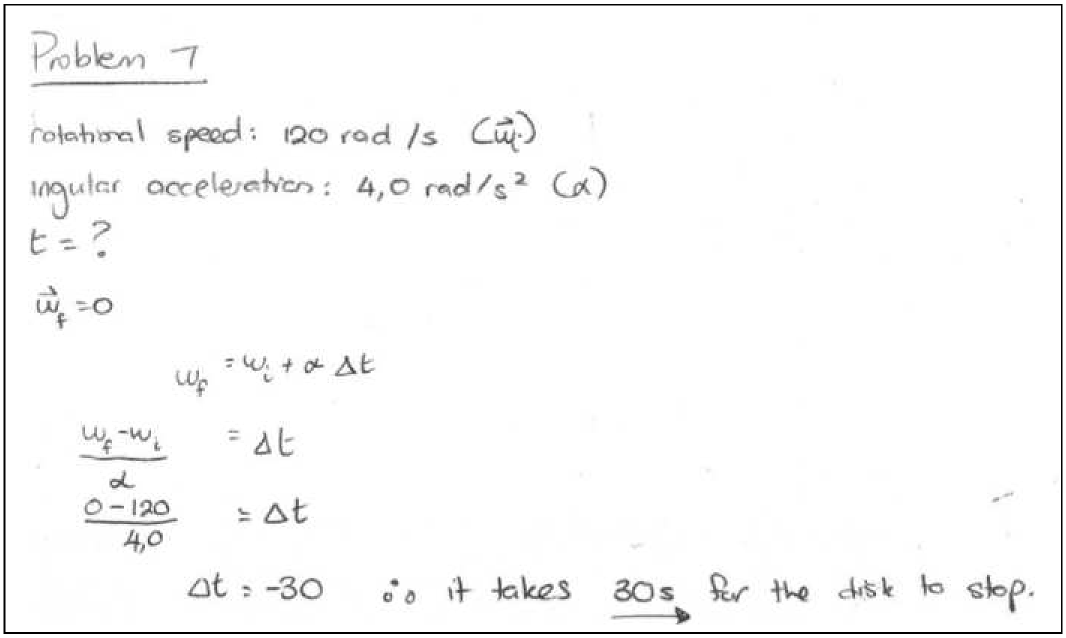
4.4.1 Learning problem-solving skills

The problem-solving exercise was designed to be an individual activity, with each problem in the exercise treated individually. That is, the first problem was to be treated first and submitted immediately, before the second or third. The worked-out examples and assessment rubric were designed to reinforce the prescribed problem-solving strategy. Feedback was given within twenty-four hours, if not immediately. The second problem was to be treated only after feedback to the first problem had been received. All the problems were to be treated in a similar manner, consecutively. This procedure is similar to the one used in the study by Schroeder, Gladding, Gutmann, and Stelzer (2015) in a face-to-face setting.

This approach was expected to progressively develop students' problem-solving skills. It was expected that all solutions would be presented in a format consistent with the assessment rubric. However, it was not expected that it would be necessary to complete all twelve formative practice problems since the blended-learning approach incorporated repetitions of the problem-solving strategy in the form of worked-out examples.

During each face-to-face class, the problem-solving session was preceded by a brief discussion of mechanics concepts, treatment of two examples covered in the two units, and the solution-grading rubric. These discussions were not expected to be sufficient to adequately address the content component of the problem-solving instruction. Students were expected to have studied these concepts in advance. The learning activities for the class focused more on the *process* of problem solving and the format of a typical problem solution. Because of time constraints students were allowed 10 minutes to complete a problem. This time limit may have added to their reactive effects (Lesaux, Pearson, & Siegel, 2006; Tsui & Mazzocco, 2006) and probably interfered with their learning and practice of problem-solving skills. An example of the effects of the feedback-corrective measures is depicted in Figure 4.1. Similar effects were observed in the online and e-mail submissions that adhered to the prescribed formative practice procedure.

Not all the students could complete the first problem in 10 minutes, probably, because of anxiety (Tsui & Mazzocco, 2006). Most could not complete the first task of extracting *useful information* from the problem statement as illustrated in Figure 4.1. The reasons cited for this seemingly slow response to the task were (1) the implicit information given in, and (2) the lack of self-confidence in the information extracted from the problem statement. These reasons are consistent with the identification of the "implicit given information" in the problem statement



Problem 7

rotational speed: 120 rad /s ($\vec{\omega}_i$)

ingular acceleration: 4,0 rad/s^2 (α)

$t = ?$

$\vec{\omega}_f = 0$

$$\omega_f = \omega_i + \alpha \Delta t$$

$$\frac{\omega_f - \omega_i}{\alpha} = \Delta t$$

$$\frac{0 - 120}{4,0} = \Delta t$$

$\Delta t = -30$ ∴ it takes 30 s for the disk to stop.

Figure 4.1: The solution attempt for practice Problem 7 by L8.

as a characteristic of a “difficult problem” (P. Heller et al., 1992; Maloney, 2011). After feedback on their solution attempt and an illustrative example, students were given 10 minutes to solve the second problem. Although they could all successfully extract useful information from the problem statement and identified the correct applicable physics concepts, some of the students could not complete the solution in the given time. Many of those who could do so managed to identify the correct applicable physics concepts, but did not explain the reason for the applicability of the concepts. That is, they merely stated and applied the equations as illustrated in Figure 4.2. One of the reasons cited for not justifying the choice of the physics equations used was *lack of self-confidence* about the content and format of such a justification. Feedback on the students’ performance in the problem was given and one more illustrative example was treated.

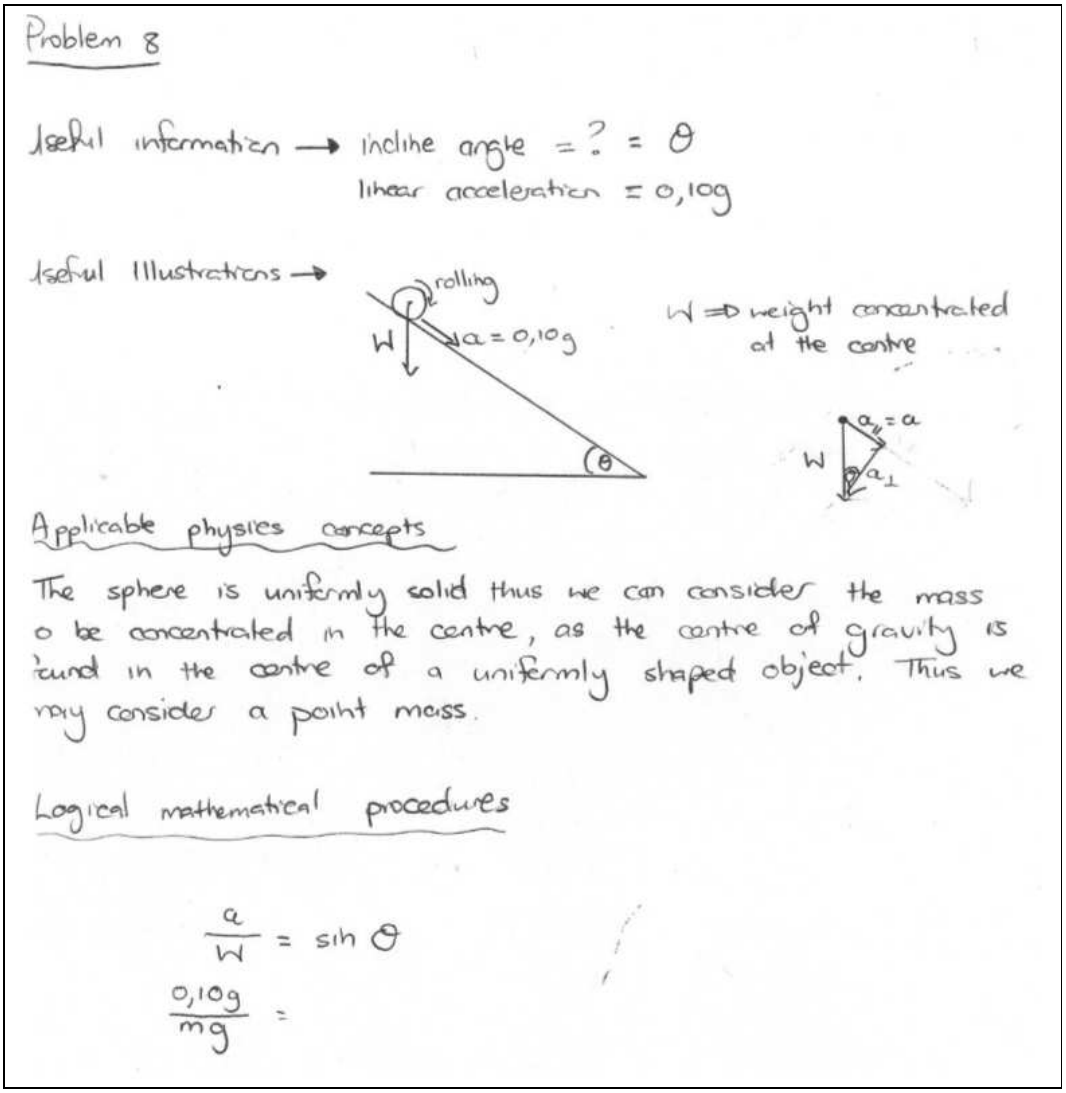


Figure 4.2: The solution attempt for practice Problem 8 by L8.

4.4.2 Number of problems solved

The official UNISA practice on moderation is to first sort the examination worksheets in ranges of marks obtained. The usual mark ranges are above 70%, between 50% and 70%, between 40% and 50% and below 40%. Then, each of the four sets of worksheets would be randomly sampled for moderation. This systematic sampling of worksheets is consistent with the Fleiss' Kappa benchmark scale (Gwet, 2010). Based on this benchmark, the number of problems attempted with complete solutions, the frequency of strategy use in solving the problems as well as the achievement marks were divided into three categories as shown in Table 4.4.

Table 4.4: Coding of performance measures in this study.

Category	**No. of problems**	**Strategy use**	**Achievement mark**
A	8 or more	6 or more	70 or more
B	5, 6 or 7	3, 4 or 5	50 to 69
C	4 or less	2 or less	49 or less

It should be noted that a Category A assignment is likely to lead to a higher achievement mark than a Category C assignment. The problem-solving performance for the formative assignment and summative examination were categorized following Table 4.4. The results for the number of problems solved along with the category mean for the formative and summative assessment are shown in Table 4.5 and Table 4.6, respectively.

It can be seen from Table 4.5 that 87% of the students using the online learning managed to generate high quality responses ($M_L = 74\%$) for the formative as-

Table 4.5: The average problem-solving performance based on the number of problems solved for the formative assignment. N is the number of students in the group and M the mean.

Category	**Correspondence**		**Face-to-face**		**Online**	
	N	$\mathbf{M_C}$	**N**	$\mathbf{M_F}$	**N**	$\mathbf{M_L}$
A	11	69.7	11	66.0	13	74.2
B	3	48.0	3	33.7	2	62.0
C	1	18.0	1	17.0	–	–

signment while 73% of the students in the correspondence and face-to-face groups ($M_C = 70\%$, $M_F = 66\%$) generated Category A responses. The instructional materials on problem-solving (rubric, strategy, worked-out examples) were available on line at the start of the semester. Therefore, the online group could interact with the material long before the other two groups. This could explain the high quality responses of the online group. However, there is not much difference in the quality of the solutions of the correspondence and face-to-face groups. The lack of difference can be explained by the fact that the face-to-face classes were held a week before and after the submission date for the formative assignment. Therefore, many of the students in the face-to-face group submitted the formative assessment before attending the class.

In the case of the summative examination (Table 4.6), the majority (53%) of the students in the correspondence group generated Category A responses with $M_C = 52\%$, while fewer students (27%) generated Category C responses with

Table 4.6: The average problem-solving performance based on the number of problems solved for the summative examination responses. N is the number of students in the group and M the mean.

Category	**Correspondence**		**Face-to-face**		**Online**	
	N	$\mathbf{M_C}$	**N**	$\mathbf{M_F}$	**N**	$\mathbf{M_L}$
A	8	52.4	3	39.7	4	59.5
B	3	33.0	11	39.1	9	42.7
C	4	34.2	1	21.0	2	20.0

$M_C = 34\%$. These results show a similar trend to that in the formative assignment. The majority of the students in the face-to-face and online groups (73% for face-to-face and 60% for online) produced response of Category B quality with $M_F = 39\%$ and $M_L = 43\%$. These results display a normal distribution. In general, the quality, in terms of the number of problems solved, of the students' responses in the summative examination appears lower than in the formative assignment. However, it is noted that the two responses were generated under different conditions. The summative examination responses were generated under limited time, high-stakes invigilated conditions. These conditions may have affected the problem-solving performence of the students (Tsui & Mazzocco, 2006).

The general trend of the results in Table 4.5 is that in all the three groups the majority of students generated Category A responses while few students generated Category B and fewer generated Category C responses. The results in Table 4.6 show that the responses in the correspondence group for the summative examination followed a similar trend to that in the formative assignment. However, for the face-to-face and online groups the majority of students generated Category B responses while few generated Category A and C responses. This trend follows a normal distribution. The difference in the trends of the results for the formative and summative responses indicates that the blended-learning approach affected only the face-to-face and online groups.

A one-way analysis of variance was used to further investigate the performance of the students presented in Table 4.6 for the number of problems solved. The F statistic and the p-value for the three groups were calculated with a 95% confidence level ($\alpha = 0.05$) assuming equal variance in the groups. The results are given in Table 4.7. The calculated p-value is 0.583, and the F statistic value is 0.547 with a critical value $F_c = 3.2199$. These results indicate that combining the learning modes had no statistically significant effect on the number of problems solved ($F < F_c$, $p > 0.05$).

Table 4.7: Inferential statistics for the number of problems solved in the summative examination.

Source	**df**	**SS**	**MS**	**F**	**p**	**F_c**
Between groups	2	4.044	2.022	0.547	0.583	3.2199
Within groups	42	155.2	3.695			
Total	44	159.2				

4.4.3 Frequency of strategy use

The success in the acquisition of problem-solving skills is reflected in the frequency of implementing a problem-solving strategy in solving given problems. The frequency N_{SU} of strategy use in solving problems in the summative examination was determined. This consisted in the number of solved problems in which a strategy was implemented. The average problem-solving performance based on the frequency of strategy use for the summative examination is reported in Table 4.8. It is evident seen from the table that the majority of the students in the correspondence (80%) and online (57%) groups had a low frequency of strategy use (Category C) compared to 13% of the face-to-face group. The majority of the students in the face-to-face group (87%) used a strategy (Category B) in solving problems whereas not many students in the correspondence and online groups (20% and 47%, respectively) used a strategy. The results in the table indicate a similarity in the performance of the online and correspondence groups. However, the face-to-face group displays a better performance than the other two groups.

The range, maximum value of N_{SU}, mean (M), standard deviation (SD) and standard error (SE) were then calculated with a 95% confidence level ($\alpha = 0.05$). The results are given in Table 4.9. It can be seen from this table that the mean for the face-to-face and online groups are similar, ($M_F = 3.3$, $M_L = 3.2$), and higher than the mean for the correspondence group which is lower ($M_C = 1.9$). These results (higher mean and lower range) indicate that the face-to-face group was more consistent in using a problem-solving strategy in the summative examination than the other two groups. Therefore, the blended-learning approach had some effect in the learning of problem-solving skills in the face-to-face and online groups.

One-way analysis of variance was used to further investigate the descriptive

Table 4.8: The average problem-solving performance based on the frequency of strategy use in solving problems for the summative examination.

Category	**Correspondence**	**Face-to-face**	**Online**
A	1	0	3
B	2	13	4
C	12	2	8

Table 4.9: Descriptive statistics for the frequency of strategy use in the summative examination (data given in Table 4.3).

Group	**N_S**	**Max**	**Range**	**M**	**SD**	**SE**
Correspondence	15	9	9	1.9	2.2	0.6
Face-to-face	15	5	3	3.3	0.9	0.2
Online	15	10	10	3.2	2.8	0.7

statistics of the frequency of strategy use presented in Table 4.9. The F statistic and p-value for the three groups were calculated with a 95% confidence level ($\alpha = 0.05$) assuming equal variance in the groups. The results are given in Table 4.10. The calculated p-value is 0.125, and the F statistic value is 2.187 with a critical value $F_c = 3.2199$. Therefore, the analysis of the descriptive data indicates that the use of the blended-learning approach had no statistically significant effect on the frequency of strategy use ($F < F_c$, $p > 0.05$). However, this finding should be treated with caution since there was no control for extraneous variables.

Table 4.10: Inferential statistics for the frequency of strategy use in the summative examination.

Source	df	SS	MS	F	p	F_c
Between groups	2	19.733	9.867	2.187	0.125	3.2199
Within groups	42	189.467	4.511			
Total	44	209.2				

4.4.4 Achievement marks

The average problem-solving performances based on the achievement marks for the summative examination were also determined, and the results are shown in Table 4.11. The similarity in the performance of the three groups can be clearly seen in this table: the majority of the students in all the groups (67% for correspondence and online, and 73% for face-to-face) did not perform well in the summative examination (Category C scores). Few students managed to score more than 50% (Category B) in all the groups. Descriptive statistics of the examination marks were calculated to determine the significance level of observed effect. The mean (M), standard deviation (SD), standard error (SE) and variance were calculated with a 95% confidence level ($\alpha = 0.05$), and the results are given in Table 4.12. It is evident from this table that the means for the correspondence and online groups are similar ($M_C = 43.6$, $M_L = 44.1$), while the mean for the face-to-face group is slightly lower ($M_F = 38.0$). These results do not reflect significant differences in the means of the three groups.

Table 4.11: The average problem-solving performance based on the achievement marks for the summative examination.

Category	Correspondence	Face-to-face	Online
A	1	0	1
B	4	4	4
C	10	11	10

Table 4.12: Descriptive statistics for the summative examination marks shown in Table 4.3.

Group	N_S	M	SD	SE	Variance
Correspondence	15	43.6	16.3	4.2	264.686
Face-to-face	15	38.0	13.5	3.5	183.429
Online	15	44.1	18.2	4.7	331.695

A one-way analysis of variance for the descriptive statistics in Table 4.12 was also conducted. The F statistic and p-value for the three groups were calculated with a 95% confidence level ($\alpha = 0.05$). The results are given in Table 4.13. The calculated p-value is 0.519, while the F statistic value is 0.666 with a critical value

$F_c = 3.2199$. Therefore, the analysis of the descriptive data indicates that the use of the blended-learning approach had no statistically significant effect on the summative examination marks of the students ($F < F_c$, $p > 0.05$).

Table 4.13: Inferential statistics for the descriptive statistics data of the summative examination marks shown in Table 4.11.

Source	**df**	**SS**	**MS**	**F**	**p**	$\mathbf{F_c}$
Between groups	2	346.311	173.156	0.6661	0.5190	3.2199
Within groups	42	10917.333	259.937			
Total	44	11263.644				

4.5 Discussion of the results

This study investigated the effects of a blended learning approach in the learning of problem-solving skills in a distance education physics module. The levels of blended learning were determined by combinations of correspondence, face-to-face and online activities in the module. The effect was measured by the number of problems solved (out of ten problems), the frequency of strategy use and achievement marks in the summative examination. An *ex post facto* research design with stratified sampling was used to collect the data (Cohen et al., 2007). The results show that for all the three problem-solving performance measures, the blended learning approach had no significant difference in the learning of problem-solving skills. This means that students can learn problem solving equally well in any of the three module presentation modes.

This finding is in agreement with findings of many similar studies on the effect of technology and media on learning (Bonham et al., 2003; Clark, 1983; Russell, 2001). However, the affordances of the technologies involved were not fully utilized to maintain equity in the module content delivered through the different module presentation modes. The findings of this study differ from some of the findings reported in the literature (Gök & Silay, 2010; Lin & Singh, 2011; Selçuk et al., 2008) on the effect of explicit teaching of a problem-solving strategy on problem-solving skills and achievement. However, these studies were experimental investigations conducted in traditional classroom settings. Moreover, the present study focused more on the effect of technology on the learning than on the instructional approach.

The results of this study must be treated with caution, although several measures were taken to maximize the reliability and validity of the study under the research circumstances. This is because there were limitations on the findings of the study, mainly because of the research design and instrumentation of the study. The research design of the study (*ex post facto*) did not allow for random assignment of subjects to groups and did not allow for control over extraneous variables. This means the results cannot be generalized (Creswell, 2012). Also the data collection instrument was a timed high-stakes summative examination which raises questions over the reliability of the instrument as well as the validity of the results (Phipps & Merisotis, 1999). Also, the affordances of the technologies used for the research were not fully utilized. This may have contributed to neutralizing the effect of the technology in the students' performance (Bates & Poole, 2003). The conclusion to this chapter are presented in the next section.

4.6 Conclusion

In this chapter student participation in the module and the sample size was discussed. The primary and secondary data for the study were presented and analyzed. The next chapter presents reflections on the results and research questions. The implications of the findings of the study will be addressed and conclusions drawn.

Chapter 5

Conclusions

5.1 Introduction

This *ex post facto* research was conducted to investigate the effect of a blended-learning approach on the learning of problem-solving skills in a DE physics module. The presentation of the module entailed highlighting important concepts, laws and principles of physics to be learned and direct teaching of a prescribed problem-solving strategy. Worked-out examples were used to stress key aspects of the problem-solving strategy and formative practice problems were given for immediate feedback. Two face-to-face discussion classes were scheduled as well as weekly online discussions of the module. The study was conducted in an actual DE module which was presented through correspondence, online and two face-to-face classes. The effect of the blended-learning approach on the learning of problem-solving skills was measured by the number of problems solved, the frequency of strategy use and achievement marks in the summative examination.

It was expected that the use of a blended-learning approach, where all the three modes are utilized, would not enhance the problem-solving skills of the students and increase their problem-solving performance because of the "no significant difference" phenomenon on the use of technology in teaching (Bonham et al., 2003; Russell, 2001). The hypothesis of this study was that the use of the blended learning approach would increase the problem-solving performance, frequency of strategy use as well as the achievement scores of the students. Reflections on the results of this study for each problem-solving performance measure are given in the following sections.

5.2 The number of problems solved

The number of problems with complete solutions were determined for formative and summative assessment tests. All the three groups had a similar trend in the number of problems solved for the formative assignment with more students producing Category A assignments. However, the trend in the summative examination was not the same for the three groups. The results of this study demonstrated that the responses in the correspondence group for the summative examination followed a similar trend to that evident in the formative assignment. However, the responses in the face-to-face and online groups for the summative examination indicated a different trend from the formative assignment. The differences in the trends of the results for the formative and summative responses indicate that the blended-learning approach affected the problem-solving performance of the face-to-face and online groups. Further analysis of the results revealed that the differences in the means of the three groups were not statistically significant.

5.3 The frequency of strategy use

The frequency of strategy use in solving problems in the summative examination was determined. This is the number of solved problems in which a strategy was implemented. Descriptive statistics of this performance measure showed that the means for the face-to-face and online groups are similar to but higher than the mean for the correspondence group. These results indicate that the face-to-face and online groups were more consistent in using a problem-solving strategy in the summative examination than the correspondence group. Therefore, the blended-learning approach had a practical effect in the learning of problem-solving skills. However, the results did not show any statistically significant differences in the mean frequency of strategy use.

5.4 Achievement marks

All the three groups exhibited similar performance in the achievement marks of the summative examination based on their categories. However, descriptive statistics of the summative examination marks were calculated to determine the statistical differences in the means of the observed effect of the use of a blended-learning approach. The means for the correspondence and online groups were similar while the mean for the face-to-face group was slightly lower. Then, the inferential statistics for the achievement marks of the summative examination were determined to assess the significance level of the differences between the means of the groups. The results did not identify any statistically significant differences in the means of the three groups. Therefore, the analysis of the descriptive data indicates that the use of the blended-learning approach had no statistically significant effect on the summative examination achievement marks of the students.

5.5 Conclusion

It can be concluded, based on the results of this study, that the blended-learning approach, combining correspondence, online and face-to-face learning technologies, had no significant difference in the teaching of problem-solving skills in a DE module. This finding is in agreement with the "no significant difference" phenomenon (Bonham et al., 2003; Russell, 2001) on the effect of technology, but in contrast with the findings of studies on the effect of problem-solving strategies in student achievement (Gök & Silay, 2010; Selçuk et al., 2008). The conclusion of the meta-analysis by Russell (2001) is that different technologies will produce similar achievements in learning outcomes if the same instructional method is used. This implies that the most affordable technologies can be utilized in mediating teaching without compromising the quality of learning. Therefore, higher education institutions, like UNISA, which service developing countries that are challenged by socio-economic and technology-support factors do not have to invest in expensive technological infrastructure to provide quality courses (Lievrouw, 2001). That is, in integrating technology in teaching, UNISA can adopt low cost technologies and still provide the same high quality courses as traditional higher education institutions.

There were limitations associated with the design of and the instrumentation used in the study (Bates & Poole, 2003; Phipps & Merisotis, 1999). These affected the validity and reliability of the results of the study to some extent. However, the results of the study still hold because sufficient measures (Creswell, 2012) were taken to improve the validity and reliability of the results. The results of the study provide a starting point for future investigations into the effect of different technologies on student achievement in distance education. The implications of the findings of this study are that more effort should be focused on improving instructional methods in DE than on the effect of the technology used. Also, studies on technology use in education should fully incorporate the affordances of the technologies investigated. Further investigations are required, first, to validate the findings of this study and, second, to determine sources and implications of the observed practical difference in the results.

Appendix A

Ethics clearance

UNISA college of education

Research Ethics Clearance Certificate

This is to certify that the application for ethical clearance submitted by

G J Rampho [8544263]

for a M Ed study entitled

Teaching problem-solving skills in distance education programme: A blended-learning approach

has met the ethical requirements as specified by the University of South Africa College of Education Research Ethics Committee. This certificate is valid for two years from the date of issue.

Prof KP Dzvimbo
Executive Dean : CEDU

Dr M Claassens
CEDU REC (Chairperson)
mcdtc@netactive.co.za

Reference number: 2014 JULY/8544263/MC

16 JULY 2014

Appendix B

Assessment instruments

B.1 Formative practice problems

All the twelve problems are taken from the textbook by Halliday et al. (2001).

UNIT 1

1. A jumbo jet must reach a speed of 360 km/h on the runway for takeoff. What is the least constant acceleration needed for takeoff from a 1.80 km runway? [20]

2. A small ball rolls horizontally off the edge a tabletop that is 1.20 m high. It strikes the floor at a point 1.52 m horizontally away from the edge of the table. How long is the ball in the air? [20]

3. An electron with a speed of 1.2×10^{7} m/s moves horizontally into a region where a constant vertical force of 4.5×10^{-16} N acts on it. The mass of the electron is 9.11×10^{-31} kg. Determine the vertical distance the electron is deflected during the time it has moved 30 mm horizontally. [20]

UNIT 2

1. A proton is of mass 1.67×10^{-27} kg is being accelerated along a straight line at 3.6×10^{15} m/s^2 in a machine. If the proton has an initial speed of 2.4×10^7 m/s and travels 3.5 cm, what then is its speed? [20]

2. At $t = 0$ a 1.0 kg ball is thrown from the top of a tall tower with velocity $\boldsymbol{v} = (18\,\mathrm{m/s})\,\hat{\boldsymbol{i}} + (24\,\mathrm{m/s})\,\hat{\boldsymbol{j}}$. What is the change in the potential energy of the ball-Earth system between $t = 0$ and $t = 6.0$s? [20]

3. A shell is shot with an initial velocity of 20 m/s at an angle of 60^o relative to the horizontal. At the maximum height the shell explodes into two fragments of equal mass. One fragment, whose speed immediately after the explosion is zero, falls vertically. How far from the gun does the other fragment land? Neglect air drag. [20]

UNIT 3

1. A disk, initially rotating at 120 rad/s, is slowed down with a constant angular acceleration of magnitude 4.0 rad/s^2. How much time does the disk take to stop? [20]

2. A uniform solid sphere rolls down an inclined. What must be the incline angle if the linear acceleration of the center of the sphere is to have a magnitude of $0.10\,g$? (g is the acceleration due to gravity.) [20]

3. A rope of negligible mass is stretched horizontally between two supports that are 3.44 m apart. When an object of weight 3160 N is hung at the center of the rope, the rope is observed to sag by 35.0 cm. What is the tension in the rope? [20]

UNIT 4

1. A spaceship is on a straight-line path between Earth and its moon. At what distance from Earth is the net gravitational force on the spaceship zero? [20]

2. Water is moving with a speed of 5.0 m/s through a pipe with a cross-sectional area of 4.0 cm^2. The water gradually descends 10 m as the pipe increases in the cross-sectional area to 8.0 cm^2. What is the speed of the water at the lower level? [20]

3. Two particles execute simple harmonic motion of the same amplitude and frequency along close parallel lines. They pass each other moving in opposite direction each time their displacement is half their amplitude. What is their phase difference? [20]

B.2 Formative assessment problems

All the ten problems are taken from the textbook by Knight (2013).

1. A typical laboratory centrifuge rotates at 4000 rpm. Test tubes have to be placed into a centrifuge very carefully because of the very large accelerations.
   (a) What is the acceleration at the end of a test tube that is 10 cm from the axis of rotation? (5)
   (b) For comparison, what is the magnitude of the acceleration a test tube would experience if dropped from a height of 1.0 m and stopped in a 1.0-ms-long encounter with a hard floor? (5)

   [10]

2. A 2.0 kg steel block is at rest on a steel table. A horizontal string pulls on the block.

   (a) What is the minimum string tension needed to move the block? (4)

   (b) If the string tension is 20 N, what is the block's speed after moving 1.0 m? (3)

   (c) If the string tension is 20 N and the table is coated with oil, what is the block's speed after moving 1.0 m? (3)

   [10]

3. A father stands at the summit of a conical hill as he spins his 20 kg child around on a 5.0 kg cart by holding on to a 2.0 m long rope attached to the cart. The sides of the hill are inclined at 20^o. He again keeps the rope parallel to the ground, and friction is negligible. What rope tension will allow the cart to spin at 14 rpm? [10]

4. A 75 kg shell is fired with an initial speed of 125 m/s at an angle of 55^o above the horizontal. Air resistance is negligible. At its highest point the shell explodes into two fragments, one four times more massive than the other. The heavier fragment lands directly below the point of the explosion. If the explosion exerts forces only in the horizontal direction, how far from the launch point does the lighter fragment land? [10]

5. A 500 g rubber ball is dropped from a height of 10 m and undergoes a perfectly elastic collision with the earth.

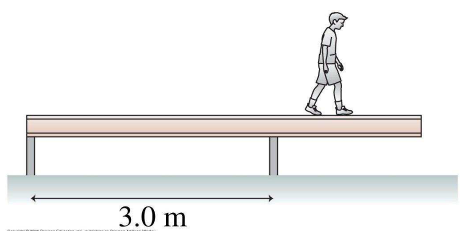
   (a) What is the earth's velocity after the collision? Assume the earth was at rest just before the collision. (5)

(b) How many years would it take the earth to move 1.0 mm at this speed? (5)

[10]

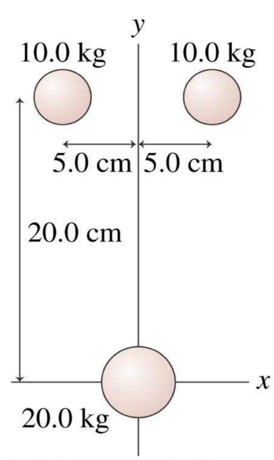
6. Susan's 10 kg baby brother Paul sits on a mat. Susan pulls the mat across the floor using a rope that is angled 30^o above the floor. The tension is a constant 30 N and the coefficient of friction is 0.20. Use work and energy to find Paul's speed after being pulled 3.0 m. [10]

7. The figure below shows a 40 kg, 5.0 m long beam is supported, but not attached to, the two posts. A 20 kg boy starts walking along the beam. How close can he get to the right end of the beam without it falling over?



[10]

8. The figure below shows three masses.



What are the magnitude and the direction of the net gravitational force on the 20.0 kg mass? Give the direction as an angle. [10]

9. A 100 g mass on a 1.0 m long string is pulled 8.0^o to one side and released. How long does it take for the pendulum to reach 4.0^o on the opposite side?

   [10]

10. Your science teacher has assigned you the task of building a water barometer. You have learned that the pressure of the atmosphere can vary by as much as 5% from 1 standard atmosphere as the weather changes.

    (a) What minimum height must your barometer have? (5)

    (b) One stormy day the TV weather person says, "The barometric pressure this afternoon is a low 29.55 inches." What is the height of the water in your barometer? (5)

    [10]

B.3 Summative assessment problems

All the problems are taken from the textbook by Knight (2013).

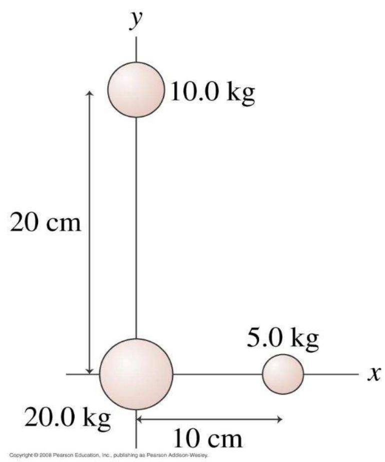
1. A 1.0 kg rocket with a thrust of 2.0 N is released from rest on top of a 2.0 m high frictionless table. The rocket travels 4.0 m on the table before dropping off the edge of the table. How far does the rocket land from the base of the table?

2. A man whose mass is 75 kg starts to slide down a 50 m high frictionless slope of angle 20°. A strong headwind exerts a horizontal force of 200 N on him as he slides. Calculate his speed at the bottom of the slope

   (a) using work and energy.

   (b) using Newton's laws.

3. The figure below shows three masses.



Calculate the magnitude and the direction of the net gravitational force on

(a) the 20.0 kg mass.

(b) the 5.0 kg mass. Give the direction as an angle.

4. The speed of a satellite in a circular orbit of radius r around a planet of mass M is $v = \sqrt{\frac{GM}{r}}$. Determine the equation relating the period T of the satellite and the radius r.

5. Calculate the moment of inertia of a thin rod of length L and mass M with uniform density, rotating about an axis through one end of the rod.

6. A 15 cm long 200 g rod is pivoted at one end. A 20 g ball of clay is stuck on the other end. What is the period if the rod and clay ball swing as a pendulum?

7. A 2.0 mL syringe has an inner diameter of 6.0 mm, a needle with inner diameter 0.25 mm, and a plunger pad (where you place your finger) diameter of 1.2 cm. A nurse uses the syringe to inject medicine into a patient whose blood pressure is 140/100.

(a) What is the minimum force the nurse needs to apply to the syringe?

(b) The nurse empties the syringe in 2.0 s. What is the flow speed of the medicine through the needle?

Appendix C

Problem-solving rubric

Table C.1: The problem-solving rubric of Docktor (2009)

Criterion	**5**	**4**	**3**	**2**	**1**	**0**
PROBLEM DESCRIPTION	is useful and complete	is useful with minor omis-sions/ errors	parts not useful, missing or contain errors	most not useful, missing or contain errors	all not useful or contain errors	no de-scription provided
PHYSICS APPROACH	is appro-priate and complete	is appro-priate with minor omissions /errors	parts not appropri-ate, missing or contain errors	most not appropri-ate, missing or contain errors	all not appropri-ate	no approach provided
MATHEMATICS PROCEDURES	is appro-priate and complete	is appro-priate with minor omissions /errors	parts not appropri-ate, missing or contain errors	most not appropri-ate, missing or contain errors	all not appropri-ate	no approach provided
LOGICAL PROGRESSION	is clear, focused and consistent	is clear and focused with minor omissions /errors	parts not clear, not focused or not consistent	most not clear, not focused or not consistent	all not clear, not focused or not consistent	no evidence of logical progres-sion

References

Anderson, T. (2003). Handbook of distance education. In M. G. Moore & W. G. Anderson (Eds.), *Modes of interaction in distance education: Recent developments and research questions.* New Jersey: Lawrence Erlbaum Associates.

Anderson, T., & Dron, J. (2011). Three generations of distance education pedagogy. *International Review of Research in Open and Distance Learning*, *12*(3), 80-97.

Bates, A. W., & Poole, G. (2003). *Effective teaching with technology in higher education: Foundations for success.* San Francisco: Jossey-Bass.

Black, P. (2000). Research and the development of educational assessment. *Oxford Review of Education*, *26*(3-4), 407-419.

Bloom, B. S. (1984). The 2 sigma problem: The search for methods group instruction as effective as the one-on-one tutoring. *Educational Researcher*, *13*(6), 4-16.

Bolton, J., & Ross, S. (1997). Developing students' physics problems-solving skills. *Physics Education*, *32*, 176-185.

Bonham, S. W., Deardorff, D. L., & Beichner, R. J. (2003). Comparison of student performance using web and paper-based homework in college-level physics. *Journal of Research in Science Teaching*, *40*(10), 1050-1071.

Campbell, D. T., & Stanley, J. C. (1963). Experimental and quasi-experimental designs for research. In N. L. Gage (Ed.), *Handbook of research on teaching.* Boston: Houghton Mifflin Company.

Caplan, D., & Graham, R. (2008). The development of online courses. In T. Anderson (Ed.), *Theory and practice of online learning.* Edmonton: Athabasca University.

Capon, N., & Kuhn, D. (2004). What's so good about problem-based learning? *Cognition and Instruction*, *22*(1), 61-79.

Clark, R. E. (1983). Reconsidering research on learning from media. *Review of Educational Research*, *53*(4), 445-459.

Coates, H., James, R., & Baldwin, G. (2005). A critical examination of the effects of learning management systems on university teaching and learning. *Tertiary Education and Management*, *11*, 19-36.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education* (6th ed.). New York: Routledge.

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Boston: Pearson Education, Inc.

Docktor, J. L. (2009). *Development and validation of a physics problem-solving assessment rubric* (Unpublished doctoral dissertation). Physics, University of Minnesota.

Docktor, J. L., & Heller, P. (2009). Robust assessment instrument for student problem solving. In *Proceedings of the narst 2009 anual meeting.*

Garrison, D. R., & Anderson, T. (2003). *E-learning in the 21st century: A framework for research and practice.* London: Routledge.

Garrison, D. R., & Cleveland-Innes, M. F. (2010). Foundations of distance education. In M. F. Cleveland-Innes & D. R. Garrison (Eds.), *An introduction to distance education: Understanding teaching and learning in a new era.* New

York: Routledge.

Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *The Internet and Higher Education*, *7*(2), 95-105.

Gök, T., & Silay, İ. (2010). The effects of problem solving strategies on students achievement, attitude and motivation. *Latin American Journal of Physics Education*, *4*(1), 7-21.

Gonen, S., & Basaran, B. (2008). The new method of problem solving in physics education by using scorm-compliant content package. *Turkish Online Journal of Distance Education*, *9*(3), 112.

Graham, C. R. (2005). Blended learning systems: Definition, current trends, and future directions. In C. J. Bonk & C. R. Graham (Eds.), *Handbook of blended learning: Global perspectives, local designs.* San Francisco: Pfeiffer Publishing.

Graham, C. R., & Allan, S. (2005). Blended learning environments. In C. Howard, J. V. Boettecher, L. Justice, K. D. Schenk, P. L. Rogers, & G. A. Berg (Eds.), *Encyclopedia of distance learning.* Hershy: Idea Group Inc.

Gulati, S. (2008). Technology-enhanced learning in developing nations: A review. *International Review of Research in Open and Distance Learning*, *9*(1), 1-16.

Gwet, K. L. (2010). *The handbook of inter-rater reliability: The definitive guide to measuring the extent of agreement among multiple raters* (2nd ed.). Gaithersburg: Advanced Analytics, LLC.

Halliday, D., Resnick, R., & Walker, J. (2001). *Fundamentals of physics* (6th ed.). New York: Wiley.

Halliday, D., Resnick, R., & Walker, J. (2011). *Principles of physics* (9th ed.). New York: Wiley.

Haughey, M. (2010). Teaching and learning in distance education before the digital age. In M. F. Cleveland-Innes & D. R. Garrison (Eds.), *An introduction to distance education: Understanding teaching and learning in a new era.* New York: Routledge.

Heller, K., & Heller, P. (2010). *Cooperative problem solving in physics: A user's manual.* Minnesota: National Science Foundation, University of Minnesota, and the USA Department of Education.

Heller, P., Keith, R., & Anderson, S. (1992). Teaching problem solving through cooperative grouping. part 1: Group versus individual problem solving. *American Journal of Physics*, *60*(7), 627-636.

Hoffman, D. (1997). Effects of explicit problem solving instruction on high school students' problem-solving performance and conceptual understanding of physics. *Journal of Research in Science Teaching*, *34*(6), 551-570.

Holmberg, B. (2008). *The evolution, principles and practices of distance education* (Vol. 11). Oldenburg: BIS-Velag.

Hull, M. M., Kuo, E., Gupta, A., & Elby, A. (2013). Problem-solving rubrics revisited: Attending to the blending of informal conceptual and formal mathematical reasoning. *Physical Review Special Topics - Physics Education Research*, *9*(1), 010105.

Jhurree, V. (2005). Technology integration in education in developing countries: Guidelines to policy makers. *International Education Journal*, *6*(4), 467-483.

Kinuthia, W., & Dagada, R. (2008). E-learning incorporation: An exploratory study of three south african higher education institutions. *International Journal on E-Learning*, *7*(4), 623-639.

Knight, R. D. (2013). *Physics for scientists and engineers: A strategic approach* (3rd ed.). San Francisco: Pearson.

Knowls, M. S. (1980). *The modern practice of adult education: from pedagogy to andragogy.* New York: Cambridge.

Krathwohl, D. R. (2002). A revision of bloom's taxonomy: An overview. *THEORY INTO PRACTICE*, *41*(4), 212-218.

Krauss, F., & Ally, M. (2005). A study of the design and evaluation of a learning object and implications for content development. *Interdisciplinary Journal of Knowledge and Learning Objects*, *1*(1), 1-22.

Larkin, J. H., & Reif, F. (1979). Understanding and teaching problem solving in physics. *European Journal of Science Education*, *1*(2), 191-203.

Leacock, T. L., & Nesbit, J. C. (2007). A framework for evaluating the quality of multimedia learning resources. *Educational Technology and Society*, *10*(2), 44-59.

Lesaux, N. K., Pearson, M. R., & Siegel, L. S. (2006). The effects of timed and untimed testing conditions on the reading comprehension performance of adults with reading disabilities. *Reading and Writting*, *19*, 21-48.

Lievrouw, L. A. (2001). Instructional media and the no significant difference phenomenon. *ICA Newsletter*, *29*(5), 5-6.

Lin, S., & Singh, C. (2011). Using isomorphic problems to learn introductory physics. *Physical Review Special Topics - Physics Education Research*, *7*(2), 020104.

Maloney, D. P. (2011). An overview of physics education research on problem solving. *Reviews in Physics Education Research*, *2*(1), 1-33.

Mateycik, F., Jonassen, D., & Rebello, N. S. (2009). Using similarity rating tasks to assess case reuse in problem solving. In *American institute of physics conference proceedings* (Vol. 1179, p. 201).

McMillan, J. H. (1996). *Educational research: Fundamentals for the consumer distance education: A systems view* (2nd ed.). New York: HarperCollins.

Mishra, A., Vijayshri, & Garg, S. (2009). Evaluation of the undergraduate physics programme at indira gandhi national open university: A case study. *International Review of Research in Open and Distributed Learning*, *10*(6).

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017-1054.

Moody, D. L., & Sindre, G. (2003). Evaluating the effectiveness of learning interventions: An information systems case study. In *Ecis 2003 proceedings. paper 80.* Retrieved from http://aisel.aisnet.org/ecis2003/80

Moore, M. G., & Kearsley, G. (2005). *Distance education: A systems view* (2nd ed.). Belmont: Wadsworth.

Moreno, R. (2006). When worked examples don't work: Is cognitive load theory at an impasse? *Learning and Instruction*, *16*, 170-181.

Paas, F., & van Gog, T. (2006). Optimizing worked example instruction: Different ways to increase germane cognitive load. *Learning and Instruction*, *16*, 87-91.

Peters, O. (1998). *Learning and teaching in distance education: Pedagogical analyses and interpretations in an international perspective.* New York: Routledge.

Peters, O. (2004). *Distance education in transition: New trends and challenges* (4th ed.). Oldenburg: BIS-Velag.

Peters, O. (2010). *Distance education in transition: Developments and issues* (5th ed.). Oldenburg: BIS-Velag.

Phipps, R., & Merisotis, J. (1999). What's the difference? a review of contemporary research on the effectiveness of distance learning in higher education. *Washington, DC: The Institute for Higher Education Policy*, 1-49.

Russell, T. L. (2001). *The no significant difference phenomenon: as reported in*

355 research reports, summaries and papers. Raleigh: North Carolina State University.

SAPO. (19 August 2014). *Casual workers embarked on unprotected industrial action.* Retrieved from `http://www.postoffice.co.za/group/pressreleases/`

Schroeder, N., Gladding, G., Gutmann, B., & Stelzer, T. (2015). Narrated animated solution videos in a mastery setting. *Physical Review Special Topics - Physics Education Research*, *11*, 010103.

Selçuk, G. S., Çalişkan, S., & Erol, M. (2008). The effects of problem solving instruction on physics achievement, problem solving performance and strategy use. *Latin American Journal of Physics Education*, *2*(3), 151-166.

Sener, J. (2004). Escaping the comparison trap: Evaluating online learning on its own terms. *Innovate*, *1*(2).

Stacey, E., & Gerbic, P. (2008). Success factors for blended learning. In *Hello! where are you in the landscape of educational technology? proceeding ascilite melbourne 2008.*

Swan, K. (2010). Teaching and learning in post-industrial distance education. In M. F. Cleveland-Innes & D. R. Garrison (Eds.), *An introduction to distance education: Understanding teaching and learning in a new era.* New York: Routledge.

Sweller, J., & Cooper, G. A. (1985). The use of worked examples as a substitute for problem solving in learning algebra. *Cognition and Instruction*, *2*(1), 59-89.

Tsui, J. M., & Mazzocco, M. M. M. (2006). Effects of math anxiety and perfectionism on timed versus untimed math testing in mathematically gifted sixth graders. *Roeper Review*, *29*(2), 132-139.

UNISA. (2014). *Student population.* Retrieved from http://www.unisa.ac.za/Default.asp?Cmd=ViewContent&ContentID=15888

Vaughan, N. D. (2010). Blended learning. In M. F. Cleveland-Innes & D. R. Garrison (Eds.), *An introduction to distance education: Understanding teaching and learning in a new era.* New York: Routledge.

Veletsianos, G. (Ed.). (2010). *Emerging technologies in distance education.* Edmonton: Athabasca University.