

The implementation of problem-based learning to foster pre-service teachers' critical thinking in education for sustainable development

SE Heystek

 **orcid.org/0000-0003-0532-0401**

Dissertation accepted in fulfilment of the requirements for the degree *Masters of Education in Curriculum Studies* at the North-West University

Supervisor: Prof BW Richter

Co-supervisor: Dr I Muller

Assistant-Supervisor: Prof A Golightly

Graduation ceremony: May 2021

Student number: 10084355

DECLARATION

DECLARATION

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

A handwritten signature in black ink, appearing to be 'H. J. van der Merwe', written in a cursive style.

Signature

15 September 2020

Date

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ETHICS APPROVAL FROM NWU FACULTY OF EDUCATION



NORTH-WEST UNIVERSITY
YUNIBESITHI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

Fakulteit Opvoedkunde / Faculty Education
Privaatsak / Private Bag X6001, Potchefstroom
Suid-Afrika / South Africa 2520
T: 018 299 4656
F: 086 661 8589
<http://www.nwu.ac.za>

23 January 2019

To Whom It May Concern

I hereby confirm that the ethics application, as stated below, is approved by the members of the Ethics Committee of the Faculty of Education and will be minuted at the Ethics Committee meeting on 21 February 2019.

Ethics number: NWU-00070-19-A2

Project head: Prof B Richter

Project team: Ms S Reyneke

Title: The implementation of problem-based learning to foster preservice teachers' critical thinking in education for sustainable development

Period: 23 January 2019 – 23 January 2020

Risk level: Low

Should you have further enquiries in this regard, you are welcome to contact Prof Jako Olivier at 018 285 2078 or by email at Jako.Olivier@nwu.ac.za or Ms Ema Greyling at 018 299 4656 or by email at Ema.Greyling@nwu.ac.za.

Yours sincerely

Prof J Olivier
Chair Edu-REC

STATISTICAL CONSULTATION SERVICES



Private Bag X6001, Potchefstroom
South Africa 2520

Tel: 018 299-1111/2222
Web: <http://www.nwu.ac.za>

Statistical Consultation Services
Tel: +27 18 285 2018
Fax: +27 0 87 231 5294
Email: suria.ellis@nwu.ac.za

27 August 2020

Re: Dissertation, Ms SE Heystek, student number 10084355

We hereby confirm that the Statistical Consultation Services of the North-West University analysed the data of the above-mentioned student and assisted with the interpretation of the results. However, any opinion, findings or recommendations contained in this document are those of the author, and the Statistical Consultation Services of the NWU (Potchefstroom Campus) do not accept responsibility for the statistical correctness of the data reported.

Kind regards

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Prof SM Ellis (Pr. Sci. Nat.)

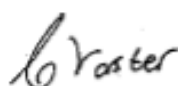
Associate Professor: Statistical Consultation Services

LANGUAGE PRACTITIONER

DECLARATION

I, C Vorster (ID: 710924 0034 084), Language editor and Translator and member of the South African Translators' Institute (SATI member number 1003172), herewith declare that I did the language editing of a dissertation, written by SE Heystek (student number 10084355) from the North-West University.

Title of the dissertation: The implementation of problem-based learning to foster pre-service teachers' critical thinking in education for sustainable development



15 September 2020

C Vorster

Date

Express Editing 24

PREFACE

All praise, honour and glory to our Heavenly Father for providing the wisdom, endurance and opportunities, which made this study possible.

This dissertation is dedicated to the memory of my father, Fanus Heystek.

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ABSTRACT

The emergence of unprecedented environmental problems and sustainability concerns since the industrial revolution has risen and prevail in modern civilisation. These environmental challenges require critical reconsideration of all our actions, which includes rethinking the role of education to inform and transform societies. The efficient training of pre-service teachers plays a paramount role in the accomplishment of the desired outcomes of sustainable development. Delivering pre-service teachers who are able to think critically about the environmental problems around us and who are encouraged to act as change agents in their communities, should be a priority of higher education institutions. Constructivist teaching and learning strategies can be applied to enhance critical thinking and other soft skills required by pre-service teachers in the 21st century. Problem-based learning (PBL) is an example of active learning that underwrites the principles of social constructivism and allows pre-service teachers to collaborate, critically evaluate, consider and solve a given environmental problem in PBL groups. The purpose of this study was to determine if the implementation of PBL in education for sustainable development, could foster the development of pre-service teachers' critical thinking skills. This study used a convergent parallel mixed methods research design in which quantitative and qualitative research methods were implemented in a pragmatic way to explore the following three aims: investigating the ways in which PBL can be implemented in education for sustainable development; determining the pre-service teachers' experience of PBL in education for sustainable development; and exploring the development of the pre-service teachers' critical thinking skills after the PBL intervention in education for sustainable development. In order to achieve the research aims, PBL was implemented in the Education for Sustainable Development (ESD) module (6 credits) for one semester (12 weeks). The quantitative and qualitative results indicated that PBL was perceived as a positive experience by most of the pre-service teachers and can be successfully implemented in the teaching and learning of education for sustainable development. The quantitative results from the WG³CTA test instrument indicated that the pre-service teachers' critical thinking skills have not improved after one semester of implementing PBL in Education for Sustainable Development, however, the qualitative results indicated that the pre-service teachers perceived that some aspects of their critical thinking skills have improved.

Key terms:

Environmental education; education for sustainable development; problem-based learning; critical thinking; pre-service teachers.

OPSOMMING

Die moderne samelewing word gekonfronteer met 'n toenemende bewustheid van ongekeerde omgewingsprobleme en volhoubaarheidsvraagstukke wat sedert die industriële rewolusie voorkom en steeds toeneem. Hierdie omgewingsuitdagings vereis 'n kritiese heroorweging van alle menslike optrede, wat insluit die herbesinning van die rol van onderwys om gemeenskappe in te lig en sodoende transformasie te bewerkstellig. Die doeltreffende opleiding van voor-diensaanvaarding onderwysers kan 'n deurslaggewende rol speel in die bereiking van die verlangde uitkomst van volhoubare ontwikkeling. Hoër onderwys instellings behoort daarom voor-diensaanvaarding onderwysers te lewer wat in staat is om krities te dink oor omgewingsprobleme en gemotiveerd is om as veranderingsagente op te tree in hulle onderskeie gemeenskappe. Konstruktivistiese onderrig- en leerstrategieë kan geïmplementeer word om kritiese denke en ander sagte vaardighede, wat in die 21^{ste} eeu vereis word, by voor-diensaanvaarding onderwysers te bevorder. Probleem-gebaseerde leer (PGL) is 'n voorbeeld van aktiewe leer, wat die beginsels van sosiale konstruktivisme ondersteun en voor-diensaanvaarding onderwysers die geleentheid bied om saam te werk om sodoende bepaalde omgewingsprobleme krities te ontleed en op te los in hulle PGL groepe. Die doel van hierdie studie was om vas te stel of die implementering van PGL in opvoeding vir volhoubare ontwikkeling kon bydrae om voor-diensaanvaarding onderwysers se kritiese denkvermoë te verbeter. Hierdie studie het 'n konvergerende parallelle gemengde metode navorsingsontwerp gevolg waarin kwantitatiewe en kwalitatiewe navorsingsmetodes geïmplementeer is volgens 'n pragmatiese wyse om die volgende drie doelwitte te ondersoek: om die wyse waarop PGL in opvoeding vir volhoubare ontwikkeling geïmplementeer kan word na te vors; om vas te stel wat voor-diensaanvaarding onderwysers se ervaring van PGL in opvoeding vir volhoubare ontwikkeling is; en om te bepaal of die voor-diensaanvaarding onderwysers se kritiese denkvermoë ontwikkel het na die PGL-intervensie in opvoeding vir volhoubare ontwikkeling. Ten einde die navorsingsdoelwitte te bereik is PGL vir een semester (12 weke) in die Opvoeding vir Volhoubare Ontwikkeling module (6 krediete) geïmplementeer. Beide die kwantitatiewe en kwalitatiewe resultate het aangedui dat die meeste van die voor-diensaanvaarding onderwysers PGL as 'n positiewe ervaring beleef het en dat PGL wel suksesvol in die onderrig en leer van opvoeding vir volhoubare ontwikkeling geïmplementeer kan word. Die kwantitatiewe resultate van die WG³CTA toets-instrument het aangetoon dat die voor-diensaanvaarding onderwysers se kritiese denkvermoë nie verbeter het nadat PGL vir een semester in Opvoeding vir Volhoubare Ontwikkeling geïmplementeer is nie. Die kwalitatiewe resultate het egter aangedui dat die voor-diensaanvaarding onderwysers ervaar het dat sekere aspekte van hulle kritiese denkvermoë wel verbeter het.

Sleuteltermes:

Omgewingsopvoeding; opvoeding vir volhoubare ontwikkeling; probleem-gebaseerde leer; kritiese denke; voor-diensaanvaarding onderwysers.

LIST OF ACRONYMS

Aros:	Akademie Reformatoriese Opleiding en Studies
BEd:	Baccalaureus Education
CAPS:	Curriculum and Assessment Policy Statement
CT:	Critical thinking
EE:	Environmental education
ESD:	Education for sustainable development
GAP:	Global Action Programme (UNESCO)
IP:	Intermediate Phase
NWU:	North-West University
PBL:	Problem-based learning
RLJ:	Reflective learning journals
RP-MRTEQ:	Revised Policy on the Minimum Requirements for Teacher Education Qualifications
SA:	South Africa
SD:	Sustainable development
SDGs:	Sustainable development goals
UN:	United Nations
UN-DESD:	United Nations decade of education for sustainable development
UNESCO:	United Nations Educational, Scientific and Cultural Organization
WG ³ CTA:	Watson-Glaser ³ Critical Thinking Appraisal

TABLE OF CONTENTS

DECLARATION	I
ETHICS APPROVAL FROM NWU FACULTY OF EDUCATION	II
STATISTICAL CONSULTATION SERVICES	III
LANGUAGE PRACTITIONER	IV
PREFACE	V
ABSTRACT	VI
OPSOMMING	VII
LIST OF ACRONYMS.....	IX
CHAPTER 1 INTRODUCTION TO THE STUDY	1
1.1 INTRODUCTION AND PROBLEM STATEMENT	1
1.2 CLARIFICATION OF CONCEPTS	2
1.3 LITERATURE REVIEW	3
1.3.1 Education for sustainable development (ESD).....	3
1.3.2 Constructivism	5
1.3.3 Active learning	6
1.3.4 Problem-based learning (PBL).....	7
1.3.5 Critical thinking (CT)	9
1.4 RESEARCH QUESTIONS.....	11

1.5	AIMS OF THE STUDY	11
1.6	RESEARCH DESIGN AND METHODOLOGY	12
1.6.1	Research paradigm	12
1.6.2	Research design.....	12
1.6.3	Review of literature	13
1.6.4	Site, sample and study context	13
1.6.5	Data collection and analysis	14
1.6.5.1	Quantitative data	14
1.6.5.1.1	Data collection	14
1.6.5.1.2	Analysis, validity and reliability of quantitative data.....	15
1.6.5.2	Qualitative data.....	16
1.6.5.2.1	Data collection	16
1.6.5.2.2	Analysis and trustworthiness of qualitative data.....	17
1.6.6	Ethical aspects of research.....	18
1.6.7	The role of the researcher	18
1.7	DIVISION OF CHAPTERS	18
1.8	CONTRIBUTION OF THE STUDY	19
1.9	ANTICIPATED PROBLEMS AND CHALLENGES OF THE STUDY	19
1.10	SUMMARY	19
CHAPTER 2	THEORETICAL AND CONCEPTUAL FRAMEWORK	21
2.1	INTRODUCTION	21
2.2	EDUCATION FOR SUSTAINABLE DEVELOPMENT (ESD)	22

2.2.1	Background and meaning of education for sustainable development.....	22
2.2.2	Education for sustainable development in South Africa	26
2.2.3	Education for sustainable development in pre-service teacher curricula	29
2.2.4	Learning outcomes and teaching and learning strategies in education for sustainable development.....	31
2.3	CONSTRUCTIVISM	33
2.4	ACTIVE LEARNING.....	36
2.4.1	Background and meaning of active learning	36
2.4.2	Advantages of active learning.....	38
2.4.3	Challenges and solutions to implement active learning.....	39
2.4.4	The flipped classroom.....	40
2.5	PROBLEM-BASED LEARNING (PBL)	42
2.5.1	Problem-based learning as teaching and learning strategy.....	42
2.5.1.1	Background and meaning of problem-based learning	42
2.5.1.2	The problem-based learning process.....	45
2.5.1.3	Advantages and challenges of problem-based learning.....	47
2.5.1.4	Role of the problem-based learning tutor and group members	48
2.5.1.5	Students' perceptions and experiences of problem-based learning	49
2.5.1.6	Problem-based learning online	50
2.5.2	Problem-based learning in pre-service teacher training	51
2.5.3	Problem-based learning in education for sustainable development.....	52
2.6	CRITICAL THINKING (CT).....	54
2.6.1	Background and meaning of critical thinking.....	54

2.6.2	Teaching and learning to develop critical thinking	55
2.6.3	Critical thinking assessment instrument – the Watson-Glaser TM	58
2.6.4	Problem-based learning and the development of critical thinking skills	59
2.7	SUMMARY	62
CHAPTER 3	RESEARCH METHODOLOGY AND STRATEGIES	63
3.1	INTRODUCTION	63
3.2	RESEARCH PARADIGM AND DESIGN	63
3.2.1	Research paradigm	63
3.2.2	Research design.....	64
3.2.2.1	Procedures for implementing the convergent parallel design	67
3.3	ROLE OF THE RESEARCHER.....	69
3.4	DESIGNING THE MODULE ESD	70
3.5	SITE AND SAMPLE	76
3.6	METHODS OF DATA COLLECTION	77
3.6.1	Quantitative data collection.....	77
3.6.1.1	Watson-Glaser ³ Critical Thinking Appraisal.....	77
3.6.1.2	PBL questionnaire	78
3.6.2	Qualitative data collection	79
3.6.2.1	Reflective learning journals (RLJ)	79
3.6.2.2	Focus-group interviews.....	80
3.6.2.3	Observational field notes	81
3.7	METHODS OF DATA ANALYSES.....	82

3.7.1	Quantitative data analysis.....	82
3.7.2	Qualitative data analysis.....	83
3.7.3	Rigour in mixed methods research	84
3.7.3.1	Quantitative results.....	84
3.7.3.2	Qualitative findings	85
3.7.4	Merge and interpret the two data sets.....	86
3.8	ETHICAL ASPECTS	86
3.9	DISCLOSURE FROM RESEARCHER	88
3.10	SUMMARY	88
CHAPTER 4	RESEARCH RESULTS AND DATA ANALYSIS	90
4.1	INTRODUCTION	90
4.2	DESCRIPTIVE STATISTICS OF THE PARTICIPANTS	90
4.3	THE RELIABILITY OF THE PBL QUESTIONNAIRE	91
4.4	THE IMPLEMENTATION OF PBL IN ESD.....	92
4.5	PRE-SERVICE TEACHERS' EXPERIENCE OF PBL IN ESD	93
4.5.1	Pre-service ESD teachers' experience of the general aspects of PBL	94
4.5.2	Pre-service ESD teachers' experience of the PBL process.....	99
4.5.3	Pre-service ESD teachers' experience of the PBL role players.....	106
4.5.3.1	Pre-service ESD teachers' experience of the tutor.....	106
4.5.3.2	Pre-service ESD teachers' experience of the group leaders	107
4.5.3.3	Pre-service ESD teachers' experience of the group members	109
4.5.4	Gender and age differences in pre-service ESD teachers' experience of PBL	111

4.6	THE INFLUENCE OF PBL ON PRE-SERVICE ESD TEACHERS' CRITICAL THINKING SKILLS	113
4.6.1	Gender and age differences in pre-service ESD teachers' critical thinking skills	118
4.7	SUMMARY	119
CHAPTER 5 SUMMARY, FINDINGS AND RECOMMENDATIONS		121
5.1	INTRODUCTION	121
5.2	FINDINGS OF THIS STUDY	121
5.2.1	The implementation of problem-based learning in ESD	121
5.2.2	Pre-service teachers' experience of problem-based learning in the module ESD	124
5.2.2.1	Pre-service ESD teachers' experience of the general aspects of PBL	124
5.2.2.2	Pre-service ESD teachers' experience of the PBL process	126
5.2.2.3	Pre-service ESD teachers' experience of the PBL role players	128
5.2.3	The influence of PBL on pre-service ESD teachers' critical thinking skills	130
5.3	SUMMARY	133
5.4	LIMITATIONS OF THE STUDY	133
5.5	CONTRIBUTIONS OF THE STUDY	134
5.6	RECOMMENDATIONS	135
5.7	CONCLUSION	136
BIBLIOGRAPHY		138
ANNEXURE A: LETTER OF ATTENDANCE FOR WORKSHOP ON QUALITATIVE DATA ANALYSIS WITH <i>ATLAS.TI</i> 8		155

ANNEXURE B: LETTER AND E-MAIL OF CONSENT FROM AROS ACADEMIC CURRICULUM COMMITTEE.....	156
ANNEXURE C: E-MAIL WITH PERMISSION FROM PEARSON TALENTLENS AND LETTER TO PARTICIPANTS	158
ANNEXURE D: INFORMATION LEAFLET AND LETTER OF CONSENT FROM PRE-SERVICE ESD TEACHERS.....	160
ANNEXURE E: PBL QUESTIONNAIRE	165
ANNEXURE F: SEMI-STRUCTURED FOCUS-GROUP INTERVIEW QUESTIONS.....	168
ANNEXURE G: REFLECTIVE LEARNING JOURNAL QUESTIONS.....	170
ANNEXURE H: EXAMPLE OF RLJ CODING.....	171
ANNEXURE I: ESD MODULE PLANNING AND ESD STUDY LETTER WITH ASSESSMENT RUBRICS	172
ANNEXURE J: LIST OF DOCUMENTS AVAILABLE ELECTRONICALLY	181

LIST OF TABLES

Table 3-1:	Work schedule of Education for Sustainable Development for 2019	73
Table 3-2:	Education for Sustainable Development learning units and problem-based learning activities	74
Table 4-1:	The Cronbach alpha values and mean inter-item correlation of the PBL questionnaire	92
Table 4-2:	Pre-service ESD teachers' experience of the general aspects of the PBL experience	95
Table 4-3:	Pre-service ESD teachers' experience of the PBL process	100
Table 4-4:	Pre-service ESD teachers' experience of the tutor in the PBL environment	106
Table 4-5:	Pre-service ESD teachers' experience of the group leaders in the PBL environment	108
Table 4-6:	Pre-service ESD teachers' experience of the group members in the PBL environment	109
Table 4-7:	Gender differences in pre-service ESD teachers' experience of the various aspects of PBL	111
Table 4-8:	Spearman's rank-order correlation between the age differences of pre-service ESD teachers' experience of PBL	112
Table 4-9:	The pre-service ESD teachers' WG ³ CTA pre- and post-test paired samples <i>t</i> -test results	113
Table 4-10:	The pre-service ESD teachers' WG ³ CTA score band results	114
Table 4-11:	The pre-service ESD teachers' WG ³ CTA <i>t</i> -test results per gender group ...	118
Table 4-12:	Spearman's rank order correlation between the age differences of pre-service ESD teachers' WG ³ CTA pre- and post-test results	119

LIST OF FIGURES

Figure 2.1:	Theoretical and conceptual framework of the literature review for Chapter 2	21
Figure 2.2:	The PBL framework used in the Earth System Science unit (Beringer, 2007: 449).....	46
Figure 3.1:	The convergent parallel mixed methods design (Creswell & Plano Clark, 2018:66).....	66
Figure 3.2:	Flowchart of the basic procedures in implementing a convergent parallel design – adopted for the study (Creswell and Plano Clark, 2018:70).	67
Figure 3.3:	Research framework	69
Figure 4.1:	Gender structure of the participants	90
Figure 4.2:	Age structure of the participants.....	91
Figure 4.3:	Pre-service ESD teachers’ reflections about what they have learned from the PBL activities	97
Figure 4.4:	The positive and negative responses of the pre-service ESD teachers regarding the PBL process and the themes investigated.....	102
Figure 4.5:	The problems encountered by the pre-service ESD teachers in completing the PBL activities	103
Figure 4.6:	The solutions proposed by the pre-service ESD teachers whilst completing the PBL activities	105
Figure 4.7:	The responses from the pre-service ESD teachers regarding the development of their CT skills in completing the PBL activities	116

CHAPTER 1 INTRODUCTION TO THE STUDY

1.1 INTRODUCTION AND PROBLEM STATEMENT

Environmental problems and concerns are growing worldwide. The world population is escalating, placing tremendous strain on natural resources and affecting environmental systems, which are influencing the climate and state of biodiversity on our planet (WWF, 2016:12). Global warming, a dilemma of climate change, is emphasised with “*climate emergency*” indicated as the 2019 word/phrase of the year by Oxford Languages (Oxford Languages, 2020). António Guterres, the UN Secretary-General, called climate change “*the defining issue of our time*” during the Climate Action Summit in September 2019 (UN, 2020). The enormous human impact on the environment since the industrial revolution has brought about the Anthropocene, the new geological era proposed by scientists, in which humans’ activities are responsible for changing the global environment (Assadourian, 2017:5; Mandikonza & Lotz-Sisitka, 2016:108; Steffen *et al.*, 2011:843).

The response to this disaster is the call for modern societies to live more sustainable, placing a responsibility on education to popularise the concept sustainability (Le Grange *et al.*, 2014:123), as emphasised by the Tbilisi Declaration (UNESCO, 1978) and the Rio Declaration (UN, 1992). The responsibility to accelerate sustainability lies not only with education but in all stakeholders of the society. Education and curriculum development are however regarded as one of the important role players in achieving sustainable development, as promoted by the United Nations Decade of Education for Sustainable Development (UN-DESD). The UN-DESD was launched as a global initiative to advance and establish the concept of “Education for Sustainable Development” (ESD) in its role to contribute to the development of a more sustainable world (UNESCO, 2017:8).

The development of an appropriate training program for pre-service teachers is crucial in the success of our future teachers’ competence to implement ESD in South African schools. Since the major environmental education (EE) conferences held by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) in the 1970s and 1980s, the need for and relevance of pre-service teacher training to introduce EE are emphasised numerously. An international literature review analysis compiled by Álvarez-García *et al.* (2015), however confirmed a lack of environmental competences amongst pre-service teachers and a gap in pre-service teacher training curriculums regarding EE. In South Africa, EE is not compulsory but is strongly advised to be included in the curriculum of pre-service teacher training. The fifth goal in the White Paper on Environmental Management

Policy (Department of Environment Affairs and Tourism, 1998:36) in South Africa concerning EE and empowerment has the objective to “*integrate environmental education in all programmes, levels, curricula and disciplines of formal and non-formal education and in the National Qualification Framework.*”

In South African schools, ESD is not an independent subject but is infused in all the subjects of the formal school curriculum (Le Grange, 2004:135). ESD is included in the main principles of the curriculum that inform all teaching and learning (Department of Basic Education, 2011:4-5). These principles recognise the relationship between environment, societies and economies to improve living standards for all (Fundisa, 2013:6) and are in accordance with the objectives of the UN-DESD.

The current trend in South Africa for training pre-service teachers and especially in ESD, is to move away from the traditional teacher-centred instruction towards a learner-centred instruction. Institutions are therefore encouraged to engage learners in real life situations that promote questioning and the development of critical thinking and problem-solving skills (Dreyer & Loubser, 2017:158; Maluleke, 2007:37). Developing students’ critical thinking plays an important role in achieving the main goal of establishing students to become lifelong learners (Elahi *et al.*, 2014:535). A teaching and learning strategy that can help develop these skills, is problem-based learning (PBL). Against this background, PBL was introduced in the education for sustainable development (ESD) module at Aros (*Akademie vir Reformatoriese Opleiding en Studies*). This study aimed to investigate if the implementation of PBL in ESD can contribute to the development of pre-service teachers’ critical thinking skills after the PBL intervention.

In the next paragraph, relevant concepts to the research study are clarified.

1.2 CLARIFICATION OF CONCEPTS

The following concepts, as related to the study are clarified, namely environmental education, education for sustainable development, problem-based learning, critical thinking and pre-service teachers.

Environmental education (EE) as defined by the International Union for Conservation of Nature (IUCN, 1971:17), is “*the process of recognising values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the interrelatedness among people, their culture and their biophysical surroundings. Environmental education also entails practice in decision making and self-formulation of a code of behaviour about issues concerning environmental quality.*”

Education for sustainable development (ESD) is according to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2018:7) commonly understood as *“education that encourages changes in knowledge, skills, values and attitudes to enable a more sustainable and just society for all. ESD aims to empower and equip current and future generations to meet their needs using a balanced and integrated approach to the economic, social and environmental dimensions of sustainable development.”*

Problem-based learning (PBL) is a teaching and learning strategy that is student-centred and uses the solving of real-world problems to initiate learning. It is defined by its founders as *“the learning that results from the process of working toward the understanding or resolution of a problem”* (Barrows & Tamblyn, 1980:18). PBL is a teaching and learning strategy that facilitates students in the process of acquiring new knowledge and developing strategies when posed with an ill-structured problem that must be solved (Hmelo-Silver, 2004:237).

Critical thinking (CT) as defined by Watson and Glaser (2018:1) is *“the ability to identify and analyse problems, as well as seek and evaluate relevant information in order to reach an appropriate conclusion.”*

Pre-service teachers are students enrolled in an undergraduate Baccalaureus Education (BEd) degree or a National Professional Diploma in Education (NPDE) at a higher education institution (Department of Higher Education and Training, 2015:14). In this study, the sample used included the third-year pre-service teachers who were students enrolled for the BEd module ESD at Aros.

To enable the researcher to link concepts of relevance in the research study, a literature review was done.

1.3 LITERATURE REVIEW

1.3.1 Education for sustainable development (ESD)

Growing environmental challenges (*cf.* 1.1) that need to be addressed led to the development of the concept ESD (UNESCO, 2018:7). Education is an important tool to achieve sustainability (Hopkins & McKeown, 2002:13). Sustainable development (SD) is globally a key concept and the focus of discussion in environmental action plans, as evident in the reports *Our Common Future* of the Brundtland Commission (WCED, 1987) and *Agenda 21* of the Rio Earth Summit (UN, 1992). The United Nations Educational, Scientific and Cultural Organization (UNESCO) implemented the UN-DESD for the period 2005-2014

as a global vision to advance ESD in all communities (UNESCO, 2017:8). The UN-DESD initiative has contributed to the concept that ESD is not an “add-on” in the curriculum alongside EE, but a holistic systems approach that also influences the development of education institutions (UNESCO, 2014:12; UNESCO, 2017:8). Education should therefore change to provide the knowledge, values, skills and attitudes needed by students to support SD (UNESCO, 2018:7). UNESCO followed up the initiative with the Global Action Programme (GAP) for 2015-2019, which includes five priority action areas that call on all education ministries and institutions to support and intensify initiatives that lead towards SD (UNESCO, 2017:9). The UN also adopted the United Nations Millennium Declaration, with its 8 Millennium Development Goals (MDGs) for the period 2000-2015 to address the needs of the poorest people in the world. This declaration was followed up by Agenda 2030 with its 17 sustainable development goals (SDGs) for the period 2015-2030. These goals aim to end poverty and promote human rights and sustainability in the world (UNESCO, 2017:10). The MDGs and SDGs also contributed to the implementation of ESD in the different spheres of education.

The third priority in GAP states that *“education for sustainable development should be integrated into the professional training of teachers, enabling them to become ‘change agents’ in implementing education for sustainable development”* (UNESCO, 2017:10). According to the literature review analysis of Álvarez-García *et al.* (2015:72), pre-service teachers lack environmental competences and there are gaps in their curricula regarding EE. This emphasises the need to effectively integrate ESD in the training programs of pre-service teachers in South Africa. Priority four in GAP focusses on mobilising the youth. ESD should therefore empower the youth to make informed decisions and act responsibly to further *“environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity”* (UNESCO 2014:12). ESD is thus an integral part of education that excels and promotes lifelong learning. In South Africa, the Constitution protect the right to a safe and healthy environment (South Africa, 1996:9) and the national school curriculum aims to develop learners who can act as responsible citizens towards the environment and the health of others (Department of Basic Education, 2011:4-5). It is therefore eminent to include ESD in the training programs of pre-service teachers to equip them to successfully convey the principles of ESD to school learners.

The quest to promote ESD in South Africa calls for pre-service teacher training programs to focus on teaching and learning strategies which support the needed knowledge, skills and attitudes in ESD. Constructivism is a teaching and learning theory that assists in the

effective implementation of ESD in higher education institutions and schools and is discussed in the next paragraph.

1.3.2 Constructivism

Constructivism is a theory that explains how we learn or how humans come to understand things (Richardson, 1997:3; Ültanir, 2012:195). It has many different applications and interpretations in a variety of fields. *"Constructivism is not a theory about teaching...it is a theory about knowledge and learning... the theory defines knowledge as temporary, developmental, socially and culturally mediated, and thus, non-objective"* (Brooks & Brooks, 1993:vii). Jones and Brader-Araje (2002:2) further collaborated by compiling a table with definitions of constructivism in education and state that the basic principle that is found in these definitions is the idea that learners need to be actively involved in their own meaning-making to develop understanding. According to Ertmer and Newby (2013:55), we 'create' meaning instead of 'acquiring' it. Knowledge is not transferred from the external world into your memory but it is acquired through individual interactions of what we already believe and the different experiences we have (Ertmer & Newby, 2013:55; Ültanir, 2012:195). Understanding therefore develops from our interaction with our environment and what we learn cannot be separated from how it is learned (Savery & Duffy, 2001:1).

In the constructivist approach, educational strategies should encourage students to actively explore topics that will move them into thinking and to validate their understanding through social negotiation. The role of the educator in this student-centred approach is still relevant and a two-folded task can be assigned to the educator (Ertmer & Newby, 2013:57, 59). Firstly, the educator instructs students on how they should construct meaning and then follow up by monitoring, evaluating and updating those constructions. Secondly, the educator's role is to design learning experiences in which relevant contexts can be experienced by the students.

Cognitive constructivism developed from the work of Piaget (2013:8) who stated that individuals organise thoughts as they adapt to things and by organising oneself, they can structure things. The student is therefore an active participant in constructing his or her own knowledge with the educator who acts as facilitator in the process of building knowledge (Richardson, 1997:5). Social constructivism is a variety of cognitive constructivism and developed from the work of Vygotsky (1978:126) who believed that learning cannot be separated from its social context. Social constructivism as a result, focusses on the social and cultural influences on the construction of knowledge (Airasian & Walsh, 1997:445).

Knowledge and comprehension of the world is thus developed jointly by individuals (Amineh & Asl, 2015:13).

In this study, a social constructivist approach was used to promote the required knowledge, skills and attitudes expected of pre-service teachers in ESD. The inclusion of constructivism in lecturing halls and classrooms can enhance students' and learners' active learning. Paragraph 1.3.3 elaborates on active learning.

1.3.3 Active learning

In contrast to traditional direct instruction, such as lecturing and demonstrations, in which students are passive and listen, active learning introduces active teaching and learning activities into the classroom (Gleason *et al.*, 2011:2; Prince, 2004:223). Active learning is embedded in constructivism and can be defined as teaching and learning activities that engage students and let them think about what they are doing (Bonwell & Eison, 1991:2). It includes a range of activities, from individual short writing exercises or pair discussions to reflecting on lectures and complex group activities that interrogate real-life problems (Faust & Paulson, 1998:4; McLaughlin *et al.*, 2014:236; Prince, 2004:225). Active learning is an approach utilising different methods, rather than a single teaching and learning strategy (Gleason, 2011:3). Activities should be designed to address the learning outcomes and thus engage students in meaningful activities that foster deep learning (Prince, 2004:226). The purpose of active learning in the classroom is thus to enhance students' knowledge and comprehension of the learning content and stimulates higher-order thinking (McLaughlin *et al.*, 2014:236). The skills required of students in the 21st century include problem-solving, good verbal and written communication, working together as team members as well as creative and critical thinking. (Butler-Adam, 2018:1; Cotet *et al.*, 2017:3). Beyleveld *et al.* (2019:17) agrees that implementing active learning in the South African higher educational system can deliver better quality students who meet the requirements of the South African Qualifications Authority (SAQA).

Technological development has made it possible to transform educational practices even further (Abeysekera & Dawson, 2015:2; Bishop & Verleger, 2013:2). Inverting the classroom, or flipped classroom, means that actions that typically take place inside the classroom, now take place at home and the homework activities take place in the classroom (Lage *et al.*, 2000:33). The flipped classroom therefore advocates posting lectures and reading materials online for students to prepare for classes. The time in class can then be used for active learning activities such as discussions, brainstorming and debates (Abeysekera & Dawson, 2015:2; McLaughlin *et al.*, 2014:237; Roehl *et al.*, 2013:45).

One teaching and learning strategy that fosters active learning, is problem-based learning (PBL). In this study, PBL was introduced in the module ESD for the pre-service teachers at the institution for this study and is discussed next.

1.3.4 Problem-based learning (PBL)

Problem-based learning (PBL) developed in the medical health education at the McMaster University, situated in Canada, in the 1960's and since then was refined and expanded into a variety of professional schools, universities and schools (Savery & Duffy, 2001:7; Savery, 2006:11). It developed as an alternative to the traditional, lectured-based approach because doctors and nurses are exposed daily to problem scenarios where they need to interpret and draw together knowledge and insights from different sources. Students are posed with real life situations that engage them into active learning opportunities (Hmelo-Silver, 2004:236).

PBL is a teaching and learning strategy that is student-centred and uses the solving of problems to initiate learning (Barrows & Tamblyn, 1980; Prince, 2004:223). According to Savery (2006:12), PBL is an *“instructional (and curricular) learner-centred approach that empowers students to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem”*. Students should be confronted with real-world problems that intrigue them to research the concepts they need to know in order to work through the problem (Duch *et al.*, 2001:6). Students are consequently placed in the active role of problem-solvers. In PBL, students work together in teams or small groups to solve problems and the teacher acts as facilitator to guide them through the tutorial process (Hmelo-Silver, 2004:236).

In a typical learning process in PBL, the real life problem is usually given as a scenario that is ill-structured, which means students can formulate more than one correct solution (Hmelo-Silver, 2004:236-237; Savery, 2006:13). The PBL process starts with students analysing the problem to identify and formulate learning issues or learning objectives. Students then engage in self-directed learning to gather information on the identified learning objectives. In the follow-up session, this new knowledge is applied to the context of the problem and to evaluate if they have achieved all the identified learning issues or objectives. As they progress, new learning issues may be identified and the cycle starts again. Afterwards, students reflect on the knowledge gained (Duch *et al.*, 2001:7; Hmelo-Silver, 2004:236-237; Savery & Duffy, 2001:7-9).

Literature distinguishes between pure, hybrid and integrated PBL formats. A pure PBL format does not include lectures and students work in groups whereas the hybrid PBL format supports students' learning by incorporating direct instructional methods, such as lectures and demonstrations, during the PBL process (Carrió *et al.*, 2016:2; Masek & Yamin, 2010:148). The embedded or integrated PBL model includes PBL for a specific period in a traditional teaching curriculum, either in the pure or hybrid format (Kivela & Kivela, 2005:437). For this study, an integrated hybrid PBL format was followed since PBL was only implemented in one module of the BEd curriculum at the institution and it was the students' first encounter with PBL.

PBL is a teaching and learning strategy that can ensure the integration of real-world learning opportunities into ESD to prepare students for unexpected problems within complex systems (Brundiers *et al.*, 2010:311; Dale & Newman, 2005:353). A study compiled by Dahlgren and Öberg (1999:80 and 2001:263) at a Sweden University is one example of implementing PBL in an Environmental Science Education program. The study compiled by Sueb *et al.* (2020:5) on the other hand introduced PBL environmental care modules in the learning of grade ten school learners to determine the development of environmental care attitudes. Although PBL has been implemented in other disciplines in South Africa, the researcher could not find any evidence of a PBL format used in ESD modules in South Africa. Examples of other disciplines in South Africa that implemented PBL include Geography modules of pre-service teachers (Golightly, 2018; Golightly & Muniz, 2013), medical training programs (Iputo & Kwizera, 2005) and nursing training programs (Rakhudu, 2011).

PBL addresses many of the outcomes that are advantageous for undergraduate education (Duch *et al.*, 2001:6). It develops students to think critically and analyse and solve complex problems; students learn from each other; they have to search, evaluate and use appropriate learning resources, which results in wide reading and life-long learning (Duch *et al.*, 2001:6; Hmelo-Silver, 2004:240; Rakhudu, 2011:86). Many researchers studied the effect of PBL on critical thinking skills of students and concluded a positive outcome (Kek & Huijser, 2011:338; Kong *et al.*, 2014:468; Masek & Yamin, 2011:219; Sujanem, 2018:5).

This study investigated the influence of PBL on the critical thinking skills of pre-service teachers at a South African higher education institution. Critical thinking is consequently discussed in the following paragraph.

1.3.5 Critical thinking (CT)

In the 21st century, one of the outcomes that is endorsed by all higher education institutions for undergraduate education is the development of higher-order thinking, which includes critical thinking skills (Bart, 2010:3; Yen & Halili, 2015:41). Defining critical thinking is challenging since numerous distinct definitions and understanding exist in literature. Some of the most widely accepted definitions include those of Ennis and Facione. Ennis (1985:45) defines critical thinking as *“reflective and reasonable thinking that is focused on deciding what to believe or do.”* According to O'Hare and McGuinness (2009:124) this definition reveals the purpose and intention but not the cognitive process of critical thinking. The Delphi report on critical thinking, Facione (1990:2) focusses on this process, stating critical thinking to be *“purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based.”* Since this study used the test instrument developed by Watson and Glaser, their definition of critical thinking was used, as stated in paragraph 1.2. Critical thinking in this study is therefore regarded as the skill that allows a person to identify and analyse a problem by seeking and judging information that is relevant in drawing applicable conclusions (Watson & Glaser, 2018:1).

Critical thinking (CT) is required to act as competent citizens in our modern society and it has become a necessity that learners at schools should be guided to enhance their critical thinking skills (Ten Dam & Volman, 2004:359). Goals in education thus focus on the development of critical thinkers who can adapt in different contexts, utilise knowledge in a logical and analytical way and to solve problems (El Hassan & Madhum, 2007:361). In South Africa, the National Curriculum Statement Grade R-12 (Department of Basic Education, 2011:5) also aims to equip learners with the skills to identify problems and solve them by applying creative and critical thinking skills. Grosser and Lombard (2008:1372) assumed that pre-service teachers in South Africa are lacking critical thinking skills as well as the understanding of how to teach critical thinking skills. Therefore, if teachers are not effectively educated in these skills, they are unable to promote critical thinking skills among their learners. This important aspect enhances the necessity of this study to promote the critical thinking skills of pre-service teachers.

Literature reveals that the ability to think critically can be developed through instruction and when it is practiced (Grosser & Lombard, 2008:1372; Kek & Huijser, 2011:332; Perry *et al.* 1996:77). Deeper learning amongst students can take place in learning environments that allow for the development of skills whilst acquiring subject knowledge (Kek & Huijser,

2011:332). According to Ten Dam and Volman (2004:359), active learning and a problem-based curriculum that promotes learning through real-life situations and interaction between students are effective teaching and learning strategies to foster students' critical thinking skills. This is confirmed in the study by Sujanem *et al.* (2018:4), in which PBL was introduced in the physics teaching of grade ten school learners. During the process of collecting and processing different sources and discussing and presenting solutions, the learners also developed their critical thinking skills. The research study by Pu *et al.* (2019:6) furthermore revealed that students with strong CT disposition performed better in a PBL curriculum and even further improved their CT disposition towards the end of the year, compared to students with a lower CT disposition. Improving tutor training is therefore important to realise the goal of effectively guiding students during the PBL process to optimise the development of CT skills (Pu *et al.*, 2019:7).

Measuring and assessing critical thinking skills pose another challenge. Critical thinking can be seen as a general cognitive ability to process information in any context versus a reasoning ability that is related to and embedded in knowledge and disciplinary contexts (O'Hare & McGuinness, 2009:124). For the purpose of this study, the focus was on the first assumption, since ESD is a cross-curricular subject. Commonly used instruments reported in the literature to assess critical thinking skills of undergraduate students, include the following:

- California Critical Thinking Skills Test (CCTST);
- California Critical Thinking Disposition Instrument (CCTDI);
- Cornell Critical Thinking Test, Level Z (CCTT);
- Ennis-Weir Critical Essay Test (Ennis-Weir); and
- Watson-Glaser Critical Thinking Appraisal (WGCTA) (Bart, 2010:3).

There is no suitable equivalent test available in South Africa and as a result, the Watson-Glaser³ Critical Thinking Appraisal (WG³CTA), was used as measuring instrument in this study. The first edition of the WGCTA was also used in the study of Grosser and Lombard (2008:1369) and Grosser and Nel (2013:4) to determine pre-service teachers' critical thinking skills in a South African context. The WG³CTA profile report provides an overall percentile score as well as individual scores for the following subscales: recognise assumptions; evaluate arguments; and draw conclusions.

This study sought to explore the influence of PBL on the development of pre-service teachers' critical thinking skills. From the literature, it is evident that PBL as teaching and

learning strategy can contribute to this goal (Kong *et al.*, 2014:468; Masek & Yamin, 2011:219; Sujanem *et al.*, 2018:4). PBL is therefore introduced in the module ESD that expects from pre-service teachers to reveal critical thinking and problem-solving skills.

This ends a brief literature review of the main concepts of this study. It is accordingly required to elaborate on the research questions and aims of this study.

1.4 RESEARCH QUESTIONS

The main research question for the study is:

What is the influence of problem-based learning on the critical thinking skills of pre-service teachers in the teaching and learning of education for sustainable development?

The subsidiary research questions include the following:

- How can PBL be implemented in the teaching and learning of ESD?
- What are pre-service ESD teachers' experience of PBL, including their role as pre-service teachers and the role of the ESD lecturer as tutor, in completing the PBL activities?
- What is the influence of PBL on the perceptions of pre-service ESD teachers regarding the development of their critical thinking skills that include to recognise assumptions, evaluate arguments and draw conclusions?

1.5 AIMS OF THE STUDY

The aims of this study can be summarised as follows:

- Investigating the ways in which PBL can be implemented as teaching and learning strategy in the module ESD for pre-service teachers.
- Determining pre-service ESD teachers' experience of PBL, which includes their role as pre-service teachers and the role of the lecturer as tutor, whilst completing the PBL activities.
- Exploring the influence of PBL on the perceptions of pre-service ESD teachers regarding the development of their critical thinking skills, which include recognising assumptions, evaluating arguments and drawing conclusion.

Investigating these aims should make it possible to judge the influence of PBL on pre-service teachers' critical thinking skills in ESD.

After clarifying the research questions and aims, the research design paradigm and research design are discussed next.

1.6 RESEARCH DESIGN AND METHODOLOGY

1.6.1 Research paradigm

This study followed a pragmatic research paradigm. Pragmatism is considered to be the best philosophical foundation to use in mixed methods research (Creamer, 2018:45; Creswell & Plano Clark, 2018:37; Ivankova *et al.*, 2020:315). The pragmatist argues that combining qualitative and quantitative methods within one study is feasible, since there are enough similarities in the fundamental values of both approaches to make them compatible (Ivankova *et al.*, 2020:333).

Pragmatism focusses on the flexibility of choice of methods in accordance with the purpose of the study, rather than on philosophical assumptions (Creamer, 2018:45). It concentrates on the questions being asked about the problem under study, rather than the methods (Creamer, 2018:45; Creswell & Plano Clark, 2018:37). The world is not seen as an absolute unity and as a result, different approaches are used for collecting and analysing data. It gives the researcher freedom of choice to choose the best applicable techniques and procedures to address the research problem (Creswell, 2014:11).

In this study, quantitative and qualitative research methods were used to collect data to generate a deeper understanding of the research question. The research design is explored next.

1.6.2 Research design

This study was conducted as a convergent parallel mixed method research design, in which quantitative and qualitative data was collected simultaneously. Mixed methods research can be described as the mixing of qualitative and quantitative methods in one research project (Creswell & Plano Clark, 2018:4). This methodological pluralism usually results in highly successful research (Johnson & Onwuegbuzie, 2004:14). Results from the quantitative and qualitative data are compared and contrasted to gain a more complete understanding of the phenomena to validate the conclusions (Ivankova *et al.*, 2020:338).

Quantitative methods focus on the exact quantification of data and the control of variables and use statistical procedures to appraise the data (Ponterotto, 2005:128). Qualitative methods are not clearly defined and it includes multiple interpretive activities and methods

(Denzin & Lincoln, 2011:6). This study compared the qualitative data to the quantitative data to produce a more complete understanding of the phenomena.

1.6.3 Review of literature

A literature review was compiled in the initial stages of this study to learn more about the themes included in the title of the study and to investigate the field of study. The key words from the title of this study as well as associated, relevant themes were thus researched. The concepts include education for sustainable development (ESD), constructivism, active learning, problem-based learning (PBL) and critical thinking. The purpose of the review is to provide an overview of the research and to identify the gap in the field of study (Maree, 2020:28). The review of literature played an important role during the planning of this study as well as supporting and guiding every step of the study. According to Fouché and Delport (2011:135), the review of literature continues throughout the entire research process. The review may assist the researcher to discover existing tools or methods or to learn about better methodologies to apply. The review of literature is therefore conducted to initiate a clearer understanding of the complexion of the problem that has been identified and hence serves as an important part of the research (Fouché & Delport, 2011:134).

The procedure that was followed included locating sources mostly through computer-accessible databases such as *Google Scholar*, *EBSCOHost*, *JSTOR*, *ERIC* and *Sabinet*. Books available in the library and using “*sources as a source of reference*” were also utilised. While reviewing literature, relevant sources that were referenced were also investigated, which in turn quoted new sources, creating a snowball effect (Fouché & Delport, 2011:136). The sources of literature that were reviewed mostly included articles in professional journals and scholarly books.

1.6.4 Site, sample and study context

The study was conducted at the Aros (*Akademie Reformatoriese Opleiding en Studies*) Campus in Waverley, Pretoria. The institution (Aros) is a private higher education institution in Pretoria, South Africa, that has been offering Baccalaureus Education (BEd) programs to prospective teachers since 2004 (Aros, 2019). A unique blended training model is used at the institution. This model makes use of distance-learning through online teaching during the week, together with contact sessions between pre-service teachers and lecturers during weekends. Distance-learning opportunities, as well as contact sessions in classrooms at the Aros Campus, were utilised to conduct the study. Distance-learning included information shared online via e-class that is embedded in the Learning Management System (LMS)

Moodle™ as well as collaboration on the *Google* platform. Participation of the pre-service teachers were at group meetings during contact sessions but also online and in their private time and location.

A convenience non-probability sampling method was utilised in this study. The pre-service teachers were selected since they are conveniently available to the researcher (Maree & Pietersen, 2020a:219). The module ESD is a compulsory module for third year Intermediate Phase pre-service teachers (Aros, 2018b:20,22). The inclusion criteria for the participants in this study therefore included all the third year BEd Intermediate Phase pre-service teachers, who have enrolled for the module ESD in 2019. It included a total of 55 participants. Qualitative research uses the term *participants* and quantitative research uses *respondents* for the people taking part in a project (Maree, 2020:43-44). For uniformity, the researcher has chosen the term participants to refer to the pre-service teachers who participated in this study, which is the preferred term in mixed methods research (Maree, 2020:45).

The module ESD aims to equip pre-service teachers with environmental competences in the subjects that they are going to teach in schools. A work schedule and study guide (available electronically) have been developed by the researcher for the purpose of this study and for implementing the module ESD at the institution. The study guide includes four PBL activities and is aligned with the outcomes for the module, as specified in the yearbook of the institution (Aros, 2018b:40).

1.6.5 Data collection and analysis

1.6.5.1 Quantitative data

1.6.5.1.1 Data collection

Two instruments, the Watson-Glaser³ Critical Thinking Appraisal (WG³CTA) and the PBL questionnaire, were utilised in this study to generate the quantitative data. The quantitative data focussed on two aspects, namely the development of the pre-service ESD teachers' critical thinking and their experience of PBL in the module ESD.

Firstly, the development of the participants' critical thinking skills was determined by using a pre-test post-test one group design. This design does not include a control group and the participants are not randomly selected. According to Fouché *et al.* (2011:145), the pre-test post-test one group design is used when resources do not allow a true experimental design. The WG³CTA, developed by Watson and Glaser (2018) was used as test instrument for

measuring the critical thinking skills. The participants completed the test online at the beginning and again at the end of the semester. The instrument served as the pre-test and post-test to determine the development of critical thinking skills. The WG³CTA is a standardised and international accredited test instrument to measure critical thinking skills (Bart, 2010:9) and there is evidence of the reliability and validity of this test instrument (El Hassan & Madhum, 2007; Watson & Glaser, 2018:27-43). The reliability and validity of the first edition of the WGCTA has been determined for pre-service teachers in South Africa in the research conducted by Lombard and Grosser (2008:561) and Grosser and Nel (2013:1). The WG³CTA is the third edition of this test instrument and it is available in different languages. For this study the English, UK version was used.

Secondly, for measuring the participants' PBL experience, a non-experimental design was followed. According to Maree and Pietersen (2020b:193), the non-experimental design is used when all the participants who partake in the research are measured on the relevant variable. Most non-experimental research designs make use of surveys that collect data with questionnaires (Delpont & Roestenburg, 2011:156; Maree & Pietersen, 2020b:193). According to Babbie (2016:248), a questionnaire is a document that contains questions that are designed to obtain information that can be analysed. The basic objective is to acquire facts and opinions about the phenomenon from the people involved (Delpont & Roestenburg, 2011:186). The participants completed a structured questionnaire survey regarding their experience in PBL at the end of the semester. The structured 45-items electronic questionnaire, adapted from the paper-based questionnaire developed by Golightly and Muniz (2013:6), was used as instrument in this study (*cf.* Annexure E). The reliability and validity of this measuring instrument for pre-service teachers in South Africa was already determined in the study conducted by Golightly and Muniz (2013:6). The questionnaire covers three main concepts: PBL in general, the PBL process and the different role players in PBL. The responses are rated using a five-point Likert scale which range from "*strongly disagree*" to "*strongly agree*".

The participants completed both the instruments in the computer centre at the institution in three sessions on the same day, accommodating 22 participants at a time. The researcher was present in the centre to administer the test and questionnaire, give instructions and monitor the participants.

1.6.5.1.2 Analysis, validity and reliability of quantitative data

The results from the online WG³CTA was made available by the company, Pearson TalentLens to the researcher. The results from the WG³CTA and the PBL questionnaire

were processed by the North-West University (Potchefstroom Campus) Statistical Consultancy Services and then analysed by the researcher. The scores and three sub-scores of the Critical Thinking instrument as well as PBL results, were compared to demographic information, which included gender and age of the pre-service teachers, by means of *t*-tests, ANOVA's and Spearman rank order correlations. To determine if critical thinking skills had improved, paired *t*-tests were used. Descriptive statistical techniques, which include the mean and standard deviation, were utilised to analyse the items in the PBL questionnaire to determine the participants' experience of PBL in the module ESD.

The two instruments that were used for collecting data are valid and reliable. The evidence of the reliability and validity of the WG³CTA is published in the WG³CTA manual (Watson & Glaser, 2018:27-44) and local studies verify the reliability and validity of the WGCTA in a South African context (Lombard & Grosser, 2008:568; Grosser & Nel, 2013:5). The reliability and validity of the PBL questionnaire was determined in the study by Golightly and Muniz (2013:6) in South Africa. The reliability of the PBL questionnaire for this study was determined by calculating the Cronbach alpha coefficient and inter-item correlation.

1.6.5.2 Qualitative data

1.6.5.2.1 Data collection

Qualitative data collection and analysis techniques were employed to ensure rich, deep data and to support triangulation of findings (Ivankova *et al.*, 2020:331). Triangulation is more than just gathering data using multiple methods. Through multiple research methods, a more substantive and complete picture of reality can be obtained that allows the verification of the different elements under investigation (Nieuwenhuis, 2020a:142). The qualitative data focussed on the pre-service teachers' experience of PBL and the development of their critical thinking skills in the module ESD. The researcher employed three strategies to collect the qualitative data, namely reflective learning journals, on-site student participatory observation field notes and semi-structured focus-group interviews.

Firstly, the pre-service teachers were instructed to keep reflective learning journals to record their own experiences of PBL in ESD. The participants reflected on their experiences of each PBL tutorial session, using Gibb's reflective cycle (Peter, 2016), see Annexure G. The journal entries were submitted online to the tutor for feedback. According to Engelbrecht (2016:117), reflective journals is a popular method in qualitative research to collect additional and supplementary data. The reflection of the participants can be a valuable contribution in the process of the research study.

Secondly, classroom observation focussed on monitoring pre-service teachers' contribution and participation in their groups' PBL activities. It includes their participation in group discussions during contact sessions and their online participation during the week. The role of the researcher in the observation of the participants can be described as observer-participant. The researcher spent limited time with the participants, who were aware that they are being observed for the purpose of this study (Engelbrecht, 2016:116). Field notes by the researcher recorded the observations of the participants and reflected on the experiences of the researcher.

Thirdly, open-ended, semi-structured focus-group interviews were conducted to collect data from two groups, one group from the Friday class and one from the Saturday class. A focus-group interview implicates that there are specific outcomes intended for the interview and that it is carefully planned beforehand (Engelbrecht, 2016:114). The interviews were digitally recorded, as the researcher seeks to explore and understand the participants' experience of PBL as well as the influence of PBL on the participants' critical thinking skills.

1.6.5.2.2 Analysis and trustworthiness of qualitative data

Data analysis in qualitative research involves examining and interpreting observations in a non-numerical manner to reveal the underlying meanings as well as patterns of relationships (Babbie, 2016:382). All the qualitative data, i.e. responses from the participants' reflective journals, observational field notes and the transcriptions of focus-group interviews from audio-digital recordings, were included to form an integrated data set. The integrated data set was qualitatively analysed using the data-analysis software program *Atlas.ti*TM. The program allows for incorporating large bodies of text and media and offers a variety of tools to systematically analyse the data.

Emergent coding procedures were followed to code the integrated data set in the *Atlas.ti* program. Coding is the process of reading line by line through the data to divide it into meaningful units that can be used for analyses. According to Nieuwenhuis (2020a:136), emergent coding, or open-coding, involves identifying the meaning units after some preliminary reading of the data.

Trustworthiness of the qualitative data is assured by focussing on credibility, transferability, confirmability and dependability (Nieuwenhuis, 2020a:144). The researcher attended a workshop to receive training in operating and utilising the *Atlas.ti* program. The coding of the qualitative data was peer reviewed by the co-supervisor.

1.6.6 Ethical aspects of research

The Research Committee and Academic Curriculum Committee at the institution gave permission for this study (*cf.* Annexure B). All enrolled Intermediate Phase pre-service ESD teachers for 2019 completed a consent form to take part in the study, stating that they agree to: complete questionnaires, tests, learning journals and reports; attend classes and take part in group activities. Participation was voluntary and pre-service teachers could withdraw from this study at any time. All data was handled confidentially and the identity of participants would not be made public. The consent form also states that participants gave permission for their results to be shared anonymously with Pearson TalentLens (*cf.* Annexure D).

An ethical clearance certificate was obtained from the NWU, reference number: NWU-00070-19-A2 (*cf.* p. ii).

Pearson TalentLens gave permission to the researcher to use the WG³CTA as test instrument and made it available online for the purpose of this study (*cf.* Annexure C).

1.6.7 The role of the researcher

The researcher was actively involved throughout the research process. The researcher's role was to fulfil the following functions. The researcher compiled the study guide for the module ESD, which includes the PBL activities. The researcher is assigned as lecturer for the module ESD and acted as tutor during the semester and facilitated the participants to complete the PBL activities. The researcher administered the pre- and post-test, questionnaire and interviews to collect the data for this study. The researcher was assisted in the administrative duties for the semester by an appointed assistant for the module ESD.

1.7 DIVISION OF CHAPTERS

- Chapter 1: Introduction to the study
- Chapter 2: Theoretical and conceptual framework
- Chapter 3: Research methodology and strategies
- Chapter 4: Research results and data analysis
- Chapter 5: Summary, findings and recommendations

1.8 CONTRIBUTION OF THE STUDY

This study aimed to emphasise the importance of ESD to be included in all pre-service teachers' training curriculums.

It further explored the possibilities and advantages of a constructivist teaching and learning strategy that promotes active learning and the development of pre-service teachers' critical thinking skills.

This study investigated the influence of an intervention, namely PBL as teaching and learning strategy in the field of ESD in South Africa, on pre-service teachers' critical thinking skills.

PBL was introduced as teaching and learning strategy for the full duration of the semester. As far as the researcher could determine, this is probably the first study to incorporate PBL for an entire semester in a teacher training module at a South African higher education institution.

1.9 ANTICIPATED PROBLEMS AND CHALLENGES OF THE STUDY

This study did not include a control group. Sufficient and differentiated data was therefore gathered to support the findings of the research.

Obtaining a standardised test instrument for critical thinking is challenging since there is no equivalent or appropriate test available in South Africa. The researcher has been successful in acquiring permission to use the WG³CTA from Pearson TalentLens for the purpose of this study.

The time frame for completing the module ESD during the twelve-week semester, including the four PBL activities, is challenging. The participants' schedules are loaded and some participants might not be prepared to cooperate with the effort required. The participants are unfamiliar with PBL as teaching and learning strategy and might struggle, especially with the first activity. Some participants do not attend the contact sessions and are not available online or willing to complete their part, which may frustrate the rest of the group members.

1.10 SUMMARY

The purpose of this chapter was to give a condensed overview of this study. It stated the research question and secondary questions that guided this study. This chapter clarified the

main concepts and included a short literature review of the main concepts. The research paradigm and research design were furthermore discussed, as well as the methodologies for collecting and analysing the data. The next chapter follows with a more in-depth literature review of the main concepts that were identified from the research question.

CHAPTER 2 THEORETICAL AND CONCEPTUAL FRAMEWORK

2.1 INTRODUCTION

A review of literature helps the researcher to explore and understand the origin and scope of the phenomena being studied. The review assists in discovering the leaders in the particular field of study and explains the findings of the study in correlation with existing knowledge (Fouché & Delport, 2011:135). As stipulated in paragraph 1.1, this study aims to investigate the influence of problem-based learning (PBL) on the critical thinking skills of pre-service teachers in education for sustainable development (ESD).

The literature review in this chapter therefore discusses the five relevant topics that were identified from the title. Figure 2.1 gives a layout of the topics and how it relates to each other. Education for sustainable development (ESD) is firstly explored in the literature and discussed in this chapter, followed by constructivism and social constructivism, which serves as the theoretical lens to discuss the findings in this study. The theoretical framework refers to the application of a particular theory in a study to explain the research problem. The conceptual framework, on the other hand, refers to the related concepts in a study that work together to provide a broader understanding of the research problem that is investigated (Imenda, 2014:189). The conceptual framework in this study includes the concepts ESD, active learning, problem-based learning (PBL) and critical thinking. The remaining three concepts are explored and discussed in the remainder of this chapter.

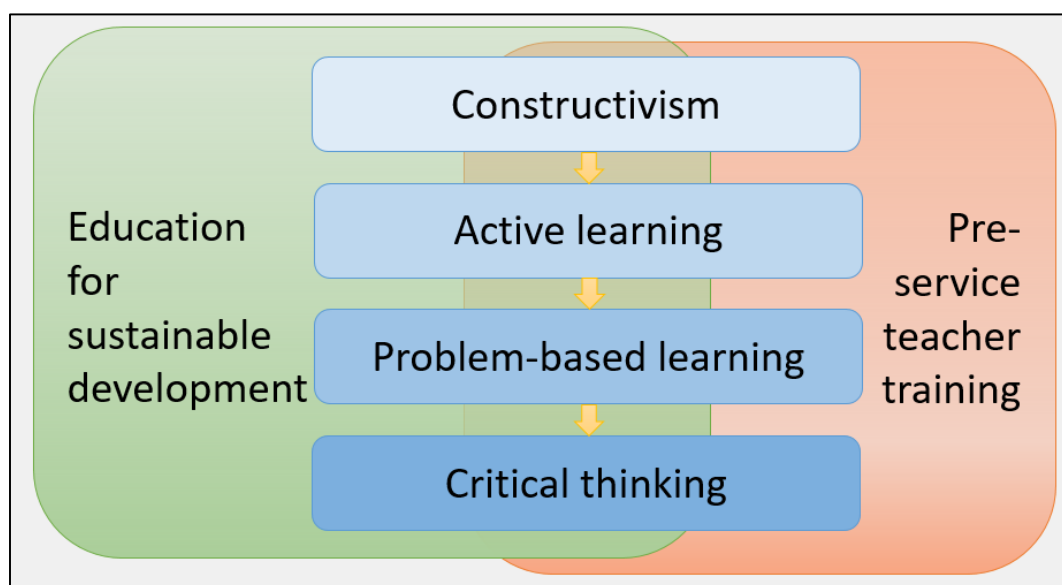


Figure 2.1: Theoretical and conceptual framework of the literature review for Chapter 2

The third goal of the Global Action Programme (GAP) on education for sustainable development (ESD) introduces the recommendation to incorporate ESD in pre-service teacher training programs (UNESCO, 2014:20). Environmental rights are endorsed in the Constitution of South Africa (1996:9) and environmental education (EE) is included as a cross-curricular subject in the school curriculum of our country (Department of Basic Education, 2011:4-5). The goal of all higher education institutions in South Africa, responsible for the training of pre-service teachers, should therefore be to equip future teachers to implement ESD in the subjects they teach, as initiated and implemented at the North-West University (Richter & De Sousa, 2019:272). The knowledge, skills and values obtained by pre-service teachers will enable them to act as responsible citizens who set an example for sustainable living. This will consequently influence the learners' behaviour and advance sustainability in their lives (Richter & De Sousa, 2019:729). Including environmental education (EE) in pre-service teacher training poses many challenges and according to Reddy (2017:118), EE does not fit easily into general pre-service teacher training curricula. Teaching and learning strategies that encourage active learning, authentic learning, problem-solving and critical thinking is advised by Dreyer and Loubser (2014:158-160). PBL was implemented in this study, which is a student-centred teaching and learning strategy that is embedded in a constructivist framework.

2.2 EDUCATION FOR SUSTAINABLE DEVELOPMENT (ESD)

The following four paragraphs firstly focus on the background and meaning of the concept education for sustainable development (ESD). This discussion is followed by clearing the state of ESD in South Africa as well as in pre-service teacher training. Lastly, the outcomes and suitable teaching and learning strategies for ESD are considered.

2.2.1 Background and meaning of education for sustainable development

The concept of environmental education has evolved over time from a rather simple understanding of the relationship between humans and their natural environment, to a complex interpretation of humans' interaction with the environment at all levels. The different levels include social, political and economic considerations (Irwin & Lotz-Sisitka, 2014:41).

The International Union for Conservation of Nature (IUCN), which was founded in 1948, and the 1977 UNESCO Inter-Governmental Conference on Environmental Education in Tbilisi (USSR), both promoted EE (*cf.* 1.1). These organisations stipulated that EE aims to help individuals and communities understand and appreciate the complex nature and

interaction between social, cultural and economic aspects with their biophysical environment. It includes solving environmental problems, decision making and managing the quality of the environment (IUCN, 1971:17). The Tbilisi Declaration stated that EE should be provided to all ages and in all sectors of education and result in a comprehensive and lifelong education (UNESCO, 1978:24).

Sustainable development (SD), as described by the Brundtland Commission Report: *Our Common Future*, is “development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs” (WCED, 1987:15). The definitions of environmental education (EE) and education for sustainable development (ESD) as specified in Chapter 1 (cf. 1.2) is integral to the discussion in this paragraph. The first international environmental conference that was held in Stockholm in 1972, the United Nations Conference on the Human Environment, formulated environmental declarations to guide the nations of the world (UN, 1972:1). According to Le Grange *et al.* (2014:127), it was already evident in the 1980s that these resolutions were inadequate to meet the needs of a developing world. The tension between developmental needs on the one side and conservation needs on the other side, let to EE’s association with sustainability (Le Grange *et al.*, 2014:127). The concept SD is constantly evolving and intends to improve the quality of life of present and future generations through reuniting environmental protection, social development and economic growth (UNESCO, 2005c:3). There are however much debate and controversy regarding these concepts, with some stating that the ultimate goal of environmental education is sustainable development, thus, the term “*environmental education for sustainable development*”, while others debate that sustainable development includes specific objectives which should be added to the objectives of EE, thus the term “*education for environment and sustainable development*” and even some stating that EE inherently includes education for sustainable development. Le Grange *et al.* (2014:127), for these reasons, concluded that the term ESD capsulises all these meanings.

ESD was a key outcome of the 1992 United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro (UN, 1992; UNESCO, 2012:5,8) (cf. 1.3.1). This conference, known as the Earth Summit, led to the publication of *Agenda 21*, an eclectic action plan for local, national and global organisations and governments to reduce the footprint of humans on the environment (UNESCO, 2012:8). UNESCO is the task-manager designated for Chapter 36 of *Agenda 21*, “*Promoting Education, public awareness and Training*”. These goals were advanced when Resolution 57/254 was adopted by the United Nations General Assembly in 2002, declaring the period of 2005-2014 as UNESCO’s Decade of Education for Sustainable Development (UN-DESD). The four goals identified in

Chapter 36, which are the aims of the UN-DESD, are briefly discussed in the following points:

Goal 1: Improving the access to basic education and the quality of education: The years of basic education and the content taught differ greatly in countries around the world. Access to basic education is furthermore unavailable to many girls and illiterate adults. Low levels of basic education hinder the plans for sustainability, but merely increasing literacy will not necessarily advance sustainable societies. Basic education therefore has to reorient in order to foster the needed knowledge, values and skills that will encourage individuals to make lifestyle changes and support community decision-making that benefits the environment and their quality of life (UNESCO, 2005a:28; UNESCO, 2005b:5).

Goal 2: Reorient the curricula: current basic and further education need to be re-evaluated since it is the educated countries that use most of the resources and energy to sustain their lifestyles (UNESCO, 2005a:29; UNESCO, 2005b:5).

Goal 3: Raise public awareness and understanding of the concept of SD: This will make it possible to develop enlightened, active and responsible citizenship locally, nationally and internationally (UNESCO, 2005a:29; UNESCO, 2005b:5).

Goal 4: Train the workforce: Continue technical and vocational education of directors and workers, particularly those in trade and industry, who will be enriched and enabled to adopt sustainable modes of production and consumption (UNESCO, 2005a:30; UNESCO, 2005b:5).

The purpose of the UN-DESD was hence to strengthen the pivotal role of education in promoting a world that is more sustainable (UNESCO, 2005c:4; UNESCO, 2012:8). This is underlined by Koïchiro Matsuura, UNESCO's Director-General, stating that: *"Education – in all its forms and at all levels – is not only an end in itself but is also one of the most powerful instruments we have for bringing about the changes required to achieve sustainable development"* (UNESCO, 2005c:3).

Although ESD is applied and defined differently in different countries and contexts, there is a general agreement on the principles of sustainability (UNESCO, 2005a:30). A list of eleven essential characteristics of ESD was compiled by the International Implementation Scheme (IIS) of the UN-DESD to give assistance in this process. In the IIS, it is stated for example that ESD is based on the principles of SD and accommodates its evolving nature; ESD is interdisciplinary; it encourages life-long learning and engage all sectors of education; ESD uses a variety of teaching and learning strategies that are learner-centred and

promotes higher-order thinking skills; ESD is culturally appropriate and locally relevant; it is based on local perceptions and needs, but acknowledges the international effects and consequences in fulfilling these needs; and ESD promotes community-based decision-making, environmental stewardship, quality of life and social tolerance (UNESCO, 2005a:30-31).

The concept of ESD gained momentum worldwide during the UN-DESD. It established itself in national policies and almost a hundred countries created ESD coordinating bodies in a range of contexts (UNESCO, 2012:5). By the end of the Decade, ESD was acknowledged as an education that is relevant to address the challenges of SD (UNESCO, 2012:5).

The UNESCO General Conference endorsed the Global Action Programme (GAP) as a follow-up to the UN-DESD in 2015, which has the goal to scale up initiatives in education at all levels to support and advance the process that fosters SD (UNESCO, 2014:14; UNESCO, 2017:9) (*cf.* 1.3.1). All role players in ESD are encouraged to commit themselves to implement ESD and create partner networks and forums to advance these priorities (UNESCO, 2017:10). The five priority areas in the GAP in which action is needed, includes firstly, policy to bring about systemic changes. Political policy plays an important role in advancing ESD and in securing the concept ESD in educational and sustainability policies. The second priority is to transform learning and training environments. Sustainability should not just be taught, it should be lived and experienced. To achieve this, the structures and values of educational institutions must change. The third area involves the educators and trainers. ESD should be included in the training of pre-service teachers to empower them to become “*change-agents*” who implement ESD. The fourth GAP priority emphasises the youth. Young people should be mobilised to participate in ESD activities and play a role in advancing political strategies that ensure ESD. The last priority area focusses on accelerating ESD at local level. Communities, including stakeholders, need to create networks that work together to achieve sustainability and improve the quality of learning platforms (UNESCO, 2014:15; UNESCO, 2017:10).

Concurrently with GAP, the General Assembly of the United Nations launched Agenda 2030 for Sustainable Development in 2015 (*cf.* 1.3.1). The seventeen Sustainable Development Goals (SDGs) and its 169 targets, aims to end poverty and promote gender equality and human rights for all, by balancing the economic, social and environmental spheres of sustainable development (UN, 2015:5). These goals are a follow-up on the Millennium Development Goals (MDGs) of 2000 that focussed on countries in the southern hemisphere, which have been mostly unsuccessful, since many people still suffer from poverty, hunger, gender inequality and wars (UNESCO, 2017:10). Agenda 2030 applies

equally to all countries, regardless of being developing, emerging or industrialised. The SDGs includes the three main dimensions of SD (economic, social and ecological) and furthermore intra- and inter-generational justice (UNESCO, 2017:10). Target 4.7 of the fourth SDGs, regarding quality education and lifelong learning, states that all learners should acquire skills and knowledge through ESD that will enable them to advance sustainable development in all spheres of society (UN, 2015:21).

This paragraph summarised the development of events that were responsible for the conceptualising and establishing of EE and ESD. In this study, EE and ESD is understood as stipulated in the definitions in the first chapter (*cf.* 1.2). Environmental education focusses on developing the knowledge, skills and attitudes that are needed to grasp the interrelatedness between humans, cultures and the natural environment, as well as the behaviour patterns and decision making that will advance the quality of the environment (IUCN, 1971:17). Education for sustainable development is education that promotes knowledge, skills, attitudes and values about sustainability, which entail that each generation should be equipped to meet their needs through balancing and integrating the social, economic and environmental dimensions of SD (UNESCO, 2018:7).

The SDGs and GAP enhance the need for promoting SD in South Africa as well. Including ESD in all spheres of society and especially in formal education, as stipulated by these goals, is significant. This study therefore sought to promote the third priority of the Global Action Programme (GAP), as well as the fourth SDG from Agenda 2030, with the development and implementation of the module ESD at a higher education institution that trains pre-service teachers. The following discussion elaborates on advancing ESD in SA.

2.2.2 Education for sustainable development in South Africa

South Africa is one of the countries forming part of the UNESCO initiative to support ESD and therefore promote sustainability. Reddy (2017:117) comments that progress has been made to incorporate environmental issues into policies and formal educational curricula in South Africa. There are, amongst others, four documents that govern and influence ESD in the present-day South African educational context. These four documents are discussed briefly.

Firstly, Resolution 24 of the *Bill of Rights* in the Constitution of South Africa (1996:9), the highest law in the country, declares that everyone has the right “*to an environment that is not harmful to their health or well-being*” and continues to state that the environment should be protected for the benefit of the countries’ present as well as future generations. Measures

to achieve this right includes reasonable legislative measures and other appropriate actions to prevent pollution and the degradation of the environment and promote conservation. It further includes securing ecological sustainable development in the process of using natural resources that promote sound social and economic development (South Africa, 1996:9).

Secondly, the policy document *White Paper on Education and Training* (Department of Education, 1995:22) outlines its values and principles in chapter four and states that EE, as an integrated, inter-disciplinary and active approach to learning, should be a vital part of all programs at all levels of education. The aim is to establish environmentally literate citizens who actively participate to ensure that present and future generations in South Africa can enjoy a sufficient quality of life where resources are used sustainably (Department of Education, 1995:22).

Thirdly, the *White Paper on Environmental Management Policy* issued by the Department of Environmental Affairs and Tourism identified seven strategic goals for achieving the ultimate goal of ESD (Department of Environment Affairs and Tourism, 1998:28). The fifth goal concerning EE and empowerment is to increase South Africans' awareness and concern of environmental issues and to participate in the development of the necessary knowledge, values and skills to achieve SD. One of the supporting objectives that is aimed at education and training is to integrate environmental education into all formal and non-formal educational programs, as well as the National Qualification Framework (NQF) that controls educational programs in South Africa (Department of Environment Affairs and Tourism, 1998:36).

The fourth document is the national school curriculum of the Department of Basic Education, the *Curriculum and Assessment Policy Statement (CAPS)*, that aims to equip grade R - 12 learners with the knowledge, skills and values needed for developing their own well-being and to act as responsible citizens in a free society. It further aims to produce learners who can effectively incorporate science and technology and apply it critically to be responsible towards the environment and consider the health of others (Department of Basic Education, 2011:4-5). The curriculum is based on seven principles that include human rights, inclusivity, and the practices of social and environmental justice as outlined in the Constitution of South Africa (Department of Basic Education, 2011:5). Environmental topics are consequently included in the curriculum of quite a few subjects, for example, Geography, Physical Science, Life Orientation and Life Sciences (Reddy, 2017:118).

These four policy documents all emphasises the concern for environmental issues and the need to educate our citizens to actively promote ESD principles in all spheres of life.

There are furthermore several governmental as well as non-governmental and community-based organisations that support curriculum-based EE in South Africa, for example the Department of Water and Environmental Affairs and the SANBI Greening and Eco-Schools programs. These organisations provide environmental programs and resources to schools and offer environmental excursions which, according to Fundisa for Change (2013:19), can assist schools in integrating environmental activities and promote the whole school development initiative. The Fundisa for Change program supports teachers in understanding how each subject engages with environmental and sustainability knowledge and aims to advance the quality of EE in the curriculum (Fundisa for Change, 2013:7,19). According to Fundisa for Change (2013:7) an environmental focus is present in each of the subjects but varies according to each subjects' unique knowledge structures. Le Grange (2004:135) however debates that, although environmental concerns are included in the curriculum policy, it does not necessarily ensure that environmental learning will occur. The curriculum provides spaces to enable EE processes, but it requires from teachers to recognise these spaces and that they understand the EE processes, which means it is pivotal to include EE in pre-service teacher training (Le Grange, 2004:139).

Msezane (2017:41) for example, investigated the incorporation of EE in the South African Further Education and Training (FET) curriculum, which includes grade 10-12, using a related theoretical framework. The number of environmental-impact topics were compared with the total number of topics in three subjects as well as the time allocation. The extent to which these topics are covered in the final Grade 12 examination papers, were then investigated. Msezane (2017:48) argues that teachers and learners are more likely to emphasise the teaching and learning of environmental-impact topics if they know it will feature in the end of the year summative assessment and in the process it may develop good environmental behaviour and cultural values related to sustainability. Msezane (2017:50) disclosed a variable coverage in the examinations and concluded that it may have a negative effect on how these topics will be addressed by teachers in the classroom and recommended that policy developers should verify that the coverage of environmental-impact topics in textbooks and summative assessments corresponds with the policy documents.

This discussion confirms the necessity of including ESD training in pre-service teachers' curricula, which is investigated in the succeeding paragraph. This discussion also emphasises the need to implement ESD in the BEd curriculum of the institution for this study.

2.2.3 Education for sustainable development in pre-service teacher curricula

The UN-DESD has contributed to establish the concept of ESD and the importance of implementing sustainability in all spheres of society, as discussed in paragraph 2.2.1. According to UNESCO (2014:12; 2017:8), ESD is not an “*add-on*” in the curriculum, but a holistic approach that offers the opportunity to rethink education. Assadourian (2017:4) agrees that education has to be systematically rethought to prepare students with the knowledge, tools and strategies needed to survive on an ever-changing planet and enable them to bring about a sustainable future. According to De la Harpe and Thomas (2009:75), many higher education institutions are introducing curriculum innovation that underlines ESD, but only a few are successful in comprehensive large-scale curriculum change.

The Global Action Programme (GAP) for 2015-2019, as discussed in paragraph 2.2.1, includes five priority action areas that call on all role players, including education ministries and institutions, to support and intensify initiatives that lead towards SD (UNESCO, 2017:9). Paragraph 1.3.1 showed that the third priority in GAP proposes the integration of ESD in the training of pre-service teachers to capacitate them to implement ESD (UNESCO, 2017:10). Álvarez-García *et al.* (2015:77) reported from a literature review on EE in primary pre-service teacher training programs that, although pre-service teachers mostly have a positive attitude regarding EE and ESD, they acquired only basic environmental knowledge and competences during their higher education training (*cf.* 1.3.1). The researchers further reported regarding the training experiences of students in EE and ESD that the most appropriate methodologies included interdisciplinary, collaborative and experiential activities. The studies analysed also emphasised the role of teachers as important contributors to environmentally educate the future generation. The researchers finally recommended that compulsory EE and ESD modules should be introduced in the training programs of pre-service teachers (Álvarez-García *et al.*, 2015:82).

In the light of the discussion so far, it is necessary to investigate pre-service teacher program requirements regarding ESD in South Africa. The Department of Higher Education and Training (DHET) adapted the policy document for pre-service teacher training in South Africa, namely the *Revised Policy on the Minimum Requirements for Teacher Education Qualifications* (RP-MRTEQ) in 2015. This policy unfortunately does not refer distinctly to the inclusion of EE in pre-service teacher training programs. The RP-MRTEQ emphasises knowledge and teachers are described as “*knowledge professionals*” (Reddy, 2017:120). Furthermore, it specifies the “*knowledge mix*” or different types of learning at different levels for each program leading to a specific qualification (Department of Higher Education and Training, 2015:15). From the five types of learning stipulated in the policy, namely

disciplinary, practical, pedagogical, fundamental and situational learning, the last one refers to an understanding of the differentiated and complex nature of our country's society and dealing with diverse challenges, which includes environmental sustainability (Department of Higher Education and Training, 2015:11). Reddy (2017:121) suggests that work-integrated learning (practical learning) and situational learning can provide space for including EE in pre-service teacher training programs. In agreement with this, Loubser (2015:99) recommended that lecturers should assess during work-integrated learning that students include EE and ESD in their lessons according to the outcomes of the subjects or modules in their program. Loubser (2015:99) furthermore emphasised the responsibility of higher education to properly train pre-service teachers and empower them to teach EE and ESD in our schools.

The students' views about the inclusion of EE and ESD in the pre-service teacher training programs at the University of South Africa and the University of Pretoria was also investigated by Loubser (2015:93). The study showed that training makes provision for the concepts EE and ESD, but students did not gain sufficient knowledge about these concepts (Loubser, 2015:96). Most of the students indicated that EE and/or ESD should be presented as a separate subject in higher education, but at school level it can be taught as an interdisciplinary subject. According to Loubser (2015:99), most higher institutions are not successful in offering EE and ESD as interdisciplinary approaches. Leal Filho *et al.* (2018:4) support this finding, stating that lecturers are either incapable or unwilling to integrate ESD in their modules.

Despite the efforts, according to Dreyer and Loubser (2014:145) as well as Mandikonza and Lotz-Sisitka (2016:107), there are still no clarity on how to include EE in formal education in South Africa and this issue is still heavily debated. Leal Filho *et al.* (2018:4) explored the application of ESD at the North-West University in South Africa and identified three obstacles for implementing sustainability in higher education in South Africa. It includes the insufficient emphasis of sustainability in the schools' curriculum, the shortfall of a specific budget to implement sustainability in the training programs of pre-service teachers and the adversity to mobilise lecturers from different subject groups to incorporate sustainability in their subjects. These obstacles highlight the importance of higher education institutions to carefully plan the implementation of sustainability principles (Leal Filho *et al.*, 2018:7). Richter and De Sousa (2019:730) confirmed these challenges and added that the assessment of the effectiveness of these implemented plans is a time consuming and costly process. The researchers further stressed that a whole institutional approach, which includes the commitment of all the role players, is imperative for the successful

implementation of ESD in a faculty or at a school and poses a major challenge for most institutions. Despite these challenges, Richter and De Sousa (2019:729) however argued that ESD can be implemented successfully in an education faculty in South Africa if there is a champion or group of champions that promotes the priority action areas of the GAP at their institution, that will consequently train teachers to champion ESD in their subjects and schools.

The Geography Education and Environmental Education subject groups at the North-West University for example has taken the responsibility of promoting ESD and environmental awareness amongst students and staff members (Leal Filho *et al.*, 2018:3; Richter & De Sousa, 2019:723). Various projects that involved the students and learners at school were launched, including the following three research studies. Kanyimba *et al.*, (2015:233) and De Sousa *et al.*, (2017:854) investigated the application of environmental management systems in South African primary schools and the possibilities to link it with pedagogical aspects. Muller (2017:2153) implemented a community-based project for water-monitoring that led to the development of a citizen science framework for educational institutions. Pre-service teachers and Grade 10 Physical Science learners who had participated, gained new knowledge, skills and experiences from this project-based learning strategy that implemented EE and social learning (Muller, 2017:2155).

The successes of these projects affirm the possibility to implement ESD effectively at higher education institutions in South Africa. It justifies the development of the module ESD for this study and the inclusion of ESD in the BEd curriculum of the institution under investigation for this study. The following discussion explores the outcomes and preferred teaching strategies that are recommended for ESD programs.

2.2.4 Learning outcomes and teaching and learning strategies in education for sustainable development

Learning outcomes in ESD should engage and balance cognitive, psychomotor and affective domains in order to give students the required knowledge, skills and values to contribute to sustainability (Dreyer & Loubser, 2014:157; Shephard, 2008:90; Sipos *et al.*, 2008:68). According to Clark *et al.* (2020:395), the main outcome of EE modules is to enhance the “*health of the environment*”. Traditionally, the cognitive domain of learning is favoured, but Shephard (2008:88) draws attention to Bloom’s taxonomy that also specifies levels of learning in the affective domain, which deals with our attitudes, values and behaviour. This is in agreement with Chapter 36 of Agenda 21 that recommends the re-

orientation of curricula to include more “*principles, knowledge, skills, perspectives and values related to sustainability*” (UNESCO, 2005a:29) (cf. 2.2.1).

The *knowledge* required in EE includes ecological and social systems. Planet earth with its resources and ecosystems is studied alongside the human impact and dependence on the environment. Knowledge of political, economic, social and development issues and challenges is furthermore needed to ensure a sustainable future (Dreyer & Loubser, 2014:157).

Investigating environmental problems and dealing with the challenges require certain *skills* from students to reach solutions. Students need to develop problem-solving techniques, be able to communicate viewpoints, gather and analyse information and work cooperatively (Dreyer & Loubser, 2014:158). Since EE is an interdisciplinary subject that deals with complex environmental issues, it particularly lends itself to develop students’ critical thinking skills (Elahi *et al.*, 2014:535). A wide range of topics is included which can be investigated from different perspectives. In the study compiled by Elahi *et al.* (2014:539) at a teacher training institution, EE had a significant impact on improving pre-service teachers’ critical thinking.

An appreciation of the beauty and fragility of the environment as well as the interdependence of all life forms are some of the *values* to be acquired by students. It should, however, develop into a personal commitment of a lifestyle that is built on sustainability principles (Dreyer & Loubser, 2014:158). Shephard (2008:90) argues that students can have the necessary knowledge and skills, but to change behaviour, their values should change. The achievement of affective outcomes is very complicated and should not be underestimated (Shephard, 2008:90). Religious convictions also influence people’s perspectives and attitudes towards the environment (Dreyer, 2014:106). Although most of the world’s religious groups support and encourage environmental care, the followers do not always act accordingly (Dreyer, 2014:117). Accentuating the role of religion, UNESCO for example held an international experts’ workshop to mobilise faith-based organisations to enhance and support the goals of the DE-ESD (UNESCOCat, 2007:4). Religions organisations are called to confront the current ecological challenges, be concerned with the well-being of communities and endorse eco-justice (UNESCOCat, 2007:17). In the Christian faith, believers are called to be stewards of God’s creation. From a Biblical perspective, environmental stewardship means that God gave humans the authority over nature, a position of trust as caretaker and not as owner and exploiter (Tshenye & Le Roux, 2012:131). According to Bullmore (1998:141), a theology of the creation should be preached and taught more often to raise awareness for environmental

concern. Four Biblical passages that explain Christian environmentalism are outlined in the article to emphasise humans' responsibility and accountability towards creation before God (Bullmore, 1998:141). The author argues that teaching Christian environmentalism can contribute to shift people from lives focussed on self-interest towards lives earnestly devoted to follow Christ's example.

Academics should furthermore explore relevant teaching and learning strategies that address these diverse and complex outcomes in ESD. Shephard (2008:91) suggests focussing on teaching and learning activities that encourage students to develop affective domain outcomes, for example open debate, role play, problem-based learning and analysis of case studies in groups. Dreyer and Loubser (2014:158) recommend active learning for environmental learning that includes a more hands-on and experiential approach and involve critical thinking and problem solving. UNESCO (2017:21) also recommends social learning strategies and contributed with a list and discussion of appropriate strategies in ESD. The seven strategies that are identified include: discovery learning, participatory or collaborative learning, interdisciplinary learning, problem-based learning, critical thinking-based learning, social learning and systems thinking-based learning (UNESCO, 2017:21). These strategies all acknowledge that learning in EE should be more than just acquiring knowledge. Interaction with others and the environment during learning is essential and it should focus on *real* issues to engage students (UNESCO, 2017:21). Introducing problem-based learning (PBL) as teaching and learning strategy in ESD for the purpose of this study is thus in line with recommendations from the named research.

The background of the concepts EE and ESD were discussed in these paragraphs, which enhances the need and importance of incorporating ESD in all levels of education in South Africa. Teachers and educators have an important role to play in advancing sustainability principles and as a result, training of pre-service teachers need to scale up. The recommended teaching and learning strategies for ESD are all non-conventional and thus student-centred. The student-centred teaching and learning strategies aim to change attitudes, values and behaviour and are founded in a constructivist framework, which is subsequently discussed.

2.3 CONSTRUCTIVISM

Constructivism is a philosophical interpretation on how people come to understand or learn (Airasian & Walsh, 1997:444; Richardson, 1997:3; Savery & Duffy, 2001:1). Constructivism is attributed to the work of various psychologists and philosophers like Piaget, Vygotsky,

Rorty, Von Glasersfeld, Bruner and Goodman (Ertmer & Newby, 2013:55; Savery & Duffy, 2001:1). It developed in opposition to the “old” view that considers knowledge as fixed and independent of the student and that knowledge is acquired by accumulating “truths” in a subject (Airasian & Walsh, 1997:445). In the constructivist approach, knowledge is produced from existing experiences and beliefs and is thus subjective and personal. This shift in depicting knowledge is described by Airasian and Walsh (1997:445) as viewing knowledge as “a set of universal truths” to “a set of working hypotheses” and by Ültanir (2012:196) as “*knowledge as a product*” to “*knowing as a process*”. Von Glasersfeld (1995:1) explains that constructivism assumes that knowledge is in peoples’ heads and the thinking person has no alternative but to construct what they know based on their own experience. The constructivist epistemology consequently argues that humans create meaning and understanding of the world from their own experiences (Ertmer & Newby, 2013:55; Ültanir, 2012:195). Savery and Duffy (2001:1) furthermore describes constructivism with these three characteristically propositions: (a) “*Understanding is in our interaction with the environment*”. The context, content, goals and activity of the student operate together to establish understanding. The relationship between student and environment forms the basis of constructivism (Ertmer & Newby, 2013:55; Savery & Duffy, 2001:1); (b) The learning environment provides stimulus for learning in the form of “*puzzlement*”, which focusses the attention of the student on what is learned and how it’s organised. The goal of the student is pivotal in the process of considering what is learned (Savery & Duffy, 2001:2); and (c) The social environment contributes to evolve knowledge and measure individual understanding opposed to views from others. The community challenge, enrich or expand the individual’s understanding on specific matters (Savery & Duffy, 2001:2).

Constructivism advocate teaching and learning strategies that involve students to actively explore and think about complex concepts (Ertmer & Newby, 2013:57). These authors confirm that knowledge is not abstract but involve the experiences of students linked to the context. Students are therefore encouraged to first construct their own understanding and then follow up with validating the new concepts by way of social negotiation. In a constructivist classroom, students are actively engaged in inquiry, problem solving and collaboration (Abdal-Haqq, 1998:2). In this learner-centred approach, the educator acts as facilitator who guides and challenge students to formulate their own opinions and conclusions since the focus is not on single correct answers or interpretations (Abdal-Haqq, 1998:2; Ültanir, 2012:195). Constructivist teaching encourages students to think critically and motivates them to learn independently (Amineh & Asl, 2015:11). According to Abdal-

Haqq (1998:2) constructivist approaches produce greater internalisation and deeper learning than traditional methods.

Within constructivism there are two main interpretations or variations. Cognitive constructivism, also known as the psychological, Piagetian or developmental approach and social or sociocultural constructivism, also known as Vygotskian constructivism (Abdal-Haqq, 1998:2; Airasian & Walsh, 1997:445; Richardson, 1997:4).

The first interpretation, cognitive constructivism assumes that knowledge structures are organised and developed in a sequence and it places the student at the centre as the “meaning-maker” (Kalina & Powell, 2009:243). This meaning-making process is individualistic and the purpose of the teaching process is to lead students to higher levels of thinking (Richardson, 1997:5). Cognitive constructivism includes assimilation and accommodation during the learning process. Assimilation occurs when students bring new knowledge to their own understanding (schema) and accommodation occurs when students must change their schemas for accommodating new knowledge (Kalina & Powell, 2009:243). Intellectual adaptation can only occur when there is a state of equilibrium between assimilation and accommodation (Piaget, 2013:7). Cognitive constructivism thus takes into consideration that students come to the classroom with prior beliefs, ideas and opinions that must be modified by the educator through devising questions and tasks that create dilemmas for the students. As students work through these dilemmas, knowledge is constructed (Abdal-Haqq, 1998:3). The educator facilitates this learning environment in which students are engaged in thinking processes and challenge students to examine concepts and beliefs in a safe atmosphere (Amineh & Asl, 2015:12; Richardson, 1997:5). Critics point out that the cultural and political background of the student and social milieu also influences the learning context and construction of knowledge (Airasian & Walsh, 1997:445; Richardson, 1997:6). Richardson (1997:6) further points out that the educator and the texts are considered authoritative by the students and they will not necessarily question it.

Social constructivism, the second interpretation, focusses primarily on the social construction of knowledge and rejects the individualistic approach of cognitive constructivism (Airasian & Walsh, 1997:445; Richardson, 1997:7). Knowledge has a “*social component*”, which implies that the knowledge constructed is influenced by the social and cultural context of the student and may result in unique meanings that are related to the student and his or her culture (Airasian & Walsh, 1997:445). During social interaction, group members share their cultural meanings, which is then internalised by the individual (Richardson, 1997:8). Vygotsky (1978:86) described this social interaction as the “*zone of*

proximal development”. In the zone of proximal development, the individual’s intellectual potential is regulated or encouraged by more advanced peers or adults (Vygotsky, 1978:126; Vygotsky, 2012:206). This means that cognitive growth firstly occurs on a social level and then within an individual (Amineh & Asl, 2015:12). Social constructivist teaching approaches emphasise peer collaboration and the involvement of knowledgeable members from the society, which is known as scaffolding. Scaffolding can be described as the assisted learning process in which students are supported by educators and peers (Kalina & Powell, 2009:244). The students’ interpretation of the truth is thus encouraged by the educator which acknowledges that it will be influenced by their culture, background and knowledge of the world (Amineh & Asl, 2015:12). Critics of social constructivism states that focussing on contextual and cultural factors, which allow differentiated meanings, might limit the recognition of universal truths that bring order to multiple variations of meanings (Airasian & Walsh, 1997:445).

Constructivism endorse the inclusion of active learning in the classrooms. This study introduced PBL, as an example of active learning, in the module ESD. It is henceforth important to clarify and discuss the concept active learning.

2.4 ACTIVE LEARNING

The concept active learning is investigated by focussing on four aspects. It includes the background and meaning of active learning, advantages as well as barriers and solutions to implement active learning. Lastly, the flipped classroom model is discussed.

2.4.1 Background and meaning of active learning

Active learning is embedded in constructivism and promotes student-centred teaching and learning (Bishop & Verleger, 2013:6; Maithri & Suresh, 2020:114). Engaging students in the classroom has numerous advantages and is worth implementing in the higher education classroom.

Active learning is generally defined as “*instructional activities involving students in doing things and thinking about what they are doing*” (Bonwell & Eison, 1991:2). Active learning is an umbrella term for teaching and learning strategies that introduce activities into the classroom (Prince, 2004:223; Roehl *et al.*, 2013:45). It is described as more of an approach to teaching than a specific method (Gleason *et al.*, 2011:2). In contrast to traditional lecturing where students are passive and listen, active learning introduces learning activities into the classroom that focus on higher-order thinking in order to engage students in the learning process (Bonwell & Eison, 1991:2; Faust & Paulson, 1998:4; Prince, 2004:223). Each

student should be actively engaged in the teaching and learning process and apply their knowledge, skills and attitudes (Gleason *et al.*, 2011:2). Active learning is thus changing the roles of the lectures and students (Maithri & Suresh, 2020:114) and is gaining momentum and applied as a viable solution to increase student achievement (Cattaneo, 2017:144).

Several studies confirm that students' concentration decrease after the first ten to fifteen minutes of a lecture (Gleason *et al.*, 2011:2; Prince, 2004:226). Engaging students in learning activities help them to concentrate and improve their attention and retention (Beyleveld *et al.*, 2019:17; Gleason *et al.*, 2011:3). Active learning can be incorporated into the classroom in various ways. In its simplest form, the pausing principal can be used, wherein the educator pauses three times in an hour long lecture and allows students to share and discuss their notes with a peer for two minutes (Bonwell & Eison, 1991:2; Prince, 2004:225). Faust and Paulson (1998:4) affirm that lectures can still be used to present information but should be supplemented by active learning techniques. To involve students in discussions is still one of the most common and effective strategies to promote active learning, according to Bonwell and Eison (1991:3).

Implementing active learning may include small randomly applied activities that are added to an existing module, or it may imply that an entire module is completely restructured with a definite active learning approach (Gleason *et al.*, 2011:3). More complex strategies, for example problem-based learning, discovery-based, team-based learning and case-based learning, can then be incorporated (Gleason *et al.*, 2011:4; Cattaneo, 2017:144). The activities should be designed to support the learning outcomes and engage students in the learning process (Prince, 2004:226).

Several academics have published hands-on descriptions of a wide range of activities that can be used. These activities can be divided into four broad categories, namely individual activities, paired activities, small groups and cooperative projects (Faust & Paulson, 1998:4; Zayapragassarazan & Kumar, 2012:3). Active learning accordingly includes a wide range of structured activities, from individual short writing exercises or pair discussions, to debating, reflecting on lectures, researching and complex group activities that interrogate real-life problems (Faust & Paulson, 1998:4; Gleason *et al.*, 2011:3; Perry *et al.*, 1996:77). A wide range of possible strategies make it thus possible to implement active learning into any module or program (Faust & Paulson, 1998:17).

Problem-based learning is one example of active learning and was incorporated in this study. The teaching and learning strategy PBL is discussed in paragraph 2.5 of this chapter.

Active learning entails many advantages for students and receives attention in the following discussion.

2.4.2 Advantages of active learning

The active learning process helps students to gain knowledge and a better understanding of learning content. Active learning is crucial in enhancing students' learning, since it goes beyond basic comprehension and focusses on analysing, evaluation and application of the module work (Bonwell & Eison, 1991:2; Braxton *et al.*, 2000:572; Perry *et al.*, 1996:77). According to Beyleveld *et al.* (2019:22,25), educators introduce active learning as they believe it encourages deep learning and develop the required skills to prepare their students for the workplace. Active learning enables students to self-regulate their learning, comprehend concepts better and make them ready for the learning process. Faust and Paulson (1998:4) and Cattaneo (2017:144) also stated that active learning increases academic performance and furthermore enhances social and psychological benefits to students. Active learning group activities, or collaborative learning, help students to develop friendships that promote networks of peer support and social integration (Braxton *et al.*, 2000:572). Collaborative learning also develops interpersonal skills, often called *soft skills*, which includes communication and listening skills, problem solving as a team and cross-cultural relations (Nealy, 2005:2). Beyleveld *et al.* (2019:20) agrees, stating that lecturers prefer using active learning since they experienced that students developed skills that they were not likely to develop through traditional direct instruction. The skills they observed include self-confidence, teamwork, critical thinking, emotional intelligence, problem solving and effective communication. Braxton *et al.* (2000:572) furthermore argues that students need less examination preparation time, thus saving time. The active learning process allows and encourages students to adapt and discover their own methods for grasping their study material (Nealy, 2005:5). The activities thus help students to focus on the most important information and to process and understand it, which in turn motivates students to learn beyond rote memorisation (Gleason *et al.*, 2011:2). Compared to traditional lecturing, active learning also increased thinking and writing skills of students (Bonwell & Eison, 1991:2; Perry *et al.*, 1996:77). Various studies confirmed that an active learning approach to teaching increased critical thinking in the modules that were assessed (Burbach *et al.*, 2004:483; Perry *et al.*, 1996:77). Active learning thus develops the necessary soft skills expected from students to thrive in the 21st century (Cotet *et al.*, 2017:3). Several studies confirm that students prefer active learning to traditional lecturing as these strategies and methods support the learning styles of many students (Bonwell & Eison, 1991:2; Roehl *et*

al., 2013:45). Active learning engages the students in the learning process, improves class attendance and make classes more enjoyable (Beyleveld *et al.*, 2019:24).

Active learning is thus preferred by lecturers and students (Beyleveld *et al.*, 2019:20; Bonwell & Eison, 1991:2; Roehl *et al.*, 2013:45). Ultimately, active learning should encourage and assist students in taking responsibility for their own learning (Zayapragassarazan & Kumar, 2012:4). This study endeavoured to develop the pre-service teachers' knowledge and skills through implementing active learning. The transition from traditional lecturing to learner-centred pedagogies can be challenging and urges further investigation.

2.4.3 Challenges and solutions to implement active learning

There are numerous barriers to implement active learning in the classroom and lecturing halls. Educators are not comfortable to move away from traditional educational practices and according to Bonwell and Eison (1991:4) their greatest barrier is probably the risk, educators feeling they lose control and will be criticised; and students might not participate, or learn sufficient content and use higher-order thinking (Bonwell & Eison, 1991:4). Faust and Paulson (1998:17) propose the “coverage-problem” debate as an important obstacle. Educators might not cover as much learning content and will have less lecturing time available when implementing active learning. Published literature however supports that students learn and retain information better when they engage actively (Faust & Paulson 1998:17). Other barriers include time in class that is limited; preparation time that might increase; difficulty in utilising active learning in large classes; and adequate equipment, materials or resources which might not be available (Bonwell & Eison, 1991:3; Gleason *et al.*, 2011:5). The barriers identified by Maithri and Suresh (2020:116) correspond with the ones listed so far. The study was compiled in Indian private schools and discusses the barriers experienced by teachers to incorporate active learning in the teaching of English. The barriers include the responsibility to complete the syllabus is straining the teachers to incorporate extra activities; the time constraint of conducting active learning activities in the class time available; the differentiated abilities of the learners make the planning and preparing of the sessions complex; and insufficient digital resources. One of the major challenges is if teachers do not have the necessary facilitation skills to support and guide the learners in the learning process (Maithri & Suresh, 2020:116).

According to Bonwell and Eison (1991:4) these barriers can be overcome by thorough and thoughtful planning. Gleason *et al.* (2011:5) agrees and suggests introducing active learning on a small scale to ensure that initial participation is fun. Furthermore, help students to

understand the rationale behind the approach and give them clear instructions on how to participate. Maithri and Suresh (2020:114) gave guidelines to teachers and proposed applicable teaching and learning strategies that can be implemented in the English classroom. It is therefore important that teachers are trained to plan, design and implement active learning in their classrooms.

In this study, the researcher foreseen some resistance from faculty and students when implementing PBL as an example of active learning. The researcher plans to overcome these challenges with thorough planning and preparation. Since the development of the concept active learning, it has advanced to the flipped classroom and the online use of active learning, which is explained next.

2.4.4 The flipped classroom

Active learning pedagogy is constantly evolving and led to the development of an educational model known as flipped classroom (Abeysekera & Dawson, 2015:2; Buil-Fabregá *et al.*, 2019:1; McLaughlin *et al.*, 2014:236; Roehl *et al.*, 2013:45). In the flipped or inverted classroom, students are assigned to prepare for class with study guides, pre-recorded lectures and prescribed learning materials that are made available to them. Contact sessions can then be utilised for student-centred and collaborative learning activities (McLaughlin *et al.*, 2014:237; Roehl *et al.*, 2013:45). Abeysekera and Dawson (2015:6) agree and further state that students can also be required to complete activities before and/or after contact sessions to fully benefit from the work that was done in class. Students are thus responsible for preparing and understanding the basic learning content before going to the contact session, which they can do at their own pace (McLaughlin *et al.*, 2014:237). The role of the lecturer thus changes to a facilitator who is responsible for creating a learning environment where participation is encouraged and misconceptions are corrected. Simultaneously, the role of the student change from a passive receiver of knowledge to a promotor of knowledge by taking responsibility for their own learning (Buil-Fabregá *et al.*, 2019:3).

Using the flipped classroom model, Lage *et al.* (2000:33) propose that the educator should start the contact session by asking the students if they have any questions regarding their preparation and should then answer questions, explain or give more examples, which implies that the class can start with a ten-minute mini-lecture. If the students have no questions, lecturing will not occur and students can engage in the group activities and discussions prepared for the contact session (Lage *et al.*, 2000:33). Educators can also initiate a pre-class quiz to determine if students have prepared and understood the work

(Bishop & Verleger, 2013:10). Students who are prepared can then engage meaningfully in class discussions and activities (McLaughlin *et al.*, 2014:237). According to Buil-Fabregá *et al.* (2019:2), the flipped classroom thus improves the critical thinking and participation of the students inside and outside of the lecturing halls.

Using technology makes it possible for educators to facilitate learning and guide students through the module content and interactive experiences (McLaughlin *et al.*, 2014:237). Abeysekera and Dawson (2015:17) also argue that, when students self-pace the pre-recorded lectures, it reduces the cognitive load and supports learning. Phillips (2005:78) contributed by giving guidelines on how to use active learning online. Online instruction can support learning after having been taught in the classroom or the educator can design online modules with active learning in mind and include student assessment, technical support and resources. Gleason *et al.* (2011:5) affirms that content can be added on the module's website to use contact sessions for active learning. The combination of technological development, the internet and the availability of information and free software, is changing the face of education (Abeysekera & Dawson, 2015:4; Bishop & Verleger, 2013:3). Phillips (2005:79) referred to examples of online active learning approaches and how feedback can be given to students. Some examples include students' assessment surveys, online tests and quizzes, online asynchronous or synchronous discussions, interactive online games, reading from hyperlinks, case studies with required responses, etcetera. Feedback can be from the educator, automatic technology feedback or the educator and peers can give feedback in asynchronous or synchronous discussion forums. Through online learning activities students' progress and participation can be tracked and feedback greatly influences student satisfaction (Phillips, 2005:77).

In the study completed by Buil-Fabregá *et al.* (2019:2), the flipped classroom was used to promote the outcomes of ESD. The aim of the study was to determine if the flipped classroom contributed to promote the learning of sustainable development (SD) issues. The perceptions of the students were analysed together with their commitment to SD. The researchers found the flipped classroom as an effective teaching and learning strategy to be used in SD curricula. The flipped classroom was successful in making students more conscious and committed to SD (Buil-Fabregá *et al.*, 2019:13).

At the institution where this study is conducted, a blended training model is used (*cf.* 1.6.4). This study thus incorporated distance-learning strategies by using the flipped classroom model. From the discussion so far, it is evident that it would be advantageous to use online active learning to develop the ESD module for the pre-service teachers. PBL was chosen

for this study since it is an example of active learning that can also be used online. The teaching and learning strategy PBL is consequently discussed.

2.5 PROBLEM-BASED LEARNING (PBL)

The following paragraphs discuss three main aspects about problem-based learning (PBL). Clarifying the concept PBL firstly focusses on the following six aspects: the background and meaning of PBL, the PBL process, the role of the tutor and group members, the students' experiences of PBL, advantages and challenges of PBL and implementing PBL online. The second main aspect discusses the implementation of PBL in pre-service teacher training and the last aspect implementing PBL in education for sustainable development (ESD).

2.5.1 Problem-based learning as teaching and learning strategy

2.5.1.1 Background and meaning of problem-based learning

Problem-based learning (PBL) is an example of active learning that can be successfully used in the flipped classroom of higher education (Bishop & Verleger, 2013:4; McLaughlin *et al.*, 2014:237; Prince, 2004:223). Since the development of PBL in the field of medicine at the McMaster University in Canada in 1965, the successes recorded led to the widespread application of this teaching and learning strategy in other fields, including law, engineering, business, economics, nursing and social work (Kong *et al.*, 2014:459; Rakhudu, 2011:81; Savery & Duffy, 2001:1; Walker & Leary, 2009:12). Implementing PBL in pre-service teacher training gained momentum in the past two decades, for example in pre-service foundational teacher training (Dean, 1999:1), pre-service teacher training (Borhan, 2014:76; De Simone, 2014:17), pre-service science teacher training (Tandoğan & Akinoğlu, 2007:71; Sezgin Selçuk, 2015:1), pre-service geography teacher training (Golightly, 2018:460; Golightly & Muniz, 2013:432), and pre-service science and geography teacher training (Morgado & Leite, 2013:2343). PBL was also introduced in ESD related programs, which are discussed in paragraph 2.5.3.

True to active learning and the flipped classroom model, PBL changes the student from a passive information recipient to an active self-directed learner and problem-solver; and the educator from lecturer to a tutor (Sezgin Selçuk, 2015:3; Tandoğan & Akinoğlu, 2007:72; Ulger, 2018:2). The tutor's role is to direct the learning process and guide the students to identify the learning issues as they brainstorm in their tutorial groups and integrate new knowledge with prior knowledge to fill the gaps (Salam, 2018:236). In PBL, students are challenged to acquire new knowledge and develop strategies when posed with problems

that need to be solved (Hmelo-Silver, 2004:236). These real world, ill-structured problems expect from students to search for alternative solutions and reflect on their learning experiences (Ulger, 2018:2).

Literature reveals a multitude of definitions for PBL as it expanded to different disciplines and contexts (Gijbels *et al.*, 2005:29; Walker & Leary, 2009:13). The definition formulated by Barrows and Tamblyn (1980:18) from the McMaster Medical School should however be mentioned. They define PBL as:

... the learning that results from the process of working toward the understanding or resolution of a problem. The problem is encountered first in the learning process and serves as a focus for the application of problem solving or reasoning skills, as well as for the search for or study of information or knowledge needed to understand the mechanisms responsible for the problem and how it might be resolved (Barrows & Tamblyn, 1980:18).

PBL is thus a constructivist teaching and learning strategy that is based on an active learning approach in which students collaboratively work on a real-world problem to reach the module outcomes (Chis *et al.*, 2018:233). Barrows and Tamblyn, who popularised the PBL approach through their research furthermore identified six core characteristics of PBL (Gijbels *et al.*, 2005:29; Savin-Baden, 2007:8; Walker & Leary, 2009:13), which are discussed briefly:

(a) The problem initiates learning. In PBL the learning cycle commences with real life problems which provide the context and motivation for learning (Prince, 2004:223). Students enter the tutorial session only with their prior knowledge when presented with a real-life problem (Schmidt & Moust, 2000:21). These problems should be ill-structured, meaning that it is complex problems that have more than one correct solution or answer, encouraging students to consider alternatives and provide good arguments for their solutions (Hmelo-Silver & Barrows, 2006:24). The problems are usually presented to the students in the form of scenarios, which are narrated as a story or dialogue that is based on real life events (Sezgin Selçuk, 2015:4).

(b) PBL is student-centred (Gijbels *et al.*, 2005:29; Walker & Leary, 2009:14). It shifts the focus from the teacher to the student (Sezgin Selçuk, 2015:3).

(c) Learning occur in small groups. Students work in teams to tackle the problem (Savin-Baden, 2007:8). According to Prince (2004:223), PBL is always active and mostly

collaborative learning, which means students work together in small groups toward a common goal.

(d) PBL promotes self-directed learning. To gain new knowledge, students apply self-directed learning (Gijbels *et al.*, 2005:30; Savin-Baden, 2007:8; Ulger, 2018:2). Students regulate what they need to learn and identify the learning issues and knowledge gaps. They engage and research the problem and are consequently responsible for their own learning. (Hmelo-Silver & Barrows, 2006:24; Savery, 2006:12). Students work independently when they do research on the formulated learning issues and collect information to use in their next tutorial session (De Simone, 2014:18).

(e) The tutor. The lecturer or teacher who is present, acts as tutor to facilitate the students in the learning process (Gijbels *et al.*, 2005:30; Ulger, 2018:2; Walker & Leary, 2009:14).

(f) The problems encountered develop the needed skills. The problems are used as tools to acquire knowledge and develop problem-solving skills (Gijbels *et al.*, 2005:30; Savin-Baden, 2007:8). According to Wood (2003:328), PBL is not essentially about solving problems, but to use suitable problems to increase knowledge and understanding.

These six key aspects explain the basic characteristics of PBL but it can still be applied differently at institutions and in their curricula. According to Savin-Baden (2007:9), there are basically two types of PBL models, namely the pure PBL and the hybrid PBL model. In the pure PBL model the entire curriculum is PBL and modelled on the McMaster version. Students meet in their groups and do not receive any lectures in the program (Savin-Baden, 2007:9). The pure model requires a dedicated facilitator facilitating the PBL tutorial sessions with motivated and experienced students in small groups. These students are required to fully apply self-directed learning (Savin-Baden, 2007:10). The hybrid PBL model combines PBL and the traditional lecture-based instruction in the curriculum (Carrió *et al.*, 2016:2). The hybrid model is designed to provide more support to the students and includes scaffolds such as added resources, mini-lectures and demonstrations from the lecturer during the PBL process (Fukuzawa *et al.*, 2017:182; Savin-Baden, 2007:10). The lectures can be set according to a timetable or it can be requested by students as needed at various points in the module (Savin-Baden, 2007:10). The integrated or embedded PBL model is a third model that can be distinguished and was applied in this study. It uses PBL as a teaching and learning strategy for a period within a traditional teacher-centred curriculum. The embedded format can be implemented either in the pure or the hybrid format (Kivela & Kivela, 2005:437; Savin-Baden, 2007:9). In this study, an integrated hybrid PBL format was implemented in the ESD module for the entire duration of the semester. The module ESD

is one of the modules in the BEd curriculum of the pre-service teachers and the hybrid model is conducive since it is the students' first encounter with PBL as teaching and learning strategy.

The following paragraph explores the process that is followed in PBL.

2.5.1.2 The problem-based learning process

In the literature, various PBL processes are discussed. At the Maastricht University in the Netherlands, faculty adopted the PBL program from McMaster University but realised that their students needed more structure and guidance, particularly in their first year (Schmidt & Moust, 2000:21). They constructed the "*Seven Jump*" approach in which students follow these seven steps to complete the PBL process: step 1: identify and clarify all the concepts that are presented in the problem scenario; step 2: define the problem or problems that need to be discussed; step 3: analyse the problem in a brainstorming session to produce all the possible explanations for the phenomena; step 4: criticise the explanations to produce a logical description of the process that underlies the problem; step 5: formulate the learning issues or learning objectives for self-directed learning; step 6: students gather information to fill the gaps in their knowledge through self-study; and step 7: students share their findings in the group. The acquired knowledge is then integrated into a comprehensive explanation for the phenomena and the tutor check the learning (Schmidt & Moust, 2000:23; Wood, 2003:329).

The PBL process, as described by Beringer (2007:448), for example adapted the framework from the medical disciplines for Geography and Environmental Science. Fieldwork and analysis is incorporated in the PBL framework (Figure 2.2) since is often required in geographical studies. It also includes student reflection of experiences which support deeper understanding that could influence the students' initial evaluation of the problem (Beringer, 2007:448).

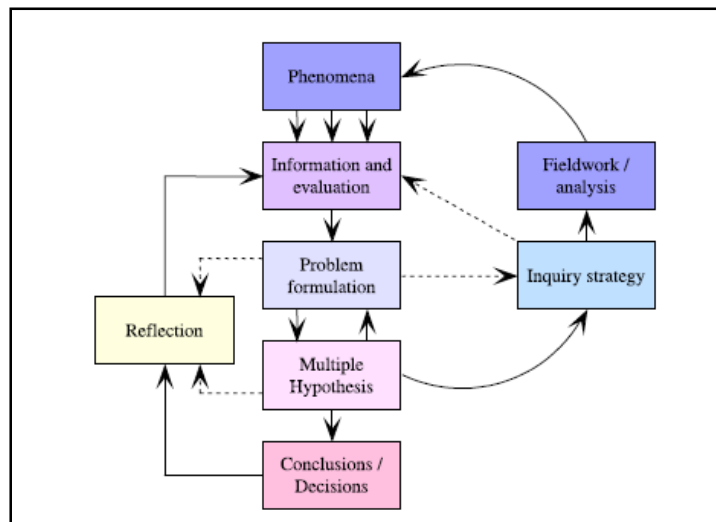


Figure 2.2: The PBL framework used in the Earth System Science unit (Beringer, 2007: 449)

Kek and Huijser (2011:336) also describe distinct stages in the PBL process. The first stage includes analysing the problem and identifying the learning issues to help students manage the problem and construct an action plan. The second or research stage gives opportunity for self-directed learning where students independently learn and apply their knowledge in a group context. It challenges students to critically evaluate their knowledge and make critical judgements regarding the application and suitability of that knowledge. During the third stage, students share and reconsider the information sources and prior discussion. In the last stage, students reflect on the learning process and give feedback of their work (Kek & Huijser, 2011:336).

The stages in the PBL process, as described by the “*Seven Jump*” approach (Schmidt & Moust, 2000:21), were incorporated in the ESD module for this study. At the end of the PBL process, the tutor assesses the PBL groups’ reports as well as the presentation of the proposed solutions to the problem that was investigated. Golightly (2020:12) furthermore advises that group members should be involved in the assessment process. Through incorporating self- and peer assessment, group members can assess their own as well as fellow group members’ contribution in the PBL activities. Including the students in the PBL assessment process, provide additional opportunities for developing the self-directed learning skills of students in the PBL environment (Golightly, 2020:12).

The following paragraph elaborates on the advantages and challenges of implementing PBL at an educational institution.

2.5.1.3 Advantages and challenges of problem-based learning

Barber *et al.*, (2015:61) emphasises the challenges faced by students in the 21st century in which new knowledge develops so fast that people cannot keep up with the content. This requires the development of skills such as collaboration, networking, problem-solving, creativity, innovation, self-motivation, self-development and leadership (Barber *et al.*, 2015:61; Cotet *et al.*, 2017:3). According to Barber *et al.* (2015:61), PBL is advantageous in developing these 21st century skills. PBL enables students to develop themselves to become self-directed, self-reflected and lifelong learners (Hmelo-Silver & Barrows, 2006:24; Savery, 2006:12; Tandoğan & Akinoğlu, 2007:73). This teaching and learning strategy challenges students to develop communication and sociability skills and to investigate events multi-dimensionally and with a more perceptive understanding (Tandoğan & Akinoğlu, 2007:73). Peers and colleagues assist in building collective knowledge and according to Barber *et al.* (2015:61), it includes the internet, since students can search the web to find information on any topic. This collaborative learning in PBL is, of course, in agreement with the learning strategies advocated in social constructivism.

Tandoğan and Akinoğlu (2007:74) also compiled a list of challenges from the literature in applying PBL. It includes the difficulty in transformation from traditional teaching strategies to a student-centred learning strategy. Initially, the students will need more time to solve problematic situations, but later, they might finish the work earlier. PBL furthermore requires research and investigating rich learning materials. Tandoğan and Akinoğlu (2007:74) argues that not all students will fully comprehend the scope or value of the problems, especially within the social contexts. Lastly, they also mention the difficulty in assessing the learning of individual students. Golightly (2020:12) recommended in this regard the inclusion of group members assessing themselves as well as fellow group members for their contribution to the PBL report (*cf.* 2.5.1.2). Wijnen *et al.* (2017:4) furthermore stresses the complexity and time-consuming process of implementing PBL. Poor implementation will affect the performance of the students and result in a discrepancy between the theoretical advantages of PBL and the reality.

Various studies highlighted the advantage of PBL in developing students' critical thinking skills (De Simone, 2014:19; Hmelo-Silver, 2004:245; Sujanem, 2018:5). As this study focussed on PBL and critical thinking skills, the relation between these two aspects is discussed in more detail in paragraph 2.6.4 of this chapter.

The next paragraph focusses on the tutor and group members in the PBL environment.

2.5.1.4 Role of the problem-based learning tutor and group members

The tutor facilitates learning instead of conveying knowledge in the PBL tutorial groups. According to Hmelo-Silver (2004:245), the role of the tutor during the PBL process is to support and guide the students through the different PBL process stages, to monitor the progress of the groups and to ensure that all students are involved. In line with the social constructivist approach, PBL encourages learning from more expert tutors and peers. These zones of proximal development allow the tutor to support the students through applying the necessary scaffolds that encourage further inquiry and discussion (Thompson, 2019:149). The tutor guides the development of the students' higher-order thinking skills by asking them complex and open-ended questions (De Simone, 2014:19). They should lead the students with these questions until they grew more responsible and start asking these questions themselves (Hmelo-Silver & Barrows, 2006:37). As the students become more familiar with PBL, the tutor should steadily remove the scaffolds until the students finally adopt most of the tutors' roles (Hmelo-Silver, 2004:245; Hmelo-Silver & Barrows, 2006:24). Thompson (2019:154) further elaborates that the tutor should initially guide students to help them in identifying the learning issues and step in when discussions head off in the wrong direction. The tutor should however have an awareness of when to step back when he or she is not needed. Regulating the tutor's presence is an important factor in encouraging group discussion and not to shut down opportunities for developing critical thinking (Thompson, 2019:154). Salam (2018:236) emphasises the important role of a good relationship between the tutor and the students for a successful PBL environment. The tutor must ensure that each member in the group understands their role and establish a climate for open and trustful discussions. The motivation and encouragement of the tutor plays an important role (Salam, 2018:236).

Azer (2005:676), the Director of PBL Training Programs at a university in Australia, furthermore gave useful tips for facilitating groups. It includes, for example, helping groups to formulate their ground rules, choose the different roles, encourage each other and build trust. During tutorials, all group members participate in the discussion and fulfil certain roles, which includes the group leader, the group representative and the scribe who records the inputs (Azer, 2005:677). According to Salam (2018:233), students learn interactive-communication skills in PBL tutorial groups. The group members must ask questions, listen to responses, respect one another's comments and negotiate the discussion according to the ground rules set by the group. Leadership skills and collaborative team building is thus important for the successful functioning of PBL tutorial groups.

The next paragraph investigates students' perceptions and experiences of PBL.

2.5.1.5 Students' perceptions and experiences of problem-based learning

Various researchers have investigated different aspects of students' perceptions and experiences of the teaching and learning strategy PBL in different fields. In this paragraph, the studies compiled by Wijnen *et al.* (2017), Fukuzawa *et al.* (2017) and Rakhudu (2011:85), are discussed as examples to explore the PBL experiences of students in higher education institutions.

In the study of Wijnen *et al.* (2017:2), the students' and lecturers' experiences, after implementing PBL as teaching and learning strategy in the school of law at a university in the Netherlands, was investigated. The results of the questionnaire revealed that PBL had a positive influence on the students' study behaviour, since the PBL process encouraged study activities on a more regular basis. Despite a favourable response to PBL in general, the law students also responded that they felt PBL had not prepared them sufficiently for the workplace. According to Wijnen *et al.* (2017:6), this response should be considered against the background that this experience was not measured in the former lecture-based curriculum and the new PBL program actually focussed more on practise and skill development. The researchers emphasised the importance of proper training of lecturers in PBL tutoring and preparing the first-year students before the program commences.

The motivation of students in a PBL anthropology module at a Canadian university through surveys, self-reflection and peer evaluations was studied by Fukuzawa *et al.* (2017:177). The results revealed favourable and disapproving aspects regarding their experience of PBL. The students agreed that PBL could be applied across disciplines, PBL taught them to work collaboratively in their groups and they learned to investigate literature. The students however did not agree that PBL supported them to think more critically about the learning material. These students were also of the opinion that PBL did not improve their learning and that they still preferred the traditional, lecture-based module. The students struggled with time management and realised that literature studies required a lot of time outside the classroom compared to traditional modules. According to the researchers (Fukuzawa *et al.*, 2017:182), the transition from a traditional to an active learning approach can be troublesome in a diverse student population. They advised a hybrid PBL model (*cf.* 2.5.1.1), that allows more scaffolding and flexibility, to introduce students to PBL. Short weekly problems are furthermore recommended in an introductory PBL module to reinforce the PBL process and motivate students. Regarding the workload of students in the PBL environment, Golightly and Muniz (2013:12) recommended that the tutors should carefully consider the number of themes included in the module.

In another study, Rakhudu (2011:82) explored South African nursing students' experience of PBL at the North-West University. The students indicated that collaboration in PBL groups developed their communication skills as well as their learning, which included their research and critical thinking skills. The negative aspects of PBL included the unfamiliarity of the strategy. The students experienced PBL as challenging and time consuming; they felt overloaded with the work and struggled to seek information. This study advocates the development of lecturers; raising awareness of the advantageous of PBL and introducing PBL from the first year of study or across the university (Rakhudu, 2011:88).

These studies confirm that there are numerous advantages in applying PBL at educational institutions. There are positive as well as negative aspects experienced by the students in the PBL environment, which needs to be considered when implementing PBL for the first time. It furthermore confirms the advantages and challenges discussed in paragraph 2.5.1.3 of this chapter. Careful planning and support to students were thus required to successfully implement PBL in the ESD module for this study. The next paragraph focusses on implementing PBL in an online environment.

2.5.1.6 Problem-based learning online

Advances in technology and access to the internet have promoted the growth of online learning and according to Verstegen *et al.* (2016:9), it can support PBL in groups that work face-to-face or online. Savin-Baden *et al.* (2016:83) endorse that effective online PBL uses synchronous collaboration tools such as *Chat*, video conferencing and shared online whiteboards to support collaboration in the small groups. *Google Docs* and *wikis* can be utilised to complete the PBL reports collaboratively on the same document and keep track of individual members' participation (Golightly & Van der Westhuizen, 2018:125). Online PBL might be challenging to students who are unfamiliar with online learning environments and it might impact their experience and the outcomes of the PBL module (Savin-Baden *et al.*, 2016:83). The tutor should therefore have access to the groups' online discussions to facilitate the learning and keep track of the groups' discussion. According to Barber *et al.* (2015:62), the success of online pedagogy depends on how effectively the tutor can develop and sustain "*a sense of belonging to the digital community*". The tutor furthermore must include the necessary scaffolds during the online PBL process to assist the students with group meetings and promote self-study (Verstegen *et al.*, 2016:27). In a South African context, Golightly and Van der Westhuizen (2018:151) reported that geography pre-service teachers perceived online PBL to be an effective teaching and learning strategy. It was accessible and flexible and more convenient for the students to work in their own time and space. The researchers concluded that online PBL is more effective than PBL in contact

environments, since the online collaboration promoted a social presence that consequently increased the cognitive presence (Golightly & Van der Westhuizen, 2018:152).

Understanding PBL as teaching and learning strategy forms the foundation for applying it in the curriculum of pre-service teachers at a South African institution. It furthermore calls for investigating the implementation of PBL in other higher education institutions, locally and internationally. This concludes the discussion of the first aspect regarding the background of PBL. The next paragraph therefore focusses on the inclusion of PBL in the training of pre-service teachers.

2.5.2 Problem-based learning in pre-service teacher training

As mentioned in the introduction (*cf.* 1.1), PBL is a teaching and learning strategy that is widely applied in many fields, including pre-service teacher training. Dean (1999:3), which studied the effectiveness of PBL in a pre-service teacher program at a university in the United States, promoted the responsibility of higher education institutions to prepare graduates for teaching in new ways. Dean (1999:8) argues that, for teachers to take strategies into the classroom that develop the required skills of critical thinking and problem solving, assumes that they have examples to model from. Teacher training curricula should therefore be redesigned to support teaching and learning strategies such as PBL, which is critical to the ultimate goal of preparing students for the challenges of the 21st century (Dean, 1999:8). Sezgin Selçuk (2015:2) further argues that pre-service teachers in PBL modules can encounter situations, or real-life problems that they might be confronted with later on in their careers. Borhan (2014:78) completed a review of the effect of PBL in pre-service teacher training and confirms that PBL enhances the development of the required knowledge and skills in pre-service teachers to prepare them for the varied roles of their profession. Teachers are facing complex challenges and are expected to collaborate with each other, parents and learners and be self-directed learners and masters of their subjects and apply pedagogical knowledge. According to De Simone (2014:17), teachers can be supported to adapt to the educational reform through the comprehensive pedagogical framework offered by PBL.

Despite these recommendations and advantages, Sezgin Selçuk (2015:3) reported in 2015 after a review of literature that the number of studies about PBL in pre-service teacher training are lacking when compared to other fields. Only a few universities in Canada, USA and Australia have restructured and applied PBL in their pre-service teacher training programs and only a few pilot studies and projects have been undertaken at a few universities in Norway, USA, Canada, Turkey and Australia (Sezgin Selçuk, 2015:3). One

example in South Africa is the study compiled by Golightly and Muniz (2013:1). They explored the PBL experience of geography pre-service teachers at a South African university and concluded a positive outcome in which the students perceived PBL to be an effective teaching and learning strategy. This results should be viewed against the fact that most pre-service teachers are familiar with lecturing and a conventional exam-driven curriculum, since a traditional behaviourist teaching approach is used in most South African schools and higher education institutions (Golightly & Muniz, 2013:20). These results were again confirmed by Golightly and Van der Westhuizen (2018:151) when they investigated third year geography students' experience of online PBL activities (*cf.* 2.5.1.6).

This discussion confirms that it is applicable and advantageous to introduce PBL for pre-service teachers at the institution for this study. Applying PBL as teaching and learning strategy in ESD is focussed on next.

2.5.3 Problem-based learning in education for sustainable development

In the research commissioned by UNESCO (2017:20), seven non-conventional teaching and learning strategies were identified to be relevant in advancing ESD. These strategies, including PBL, all consider learning to be more than just accumulation of knowledge and focusses on *real* issues that will actively engage students to interact with each other and their environment (UNESCO, 2017:21). Literature furthermore reveals several studies that applied PBL in an ESD related program or module (Dahlgren & Öberg, 1999:80; 2001:263; Kwan & So, 2008:93; Steinemann, 2003:216; Sueb *et al*, 2020:1), which are discussed briefly.

A four-year undergraduate environmental science program at a Sweden university initiated the implementation of PBL as preferred teaching and learning strategy in their modules (Dahlgren & Öberg, 1999:80; 2001:263). The complexity of environmental issues expects of environmental scientists to take the social and cultural context into account when they evaluate scientific and technical issues. Dahlgren and Öberg (2001:266) emphasises that, starting with a problem in the context of environmental science, implies that students start with asking intentional questions about the concrete environmental problem and the concepts surrounding it. In their articles they analyse the characteristics, function and structure of well-designed problems to further learning. They found that the scenarios guided students to ask not just encyclopaedic type of questions, but also relational, meaning-, value- and solution-orientated questions, which are needed to enhance learning (Dahlgren & Öberg, 2001:280).

The module “*Sustainable Urban Development*” was taught by Steinemann (2003:219) at a university in Georgia. She agrees that sustainability problems require from students flexible and multi-disciplinary approaches in their problem-solving. In this module, that comprises of students from different disciplines, students were challenged to identify a problem on campus (“*something that could be made more sustainable*”) and then propose a sustainability plan (“*how to make it more sustainable*”). Solving the problem required from students to also implement solutions and during this phase of implementing, students faced barriers. Steinemann (2003:218) argued that, through PBL, students often acquire the additional social and political skills that are needed to implement the solutions.

In another study, senior Geography learners at a school in Hong Kong were part of a study that investigated the learners’ environmental learning using a PBL field program. According to Kwan and So (2008:94), PBL seems to be an effective teaching and learning strategy to accomplish the aims of education *for* the environment. Environmental learning, focussing on knowledge, attitude and behaviour, had taken place and through applying the PBL program, learners acquired a framework for developing their self-directed learning skills (Kwan & So, 2008:110).

The study compiled by Sueb *et al.* (2020:5) affirms the results of the preceding study. Introducing environmental change modules using PBL, had positively changed the learners’ care and attitude towards the natural environment. The grade ten Mathematics and Natural Science learners of the school were involved in this quasi-experiment. The control group received learning through PBL and the experiment group received learning through the PBL environmental change modules. A pre-test post-test design was used to determine the environmental attitudes of the participants, using the Environmental Attitudes Inventory (EAI) as test instrument. The quantitative data also included environmental insight test results and qualitative data was obtained through observations and interviews (Sueb *et al.*, 2020:2). The results of the study indicated that the environmental care attitude of the experimental group is much better than the control group’s environmental care attitude.

Useful resources are available online, for example “*Exploring the Environment: Global Climate Change*” which is an online PBL program in ESD that was developed by the Center for Educational Technologies at Wheeling Jesuit University. Unfortunately, this program is now discontinued since funding from NASA has ended (ETE, 2019).

In this study, PBL was applied in the module ESD for pre-service teachers at a South African higher education institution, to advance learning. The fifth and last concept which is

discussed next, is critical thinking. This discussion also explores the influence of PBL on critical thinking skills.

2.6 CRITICAL THINKING (CT)

The concept critical thinking is explored in the following paragraphs by focussing on four aspects. Firstly, the background and meaning of the concept critical thinking are discussed, followed by clarifying how critical thinking can be taught to learners and students. The instrument used in this study to measure the critical thinking skills of the pre-service teachers, namely the Watson-Glaser³ Critical Thinking Appraisal (WG³CTA), receives attention. Lastly, the interrelation between problem-based learning (PBL) and critical thinking are discussed.

2.6.1 Background and meaning of critical thinking

Thinking is part of our human nature, but not all thinking is accurate, informed, unbiased and without prejudice and consequently affects the quality of our lives (Paul & Elder, 2014:2). Critical thinking (CT) is a higher-order thinking skill that builds on Bloom's taxonomy and relates to creative thinking, problem-solving and decision making (Facione, 1990:5; Masek & Yamin, 2012:1; Yen & Halili, 2015:41).

Literature offers a variety of descriptions and definitions for CT (*cf.* 1.3.5). Kek and Huijser (2011:330) quoted John Dewey's definition, that was formulated in 1910, describing CT as: *"active, persistent and careful consideration of a belief or supposed form of knowledge in the light of the grounds that support it."* Scriven and Paul (1987:1) made a statement at the 8th Annual International Conference on Critical Thinking and Education Reform, that describes CT as an intellectual and disciplined process in which people conceptualise, analyse, apply, synthesise and/or evaluate information that is gathered in different ways (Scriven & Paul, 1987:1). Watson and Glaser (2018:1), developers of the Watson-Glaser Critical Thinking Appraisal (WGCTA), define CT in the WG³CTA Manual, which was first published in 1952, as: *"the ability to identify and analyse problems, as well as seek and evaluate relevant information in order to reach an appropriate conclusion."* Since this study used the test instrument developed by Watson and Glaser, their definition of critical thinking was used in the clarification of concepts in the first chapter (*cf.* 1.2). Paul and Elder (2007:2; 2014:2) formulated a similar definition that defines CT as: *"the art of analysing and evaluating thinking with a view to improving it"* and further states that CT is: *"self-directed, self-disciplined, self-monitored and self-correcting thinking"*. Critical thinkers thus focus on three phases, namely analysing, assessing and then improving their thinking by using

creative thinking to replace weak thinking with stronger thinking. According to Paul (2005:28), creative thinking is therefore a result or by-product of CT. Facione, the developer of the California Critical Thinking Skills Test Family, together with a team of international CT experts, compiled the American Philosophical Association's Delphi Report. The report identified six CT cognitive skills and sub-skills that they describe as the central CT skills (Facione, 1990:4). It includes: (a) interpretation: to categorise, comprehend the significance and clarify meaning; (b) analysis: examine ideas and to detect and analyse arguments; (c) evaluation: to assess claims and judge arguments; (d) inference: to query evidence, speculate alternatives and to draw conclusions; (e) explanation: to justify procedures, state results and present arguments; and (f) self-regulation: self-examination in order to self-correct (Facione, 1990:6).

The CT experts furthermore describe the ideal critical thinker as someone who is naturally curious and focussed on inquiry; is well-informed; has good reasoning skills; is flexible and open-minded; makes far-sighted judgements; is objective in evaluation and honest in dealing with personal biases; is orderly and will diligently seek the relevant information and precise results as far as possible; is reasonable when selecting criteria; and is willing to reappraise (Facione, 1990:4).

Understanding the concept critical thinking makes it possible to address the teaching thereof. Teaching and encouraging critical thinking skills in the classroom is essential in preparing students for living in the 21st century and is elaborated on in the following paragraph.

2.6.2 Teaching and learning to develop critical thinking

Facione (1990:4) and the team of CT experts agree that CT skills of students can be improved in several ways. Students can examine and evaluate their own reasoning critically and learn to think in a more logical and objective way. They can expand their basis of information and experiences in life and use specialised procedures in different areas of thinking and inquiry. Perry *et al.* (1996:77) agree and concluded from different studies that CT can be developed through classroom practices. Certain studies confirm that the total higher education experience is responsible for improving CT and other studies suggest that CT skills can be advanced through specific classroom practices (Perry *et al.*, 1996:77). Snyder and Snyder (2008:92) state that not all students are naturally inquisitive and as a result, require training in becoming systematic, analytic, fair and open-minded thinkers. Students consequently must be educated in a learning environment that focusses on deep learning skills (Kek & Huijser, 2011:332). Discussions in previous paragraphs about active

learning (cf. 2.4.2) and PBL as teaching and learning strategy (cf. 2.5.4) confirm these strategies to be effective in fostering students' CT competence.

According to Paul (2005:27) studies regarding CT in higher education revealed that most faculties do not fully comprehend the full scope of CT and think that they are developing it successfully in their disciplines. Traditional teaching strategies that focus on content are still the norm, despite the appeal to reform. Together these factors hinder institutional change and impact the development of CT skills negatively amongst students (Paul, 2005:27; Snyder & Snyder, 2008:92). This problem can only be overcome by encouraging a substantive concept of CT across the curriculum (Paul, 2005:28). Yen and Halili (2015:43) compiled a list of six challenges faced in teaching higher order thinking from various studies: (a) time: the development of these skills develops over time. It is time-consuming to allow for students to question, articulate, reflect, discuss, interact etc.; (b) student factor: the attitude and motivation of students plays a role. Students tend to find the easy way out and they do not want to engage in complex thinking and effort when completing tasks; (c) teacher factor: not all educators are skilled in encouraging higher order skills and do not differentiate between different levels of thinking; (d) assessment: standardised tests and the goal of achieving high scores inhibit the development of higher order thinking (teach-to-test syndrome). Alternative ways of assessing higher order thinking are hindered by rigid guidelines from authorities; (e) learning environment: the traditional classroom arrangement should be replaced by stimulating environments that allow for lively discussions and debates; and lastly (f) resources: a variety of resources should be available to engage students in active learning practises, for example computers, newspapers and reference books (Yen & Halili, 2015:43-45).

These challenges need to be addressed to advance the goal of improving CT skills of students globally, but also in our country. Active and critical learning is one of the principles of the National Curriculum Statement Grade R-12 (Department of Basic Education, 2011:5) for schools in South Africa. This policy document aims to produce learners who are skilled in applying creative and critical thinking in the process of identifying and solving problems and in making decisions. It further states that learners should be skilled in collecting, analysing, organising and critically evaluating information (Department of Basic Education, 2011:5). According to the study by Lombard and Grosser (2008:573) prospective and practising teachers however lack critical thinking skills and the understanding of how to develop CT through teaching and learning practices in their classrooms. They concluded that it is due to the fact that traditional teacher-centred teaching strategies, such as lecturing and demonstrations, still prevail in most of the South African schools despite the outcomes-

based curriculum that is learner-centred and aims to develop students' higher order thinking skills.

The perceptions of students regarding teaching and learning strategies that support the development of their CT skills were explored by Carlson (2012:11) and whether it correlates with educators' perceptions of which strategies develop CT. The study found that students agreed on four out of a possible list of 20 strategies to be effective in developing their CT skills. It includes lectures with discussions, individual projects, discussions and brainstorming. All these strategies engage students in active learning activities. It was recommended that educators re-examine assumptions about teaching and learning strategies that promote CT and use different strategies that align with students' perceptions (Carlson, 2012:15).

Four useful elements to be continuously present in lessons to develop CT skills were proposed by Broadbear (2003:3-8). These elements originate from the CT definitions (*cf.* 2.6.1) and include firstly ill-structured problems. As discussed in paragraph 2.5.1.2, the PBL process starts with an ill-structured problem that allows for students to explore different contexts. Since there is no single right answer, students should recognise the complexity of the problem and propose solutions that are based on the assessment and interpretation of the evidence available and revise conclusions as new evidence comes to light. Students might struggle with these types of problems, but to persevere until reasonable solutions are reached, is part of CT. The second component is to provide students with criteria to assess thinking, for example clarity, logic, accuracy, significance et cetera. Students should consciously apply these criteria to assess others' as well as their own thinking whilst investigating different types of sources. The third element is to design lessons that involve students in assessing thinking and keep them accountable for the assessment. Students can for example do peer assessment and write reviews with strengths and weaknesses and make suggestions for improvement. The fourth and last element is to include teaching and learning strategies for improving students' thinking. CT can only reach its potential when conscious effort is made to improve it. Revision and resubmission of the work completed by students should be an ongoing element of lessons. After completing the initial assessment, stronger and weaker examples can be shown in class as revision. Broadbear (2003:9) concluded that applying these elements in lessons have assisted students in becoming more comfortable with the concept of CT as well as the practice of assessing thinking.

This paragraph explored the development of critical thinking skills. Assessing the critical thinking abilities of students can be accomplished through using different instruments. The

instrument used for assessing critical thinking skills in this study is hence discussed in the following paragraph.

2.6.3 Critical thinking assessment instrument – the Watson-GlaserTM

Assessing the CT skills of students can be achieved by using a standardised instrument. A list of possible tests available internationally was provided in Chapter 1 of this study (cf. 1.3.5). In this study, the third edition of the Watson-Glaser Critical Thinking Appraisal (WG³CTA) was used as test instrument. The Watson-GlaserTM instrument is consequently further explored and outlined.

The Watson-GlaserTM measures critical thinking and reasoning and is one of the oldest and most widely used instruments (Bernard *et al.*, 2008:15). The third edition of this test is an online version, comprising of 40 randomly selected items from the pool of scenarios and questions. There are currently 295 items in the English language bank (Watson & Glaser, 2018:25). This item-banked test is scored according to the item-response theory (IRT), which adapts for minor variations in degree of difficulty between test versions to ensure that the scores are equivalent (Watson & Glaser, 2018:1). The Watson-GlaserTM is administered with sufficient time, since it is a “*test of power*”, which implicates that it rather measures the depth of critical reasoning than the speed at which it is performed (Watson & Glaser, 2018:2). There is an untimed-version available in the U.S., but the UK Edition is a timed-version and has a 40-minute time constraint on completing the test. In this study, the preferred U.K. timed-version was used.

There are five sub-test sections, which are composed of scenarios that include real-life problems, arguments and interpretation of information. The scenarios are either neutral or controversial (Watson & Glaser, 2018:2). The neutral scenarios and items describe general situation such as business situations and scientific facts, whereas the controversial scenarios and items include political, social and economic issues that generally provoke emotional responses. The five sub-test sections of the Watson-GlaserTM are (1) inference: based on the information given, rates the probability of truth of the conclusion; (2) recognise assumptions: from the statements, identify the unstated assumptions; (3) deduction: determine from the given information if the conclusion follows logically; (4) interpretation: weigh evidence and decide if conclusions are warranted; and (5) evaluate arguments: from the issues, evaluate the strength and relevance of the arguments (Watson & Glaser, 2018:1).

The second and third edition of the Watson-GlaserTM made one important update from the original edition. Factor analyses revealed that three of the sub-tests all relate to drawing conclusions, namely inference, deduction and interpretation (Watson & Glaser, 2018:2). The second and third edition of the WGCTA therefore were simplified into a three sub-scale structure that is referred to as the “*RED-model*”, which includes: recognise assumptions (12 items); evaluate arguments (12 items); and draw conclusions (16 items).

According to Watson and Glaser (2018:6), the reading level of the instructions and items are at or below the ninth grade. For candidates who are completing the test in a language that is not their first language, reasonable precautions can be taken. This factor should also be taken into consideration when results are interpreted (Watson & Glaser, 2018:6).

Evidence of the validity and reliability of the WG³CTA is published in the final part of the manual and includes the internal consistency, test-retest reliability and alternate forms reliability (Watson & Glaser, 2018:27-31). The evidence of the validity of the WG³CTA in the manual includes content, construct and criterion-related validity (Watson & Glaser, 2018:32-44). One example of a study that was compiled to validate the WGCTA, is the project by El Hasan and Madhum (2007:379) in Lebanon with students in five modules. Their results confirmed internal consistency and correlation with test scores from other studies and confirmed the reliability and validity. The first edition of the WGCTA was used in a South African study with first year pre-service teachers that and published in two articles. The purpose of the study was to determine the success of outcomes-based education (OBE) in achieving the goal of developing school learners’ CT skills (Lombard & Grosser, 2008:562) and to determine the relationship between cultural differences and CT ability amongst pre-service teachers (Grosser & Lombard, 2008:1365). Grosser and Nel (2013:5) did a follow-up study with first-year pre-service teachers at the same university, which confirmed the validity and reliability of the WGCTA in a South African context.

This study wants to explore the influence of PBL on the development of pre-service teachers’ critical thinking skills. A pre-test post-test design was used to measure the participants CT skills. From the literature, it is evident that PBL as teaching and learning strategy can contribute to this goal. PBL will consequently be introduced in the module ESD, which expects from students to apply critical thinking and problem-solving skills. The relation between PBL and CT skills is explored in the following paragraph.

2.6.4 Problem-based learning and the development of critical thinking skills

PBL promotes learning by doing. Instead of instructing students how to solve a problem, students are given the opportunity and in the process they are developing their own

problem-solving skills (Steinemann, 2003:218). Various researchers have studied the relation between PBL and critical thinking, with varied results.

Introducing PBL in physics teaching of school learners is an example of a study that proved PBL to be effective in improving the learners' critical thinking skills (Sujanem, 2018:5). During the PBL process, the learners had to collect information to solve a problem, they had to process the information by discussing it and asking questions and present their solutions to the problem. According to Sujanem (2018:4), the learners developed their CT skills during this PBL process. A one group pre-test post-test design was followed, using an essay test with different indicators as CT test instrument. At the end of the academic year, the statistic results confirmed an improvement in CT skills amongst the learners.

The study compiled by Temel (2014:6) with pre-service teachers in Turkey, had an opposite outcome. The study utilised the Cornell Critical Thinking Disposition Inventory (CCTDI) as instrument (*cf.* 1.3.5) and was performed in one semester. Temel (2014:15) found that, although the critical thinking disposition of the experimental group was higher than the control group, it was not statistically significant. The one group pre-test post-test study by Ulger (2018:5) did not include a control group and investigated the effect of PBL on the creative thinking and critical thinking of visual arts students after one semester. The creative thinking test instrument indicated a medium difference between the pre-test and post-test. The results from the CCTDI, regarding the critical thinking disposition, however revealed no significant improvement (Ulger, 2018:9). In the study of Masek and Yamin (2012:2), 53 students in the first semester of the electrical technology module were part of an experimental, pre-test post-test study. The Cornell Critical Thinking Test Specimen (CCTTS) was used as test instrument. The control group was taught according to the traditional lectures, whereas the experimental group was taught using PBL. The results of the study indicated no significant difference in CT ability between the experimental and control group. Masek and Yamin (2012:4) considered a few aspects to explain the results. They argued that some of the PBL processes might have been less effective, considering the study sample and introducing PBL to first-year students were challenging. Critical thinking is a higher order skill and the treatment duration of ten weeks might not be sufficient to enhance the students' CT skills.

Masek and Yamin (2011:218) furthermore reviewed studies from multiple disciplines and countries that investigated the effects of PBL on students' CT skills. Most of the studies compared the PBL group with a traditional teaching and learning control group and a few studies compared a single groups' pre- and post-test results. Different instruments were utilised, including the CCTTS, CCTDI and WGCTA (*cf.* 1.3.5). Several studies indicated

positive findings, whilst other studies resulted in no significant difference or even negative findings. Based on their theoretical and empirical review, four conclusions were made by Masek and Yamin (2011:219): (a) theoretically, the processes in PBL support the development of critical thinking skills; (b) empirical evidence in general, explaining the effect of PBL on the critical thinking ability of students, is inconclusive; (c) students need to be exposed to PBL over a longer period of time to develop critical thinking skills according to some evidence; and (d) several predictors (academic achievement, educational background, age and gender) might influence the effect and calls for further investigation (Masek & Yamin, 2011:219).

In a systematic review and meta-analysis of the effectiveness of PBL on the development of critical thinking of nursing students, Kong *et al.* (2014:461) found eight studies from a possible 392 abstracts. The articles were published between 2004 and 2011 and were performed in China, Turkey, the United States and Korea and have an intervention time period of one or two semesters. The studies measured the critical thinking skills of students, using different standardised instruments, before and after the PBL intervention. Kong *et al.* (2014:464) reported that two studies showed no statistically significant difference and six studies revealed a statistically significant difference between the PBL and control groups' critical thinking scores. The pooled effects, using different models, revealed a significant difference in overall critical thinking scores in favour of the PBL intervention group compared to the traditional lectures used in the control group (Kong *et al.*, 2014:464). They concluded that PBL contributed to improve the critical thinking disposition of nursing students.

Fostering CT skills amongst students is achievable with the guidelines discussed in paragraph 2.6.2. During the PBL process, the PBL tutor should encourage students to justify their thinking and externalises self-reflection by using questioning strategies. According to Hmelo-Silver (2004:245) and De Simone (2014:19) it will assist in the development of students' higher order thinking skills. Kek and Huijser (2011:336) confirm that an important characteristic of an effective PBL process is the reiterating and reflection taking place. Thompson (2019:150) on the other hand, focussed on the learning issues in the PBL process as an opportunity for students to work collaboratively and develop CT skills. Identifying learning issues help students to assess their knowledge and the knowledge needed to resolve the case study. When the students started using the learning issues as a problem-solving space, the participation increased that led to more in-depth discussions and the development of their CT skills (Thompson, 2019:154). The PBL curriculum, including the role of the tutor, should therefore be carefully designed to effectively foster critical thinking skills (Masek & Yamin, 2011:219; Pu *et al.*, 2019:8).

Pre-service teachers are challenged to obtain the necessary skills, such as problem-solving and critical thinking, required of them in the 21st century. This will enable them to effectively educate and guide their future learners to think critically and be prepared for the challenges of the fourth industrial revolution in the 21st century.

2.7 SUMMARY

The urgent need and call for integrating ESD in pre-service teacher training were investigated in this chapter. The effective and successful implementation of teaching and learning ESD was explored with specific reference to the South African context. Constructivism was explained, which promotes the inclusion of active learning in higher education institutions. The teaching and learning strategy PBL is an example of active learning and was hence researched and consequently introduced in this study. The aim of this study is to determine if PBL can contribute to develop the critical thinking skills of pre-service teachers in the ESD module. The development of critical thinking through appropriate teaching and learning strategies was thus explored. The following chapter elaborates on the methodologies used for collecting and analysing the data in this study.

CHAPTER 3 RESEARCH METHODOLOGY AND STRATEGIES

3.1 INTRODUCTION

In this chapter, the research methodologies and strategies that were used in this study are explored. Firstly, the research paradigm and the research design are discussed. The role of the researcher is then clarified, followed by an explanation of how the module education for sustainable development (ESD) is compiled. The next discussion focusses on the site and sample of this study and an exposition of the methodologies used for collecting the quantitative and qualitative data. The methodologies for analysing the data are then dealt with. Lastly, the ethical aspects of this study are clarified.

3.2 RESEARCH PARADIGM AND DESIGN

3.2.1 Research paradigm

Creswell and Plano Clark (2018:36) identified four paradigms or worldviews that can be used individually or combined when compiling mixed method research, namely post-positivist, constructivist, participatory and pragmatist worldviews. They explain that the use of multiple paradigms is related to the design being used in mixed methods research. In a sequential design, for example, the combination of paradigms is feasible (Creswell & Plano Clark, 2018:41). In this study, a convergent parallel design is followed (*cf.* 3.2.2), which indicates that qualitative and quantitative research occurred simultaneously and independently. Pragmatism is considered by many as a paradigm that is typically applied for mixed methods research (Creamer, 2018:45; Creswell & Plano Clark, 2018:37; Ivankova *et al.*, 2020:333) (*cf.* 1.6.1).

Pragmatism originated from the ideas of John Dewey, Donald Davidson and Richard Rorty (Ivankova *et al.*, 2020:333). Reality is seen as diverse, complex and it cannot be understood in a fully objective way (Creamer, 2018:45). Pragmatists will consequently focus on the practical implications of research and will use multiple methods to collect data to best answer the research problem (Creswell & Poth, 2018:27). The consequences of research and the questions asked are of greater importance than the methods used. Multiple methods of collecting data will therefore be deployed to answer the research questions (problems) that are being studied. Pragmatism is thus pluralistic, problem orientated and pays attention to “what works” in a particular setting (Creswell & Plano Clark, 2018:37).

The methodology that is used in pragmatism combines deductive and inductive approaches as the study proceeds and quantitative and qualitative data is being mixed (Creswell &

Plano Clark, 2018:38). Deductive methods operate from the “top” down to test a theory. Deductive methods thus start from the theory and then go to the hypotheses and data to build on to the theory or to contradict it. Inductive methods work from the “bottom” up. Inductive methods therefore enquire about participants’ views and build up to broader themes to formulate a theory that interprets the themes (Creswell & Plano Clark, 2018:37). The pragmatist argues that qualitative and quantitative methods are compatible and can be combined to address different aspects of the research question to provide a more comprehensive answer (Ivankova *et al.*, 2020:333). This study incorporated quantitative and qualitative methods. A mixed methods research design was consequently used to address the aims of this study. The following paragraph pays attention to the mixed methods research design.

3.2.2 Research design

A mixed methods research design combines quantitative and qualitative methods to generate a deeper understanding of trends as well as personal experiences. The mixed methods research design therefore explains the relationship between variables and how they link with each other (Ivankova *et al.*, 2020:331).

Since the emergence of mixed methods research in the late 1980s, it developed into an independent research design due to the need to analyse more complex research problems (Creswell & Plano Clark, 2018:22). Johnson *et al.* (2007:123) explored the variety of definitions for mixed methods research and formulated the following definition: *“Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration”*. Creswell and Plano Clark (2018:5) prefer listing the core characteristics of mixed methods instead of giving one definition. From their experience, the following four components evolved over time: (a) the researcher collects and analyses rigorously both qualitative and quantitative data (based on the research questions); (b) the researcher mixes (or integrates) the two sets of data; (c) these procedures are organised into specific designs which explain the procedures and logic for compiling the study and (d) the researcher frames these procedures within philosophical worldviews (Creswell & Plano Clark, 2018:5).

There are advantages to use a mixed method research design. According to Ivankova *et al.* (2020:330) and Kumar (2014:28), the use of mixed methods enhances the research possibilities if one method alone is not suited to explore all the aims in a research project.

Mixed methods are suited for complex situations since it provides the freedom to choose the best methods applicably and even go across paradigms if necessary in complex situations (Creswell & Plano Clark, 2018:23; Kumar, 2014:28). Combining both forms of data leads to the most complete analysis of the problem. The second set of data investigates the phenomena from another perspective and makes triangulation possible, which enhances the validity of the findings (Kumar, 2014:28). Mixed methods can also be advantageous in providing additional evidence on the research topic. In certain cases, it might be necessary to acquire additional evidence to contradict or support the research question. Collecting data by implementing two different methods allows the researcher to use the second set of data for comparison to contradict or confirm the original findings (Kumar, 2014:28). In this study, the combination of quantitative and qualitative data makes it possible to acquire a more complete impression of the research question and allows triangulation between the different perspectives.

The disadvantages of using a mixed methods research design should be considered as well. According to Kumar (2014:29), it entails more work and resources. Collecting data by implementing multiple research methods implicates that the researcher must consider the additional time, effort, technical expertise and financial resources needed to collect and analyse the amount of data. Creswell and Plano Clark (2018:15) agree, stating that a mixed methods approach demands extensive time and resources that calls for careful consideration and planning. Applying mixed methods might also imply recruiting two or more study populations (Kumar, 2014:29). Mixed methods require diverse skills since different methods for analysis are used in quantitative and qualitative research (Creswell & Plano Clark, 2018:14; Kumar, 2014:29). Versatile skills are as a result, required from the researcher to analyse and triangulate the different sets of data. Lastly, the two data sets may result in opposite findings and the researcher needs to establish methods for validating the reliability of the data sets and resolve the disagreements (Kumar, 2014:29). In this study, the researcher had to do careful planning to accommodate the additional time and effort required to collect and analyse the data sets. The researcher also had to acquire the necessary skills for analysing the integrated qualitative data set (*cf.* 3.7.2).

Creswell and Plano Clark (2018: 65) identify four basic mixed methods designs, namely the convergent parallel, exploratory sequential, explanatory sequential and embedded design. According to Delport and Fouché (2011:439), different designs used in mixed methods research depend mostly on the time orientation dimension. The quantitative and qualitative phases can occur sequential, which implies that one phase follows up and can be

dependent on the previous phase, or it can occur concurrently, which means the phases are independent of each other and occurs simultaneously (Delpont & Fouché, 2011:439).

This study followed a convergent parallel design. The purpose of this design is to compare and contrast the statistical quantitative results with the findings of the qualitative data to validate the outcomes and create a deeper understanding of the phenomenon (Creswell & Plano Clark, 2018:68). The convergent parallel design implies that the qualitative and quantitative strands are implemented simultaneously and are equally prioritised during the same phase, as depicted by Creswell and Plano Clark (2018:66) in Figure 3.1. The qualitative and quantitative strands are analysed independently and during the overall interpretation of the findings, the data results are mixed (Creswell & Plano Clark, 2018:69). According to Ivankova *et al.* (2020:339), the convergent parallel design can take up less time than the sequential design, but still requires great effort to collect and analyse two sets of data simultaneously. Another immense challenge to consider is the strategies to be used for merging the two separate sets of data, especially if the results from the two sets do not correspond with each other (Ivankova *et al.*, 2020:339).

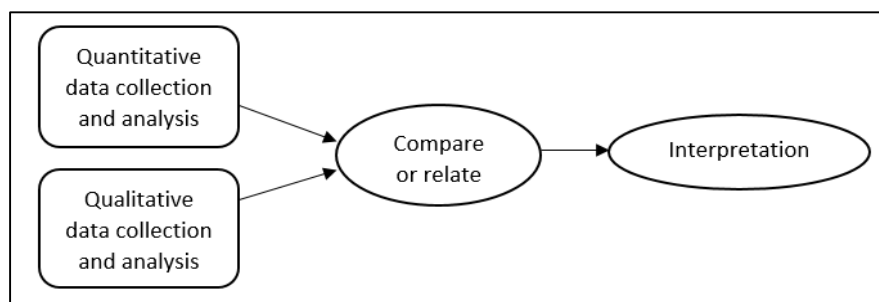


Figure 3.1: The convergent parallel mixed methods design (Creswell & Plano Clark, 2018:66).

In this study, a convergent parallel mixed methods research design was implemented to answer the multiple research aims (*cf.* 1.5). It allowed the opportunity to compare the results from the quantitative and qualitative data regarding the pre-service ESD teachers' experience in problem-based learning (PBL) and the influence of PBL on the development of the pre-service ESD teachers' critical thinking skills. It will thus enable the development of a more complete understanding of the phenomenon and enhance the validity of the results. The procedures that were used for implementing a mixed methods research design for this study are elaborated on in the following paragraph.

3.2.2.1 Procedures for implementing the convergent parallel design

This study combined the quantitative and qualitative data in a concurrent way and followed a parallel convergent mixed method design (*cf.* 3.2.2). The flowchart in Figure 3.2 illustrates the basic procedures for implementing this design. This flowchart was developed by Creswell and Plano Clark (2018:70) and was adopted by the researcher with comments applicable for this study.

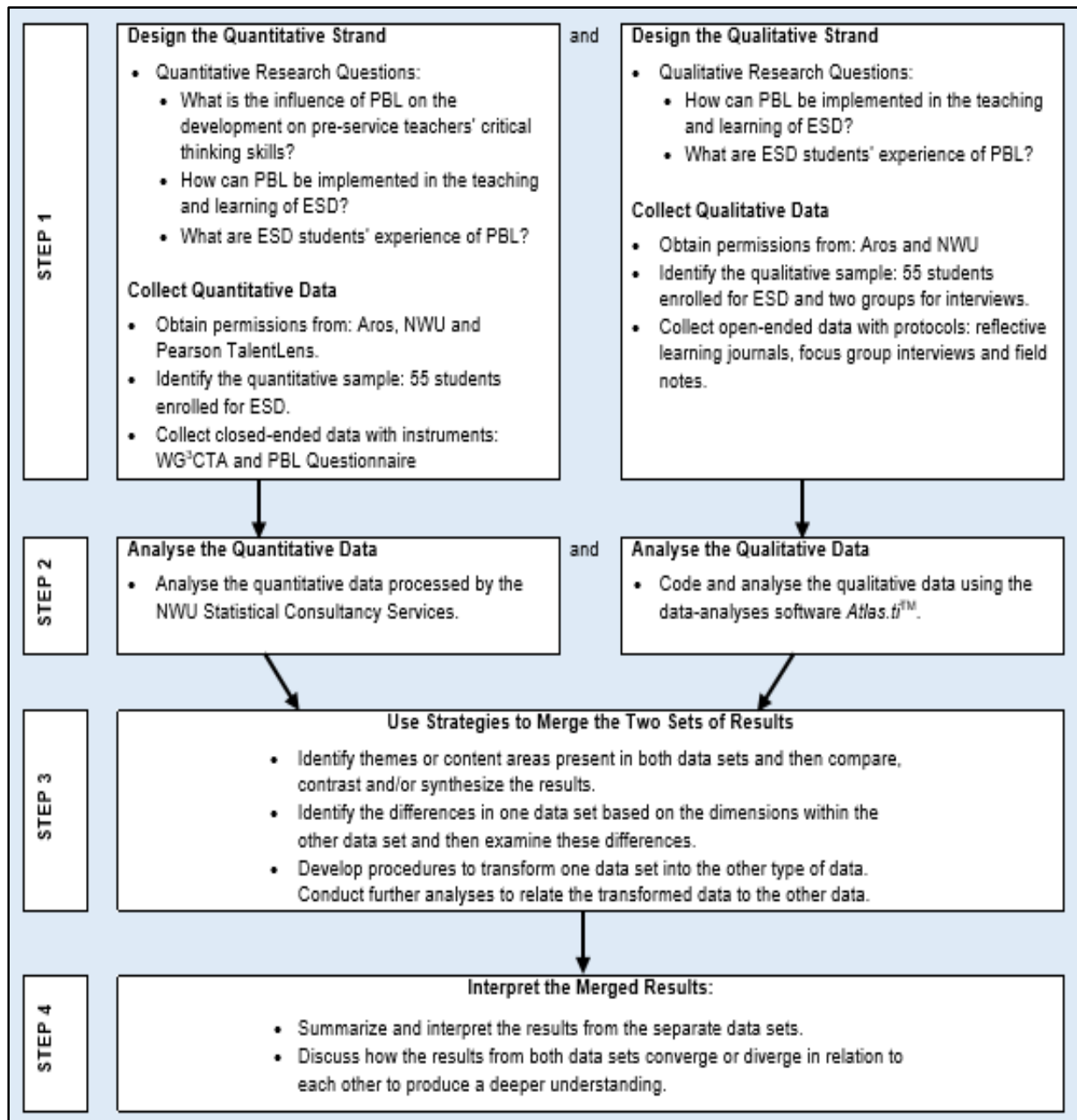


Figure 3.2: Flowchart of the basic procedures in implementing a convergent parallel design – adopted for the study (Creswell and Plano Clark, 2018:70).

Designing and collecting data was the first step. The researcher consulted various specialists, with the help from the supervisors, to acquire the quantitative tools. The data is collected simultaneously in the convergent parallel design but does not depend on each other (Creswell & Plano Clark, 2018:69). The quantitative data obtained from the WG³CTA was collected at the beginning and again at the end of the semester. The WG³CTA measured the pre-service ESD teachers' CT skills before and after the semester to determine if the CT skills had improved. The quantitative data obtained from the PBL questionnaire was collected at the end of the semester and measured the pre-service ESD teachers' experience of PBL during the semester. The qualitative data obtained from the RLJ was collected during the semester. The RLJ was completed by the pre-service ESD teachers with each PBL activity to reflect on their PBL experience and the development of their CT skills. The qualitative data obtained from the focus-group interviews was obtained at the end of the semester and investigated the pre-service ESD teachers' experience of PBL and the development of their critical thinking skills.

Step two included analysing each of the data sets independently, using the applicable quantitative and qualitative procedures. The procedures for analysing the two data sets are supplemented in paragraphs 3.7.1 and 3.7.2 of this chapter.

The third step was the integration of the data sets. Themes present in both data sets were identified and results compared to determine differences and similarities.

The fourth and last step was to summarise and interpret the results and to conclude how the two data sets corroborated to create a deeper understanding of the phenomena (Creswell & Plano Clark, 2018:69). Steps 3 and 4 are presented in Chapters 4 and 5 of this study.

The research paradigm, research design, method used for sampling and instruments for collecting the data for this study are summarised in the following diagram (Figure 3.3).

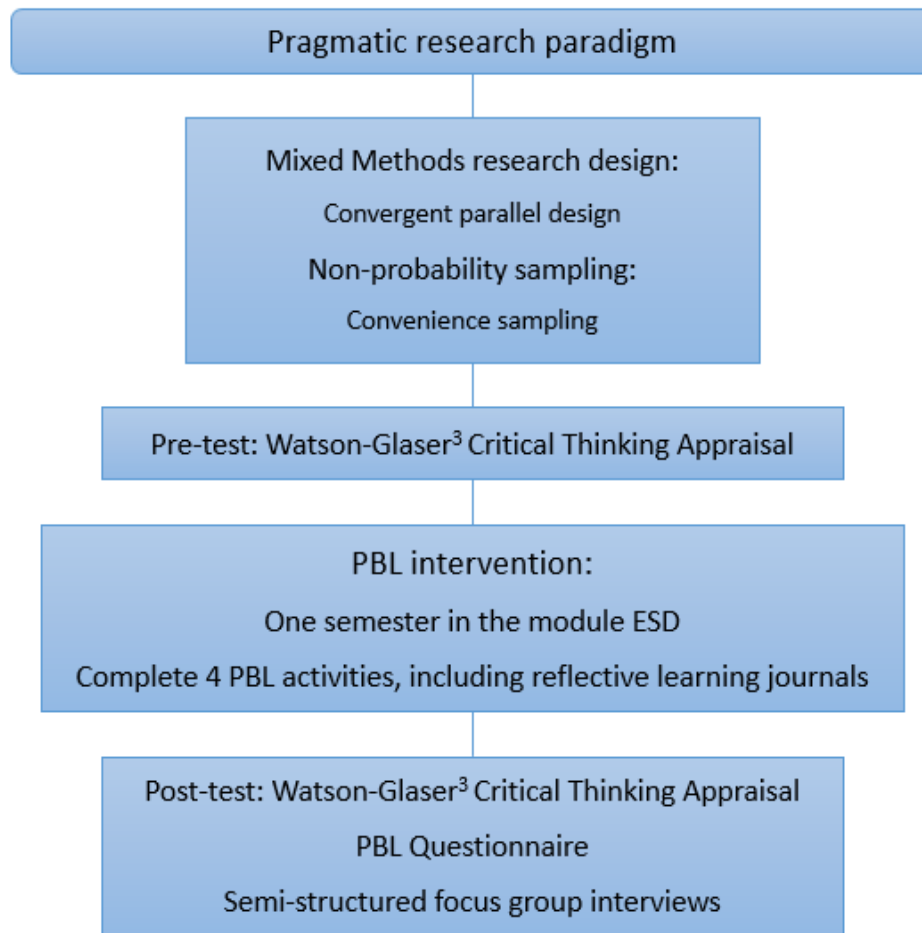


Figure 3.3: Research framework

The role of the researcher in this study is discussed in the following paragraph.

3.3 ROLE OF THE RESEARCHER

According to Maree (2020:47), the role of the researcher is to work together with the participants whilst collecting and analysing the data to create an understanding of the phenomena. The functions of the researcher in this study included the following: administering the online WG³CTA instrument; preparing and administering the reflective learning journals for each of the PBL activities; preparing and administering the online PBL questionnaire; preparing and facilitating the focus-group interviews; analysing the quantitative and qualitative data and triangulating the data.

The researcher was the lecturer assigned to the module ESD and was responsible to plan, design and implement PBL in the module ESD. The researcher compiled the study guide, presented the module and performed the administrative duties that included managing the e-class platform and performing assessments.

The assistant assigned to the module ESD acted as assistant-tutor to help the lecturer and participants. The assistant-tutor's duties included mostly administrative tasks, for example preparing the *Google Docs* and *Google Slides* for the groups, answering participant's e-mails and recording assessment marks.

In order to understand the scope of the quantitative and qualitative data that is reported in the fourth chapter, it is necessary to clarify and explain how the module ESD was designed.

3.4 DESIGNING THE MODULE ESD

For the purpose of this study, the ESD module was redesigned to implement PBL as teaching and learning strategy to involve pre-service teachers in the learning process. An integrated or embedded PBL model was followed (*cf.* 2.5.1). PBL was introduced in one module of the BEd intermediate phase curriculum, whilst the other modules in the curriculum still followed a traditional lecture-based teaching strategy.

The researcher developed the study guide and is the assigned lecturer for the module. The name of the module is *Environmental Education for Sustainable Development* and the Afrikaans name and code for the module, that appear on all the annexures, are "*Omgewingsopvoeding vir Volhoubare Ontwikkeling (GIFO311)*". In this study, the researcher refers to the module as the ESD module instead of the Afrikaans name or the module code, *GIFO311*.

The participants were divided into twelve tutorial groups, consisting of 5 to 6 members each. According to Masek and Yamin (2010:151), the scope of the project and the time frame should be considered in determining the group size. Tutorial groups can consist of 8 to 10 students according to Schmidt and Moust (2000:21), whilst Dahlgren and Öberg (2001:80) compiled groups of 5 to 8 students per group. The participants were not allowed to choose their own group members. The assistant-tutor took three aspects into consideration whilst dividing the participants into groups, namely class attendance, academic performance from previous years as well as mixing the two subject lanes. At the institution, pre-service teachers in the intermediate phase choose between Mathematics and Natural Science or Social Science and Life Orientation.

The institution has a unique blended learning model that gives the pre-service teachers the opportunity to work during the week and attend contact sessions on Fridays or Saturdays. Many of the pre-service teachers work full time as assistants at schools or tutors at learning centres and private households or they have other jobs. These pre-service teachers must complete their study commitments after hours during the week. The pre-service teachers

receive online support from the lecturers during the week, whilst on weekends, they have face-to-face contact with the lecturers. Introducing PBL as teaching and learning strategy at the institution can therefore be favourable and advantageous for its learning model.

The pre-service ESD teachers, however, still had to be prepared and trained in PBL. The teaching and learning strategy PBL was explained in the ESD study guide that the pre-service ESD teachers received during registration (available electronically). The assessment requirements were explained in the study guide and in the study letter and the assessment rubrics were included in the study letter (*cf.* Annexure I). These documents were uploaded on the e-class platform (*cf.* 1.6.4) for the participants. The assistant-supervisor of the study, who is familiar with PBL and uses PBL in the modules he teaches, prepared a tutorial video for the pre-service ESD teachers dealing with the implementation with PBL (available electronically). In the 30 minutes' video, he explains what PBL is, the PBL process, the role players involved, as well as the advantages of PBL. The video was uploaded on e-class together with a quiz to be completed by the participants before the first contact session. The quiz was placed on e-class to determine if the participants understood the basic aspects of PBL. During the pre-test sessions on registration day, the participants were informed of the new teaching and learning strategy and encouraged to read the information in the study guide and to watch the video and complete the quiz on e-class. The participants also received a message sent from e-class to remind them to perform the two e-class tasks. A short introduction to PBL was also given during the first contact session, after which the participants were divided into their tutorial groups.

The researcher chose *Google Docs* and *Google Slides* as platform to successfully introduce PBL into the module ESD and perform the group activities in an online environment. An example of one group's report on *Google Docs* and the presentation on *Google Slides* is available for reference at the links provided¹. The group members, tutor and assistant-tutor had access to the online documents. These documents made it possible for group members to work together on their report and presentation in an online environment during the week when they did not have contact with each other. It also allowed for the tutor to monitor the progress of the groups and make comments where necessary. The tutorial groups were encouraged to form *WhatsApp* groups to assist in communicating with each other during

¹ Copy of a *Google Docs* report is available at:

<https://docs.google.com/document/d/1D7hySFUoAeBloECyXE63-RMST66i4tHcCZ0ArgH0QF0/edit?usp=sharing>

Copy of a *Google Slides* presentation is available at:

https://docs.google.com/presentation/d/12pThmOWRz6J8uqf9AlqHfBYX_7tI61VgmXj1_HWOKY/edit?usp=sharing

the week. The self and peer assessment of the individual group members' participation at the end of each PBL activity were completed on *Google Forms*.

The layout of the program that was followed during the twelve-week semester is given in Table 3-1. A three-week cycle was followed for each of the PBL activities. The study letter for the participants and module planning are available in Annexure I. During the first week, participants were instructed to investigate a problem and start with the initial reading. Contact session one started with the tutor who gave a short introduction to the problem, followed by facilitated group discussions. Each tutorial session was 50 minutes in duration. During the second week, participants had the obligation to further explore the problem, formulate the learning objectives and search for information together with their group members. The groups started to compile the report on *Google Docs*, which was monitored by the tutor and comments were given where necessary. The information collected was brought to class and the groups could discuss their solutions during the second tutorial session, which was facilitated by the tutor. During the last week, the groups had the responsibility to finalise their report and prepare their presentation on *Google Slides*, which was also monitored by the tutor who gave comments when necessary. During the third tutorial session, each group had the opportunity to present their solutions to the other groups. The solutions that were presented and the quality and preparation of the presentations were assessed by the tutor and/or class members. At the end of contact session three, the tutor gave instructions to start with the initial reading and preparation for the following PBL activity. During this three-week cycle, participants were obliged to complete RLJ entries about their experience of the PBL process. After contact session three, the group leaders submitted the final report and all the participants individually submitted their RLJ on e-class.

This three-week cycle was, however, not applicable for PBL Activity 1. The participants effectively had only two weeks to complete the first activity, since the semester only commenced after the first contact session. This challenging situation was furthermore complicated by the fact that the participants still had to be introduced to the new teaching and learning strategy, namely PBL. The tutor therefore introduced more scaffolds to support the participants with the first PBL activity, which included proposed sources and extra written guidelines to assist them with the first case study. These sources and guidelines were uploaded on e-class and a comment was left for each group on their online *Google* document. For each consecutive activity, less and less assistance was given by the tutor, as the participants started to work independently. According to Verstegen *et al.* (2016:27), it is advisable to provide extra scaffolds to online PBL groups in order to help students

develop the necessary self-directed learning skills until they can function with less support from the tutor (*cf.* 2.5.1.4; 2.5.1.6).

Table 3-1: Work schedule of Education for Sustainable Development for 2019

WEEK	TUTORIAL SESSIONS	THEME	ACTIVITY
PBL Activity 1			
1	1/2 Feb.	Environmental education in South Africa	Introduction and group discussion
2	8/9 Feb.		Group discussion and facilitation
3	15/16 Feb.		Groups present solutions
PBL Activity 2			
4	22/23 Feb.	ESD: water pollution and water purification	Introduction and group discussion
5	1/2 Mar.		Group discussion and facilitation
6	8/9 Mar.		Groups present solutions
PBL Activity 3			
7	15/16 Mar.	ESD: global warming and climate change	Introduction and group discussion
8	5/6 Apr.		Group discussion and facilitation
9	12/13 Apr.		Groups present solutions
PBL Activity 4			
10	3/4 May	Environmental education in practice	Introduction and group discussion
11	10/11 May		Group discussion and facilitation Recording of micro lesson
12	17/18 May		Groups present solutions

The module ESD consists of three learning units, as outlined in Table 3-2. The researcher developed four PBL activities for the module ESD that are aligned with the module outcomes. The problems were presented as case studies to the pre-service teachers. The participants had to investigate and then find solutions to the problems in their tutorial groups. Each group completed a written report of their research and prepared an oral presentation of their solutions for each of the four PBL activities.

The first PBL activity involved investigating the concepts environmental education, sustainable development, environmental management systems and stewardship. The groups had to elaborate on the importance of EE and propose an appropriate environmental management system for their school. The second PBL activity concerned the effect of water pollution on a less privileged community and the responsibility of the school, community and local government to address the problem. The third PBL activity explored the complicated calamity of climate change and global warming. The groups had to propose possible actions that can be taken by governments, as well as by individuals and households, to reduce the impact. The fourth and last PBL activity challenged the pre-

service ESD teachers to investigate ESD and the application of EE in the subjects they teach. Each group received one of the six subjects taught in the intermediate phase of South African' primary schools. This activity included a practical component. The groups had to prepare and film a video of a micro lesson to demonstrate how they had incorporated EE in their subject. Table 3-2 reveals the PBL activities per learning unit for the module ESD.

Table 3-2: Education for Sustainable Development learning units and problem-based learning activities

Learning Unit 1 Environmental education in South Africa	PBL Activity 1	There is nowadays a growing concern for environmental problems and issues in our modern society. Environmental education (EE) is, therefore, taking a more prominent place in schools. The school management has the responsibility to govern the school according to sustainable principles. Designing an environmental management system (EMS) for a school, gives the opportunity for teachers, learners and parents to participate. At your school is no guidelines or policy for the implementation of EE. The teachers are furthermore not positive towards any changes to the existing curriculum. The principal requested you to investigate the importance of EE and to make recommendations for a possible EMS. Also refer to the role of EE in developing learners as responsible stewards living on planet earth.
Learning Unit 2 Environmental problems and sustainable development	PBL Activity 2	You are newly appointed teachers at your school in a low-income settlement close to a big town. Learners regularly suffer from gastroenteritis and are constantly absent from school. The community relies on a river (see photo) for water and ask your help to test the safety of the water and investigate the causes of the problem. Report on the possible reasons for the water pollution, the diseases caused by water pollution and solutions for reducing water pollution. Also refer to action that needs to be taken by the local government and the teachers from the local school to help to solve the problem. 

	PBL Activity 3	Across the world, it is reported that record high temperatures are reached (read the two articles). Debates on global warming and climate change are hot topics and countries are warned that global temperature changes be kept below 2°C to prevent catastrophic consequences for human societies and natural environments. The EE students are tasked to investigate the consequences of global warming on South Africa and to formulate solutions that can help to prevent climate change. Also report on the measures that can be implemented by the government, as well as individuals and households to minimise the influence of the problem. <i>"Why is climate change's 2 degrees Celsius of warming limit so important?"</i> (Titley, 2017) https://theconversation.com/why-is-climate-changes-2-degrees-celsius-of-warming-limit-so-important-82058 <i>"A city in Pakistan may have just endured the hottest April temperature ever observed on Earth"</i> (Samenow, 2018) https://www.washingtonpost.com/news/capital-weather-gang/wp/2018/05/01/a-city-in-pakistan-may-have-just-endured-the-hottest-april-temperature-ever-observed-on-earth/?noredirect=on&utm_term=.ca124bfe8844
Learning Unit 3 Environmental education in practice	PBL Activity 4	Choose one subject from the intermediate phase to investigate the problem and present solutions: The subject advisor has visited your school to monitor EE practices in the classrooms and how EE is implemented in the lessons presented. The subject advisor recommended that you give feedback to colleagues at the next district meeting regarding the requirements of the CAPS and the meaning of ESD. Also make suggestions on how teachers can effectively implement EE in their subject. For the meeting, your report should include a detailed lesson plan that demonstrates how EE can be integrated into a lesson.

The assessment requirements for the ESD module are outlined in the study guide (available electronically) and the study letter (*cf.* Annexure I). The PBL groups were assessed by the tutor for completing the PBL reports as well as the presentations of the solutions during the contact sessions. The pre-service teachers were assessed individually by the tutor for their participation in their tutorial groups and performing the prescribed activities during the semester. The participants also assessed themselves and their group members for their participation and contribution in each of the PBL activities by completing a self and peer assessment form, as recommended by Golightly (2020:12) (*cf.* 2.5.1.2). As discussed in the second chapter (*cf.* 2.6.2), Yen and Halili (2015:43) set out the challenges of developing students' higher order thinking skills and they propose alternate ways of assessment that should not be hindered by rigid guidelines from authorities. In this study, the researcher acknowledges that the Academic Committee at the institution accepted the proposed

alternative way of assessment to successfully complete this module (*cf.* Annexure B). The prescribed examination to fulfil the requirements for completing the module ESD was replaced with submitting a group portfolio consisting of the four research reports and presentations of solutions for the proposed problems set forth in the PBL activities. The portfolio thus served as a summative assessment opportunity to meet the requirements for the module ESD.

In the following paragraph, the site and sample of this study are clarified before discussing the collection and analysis of the data.

3.5 SITE AND SAMPLE

This study was conducted at Aros, as discussed in paragraph 1.6.4. The institution (Aros) has a blended training model that offers pre-service teachers the opportunity to work and study simultaneously (*cf.* 3.4). Distance-learning takes place during the week and the contact sessions between lecturers and pre-service teachers occur in two groups on Fridays and Saturdays in a twelve-week semester.

This study did not make use of a random selection of the population but used a non-probability sampling method. According to Maree and Pietersen (2020a:219), the researcher should consequently be cautious to draw conclusions about the population. The type of non-probability sampling that was used, is convenience sampling. This type was selected since the participants were easily available to the researcher. Pre-service teachers enrol for BEd at the institution in the foundation phase, intermediate phase or senior and FED phase. The module ESD is currently only implemented in the intermediate phase at the institution. The inclusion criteria that were used to select the participants, therefore, included all the undergraduate BEd intermediate phase pre-service teachers at the institution that had enrolled for the module ESD in 2019 and gave consent to participate in the study. From the 63 pre-service teachers who enrolled in January, two participants discontinued the module in February and another two participants discontinued their studies during March and April. From the 59 pre-service teachers who successfully completed the module, four participants did not complete the WG³CTA post-test and PBL questionnaire and were removed from the data. The remaining 55 pre-service teachers completed all the instruments and were thus included in the data for this study. The descriptive statistics of the participants are presented in paragraph 4.2 of the next chapter.

Collecting and analysing the quantitative and qualitative data for this study are elaborated on in the following paragraphs.

3.6 METHODS OF DATA COLLECTION

Quantitative and qualitative data collection and analysis techniques were employed to help in ensuring rich, deep data and to support the triangulation of findings in this study. Collecting the quantitative data for this study is firstly discussed, followed by the techniques for collecting the qualitative data.

3.6.1 Quantitative data collection

Collecting the quantitative data for this study included two instruments, namely the Watson-Glaser³ Critical Thinking Appraisal and the PBL questionnaire. Both these instruments are discussed in the following paragraphs.

3.6.1.1 Watson-Glaser³ Critical Thinking Appraisal

The concept of critical thinking (CT) was discussed in Chapter 1 (*cf.* 1.3.5) and the commonly used instruments that are reported in literature were listed. As explained in Chapter 1, no standardised test instrument to measure critical thinking is available in South Africa and therefore, an international test was chosen. The aim of the CT test in this study was to determine whether the pre-service ESD teachers' CT skills had improved after introducing PBL. The CT tests were administered before commencing the module and again at the end of the semester, following a pre-test post-test one-group design (*cf.* 1.6.5.1.1). This is an experimental design that was used to determine if a specific intervention had an influence on a variable dependent (Maree & Pietersen, 2020b:188). The dependant variable O_1 (critical thinking) was measured in the pre-test, after which an independent variable, X (PBL as teaching and learning strategy) was introduced. At the end of the semester, the measurement of the dependant variable O_2 was repeated in the post-test. This design in symbols is written as: $O_1 \quad X \quad O_2$ (Fouché *et al.* 2011:148).

The researcher and study supervisors interviewed Dr Grosser from the NWU who had previously used the Cornell Critical Thinking Test and WGCTA in studies conducted with pre-service teachers in South Africa. From her experience, Dr Grosser (2018) recommended that the WGCTA would be the best-suited test instrument for this study. After an extensive search, the researcher managed to negotiate a favourable arrangement with the company, Pearson TalentLens in the United Kingdom, to use the WG³CTA as test instrument. The consultant at Pearson TalentLens arranged for permission for the researcher to use the test instrument free of charge after they had reviewed the initial research proposal. The researcher made arrangements with the consultant for the pre- and post-test.

The WG³CTA is an online version which is administered through the online testing platform of Pearson TalentLens (*cf.* 2.6.3). It is an internet-based testing system that is designed to administrate, score and report the assessment (Watson & Glaser, 2018:6). The consultant from Pearson TalentLens sent the researcher an access code for 65 entries for the pre-test and again for the post-test. The tests were completed under the supervision of the researcher in the computer centre at the institution. The pre-test was completed on the 24th of January 2019 during the third-year pre-service teachers' registration-day at the institution. The contact sessions for the semester commenced on 1 February 2019. An additional opportunity was given to participants to complete the pre-test on Wednesday, the 6th of February. The post-test was completed on the day of the last tutorial session, 17 and 18 May, with an additional opportunity on Wednesday, 21 May 2019. The consultant from Pearson TalentLens sent the summary of the results in an *Excel* spreadsheet to the researcher on completion of the two tests.

3.6.1.2 PBL questionnaire

The structured questionnaire survey that was used in this study consists of 45 items. This instrument was introduced to explore the pre-service ESD teachers' experience of PBL. The survey is the most common instrument that is used in a non-experimental design (Maree & Pietersen, 2020b:193), which was followed for applying the instrument in this study (*cf.* 1.6.5.1.1).

The supervisors referred the researcher to the 43-items PBL questionnaire survey that was developed by Golightly and Munich (2013:6). It was developed by the researchers to determine the PBL experience of pre-service teachers in Geography at the NWU. The PBL questionnaire consists of three sections, namely the PBL experience in general, the PBL process and the PBL role players. The sub-section about the PBL role players focusses on the tutor, the group leaders and the group members.

Three minor changes were made to adapt the PBL questionnaire for the participants in this study (*cf.* Annexure E). It included dividing one question about group leaders into two questions, replacing *Geography* with *other third- and fourth-year modules* and adding an additional question regarding CT skills. As discussed in Chapter 1 (*cf.* 1.6.5.1.1), the researcher furthermore adapted the paper-based questionnaire to an electronic version to be completed online. The PBL questionnaire was created on *Google Forms* and a copy of the adapted PBL questionnaire is available for reference². The online version of the PBL

² A copy of the adapted PBL questionnaire is available for reference at <https://forms.gle/vBJskGc5Brbqznyy6>

questionnaire consists of the 45 items in the three sections mentioned. It also uses the five-point Likert scale responses, namely strongly disagree, disagree, neutral, agree and strongly agree. This scale, developed by Rensis Likert in 1931, attempts to improve the measuring levels by using standardised response categories (Babbie, 2016:175). These categories measure the relative intensity of the items in the survey questionnaire.

The participants completed the online PBL Questionnaire together with the WG³CTA on 17 and 18 May, with an additional opportunity on Wednesday, 21 May 2019. The researcher downloaded the participants' responses as an *Excel* spreadsheet after completion.

The advantage of using an electronic survey is that the data is recorded into an electronic database and the results are available immediately (Delpont & Roestenburg, 2011:189). This eliminates making mistakes as in the case of recording results from a paper-based survey. A disadvantage is, however, that, for validation purposes, there is no paper trail available (Delpont & Roestenburg, 2011:190). The researcher assured the validation of this survey with the following arrangements. The participants signed the attendance register for the sessions in the computer centre. The researcher facilitated the sessions and was present for the entire duration of the sessions. The technical support personnel from the institution assisted the researcher to ensure internet connection and functionality of the computers. The study leaders checked and completed the electronic questionnaire beforehand to ensure that everything was in order.

This concludes the collection of the quantitative data set. Concurrently with the quantitative data, the qualitative data was collected, as explained in the research design (*cf.* 3.2.2.1). Collecting the qualitative data for this study is therefore discussed next.

3.6.2 Qualitative data collection

To collect the qualitative data, three data-gathering techniques were utilised and are discussed in the following paragraphs. The three techniques included reflective learning journals, semi-structured focus-group interviews and observational field notes by the tutor.

3.6.2.1 Reflective learning journals (RLJ)

The participants were instructed to complete a reflective learning journal (RLJ) to record their experiences of PBL in ESD during the course of the semester. Journal writing promotes reflection that is a process of self-examining our lives and experiences (Jado, 2015:89). The learning journal is a document that provides concrete evidence of a students' thought process and understanding (Jado, 2015:89; Engelbrecht, 2016:117). Bashan and Holsblat

(2017:2) for example used reflective journals as a research tool to explore pre-service teachers' development of teamwork. It gave the opportunity for lecturers to "*hear the voice of the students*" as they expressed their thoughts and challenges during the learning experience.

In this study, the pre-service ESD teachers were guided with six questions in the RLJ to enable them to reflect on their experiences for each of the four PBL activities (*cf.* Annexure G). The first five questions followed the reflective model developed by Graham Gibbs (Peter, 2016). It started with a description of what happened, followed by identifying and writing about the emotions that were experienced before, during and after the activity. The next step was the evaluation of the positive and negative aspects of the activity and the causes thereof. The fourth step involved drawing conclusions about what they could have done differently and what they had learned from the activity. The last step is to compile an action plan and make suggestions to deal with similar problems in the next activity. These five questions guided the participants to reflect on their experience of the PBL activity. The sixth question that was added guided the participants to reflect on the critical thinking skills they had developed whilst completing the activity.

The participants completed reflective journal entries after completion of each of the four PBL activities during the course of the semester. According to Engelbrecht (2016:117), it is advisable to record the reflection of the experiences as soon as possible. It also gives the researcher the opportunity to monitor the participants throughout the process. The RLJ was completed individually by the participants and then submitted to the lecturer on e-class on prescribed dates. The analysed reports of these journals are available electronically.

3.6.2.2 Focus-group interviews

Open-ended, semi-structured focus-group interviews were conducted to collect qualitative data from two of the twelve groups that were part of this study. The open-ended questions that were prepared for this study (*cf.* Annexure F) focussed on the research questions. It aimed to build a better understanding of the pre-service teachers' experience of PBL in ESD and the influence of PBL on the development of their CT skills.

Focus-group interviews are planned to achieve specific outcomes (Engelbrecht, 2016:114). In a focus-group, the participants are interviewed together (Babbie, 2016:314). Open-ended questions give the participants the opportunity to give their own answers to the questions asked (Babbie, 2016:249). According to Nieuwenhuis (2020b:110), focus-group interviews encourage group interaction that enhances a widening in the range of responses and allows

members to disclose information that might have been forgotten. During focus-group interviews, topics are discussed and debated within the group and in the process, group dynamics encourage data generation (Nieuwenhuis, 2020b:111).

Two groups were selected by the researcher through purposive sampling. This type of sampling selects the participants based on the researcher's judgement (Babbie, 2016:18). The two groups were chosen because they were a good representation of the twelve groups that were involved in this study. The Friday Group consisted of five group members who were all present for the interview. This group performed average to above average during the PBL activities and was chosen for their group dynamics. The Saturday group consisted of five members of whom one member was absent for the interview. This group was chosen for their excellent performance during the PBL activities.

The researcher chose a date and time convenient to the participants for the focus-group interviews. The dates chosen were during the examination period on days that the third-year pre-service teachers were on campus for examination. The time chosen was after the examination session. The Friday Group attended the interview on Monday 10 June from 11h30 to 12h40 and the Saturday Group attended the interview on Thursday 13 June from 11h30 to 12h50.

The researcher facilitated the interviews that were held in a meeting room on campus. The questions for discussion were presented one at a time on the presentation screen. The one-hour interviews were recorded digitally and then transcribed verbatim to enable the analyses of the data. According to Nieuwenhuis (2020a:135), transcribing the data is best done by the researcher and if a typist is used, it is important to brief the person. For this study, the researcher prepared the question-by-question format of the transcripts and completed the transcriptions of the first five minutes of both focus-group interviews. The typist continued and finished the transcriptions for the rest of the interviews, with clear instructions from the researcher. The transcription of the Saturday focus-group interview was shortened to remove repeated and irrelevant comments, as disclosed in the discussion of ethical aspects (*cf.* 3.9). The voice recordings and transcriptions of both interviews are available electronically.

3.6.2.3 Observational field notes

Nieuwenhuis (2020a:105) describes that observation involves the recording of the behaviour of the participants in a systematic way without necessarily questioning them. For

the purpose of this study, the researcher observed the participants' experience of PBL as teaching and learning strategy.

The researcher's observational field notes, available electronically, mainly focussed on monitoring and recording the progress of the groups whilst completing the PBL activities on *Google Docs* and *Google Slides*. The notes give a week by week account of the PBL activities completed by the tutor and the participants. Some of the comments made to the groups to guide and encourage them, were recorded. The necessary scaffolds that were applied by the tutor in the PBL process, such as proposed sources and additional written guidelines for the first PBL activity, were recorded (*cf.* 3.4). Notes were made about problems encountered, for example, correspondence received from participants. Classroom observation focussed on the participation and attitude of the participants during the tutorial sessions and the group presentations, which included comments made by participants regarding PBL.

This concludes the collection of the qualitative data set, which is presented as the first step of the research design (*cf.* 3.2.2.1). The second step concerns the analysis of the quantitative and qualitative data. The quantitative data analysis is discussed first, followed by the qualitative data analysis.

3.7 METHODS OF DATA ANALYSES

3.7.1 Quantitative data analysis

The results from the WG³CTA and PBL questionnaire on the *Excel* spreadsheets were processed by the Statistical Consultation Services of the NWU (Potchefstroom Campus). The letter of approval is included to confirm the reliability of the reported results (*cf.* p. iii).

The results from the two instruments were compared to the demographic information by means of *t*-tests, ANOVA's and Spearman's rank-order correlations. It includes reporting the means, standard deviation and effect size for each of the sections. According to Ellis and Steyn, (2003:53), it is recommended to report descriptive statistics together with effect size. The practical significance (effect size) makes the difference "*independent of units and sample size*" and also relates it with "*the spread of the data*" (Ellis & Steyn, 2003:52).

Convenience sampling was used to recruit the participants in this study (*cf.* 3.5). According to Ellis and Steyn (2003:51), statistical inference and *p*-values are not applicable for data obtained through convenience sampling since it is considered as small populations. The *p*-values are however reported for completeness sake. The results of the data for this study

can nonetheless not be generalised to the population. The data was analysed to give feedback on the experience of these specific participants.

The correlation between the CT pre-test and the post-test was calculated by means of paired *t*-tests to determine the influence of PBL on pre-service teachers' critical thinking skills. Descriptive statistical techniques were used to analyse the results from the PBL questionnaire to determine the pre-service' teachers experience of PBL. The descriptive statistics include the mean and standard deviation for each of the items in the PBL questionnaire.

This paragraph depicted the analysis of the quantitative data set. The two data sets were collected and analysed separately, according to the research design. Collecting and analysing the qualitative data set are discussed next.

3.7.2 Qualitative data analysis

The qualitative data set was analysed using the data-analysis software program *Atlas.ti*TM (cf. 1.6.5.2.2). For this study, the latest version, *Atlas.ti*TM8, was used. The integrated data set includes the participants' individual RLJ for each of the four PBL activities and the transcripts of the two semi-structured focus-group interviews. It includes a total of 193 documents, which are available digitally.

The process of analysing and reporting qualitative data is ongoing and iterative, which implies that it does not follow successive steps (Nieuwenhuis, 2020a:124). The data texts must be explored by reading and re-reading it to gain a clear understanding (Creswell & Plano Clark, 2018:213; Nieuwenhuis, 2020a:136). The data can then be coded. Coding the data is the process of allocating descriptive words or symbols to segments of data in order to retrieve all the data with the same thematic idea (Nieuwenhuis, 2020a:136) (cf. 1.6.5.2.2). Babbie (2016:328) defines it as the process of transforming raw data into a standardised form that is suitable for analysis. Following open-coding procedures (cf. 1.6.5.2.2), the researcher developed a code list for labelling the quotations from the RLJ and focus-group interview transcriptions. The code list report is available electronically and an example of one page of an RLJ with coding is included in Annexure H.

In reporting the quotations from the RLJ and interviews in Chapter 4, each comment is referenced according to the document number and number of quotations in the specific document. In some cases, the number of the activity is added. The reference (D19:5) for example means that it is document number 19 and it is the fifth quotation that was labelled in the specific document. The reference (Fem34.Act1) means this comment was made by

female participant 34 whilst completing the first PBL activity. All the quotations, labelling and references can be verified in the *Atlas.ti8* reports that are available electronically.

A detailed account of the analysed qualitative data is not reported in the fourth chapter since the scope of the qualitative data that was collected is too wide. For the purpose of this study, the qualitative data that corresponds with the quantitative data and contributes to answering the subsidiary research questions, is incorporated and reported.

The next paragraphs focus on the criteria to enhance the rigour of the results in this study.

3.7.3 Rigour in mixed methods research

Regarding the quantitative and qualitative data analyses, the following criteria were followed to uphold rigour.

3.7.3.1 Quantitative results

Validity of an instrument determines the extent to which the instrument measures what it intended to measure (Pietersen & Maree, 2020b:261). The evidence of the content validity, construct validity and criterion-related validity of the WG³CTA is published in the manual (Watson & Glaser, 2018:32-38) (*cf.* 2.6.3). The WG³CTA criterion validity furthermore pays attention to power versus speed, the fairness and group comparisons, which include male-female comparisons, ethnic origin comparisons, age comparisons, primary language comparisons and differential validity (Watson & Glaser, 2018:38-43). The validity and reliability of the WGCTA instrument in a South African context were also discussed in paragraph 2.6.3 of this study. The validity of the PBL questionnaire for use in South Africa with pre-service teachers was determined in the research compiled by Golightly and Muniz (2013:6) (*cf.* 1.6.5.1.1).

Reliability of an instrument implies that, if an instrument is used at different times or with different respondents that are from the same population, similar results should be obtained (Creswell & Plano Clark, 2018:217; Pietersen & Maree, 2020b:261). Evidence of the methods that were used to determine the reliability of the WG³CTA is also available from the manual (Watson & Glaser, 2018:27-31). It includes the internal consistency reliability of the test items, which refers to the Cronbach's alpha coefficient and split-half reliability, the test-retest reliability, which indicates the stability of scores over a period of time and the alternate forms reliability, which assures consistency of scores across alternate forms. The reliability of the PBL questionnaire for this study was determined by calculating the

Cronbach alpha coefficient and inter-item correlation, which is reported in the fourth chapter of this study (cf. 4.3).

3.7.3.2 Qualitative findings

Establishing trustworthiness of the qualitative data was obtained by focussing on credibility, transferability, confirmability and dependability.

Credibility aims to ensure that the findings correspond with reality and will be clear to the readers (Nieuwenhuis, 2020a:144). Credibility can be obtained through applying solid research methods and choosing a research design that will best answer the research question. In this study, the convergent parallel mixed methods research design allowed the collection and combination of quantitative and qualitative data that makes triangulation possible and enhances the credibility of the findings. The researcher furthermore attended a two-day advanced *Atlas.ti8* workshop at NWU to receive training in using the software program for analysing qualitative data (cf. Annexure A).

Transferability in this study was obtained by providing a thick description, which means that the reader is provided with a full and purposeful account of the participants and context of the study, which included a description of how the ESD module was designed. This should allow the reader to determine if the findings of this research are transferable to their experiences and context of research (Nieuwenhuis, 2020a:145).

Confirmability refers to the maintaining of neutrality to overcome bias or interest of the researcher, which means the findings of the research should be constructed from the participants' experiences and perceptions (Nieuwenhuis, 2020a:145). The "audit trail" can be valuable in this regard. The steps of the research can thus be traced and observed to assure confirmability. Relevant quotations from the participants' reflective learning journals and focus-group interviews were chosen to be reported in this study. These quotations were chosen to give examples of the topics that were identified from the qualitative data, which in turn correspond with the topic provided by the quantitative data. The full *Atlas.ti8* reports with quotations from the reflective learning journals for each of the four PBL activities and focus-group interviews are available electronically for verification.

Dependability is the preferred concept in qualitative research to refer to reliability and is closely related to credibility (Nieuwenhuis, 2020a:145). Dependability is achieved through the accurate procedures of implementation the research design. In this study, dependability was assured by means of peer reviewing. The *Atlas.ti8* code list and the reports with quotations from the reflective learning journals and focus-group interviews were peer

reviewed by the co-supervisor of this research study. The co-supervisor checked the coding process of the quotation that was completed by the researcher, to ensure that the coding was done correctly.

The final two steps in the convergent parallel design, the merging and interpretation of the data sets, receive attention in the following paragraph.

3.7.4 Merge and interpret the two data sets

Reporting and merging the analysed quantitative and qualitative data sets (step 3 of the research design) (*cf.* 3.2.2.1) are presented in Chapter 4 of this study. The fourth chapter uses the three subsidiary research questions as main framework. Firstly, the implementation of PBL in the module ESD is discussed (*cf.* 4.4). Secondly, the pre-service ESD teachers' experience of PBL is reported (*cf.* 4.5). The quantitative data from the PBL questionnaire is presented, followed by the qualitative data from the RLJ and focus-group interviews that correspond with the items from the PBL questionnaire. The qualitative data is thus integrated to give a broader and deeper interpretation of the participants' experience of PBL. Third and lastly, the development of critical thinking skills of the pre-service ESD teachers is discussed (*cf.* 4.6). The pre- and post-test results from the WG³CTA are presented, followed by a discussion of the relevant qualitative data that was retrieved from the RLJ and focus-group interviews. The differences and similarities from the two sets of data are identified and discussed. The final interpretation of the data, step 4 (*cf.* 3.2.2.1), is presented in Chapter 5 of this study (*cf.* 5.2).

The following discussion gives attention to the ethical considerations for this study.

3.8 ETHICAL ASPECTS

Ethical clearance for conducting this study was obtained from the North-West University's ethical committee as well as the steering committee of the institution where this study was performed (*cf.* 1.6.6; Annexure B).

The participants for the study were recruited during January 2019. All the third-year intermediate phase pre-service teachers received an email during the second week of January 2019 to invite them to attend the information session about the research study on the 24th of January 2019 and to complete the critical thinking pre-test. The information sessions took place when the pre-service teachers were on campus for the registration-day and an alternative date, 6 February 2019, was set for participants that could not attend on the 24th of January.

Dr M. Diedericks, a colleague at the institution, acted as gatekeeper. He facilitated the information sessions and explained the study to the pre-service ESD teachers. The pre-service teachers had the opportunity to ask questions and then sign the consent forms in which they gave their permission to voluntarily participate in the study (*cf.* Annexure D). The gatekeeper explained to the pre-service ESD teachers that, if they were not willing to participate in the study, they could still complete the module ESD and they could also withdraw from the study at any time without being penalised. The pre-service teachers who enrolled for the module ESD all gave their informed consent and completed the pre-test for the study. Informed consent, according to Babbie (2016:64), means that the participants give their voluntary participation in the proposed research project, based on a full understanding of the risks that it may involve.

The participants for this study included pre-service teachers and they were as a result seen as vulnerable participants, since the lecturer might exert influence on them. The researcher, who acted as lecturer or tutor for the module, was therefore not present during the information sessions and could on that account not influence or pressure the pre-service teachers to participate in the study. If any grievances occurred during the semester or if participants felt that they were unfairly treated, they could follow the procedures as outlined in the document Aros 101 (2018a:40), available to the participants on their online portal³.

The participants were informed that measures were implemented to ensure privacy and confidentiality. According to Maree (2020:48), the protection of participants' identities is a crucial ethical aspect of any research project. The researcher and assistant-tutor have access to the personal data of the participants but will not disclose any personal information about the participants or their participation. All data would be reported in a non-personal identifiable form. Participants would complete the various instruments using their student numbers instead of their names. The participants were numbered according to gender and are referred to accordingly when reporting the analysed data in Chapter 4, for example [Fem23] or [Male8].

All the data collected for this study is in electronic format and stored in electronic format only. It is stored on the researcher's computer that is password-protected and on the researcher's private network on the server at the institution and will be kept for a period of three years. Pearson TalentLens will store the WG³CTA results in accordance with the General Data Protection Regulation (GDPR). It is Pearson TalentLens' policy to store all

³ The link to the student portal is available at <https://www.aros.ac.za/Web>

test results for a period of six months. After this period, the results are made anonymous and then used for monitoring and research (cf. Annexure C).

There was no form of incentive and/or reimbursement offered to the participants. Pre-service teachers enrolled for the module ESD took part in the study whilst completing the module as part of their degree requirements. The advantage for the participants in completing this module was that they gained valuable experience in PBL, which is a student-centred teaching and learning strategy. They were also exposed to research, being part of this study. These experiences can be applied in their future education profession and personal studies.

3.9 DISCLOSURE FROM RESEARCHER

The quotations from the RLJ that were reported in Chapter 4 of this study had been translated by the researcher and placed together with the original quotation of the participants in Afrikaans. The researcher hereby discloses that the obvious spelling mistakes in the original Afrikaans quotations were corrected. The researcher hereby confirms that no words or sentence structures were changed or corrected, which means that the meaning of the sentences was not changed. No punctuation marks, translation, sentence structure or capitalisations were corrected. The spelling mistakes that were corrected included for example: *“aktwiteit / aktiwiteit – aktiwiteit, vroëer – vroeër, oor die algeen – oor die algemeen, voltooiing – voltooiing, assesstent – assistent, leerdowlwitte – leerdoelwitte, beswus - bewus”*. The reason for correcting the spelling mistakes was to improve the readability of the chapter.

The researcher furthermore discloses that the transcription of the Saturday focus-group interview was shortened, as mentioned in paragraph 3.6.2.2 of this chapter. The reason for the shorter version was that the lively discussion included a lot of repetition and at times the participants interrupted each other or talked together. This made it difficult to transcribe the interview at some instances. There are also sections where the participants elaborated on a topic that was not relevant for the purpose of this study. The shorter version, therefore, is more clear and easier to read and to analyse. The researcher confirms that no meaning was changed from what the participants answered or discussed during the interview. The original digital recordings are available electronically for confirmation or reference.

3.10 SUMMARY

An overview of the pragmatic research paradigm and the mixed methods research design were discussed in this chapter. The methodologies used for collecting and analysing the

data were also explored. The ethical considerations for this study were clarified and the compilation of the module ESD and the role of the researcher were explained. In the following chapter, the data analyses and the findings from the collected data are reported and discussed.

CHAPTER 4 RESEARCH RESULTS AND DATA ANALYSIS

4.1 INTRODUCTION

The research paradigm and the mixed methods research design were discussed in the third chapter of this study. This succeeding chapter focusses on presenting the analysed data of this study. Firstly, the analysed data of the participants is presented, after which the reliability of the PBL questionnaire is discussed. The remaining of the chapter focusses on reporting the analysed results of this study according to the three subsidiary research questions. The results of the analysed quantitative data are reported first, followed by the results of the analysed qualitative data, in order to give a broader understanding of the participants' experiences (*cf.* 3.7.4). The purpose of this analysis is to determine the influence of PBL on pre-service teachers' critical thinking skills in the module ESD.

4.2 DESCRIPTIVE STATISTICS OF THE PARTICIPANTS

The site and sample of this study was discussed in paragraphs 1.6.4 and 3.5 of this study. The descriptive statistics of the participants are presented and discussed in this paragraph. Descriptive statistics include different statistical methods that are used to summarise and organise data. The data can then be displayed in numerical ways or graphically (Pietersen & Maree, 2020c:226).

The gender structure and age structure of the participants is presented in the following two graphs (*cf.* Figure 4.1; Figure 4.2).

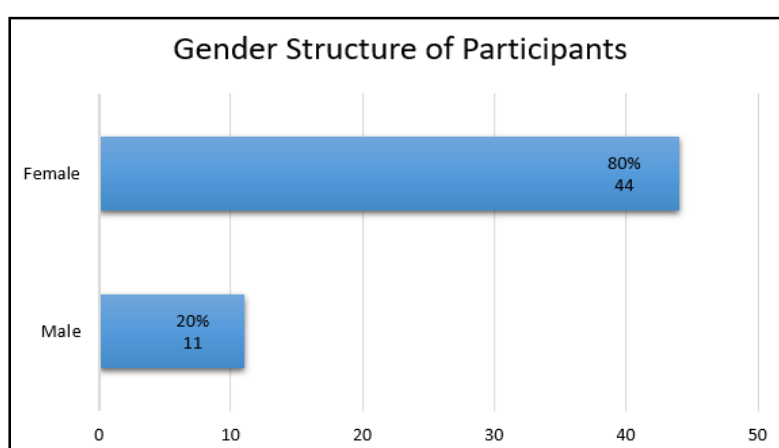


Figure 4.1: Gender structure of the participants

The medium of instruction at the institution is Afrikaans. Most of the participants are as a result, white Afrikaans first language speaking citizens. The demographic composition of

the participants ($n = 55$) consists of 44 (80%) female participants and 11 (20%) male participants (cf. Figure 4.1). Most of the participants, (42 or 76,4%) are between the ages 20-22 years; 11 (20%) of the participants are between the ages 23-26 years and 2 (3,6%) are between 40 and 50 years (cf. Figure 4.2). The participants were divided into 12 groups for taking part in the PBL activities by the researcher and assistant-tutor allocated for the module ESD. There were 6 groups respectively in the Friday and Saturday class groups (cf. 3.4).

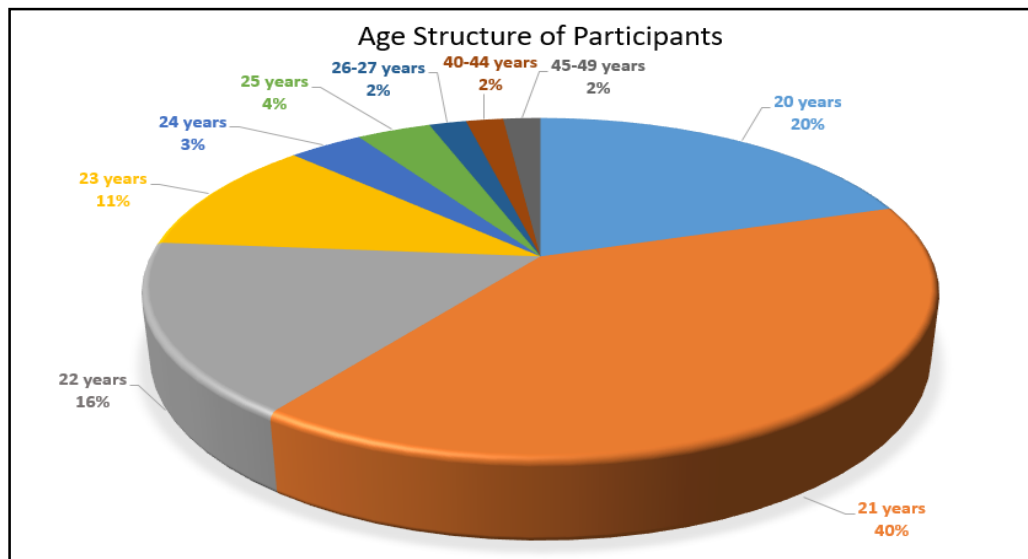


Figure 4.2: Age structure of the participants

Secondly, the reliability of the PBL questionnaire is discussed before presenting the analysed quantitative and qualitative data results of this study.

4.3 THE RELIABILITY OF THE PBL QUESTIONNAIRE

The reliability of the PBL questionnaire, as mentioned in paragraph 3.7.1, was determined by calculating the Cronbach alpha coefficient and inter-item correlation and are accordingly reported. According to Gliem and Gliem (2003:88) it is important to report the Cronbach alpha coefficient to determine the internal consistency reliability when using Likert-type scales. The Cronbach alpha coefficient measures the degree of similarity between the items, with 0.9 generally indicating a high reliability, 0.8 a moderate and 0.7 a low reliability (Pietersen & Maree, 2020b:261). According to Kline (cited by Field, 2009:675), values of even below 0.7 is acceptable in the case of ability tests since it measures a diversity of constructs.

Table 4-1: The Cronbach alpha values and mean inter-item correlation of the PBL questionnaire

Sections and subsections	Questions	Cronbach's Alpha	Mean inter-item correlation
General aspects of PBL Experience	1-8	0.88	0.48
PBL Process	9-21	0.82	0.28
Themes	9	*	
Problem delimitation	10	*	
Learning issues	11	*	
Collaborative learning	12-15	0.78	0.46
Independent learning	16	*	
Workload	17	*	
Study material	18-19	0.76	0.62
Assessment rubric	20-21	0.85	0.75
PBL Role players	22-45	0.89	0.28
Tutor	22-29	0.89	0.53
Group leaders	30-36	0.80	0.41
Group members	37-45	0.86	0.43
* Consist of one item, Cronbach's Alpha not applicable.			

The Cronbach alpha (α) that was calculated for the three subsections varied from 0.76 to 0.89 (Table 4-1). The three main sections of the questionnaire (*cf.* 3.6.1.2) have α -values of ≥ 0.8 . Five subsections from the section “PBL Process” consist of single items, namely themes, problem delimitation, learning issues, independent learning and workload, which were removed since the α -value is not applicable. The remaining subsections have α -values of ≥ 0.76 to ≥ 0.85 . The combined α -value of 0.82 for this section consisting of 12 items, is however consistent. The subsections from “PBL Role players” all have α -values of ≥ 0.8 . The Cronbach alpha coefficient range between 0 and 1. The closer to 1.0, the more consistent is the items. A coefficient of 0.8 is a reasonable indication of consistency according to Gliem and Gliem (2003:87). It can thus be concluded that the results from the PBL questionnaire, using a five-point Likert-scale, are reliable.

The remaining of this chapter focusses on reporting the analysed data according to the three subsidiary research questions. The first subsidiary question, regarding the implementation of PBL in the module ESD, is discussed next.

4.4 THE IMPLEMENTATION OF PBL IN ESD

The first subsidiary research question focusses on implementing PBL as teaching and learning strategy in the module ESD for the pre-service teachers at the institution.

The following synopsis set the background for the implementing of PBL in ESD at Aros (the institution for this study). Paragraph 3.4 indicates that the module ESD was introduced at the institution, involved in the research, during the first semester of 2019. This was the first module that implemented PBL as a teaching and learning strategy in the institution and are therefore the pre-service ESD teachers' first encounter with PBL. Paragraph 3.4 also indicated that measures were implemented to prepare the pre-service ESD teachers by introducing this new teaching and learning strategy. It included information about PBL in the study guide of the module and in a study letter, a PBL training video and a short introduction during the first contact session with the participants.

The blended learning model at the institution (*cf.* 3.4), allows contact with participants online during the week and face to face during the twelve contact sessions of the semester. As indicated in paragraph 3.4, the four PBL activities was completed in a three week cycle (*cf.* Table 3-1). The online *Google* platform was utilised to complete the PBL activities (*cf.* 3.4). The groups collaboratively completed the reports on *Google Docs* and prepared the class presentations on *Google Slides*. The self- and peer assessments were completed on *Google Forms*. The participants also formed *Whatsapp*-groups to assist with communication within their respective groups.

The case studies for each of the four PBL activities, as displayed in Table 3-2 and discussed in paragraph 3.4, are repeated briefly for a better understanding of the results. The first PBL activity concerns the importance of EE and implementing an environmental management system in schools. The second PBL activity tackled the problem of water pollution in a low-income settlement. The third activity confronts global warming and climate change issues and how every individual is responsible for his/her actions. The last activity challenged the pre-service teachers to implementing ESD in a specific subject. This activity was more practical and expected of the pre-service ESD teachers to plan and present a micro-lesson in addition to the report and presentation.

This concludes the discussion of the first subsidiary research question about the implementation of PBL in the module ESD. The second subsidiary research question concerns the participants' experience of PBL in the module ESD.

4.5 PRE-SERVICE TEACHERS' EXPERIENCE OF PBL IN ESD

The second subsidiary research question seeks to understand the pre-service teachers' experience of PBL as teaching and learning strategy in the module ESD. The quantitative results from the PBL questionnaire are firstly reported, followed by the qualitative results

from the participants' reflective learning journals (RLJ) and the focus-group interviews, to give a deeper understanding of the quantitative results.

It is not possible to discuss the full range of all the qualitative data that was collected in this study, since it would distract the focus from the main research question. To streamline the reporting of the data for the second subsidiary research question, the discussion of the quantitative data only focusses on the highest and lowest scoring items and not discuss all the items. The qualitative data that corresponds with each section of the PBL questionnaire is discussed and the rest of the data that was collected is not reported in this study.

The PBL questionnaire consists of three sections, namely the general aspects of PBL, the PBL process and the PBL role players (*cf.* 3.6.1.2). The general aspect of the PBL experience is discussed in the following paragraph.

4.5.1 Pre-service ESD teachers' experience of the general aspects of PBL

The first section of the PBL questionnaire consists of eight items and investigates the participants general experience of PBL as teaching and learning strategy. The descriptive statistical results of this section of the PBL questionnaire is reported in Table 4-2 and includes the percentages of the five-point Likert scale responses, the mean and standard deviation of the mean. The mean is calculated as the arithmetic average of the five-point Likert scale responses. The standard deviation indicated the spread of the distribution of the responses, or the mean distance from the arithmetic average and is calculated from the square root of the variance (Pietersen & Maree, 2020c:230).

Table 4-2: Pre-service ESD teachers' experience of the general aspects of the PBL experience

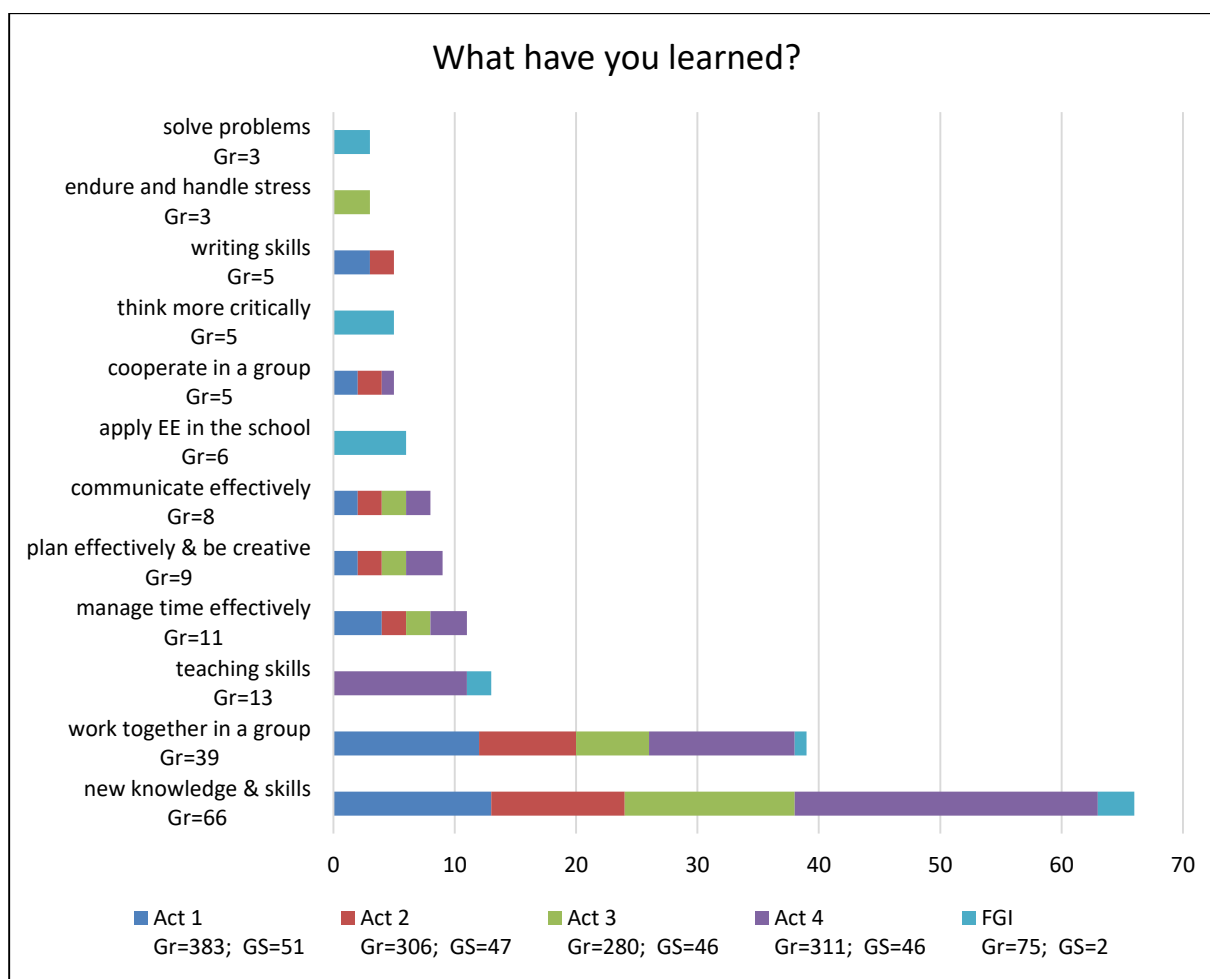
PBL Experience	strongly disagree	disagree	neutral	agree	strongly agree	mean	standard deviation
I mastered new knowledge through PBL.	0.0	3.7	20.4	44.4	31.5	4.04	0.823
I perceive problems as challenges.	1.9	5.6	25.9	40.7	25.9	3.83	0.947
The PBL activities developed my critical thinking skills.	0.0	7.4	37.0	35.2	20.4	3.69	0.886
The PBL experience was effective and meaningful.	1.9	9.3	33.3	35.2	20.4	3.63	0.977
Initially I was negative regarding PBL, but I became more positive as we progressed towards the solving of the problem.	3.7	13.0	24.1	37.0	22.2	3.61	1.089
PBL motivates me to learn.	7.4	9.3	40.7	33.3	9.3	3.28	1.017
I prefer PBL above the traditional lecture-based teaching strategies.	16.7	16.7	33.3	25.9	7.4	2.91	1.186
PBL should definitely be integrated in other third- and fourth-year modules.	27.8	14.8	22.2	24.1	11.1	2.76	1.386

From the eight items in the first part of the PBL questionnaire, six items scored high above average ($\bar{x} = 3.28$ to 4.04). More than 75% of the participants responded that they had mastered new knowledge through PBL. It is also the highest scoring item ($\bar{x} = 4.04$), followed by “*I perceive problems as challenges*” with a mean of 3.83 (*cf.* Table 4-2). The participants’ experiences of the development of their critical thinking skills (the third ranking item) are presented in paragraph 4.4 of this chapter.

Two items from the PBL questionnaire scored lower, but still have above average means. The item, “*I prefer PBL above the traditional lecture-based teaching strategies*”, scored in three equal parts: 34% of the participants recorded that they strongly disagreed and disagreed with the statement; 33% were neutral and 34% agreed and strongly agreed with the statement. The standard deviation of this item also indicates the widest spread, namely 1.4, compared to the seven other items, that range between 0.8 and 1.2. The item, “*PBL should definitely be integrated in other modules*”, scored a mean of 2.76 and 27.8% of the participants, i.e. strongly disagreed with the statement. This is the highest strongly disagree component from this section of the questionnaire. Despite this high strongly disagree component, 24% of participants still agreed and 11% strongly agreed that PBL should be integrated in other modules (*cf.* Table 4-2).

The qualitative data obtained from the semi-structured focus-group interviews and the participants' reflective learning journals (RLJ) for each of the four PBL activities, were coded in the scientific software analysis program *Atlas.ti*^{TM8} to identify trends (*cf.* 3.7.2). Two aspects that correlate with the items from the quantitative data are discussed in this paragraph (*cf.* 3.7.2; 4.5). The two aspects include what the participants had learned and comparing PBL to traditional strategies.

In the RLJ, the participants were guided to consider, amongst other, what they had learned whilst completing the PBL activities in the module ESD (*cf.* 3.6.2.1). In the software program, the responses to this question were categorised under the group code *learned*. From the responses, thirteen sub-codes were identified from the data about aspects the participants had learned. During the focus-group interviews, the participants were also questioned regarding new knowledge and skills gained whilst completing the module ESD that incorporated PBL. The thirteen aspects from the RLJ and focus-group interviews are presented in Figure 4.3. The graph in Figure 4.3 was compiled from the code-document table that was constructed in the *Atlas.ti* program. The code-document table is one of the analysing tools available in the software program. The graph illustrates the responses that were coded *learned* in the respective document groups. The five document groups include the four PBL activities and the transcriptions of the focus-group interviews (FGI). The graph thus presents the number of entries for each of the thirteen sub-codes in each of the document groups.



Gr	Groundedness of Codes (number of quotations coded by a code) or Documents (quotations created for a document)
GS	Number of documents in a document group or number of codes in a code group

Figure 4.3: Pre-service ESD teachers’ reflections about what they have learned from the PBL activities

Many of the participants responded for all the activities, but especially during activity 4, that they had learned new knowledge and skills. The participants indicating in the qualitative data that they had learned new knowledge (*cf.* Figure 4.3), correspond with the participants’ responses in the quantitative data, in which the highest ranking item from the PBL questionnaire states that they had mastered new knowledge through PBL (*cf.* Table 4-2). The participants also mentioned a high frequency of times that they had learned about group work. This aspect is discussed in paragraph 4.5.3.3 about the PBL role players.

The following two quotations from the RLJ substantiate that the participants had learned new knowledge. Participant [Fem9.Act1] reported in the RLJ that: *“It was good for me to complete the research on the topic of environmental education. I have learned a tremendous amount about the topic that I haven’t known before.”* (*“Dit was vir my baie goed gewees om navorsing te doen oor die onderwerp van omgewingsopvoeding. Ek het*

ongelooflik baie geleer oor die onderwerp wat ek nie voorheen geweet het nie", D40:2). Participant [Fem21.Act3] reported: *"My knowledge about climate change and global warming has certainly broadened."* (*"My kennis oor klimaatsverandering en aardverwarming het verseker verbreed"*, D111:2). She further commented: *"I now have the knowledge to persuade other people to make lifestyle changes. I was even able to persuade my family to apply some suggestions in and around the house."* (*"Ek het nou die kennis om ander mense te oordeel om 'n aanpassing in hulle leefstyle te maak. Ek het selfs my gesin kon oordeel om 'n paar voorstelle toe te pas in en om die huis...."* (D111:4).

The following quotations highlight some of the specific skills mentioned by the participants, whilst performing the PBL activities. Participant [Fem42.Act1] reported: *"I have gained more confidence as we progressed with this project."* (*"Ek het meer selfvertroue opgebou met die verloop van hierdie projek"*, D33:2). Participant [Fem12.Act4] commented: *"A skill I have learned is to creatively incorporate unusual learning content into the subjects offered at school. It taught me to think out of the box."* (*"'n Vaardigheid wat ek geleer het is om op 'n kreatiewe manier ongewone leerinhoud in te sluit op die vakke wat die skool aanbied. Dit het my geleer om uit die boks te dink"*, D148:4).

Several participants mentioned that the micro-lesson, as part of Activity 4 (cf. 3.4), had developed their teaching skills, for example Participant [Male5.Act4]: *"I also learned how to better plan a lesson by looking at other people's strategies of how they plan a lesson."* (*"... en ek het ook geleer hoe om 'n les beter te beplan deur na ander se strategieë te kyk van hoe hulle 'n les beplan"* (D187:6). Working together on the online document also improved their writing skills. Participant [Fem37.Act1] reported: *"It was beneficial to me to observe the other students' writing style and learn from them."* (*"Wat vir my goed was van die taak is om die ander studente se skryfstyl te kon sien en by hulle te leer"*, D37:2). These quotations and discussion thus confirm that the results from the qualitative data correspond with the quantitative data, in which pre-service teachers responded that they had mastered new knowledge through PBL.

The second aspect compares PBL to the traditional direct instructional strategies such as lectures and demonstration. The quantitative results from the PBL questionnaire indicate that the participants equally responded that they preferred, were neutral and did not prefer PBL as teaching and learning strategy. During both the focus-group interviews, all the participants however responded positively to the question that they preferred PBL above the traditional lecture-based teaching strategy in the module ESD. Responses to confirm these statements include the following two comments. Participant [Fem44], for example, answered: *"I think we learned a lot more from it because we had to investigate it ourselves,*

we weren't forced into a box. You could literally search as much as possible about the situation. ... I have learned more from it, rather than by just attending a class." ("Ek dink ons het baie meer daaruit geleer omdat ons dit self kon soek, ons was nie in 'n boksie gedruk nie. Jy kon letterlik soveel as moontlik gaan opsoek oor daardie situasie. ... ek het meer geleer uit dit uit as 'n vak waar ek net in die klas sit", D196:13).

Participant [Fem23] agreed and also responded favourably, but complained that the PBL activities were time consuming. She commented that PBL was a good teaching and learning strategy since you learned more from investigating the issues yourself. She however complained that, taking into consideration the amount of work they had to complete during the twelve weeks together with their other subjects, they had been put under a lot of pressure. She said it was a good strategy but they needed more time. (*"...dis 'n goeie strategie, want jy ervaar half die goed self en jy gaan vors dit self na, so daar is nie iemand wat voor in die klas staan en al die goed vir jou sê nie Maar iets wat vir my bietjie negatief was, was die hoeveelheid werk wat in die twaalf weke ingepas moet word, dit het druk gegaan saam met al die ander vakke*, D196:12). The time constraint and work load receive attention in the following paragraph (cf. 4.5.2).

This concludes the reporting of the data for the first part of the PBL questionnaire on the general aspects of the PBL experience. The next paragraph pays attention to the second part of the PBL questionnaire regarding the PBL process.

4.5.2 Pre-service ESD teachers' experience of the PBL process

The second section of the PBL questionnaire consists of 8 subsections and a total of 13 items. The descriptive statistics from the PBL questionnaire, including the percentages of the five-point Likert scale responses, the mean and standard deviation, are reported in Table 4-3.

Table 4-3: Pre-service ESD teachers' experience of the PBL process

PBL Process		strongly disagree	disagree	neutral	agree	strongly agree	mean	standard deviation
Workload	PBL enhances the workload of students.	1.9	7.4	18.5	20.4	51.9	4.13	1.082
Study material	PBL encourages the integration of different study materials (sources) to find solutions to problems.	0.0	3.7	14.8	50.0	31.5	4.09	0.784
	PBL enables you to identify the most important study materials from different resources.	0.0	7.4	16.7	48.1	27.8	3.96	0.868
Assessment rubric	The assessment rubric enabled group members to monitor their progress.	0.0	1.9	27.8	42.6	27.8	3.96	0.800
	The assessment rubric for the PBL report effectively guided the group in the writing of the report.	0.0	7.4	29.6	42.6	20.4	3.76	0.867
Collaborative learning	I had the opportunity to share my knowledge with the other students.	0.0	3.7	20.4	51.9	24.1	3.96	0.776
	My interaction with fellow students enabled me to judge or value the views of my fellow students.	1.9	11.1	24.1	46.3	16.7	3.65	0.955
	I find it to be effective when fellow students assist me with the mastering of skills and knowledge.	3.7	9.3	35.2	33.3	18.5	3.54	1.023
	I experienced quality interaction with fellow students in terms of learning.	7.4	11.1	40.7	29.6	11.1	3.26	1.049
Themes	The themes studied during the PBL activity was very interesting.	0.0	5.6	31.5	48.1	14.8	3.72	0.787
Independent learning	PBL will definitely assist me in becoming an independent, life-long learner.	0.0	9.3	35.2	44.4	11.1	3.57	0.815
Learning issues	The group easily identified the learning outcomes (learning issues) to solve the problem.	7.4	5.6	22.2	51.9	13.0	3.57	1.039
Problem delimitation	The delimitation of the problem is difficult.	5.6	25.9	29.6	29.6	9.3	3.11	1.076

The highest scoring item from the 13 items in this section is *workload* with a mean of 4.13. More than 70% of the participants agreed that PBL enhanced their workload. The participants responded that PBL encouraged them to integrate ($\bar{x} = 4.09$) and identify ($\bar{x} = 3.96$) different study materials, a skill that many undergraduate students struggle with. The remaining five subsections also scored favourable, with means that range between 3.57 to

3.96 for the separate items. Regarding the assessment rubric, the item *“the assessment rubric enabled group members to monitor their progress”* scored a mean of 3.96. The highest item regarding collaborative learning, also with a mean of 3.96, was: *“I had the opportunity to share my knowledge with the other students”*.

The lowest mean score ($\bar{x} = 3.11$) is for an item that is a negative statement, namely *“the delimitation of the problem is difficult”*. More than 30% of the participants disagreed with the statement and 38% agreed, which confirms that many of the participants found it difficult (cf. Table 4-3). The standard deviation of all the items ranges between 0.8 and 1.0, indicating a low distribution or variation of the data from the mean.

Different aspects emerged from the participants' responses in the reflective learning journals (RLJ) that correlate with the items in the second section of the PBL questionnaire. As explained previously (cf. 3.7.2; 4.5), the relevant qualitative data is reported in relation to the quantitative data to give a broader understanding. The discussion of the qualitative data therefore focusses on three aspects, which include the positive and negative aspects of the PBL process experienced by the participants, the problems encountered and the solutions proposed.

In the RLJ, the participants were instructed to evaluate on the positive and negative issues they experienced whilst completing the PBL activities (cf. 3.6.2.1). The comments from the participants were labelled with the descriptive codes *positive* or *negative* together with the aspects that was mentioned. Figure 4.4 illustrates the aspects that were identified and coded *PBL process* and the code *themes* refer to the four PBL activities. The graph was constructed from the code co-occurrence table that was created in the *Atlas.ti* program. It presents the number of times the codes *PBL process* and the code *themes* co-occurred with the descriptive codes *positive* or *negative*.

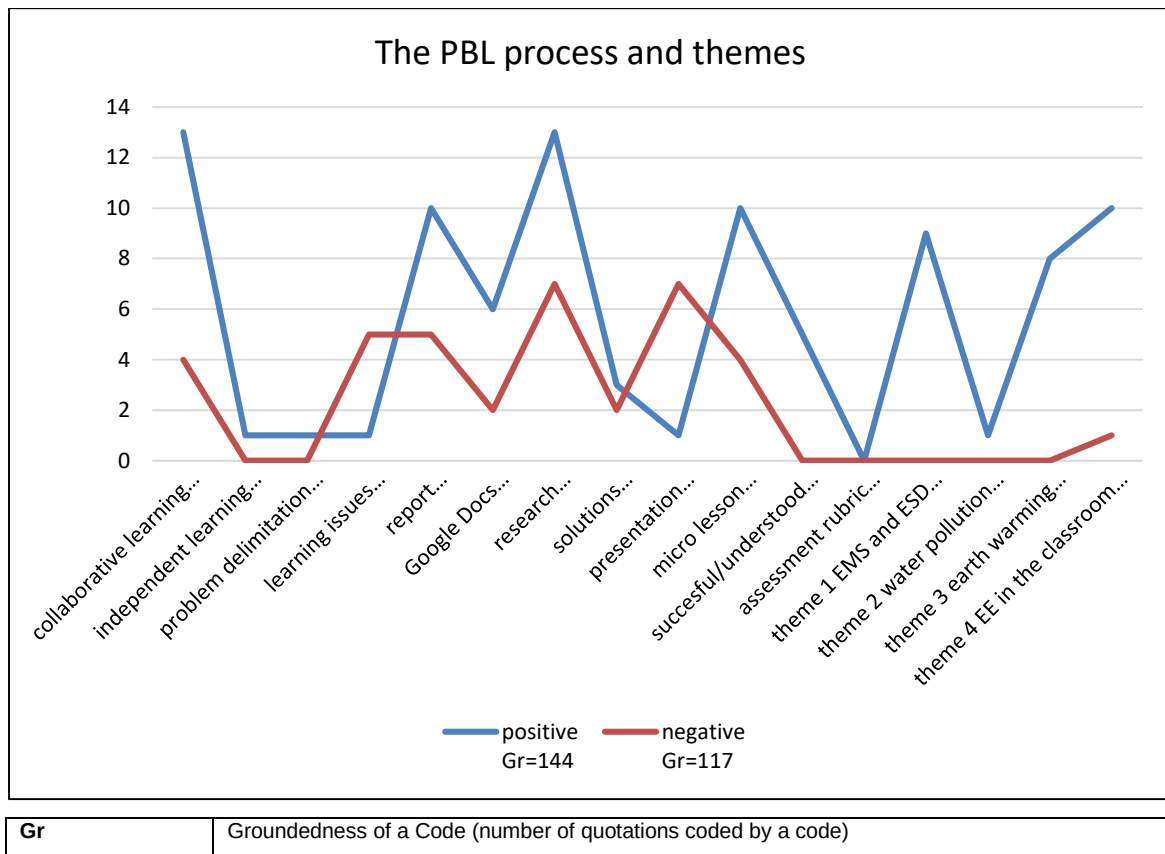
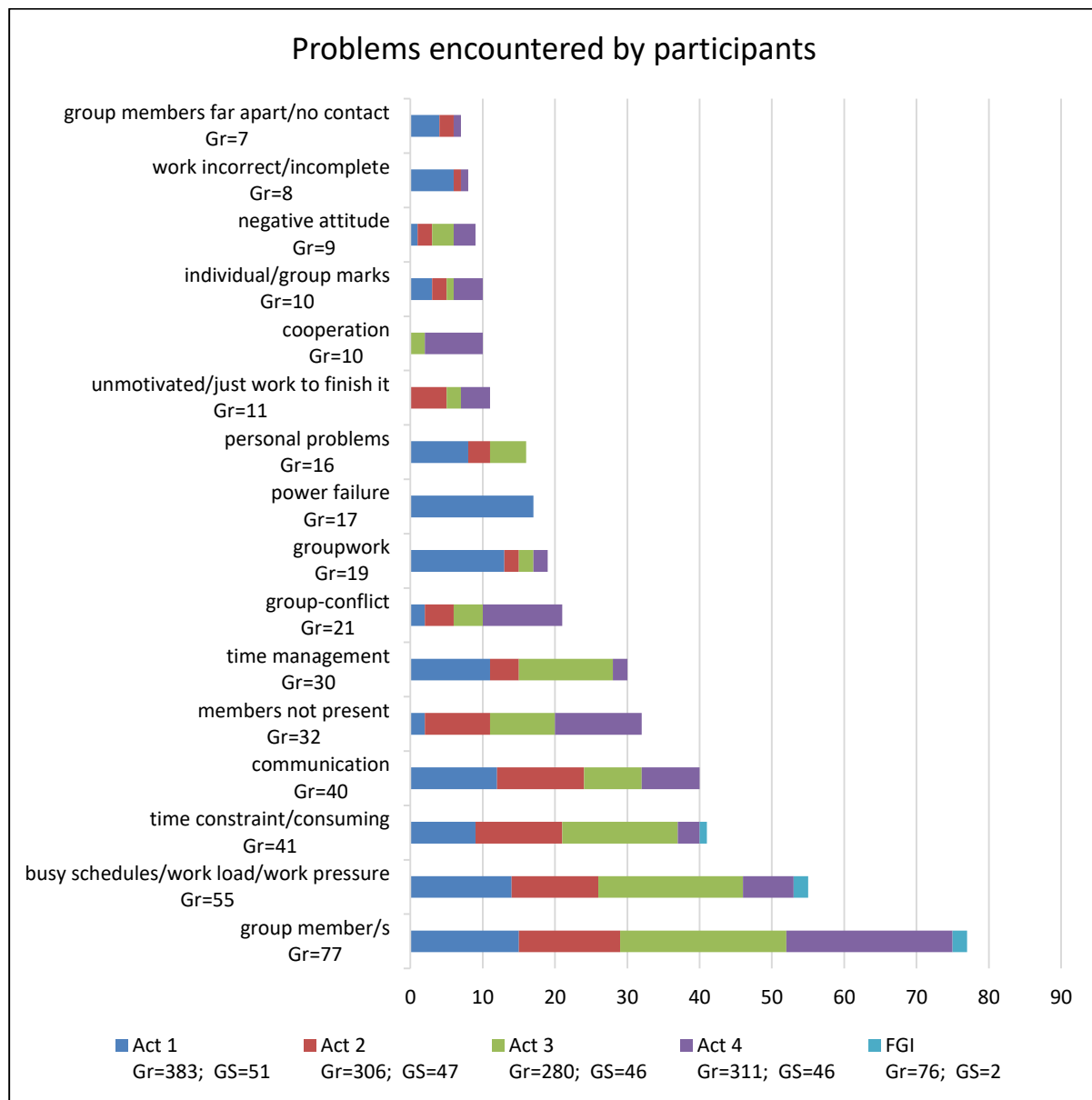


Figure 4.4: The positive and negative responses of the pre-service ESD teachers regarding the PBL process and the themes investigated

Collaborative learning was recorded as one of the most positive experiences (*cf.* Figure 4.4) and concurs with the findings of the quantitative results, in which collaborative learning is indicated as the third highest item in the PBL questionnaire (*cf.* Table 4-3). Participant [Fem23] for example commented that she enjoyed working together and sharing ideas (*“Ek het dit geniet om saam met die groep te werk en ons idees met mekaar te kon deel”*, D15:6). The participants were positive about the research they completed and the reports they compiled. They commented that they felt proud of their work and achievement. Some of the participants however mentioned it as a negative experience. They commented that it was difficult to find sufficient academic sources to complete the activities. The participants perceived the micro-lesson and the themes that were investigated in the PBL activities as positive experiences (*cf.* 3.4). Many participants reflected that they enjoyed the themes and found it interesting. Identifying the learning issues and doing the class presentations are two aspects that were mentioned as negative experiences. For some of the participants it was difficult to do the presentation in front of the class. These responses correspond with the quantitative data, in which collaborative learning also scored a higher mean, whilst identifying the learning issues scored a lower mean (Table 4-3).

In addition to the above-mentioned aspects, the participants mentioned a variety of problems they encountered as they reflected on completing the PBL activities. The problems were coded and 16 problems emerged under the group code *problems*. The results are illustrated in Figure 4.5. This graph was compiled from the *Atlas.ti* code-document table. It presents the number of occurrences of the 16 sub-codes *problems* in the four document groups, which are the four PBL activities.



Gr	Groundedness of Codes (number of quotations coded by a code) or Documents (quotations created for a document)
GS	Number of documents in a document group or number of codes in a code group

Figure 4.5: The problems encountered by the pre-service ESD teachers in completing the PBL activities

The most frequent problem encountered by the participants concerns the group members and is discussed in paragraph 4.5.3.3 about PBL group members. The second most frequent problem mentioned by the participants in the RLJ, concerns the workload of PBL. This correlates with the quantitative results from the PBL questionnaire in which more than 50% of the participants very strongly agreed that “*PBL enhances the workload of students*” (cf. Table 4-3). The participants commented in the RLJ that their schedules were very full and that they experienced a lot of work pressure. In conjunction with that, many participants commented in the RLJ that completing the PBL activities were very time consuming. Participant [Fem27.Act1] commented that she was employed full time as an assistant-teacher at a primary school. She was furthermore responsible for extra-curricular activities and only arrived home after 5pm. It was challenging to tend to all her study responsibilities and still make a success of everything, especially when it came to group work (“... *Vir my as assistent onderwyser by Laerskool X wat elke dag van 06:45 – 13:45 werk en daarna RO, Netbal en Revue moet afrig, raak mens se ure maar min as ek eers na 17:00 by die huis kom. Dus is dit moeilik om by alles uit te kom en ’n sukses daarvan te maak, veral as dit groepswerk is*” [sic], (D18:7).

A further time constraint during the first two weeks was the nationwide electricity shortages, resulting in phase two and three load shedding. The electricity shortage was the highest occurring problem encountered during Activity 1 (cf. Figure 4.5) and caused frustration amongst the participants who struggled to complete the first report in time. The third activity, which was completed during week seven to nine, was also very challenging for the participants. They were completing their work integrated learning (practical education period) at schools and had to prepare and present lessons and an assessment lesson. The participants commented about the time constraint and busy schedules, as evident from Participant [Fem39.Act3]. She wrote that they had a few other projects to hand in as well and that she felt overwhelmed at times and struggled to keep her head above the water (“*Met die PRAK-tydperk wat begin het, en al die ander opdragte wat die afgelope paar weke moes ingehandig word, het ek ten tye oorlaai gevoel en gesukkel om kop bo water te hou. Dit was beslis een van die rofste paar weke van die jaar*” [sic], D127:2). These comments and discussion from the qualitative data thus confirm the quantitative data regarding the workload of PBL.

The pre-service ESD teachers were also prompted in the RLJ to propose solutions to their problems. This guideline formed part of the action plan and encouraged the participants to formulate possible solutions for the problems they encountered whilst completing the PBL activities (cf. 3.6.2.1). The solutions that were proposed by the participants, are presented

in Figure 4.6. This graph was compiled from the data extracted from the *Atlas.ti* code-document table that includes the code *solutions* in the four document groups.

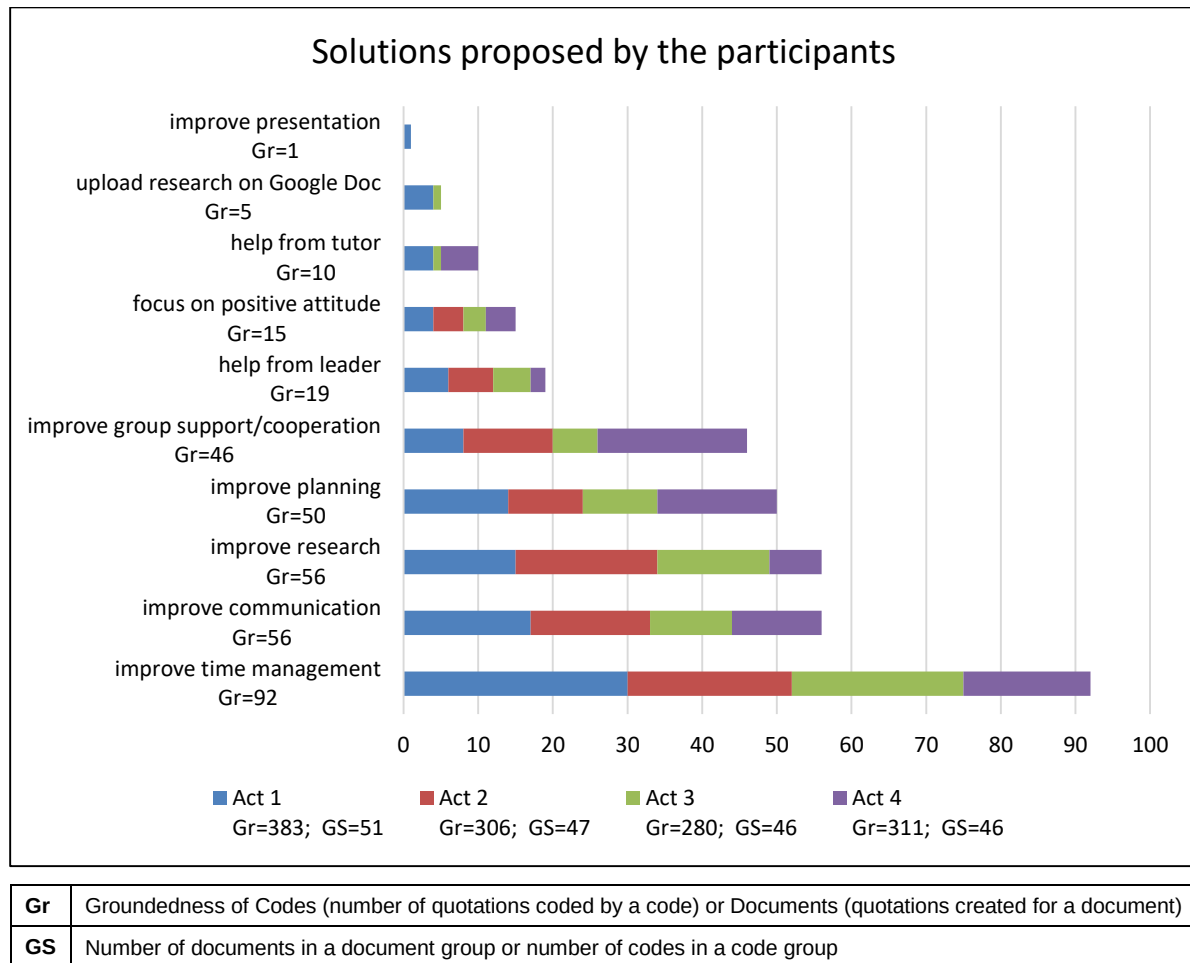


Figure 4.6: The solutions proposed by the pre-service ESD teachers whilst completing the PBL activities

In the RLJ, the highest occurring solution proposed includes time management. The participants had limited time available during the week to attend to all the academic obligations. They suggested repetitiously that they should plan their time better. The second highest solution proposed concerned measures to improve the research. Most of the participants commented that they could have used more sources and expanded their section on the report. Solutions for improving communication, better planning and supporting each other were also suggested. The participants realised that it was important to upload their research on the online document as soon as possible. This would have enabled the group to work more effectively and prevent group members from writing repetitive information, as mentioned by Participant [Fem20.Act2] (*“Ek dink hoe ons hierdie keer die taak aangepak het dat almal dadelik op Google Docs werk is die beste, want toe*

kon ons sien wie wat skryf en is niks dubbeld geskryf nie. Ek sal hierdie keer net probeer om my goed vroeër op te laai”, D63:4).

This concludes the discussion about the second section of the PBL questionnaire regarding the PBL process. The next paragraph elaborates on the PBL role players.

4.5.3 Pre-service ESD teachers' experience of the PBL role players

The third section of the PBL Questionnaire consists of three subsections. In the PBL environment, the lecturer acts as tutor to facilitate tutorial sessions and guide participants through the learning process (*cf.* 2.5.1.4). Pre-service teachers act as members of a group in the PBL environment under the leadership of a chairperson who acts as the group leader. Although different roles may be delegated to group members, the questionnaire only focussed on group leaders and group members as the two main roles (*cf.* 3.6.1.2).

4.5.3.1 Pre-service ESD teachers' experience of the tutor

The first subsection on role players focussed on the tutor. The descriptive statistics of the eight items are presented in Table 4-4 and include the percentages, mean and standard deviation.

Table 4-4: Pre-service ESD teachers' experience of the tutor in the PBL environment

PBL Role Players - tutor	strongly disagree	disagree	neutral	agree	strongly agree	mean	standard deviation
The tutor allowed the students self-discovery.	0.0	0.0	20.4	35.2	44.4	4.24	0.775
The tutor treated all students as equals and promotes an atmosphere of mutual respect.	0.0	7.4	7.4	40.7	44.4	4.22	0.883
The tutor was available to assist students outside of scheduled contact classes.	0.0	1.9	20.4	37.0	40.7	4.17	0.818
The tutor encouraged the students to accept responsibility for individual and collective learning.	0.0	0.0	22.2	40.7	37.0	4.15	0.763
The tutor gave constructive feedback to individuals and to the group as a whole.	0.0	5.6	13.0	46.3	35.2	4.11	0.839
The tutor guided the group by stimulating well thought-out discussion.	0.0	9.3	29.6	33.3	27.8	3.80	0.959
The tutor facilitated participation by all group members.	0.0	14.8	29.6	22.2	33.3	3.74	1.085
The tutor maintained a non-authoritative role during tutorial sessions.	5.6	14.8	25.9	33.3	20.4	3.48	1.145

The overall response of the participants regarding the conduct of the tutor during the PBL process is very positive, with 5 items scoring a mean above four. On average, 80% of the participants agreed and strongly agreed that the tutor allowed the participants self-discovery ($\bar{x} = 4.24$) and treated all the participants equally and with respect ($\bar{x} = 4.22$). Although most of the participants (56%) responded that the tutor facilitated participation, 15% of the participants did not agree. For the last item, 20% of the participants reported that they perceived the tutor as authoritative during the tutorial sessions, whereas 54% reported that the tutor was non-authoritative (cf. Table 4-4). The standard deviation for the items ranges between 0.76 and 1.15. The low standard deviation (ranging from 0.8 to 1.1) indicates that the values of the responses are close to the mean.

The following comments made by participants in the RLJ confirm the quantitative data. Participant [Male10.Act2] for example wrote about the tutor: *"I appreciate the help, advice and commendation from our lecturer during feedback on our Google Docs and Google Slides – it keeps you motivated."* (*"Ek waardeer die hulp, raad en aanprysings vanaf ons dosent tydens die terugvoer op ons Google Docs en Google Slides – dit hou mens gemotiveerd"*, D91:1).

During the focus-group interviews, both groups confirmed that the guidance from the tutor on the online document was very helpful and encouraging. Participant [Fem13] commented: *"Because you could have seen right away you might have to do it differently ..."* (*"Want jy kon dadelik gesien het dalk moet jy dit anders doen...."*, D197:22) and participant [Fem32] responded with: *"It was nice to see that the tutor didn't just give us the assignment and then just left us on our own."* (*"Dis lekker om te sien dat Mevrouw nie net vir ons die taak gee en ons dan net los nie"*, D197:23).

The following paragraph discusses the participants' experience of the PBL group leaders.

4.5.3.2 Pre-service ESD teachers' experience of the group leaders

The second subsection in the PBL questionnaire regarding the role player, concerns the group leaders. The descriptive statistics, including the mean and standard deviation of the seven items, are presented in Table 4-5.

Table 4-5: Pre-service ESD teachers' experience of the group leaders in the PBL environment

PBL Role Players – group leaders	strongly disagree	disagree	neutral	agree	strongly agree	mean	standard deviation
The group leader treated all the group members with the necessary respect in all the PBL activities.	1.9	1.9	7.4	37.0	51.9	4.35	0.850
The group leader performed his/her duties effectively.	0.0	1.9	18.5	37.0	42.6	4.20	0.810
The group leader encouraged group members to share their own opinions during group discussions.	0.0	3.7	18.5	37.0	40.7	4.15	0.856
The group leader involved group members in meaningful discussions and communications.	1.9	5.6	13.0	44.4	35.2	4.06	0.940
The group leader delegated the learning tasks.	3.7	5.6	11.1	44.4	35.2	4.02	1.019
The group leader did not contribute anything to the group activities.	57.2	16.7	9.3	9.3	7.4	1.93	1.315
The group leader forced his opinions and views onto group members.	63.0	20.4	7.4	1.9	7.4	1.70	1.176

Five of the seven items scored a mean above four, stating that the group leaders in the different groups treated members with respect ($\bar{x} = 4.35$) and they performed their duties effectively ($\bar{x} = 4.20$). The last two items scored very low but were negative statements. For the item *“leaders didn’t contribute anything to the group activities”*, 74% of the participants disagreed and for the item *“leaders forced his/her opinions and views onto group members”*, 83% participants disagreed (cf. Table 4-5). The standard deviation ranges between 0.8 and 1.3.

The qualitative data from the RLJ and focus-group interviews confirms the quantitative data. There were very few negative comments made about the group leader, compared to the many positive comments. Participant [Fem16.Act2] for example commented: *“I am disappointed in our group leader because he is one of those that did very little and just believed that everything is in order”* (*“...ek is teleurgesteld in ons groepleier want hy is een van die wat min gedoen het en net glo als is okay [sic], D58:2*).

Participant [Fem28.Act1] reflected in the RLJ that their group leader was an excellent leader (D19:8) and confirmed it during the interview: *“I think if she had been absent, our group would have fallen apart. She really was like our corner stone. She did more than what was expected from her.”* (*“Ek dink as sy nie daar was nie, het die groep uitmekaar geval. Sy was soos ons ‘corner stone’, regtig. Sy het meer gedoen as wat daar van haar verwag is [sic]”, D196:19*). The participants also commented that the group leaders successfully guided their groups, for example Participant [Male10.Act4] wrote: *“Our group leader has honestly always*

kept everyone informed of what has to be done”. (“Ons groepleier het eerlikwaar altyd almal op hoogte gehou van wat gedoen moes word...”, D183:1).

The discussion about the PBL role players lastly focusses on the group members.

4.5.3.3 Pre-service ESD teachers’ experience of the group members

The third and last subsection of the PBL questionnaire regarding the PBL role players concerns the group members. The descriptive statistics of the analysed data are presented in Table 4-6 and include nine items. It focusses on the participants’ experience to function as a member of a group.

Table 4-6: Pre-service ESD teachers’ experience of the group members in the PBL environment

PBL Role Players – Group members	strongly disagree	disagree	neutral	agree	strongly agree	mean	standard deviation
Group members exhibited respect and understanding for one another’s opinions and views.	1.9	7.4	20.4	44.4	25.9	3.85	0.960
All group members reached out to one another to realise the outcomes on or before due dates.	1.9	11.1	27.8	24.1	35.2	3.80	1.105
The group members got on well together.	3.7	3.7	38.9	40.7	13.0	3.56	0.904
The PBL activities helped me to foster good interpersonal relationships with my fellow students.	9.3	9.3	24.1	35.2	22.2	3.52	1.209
Group members helped me to understand the necessary concepts, ideas and study content towards the problem solution.	3.7	11.1	40.7	25.9	18.5	3.44	1.040
The group listened to the concerns of the individual group members.	3.7	14.8	33.3	31.5	16.7	3.43	1.057
PBL enhances tension and frustration among students.	9.3	18.5	29.6	24.1	18.5	3.24	1.228
All group members were well prepared for the tutorial sessions.	9.3	20.4	33.3	29.6	7.4	3.06	1.089
Group members negatively influenced one another regarding PBL activities.	22.2	16.7	31.5	24.1	5.6	2.74	1.216

The item that scored the highest mean of 3.85 in this subsection is: “*Group members exhibited respect and understanding for one another’s opinions and views*”. The participants responded that the group members reached out to one another ($\bar{x} = 3.80$) and got on well together ($\bar{x} = 3.56$). The lowest scoring item ($\bar{x} = 2.74$) was a negative statement and 30% of the participants agreed that group members influenced each other negatively and 39% of the participants disagreed with the statement (*cf.* Table 4-6). The standard deviation is low and ranges between 0.9 and 1.2.

The quantitative data illustrated in Figure 4.5 and mentioned in paragraph 4.5.2 highlights that the participants encountered problems with a group member or group members that did not fully cooperate with the group. Participant [Fem44.Act3] reflected about this: *“...it had a negative impact on me that all the members worked hard and there was one group member who did not do their part. This increased the workload of the other members, especially the group leader.”* (“Verder was dit vir my negatief dat al die lede hard werk en daar een groeplid was, wat nie hul deel gedoen het nie. Dit het die werkslading van die ander lede, veral die groepleier vermeerder”, D132:4).

Participant [Male10.Act4] however commented positively regarding his group members and reflected: *“Teamwork is essential when it comes to completing projects. By now we know where the strengths of the various group members are. We helped each other where necessary.”* (“Spanwerk is noodsaaklik as dit by die voltooiing van projekte kom. Teen hierdie tyd weet ons darem waar die verskillende groeplede se sterkpunte lê. Ons kom mekaar uithelp waar nodig”, D183:3).

Despite the comments regarding problems experienced with certain group members, there were more than double the amount of comments regarding group cooperation in the RLJ. In the quantitative data from the PBL questionnaire, most of the participants also favourably responded that group members respected each other, reached out to one another and that they got along.

In paragraph 4.5.1, graph Figure 4.3 illustrates what the participants had learned. The participants highlighted that they had learned to work together in a group. Two quotations that shed more light in this matter, include Participant [Fem42.Act4] that wrote: *“I have learned that conflict is part of any assignment that needs to be completed in a group context. It is inevitable but not insoluble. We as a group have grown from completing this activity.”* (“Ek het geleer dat konflik deel is van enige opdrag wat in groepsverband voltooi moet word. Dit is onvermydelik, maar nie onoplosbaar nie. Ons as groep het gegroei deur die afhandeling van die aktiwiteit”, D175:2); and Participant [Fem31.Act4] commented: *“Working together as a group during the 12 weeks has taught us to be more open to others’ opinions and the suggestions they have, it has also taught us how to accept others’ weaknesses and still incorporate them to complete the activity.”* (“Om as ’n groep saam te werk gedurende die 12 weke het dit ons geleer om meer oop te wees vir ander se opinies en die voorstelle wat hulle het, dit het ons ook geleer hoe om ander se swakhede te aanvaar en dit steeds te gebruik om die aktiwiteit te voltooi”, D166:3).

This concludes the discussion on the PBL role players, the last of the three sections from the PBL questionnaire. The gender and age differences of the participants receive attention in the next paragraph.

4.5.4 Gender and age differences in pre-service ESD teachers' experience of PBL

This part investigates the differences between the genders and age groups regarding their experiences of PBL in ESD as reported in the PBL questionnaire. The summary of the means, standard deviation and effect size for each of the sections and subsections in the PBL questionnaire is presented in Table 4-7. The effect size is a standardised, scale-free way of measuring the extent of the difference being tested and according to Pietersen and Maree (2020d:255), it is not affected by the sample size.

Table 4-7: Gender differences in pre-service ESD teachers' experience of the various aspects of PBL

Sections and subsections	Mean		Standard Deviation		<i>p</i> -value Sig. (2-tailed)	Effect Size
	Male	Female	Male	Female		
General aspects of PBL Experience	3.48	3.47	0.63	0.81	0.96	0.02
PBL Process	3.38	3.57	0.30	0.56	0.15	0.33
Themes	3.45	3.79	0.52	0.83	0.11	0.40
Problem delimitation	2.73	2.93	1.19	1.06	0.61	0.17
Learning issues	3.55	3.58	0.93	1.07	0.91	0.03
Collaborative learning	3.52	3.62	0.60	0.78	0.65	0.13
Independent learning	3.73	3.53	0.65	0.85	0.42	0.23
Workload	2.00	1.84	1.10	1.09	0.67	0.15
Study material	3.68	4.12	0.75	0.72	0.11	0.58
Assessment rubric	3.50	3.95	0.50	0.82	0.03	0.56
PBL Role players	3.54	3.89	0.47	0.55	0.05	0.64
Tutor	3.81	4.03	0.57	0.71	0.28	0.32
Group leaders	3.62	4.30	0.57	0.64	0.01	1.06
Group members	3.24	3.45	0.80	0.75	0.45	0.26

The differences between the male and female participants were practically significant for five items on the PBL questionnaire. According to Cohen's *d*-values, a value of $d = 0.2$ indicates a small effect, $d = 0.5$ a medium and $d = 0.8$ a large effect (Cohen, 1988:27-28). The themes ($d = 0.40$), study materials ($d = 0.58$), assessment rubric ($d = 0.56$) and PBL role players ($d = 0.64$) therefore indicate a medium effect, whereas group leaders ($d = 1.06$) indicate a large effect. This indicates that the female participants were more positive towards the themes, study material, assessment rubric and especially the group leaders as

role players, than the male participants. For the rest of the items, there were no differences between the male and female participants (*cf.* Table 4-7).

The Spearman's Rank-Order Correlation was used to compare the different aspects of the participants' experience of PBL with age. The results are reported in Table 4-8. The Spearman correlation coefficient is a non-parametric correlation coefficient that uses ranks instead of the actual values to calculate the distribution of two variables (Pietersen & Maree, 2020a:289).

Table 4-8: Spearman's rank-order correlation between the age differences of pre-service ESD teachers' experience of PBL

Age	Correlation Coefficient	p-value Sig. (2-tailed)
General aspects of PBL Experience	0.307*	0.024
PBL Process	0.154	0.265
Themes	0.284*	0.037
Problem delimitation	0.069	0.619
Learning issues	0.089	0.520
Collaborative learning	-0.021	0.881
Independent learning	0.261	0.056
Workload	0.227	0.099
Study material	0.200	0.148
Assessment rubric	-0.075	0.588
PBL Role players	0.085	0.540
Tutor	0.128	0.356
Group leaders	0.125	0.369
Group members	-0.084	0.544
* Correlation is significant at the 0.05 level (2-tailed).		
** Correlation is significant at the 0.01 level (2-tailed).		

According to the Spearman's Rank-Order Correlation (*cf.* Table 4-8), there was a significant correlation of .307 between PBL experience in general and age at the 0.5 level. A value of $r = 0.1$ indicates a small effect, $r = 0.3$ a medium and $r = 0.5$ a large effect (Cohen, 1988:81). This indicates that elder participants tended to be more positive towards the PBL experience in general than the younger participants. The elder participants were also more positive about the themes that were investigated in the PBL activities ($r = .284$ at the 0.5 level). Independent learning ($r = .261$) and workload ($r = .227$) were significant at the 0.1 level, indicating a medium relevance.

The second subsidiary research question investigated the pre-service teachers' experiences of PBL in ESD. The analysed quantitative data from the three sections of the

PBL questionnaire was presented, followed by the analysed qualitative data from the reflective learning journals and focus-group interviews. The third and last subsidiary research question concerns the critical thinking skills of the pre-service ESD teachers.

4.6 THE INFLUENCE OF PBL ON PRE-SERVICE ESD TEACHERS' CRITICAL THINKING SKILLS

The third subsidiary research question examines the influence of PBL on the development of the pre-service ESD teachers' critical thinking (CT) skills. The descriptive statistics and frequency variables from the Watson-Glaser³ Critical Thinking Appraisal (WG³CTA) are reported and discussed, followed by the qualitative data analysis from the participants' reflective learning journals (RLJ) and the focus-group interviews.

The participants' CT skills were measured before the ESD classes commenced for the semester, using the online WG³CTA as test instrument (*cf.* 3.6.1.1). During the semester, PBL was implemented as teaching and learning strategy in the module ESD (*cf.* 3.4). At the end of the PBL intervention, the participants' CT skills were measured again with the same instrument.

The descriptive statistics of the WG³CTA for the pre- and post-test results as well as the paired samples *t*-test results are presented in Table 4-9. The paired samples *t*-test compared the individual participant's pre-test results with their post-test results. The WG³CTA consists of five parts and a total of 40 multiple choice type of questions that are randomly chosen from the question bank for each participant (*cf.* 2.6.3; 3.6.1.1).

Table 4-9: The pre-service ESD teachers' WG³CTA pre- and post-test paired samples *t*-test results

	Pre-test				Post-test				<i>p</i> -value Sig. (2- tailed)	Effect size
	Mini- mum	Maxi- mum	Mean	Standard Deviation	Mini- mum	Maxi- mum	Mean	Standard Deviation		
Number correct (/40)	12	26	19.4 2	3.04	13	30	19.5 1	3.73	0.88	0.03
Percentile score	1	54	11.8 4	12.31	1	73	15.4 4	18.88	0.13	0.29
<i>t</i> -score	25	51	35.1 3	7.43	25	56	35.2 9	9.61	0.90	0.02
Recognition of assumptions	6.3	72.8	20.0	11.9	5.1	64,6	21.0	14.4	0.66	0.08
Evaluation of arguments	2.5	69.0	30.3	16.0	1.9	65,2	30.3	17.0	0.98	0.00
Drawing conclusions	1.3	70.9	20.6	15.5	1.9	86,7	22.7	19.9	0.49	0.14

The WG³CTA is a reliable test instrument, as discussed earlier in this study (*cf.* 2.6.3; 3.7.3.1) and therefore, the Cronbach alpha coefficient is not calculated and reported here.

The percentile scores for the 55 participants are between 1 and 54, with a mean of 11.8 for the pre-test. The *t*-score results compared the participants with the UK Population that was used as the norm group in the Pearson TalentLens data base. The *t*-score results are between 25 and 51, with a mean of 35.1. The percentile scores for the post-test are higher and range between 1 and 73, with a mean of 15.4. The *t*-score results are between 25 and 56, with a mean of 35,3 for the post-test (*cf.* Table 4-9).

The effect size of the percentile score ($d = 0.29$) in the paired samples *t*-test indicates a small effect. According to Cohen's *d*-values, 0.2 indicates a small, 0.5 a medium and 0.8 a large effect (Cohen, 1988:27-28) (*cf.* 4.5.4). A small relationship is however not considered practically significant (Ellis & Steyn, 2003:53).

The five parts of the WG³CTA are consequently divided into three subsections. The recognition of assumptions has a mean of 20 in the pre-test and a mean of 21 in the post-test. The evaluation of arguments' mean is the same between the pre- and post-test (30.3). The mean for drawing conclusions improved from 20.6 to 22.7. The effect size of the subsections however indicates no practically significant improvement.

The score band results for the pre- and post-test is presented in Table 4-10.

Table 4-10: The pre-service ESD teachers' WG³CTA score band results

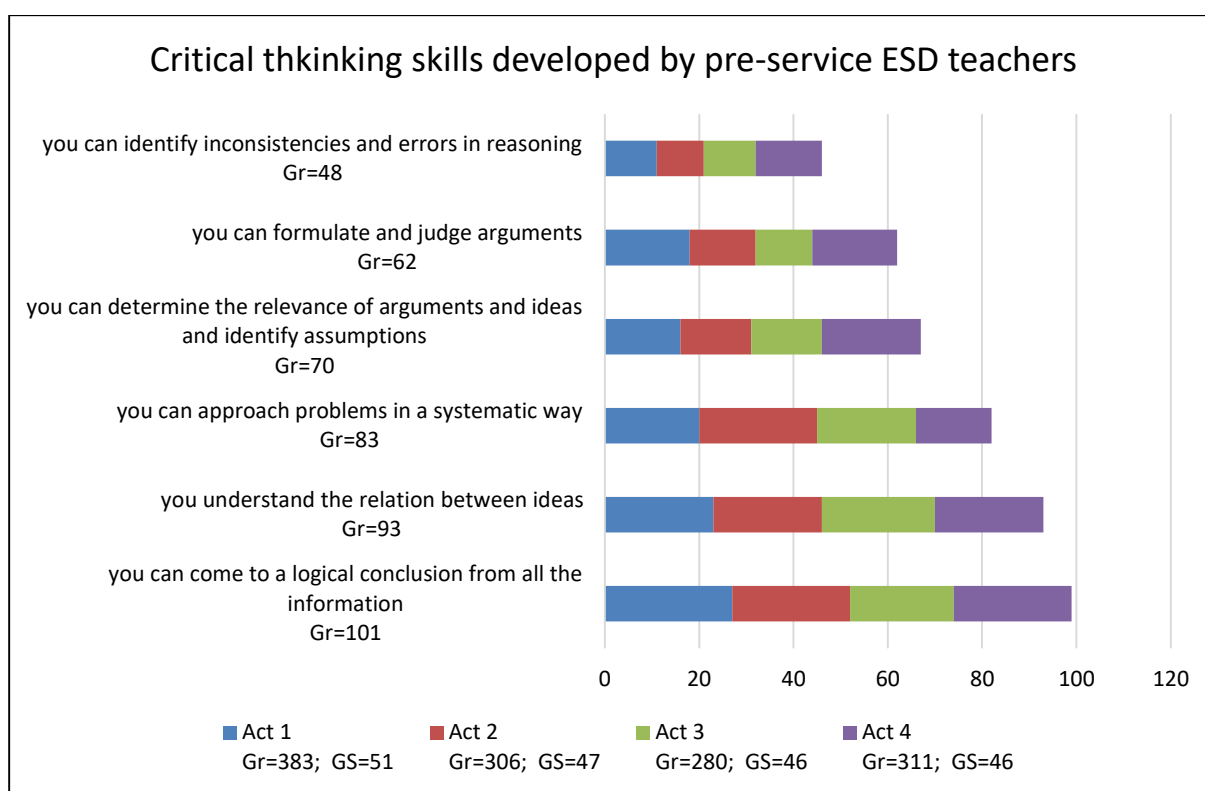
Score Band	Percentile score	Pre-test	Post-test
Well above average	91+	0	0
Above average	71-90	0	1
Average	31-70	5	11
Below average	11-30	25	12
Well below average	1-10	31	31

The score band results for the pre-test reveal that 31 participants scored well below average, 20 participants below average and 4 participants scored average. The score band results for the post-test show the same amount of participants scoring well below average, 12 participants scored below average, 11 participants average and one participant scored above average (*cf.* Table 4-10).

The descriptive statistics of the WG³CTA therefore indicate that the overall critical thinking appraisal of the participants did not improve. Although some individual participants

improved their scores, there were also participants who scored lower results in the post-test (*cf.* Table 4-9). The three sub-sections, namely recognition of assumptions, evaluation of arguments and drawing conclusions, also indicate no statistically significant outcome.

The results of the qualitative data however indicate that the pre-service ESD teachers perceived that their critical thinking skills had improved. The participants' experience regarding the development of their CT skills were recorded in the PBL questionnaire, the reflective learning journals and the focus-group interviews. Paragraph 4.5.1 reported the statistical results of the first part of the PBL questionnaire. The item: "*The PBL activities developed my critical thinking skills*", scored a mean of 3,69. It is the third highest item of the first section of the PBL questionnaire. More than 55% of the participants agreed and strongly agreed that their CT skills have improved, 37% were neutral and only 7,4% disagree with the statement (*cf.* Table 4-2). These results correspond with the responses from the RLJ for the four PBL activities. The RLJ guideline to reflect on the development of critical thinking skills gave the option to choose from six possible responses (*cf.* Annexure G). The six options in the RLJ were coded *in vivo* in the *Atlas.ti* program and are reported for the four PBL activities in Figure 4.7 that was compiled from the code-document table. Coding *in vivo* means that the direct quotation is used as a code.



Gr	Groundedness of Codes (number of quotations coded by a code) or Documents (quotations created for a document)
GS	Number of documents in a document group or number of codes in a code group

Figure 4.7: The responses from the pre-service ESD teachers regarding the development of their CT skills in completing the PBL activities

The three CT skills that are reported for being developed by most of the participants during the four PBL activities, are that they can “*come to a logical conclusion from all the information*”; they can “*approach problems in a systematic way*”; and they “*understand the relation between ideas*”. The CT skill that developed the least during the four PBL activities was that they can “*identify inconsistencies and errors in reasoning*”.

During the focus-group interview at the end of the semester, the participants responded with favourable remarks when asked if their CT skills had improved. As mentioned in paragraph 4.5.1 that discusses what the participants had learned, the participants perceived that their problem-solving and critical thinking skills had improved (*cf.* Figure 4.3). They verbalised their experiences as follows. Participant [Fem28] commented:

These PBL activities taught me not only to accept something, because many times you come across sources that looks true, but you still doubt it, so it encouraged me to get a second opinion and do some more reading before assuming that that was the correct answer. It helped me to think critically about a matter. (“Hierdie PGL-aktiwiteite het my geleer om nie net iets te aanvaar

nie, want baie keer het jy op bronne afgekom, dit klink waar, maar jy twyfel nog so bietjie, so dit het my aangemoedig om 'n tweede opinie te gaan kry en nog bietjie te gaan lees voor ek net aanvaar dit is die antwoord. Dit het my gehelp om bietjie krities te dink oor 'n saak", D196:11).

Participant [Fem23] replied that she perceived that her critical thinking skills had improved since she now looked at the sources in a different way. She now better understood how to judge sources and how to approach a problem, to break it up in different parts and then to elaborate and search deeper.

(Vir my persoonlik dink ek my kritiese denkvaardighede het verbeter, want ek kyk nie meer dieselfde na al die bronne nie. Ek weet nou bietjie meer oor hoe om te gaan kyk en dat ek na meer as een bron moet gaan kyk en ook hoe om 'n probleem te benader, dat mens hom nie net so moet na kyk, soos wat hy daar staan nie, maar dat jy dit kan opbreek, bietjie kan uitbrei, bietjie dieper en meer in detail in te gaan op die probleem, D196:31).

When asked: *"During which part of the PBL process did you have to apply CT?"*, both groups responded that they had used CT skills during the entire PBL process. Discussing the problem delimitation, formulating the learning issues, compiling the research and presenting the solutions all required CT skills. Participant [Fem32] for example commented that, as part of the PBL process, they had to convert their solutions into a *Powerpoint Presentation*: *"... it was also good for developing our critical thinking skills. Since you have collected all this abstract information as part of the activity and now you had to think about it visually and constructively to really make it applicable."* (*"...was ook baie goed gewees vir die ontwikkeling van ons kritiese denkvaardighede. Want ja, jy het nou al hierdie abstrakte inligting wat jy invoer by 'n taak, maar nou moes jy eintlik visueel en konstruktief daaroor gaan nadink ... dit werklik toepasbaar maak, D197:40).*

The participants also responded that problem-solving and CT skills contributed to develop a better understanding and insight of environmental problems and how to solve it. Participant [Fem13] for example commented: *"...you can now apply all these skills that you have acquired to other environmental issues as well."* (*"... want jy kan nou al hierdie vaardighede wat jy al geleer het op 'n ander omgewingskwessie ook toepas", D197:43), and Participant [Fem19] responded: "But not only that, without critical thinking, you cannot really solve environmental problems in such a way that it is effective and sustainable."* (*"Maar nie net dit nie, sonder kritiese denke kan jy nie regtig omgewingsprobleme op so 'n manier oplos dat dit effektief en volhoubaar is nie", D197:43).*

The following discussion focusses on the differences between gender and age in the WG³CTA results to determine if there is any outcome.

4.6.1 Gender and age differences in pre-service ESD teachers' critical thinking skills

The descriptive statistics in Table 4-11 report the results of the WG³CTA *t*-test between the male and female participants. It includes the mean, standard deviation, *p*-value and effect size.

Table 4-11: The pre-service ESD teachers' WG³CTA *t*-test results per gender group

		Mean		Standard Deviation		<i>p</i> – value Sig. (2- tailed)	Effect size
		Male	Female	Male	Female		
Number correct (/40)	Pre-test	18.0	19.8	2.5	3.1	0.06	0.58
	Post-test	19.2	19.6	4.6	3.5	0.79	0.09
Percentile Score	Pre-test	8.2	12.8	10.1	12.7	0.22	0.36
	Post-test	17.3	15.0	25.3	17.2	0.78	0.09
<i>t</i> -score	Pre-test	32.2	35.9	7.6	7.3	0.17	0.48
	Post-test	35.2	35.3	11.3	9.3	0.97	0.01
Recognition of assumptions	Pre-test	16.5	20.9	5.7	12.9	0.10	0.34
	Post-test	21.5	20.9	13.4	14.8	0.90	-0.04
Evaluation of arguments	Pre-test	26.9	31.1	16.7	15.9	0.46	0.26
	Post-test	33.1	29.7	15.7	17.4	0.53	-0.20
Drawing conclusions	Pre-test	15.3	21.9	9.2	16.5	0.09	0.40
	Post-test	24.1	22.4	23.9	19.1	0.83	-0.07

The male participants' WG³CTA results were compared with the female participants' results. The females scored higher than the males in the pre-test, but in the post-test the males did not score different from the female participants. For example, the mean *t*-score was 32 for the males and 35 for the females in the pre-test. In the post-test, the mean *t*-score for both males and females was 35. The mean percentile score for the males was 8 and for the females 12.8 in the pre-test. In the post-test the males scored a mean of 17.3 and the females 15.0. In the recognition of assumptions, evaluation of arguments and drawing conclusions, the male participants also scored lower than the females in the pre-test, but not different than the females in the post-test, whilst the female participant's results remained mostly the same between the pre- and post-test (*cf.* Table 4-11). According to Cohen (1988:27-28), the effect size for the relationship between two variables are interpreted according to the following guidelines: *d* = 0.2 is a small effect, *d* = 0.5 is a medium effect and *d* = 0.8 is a large effect (*cf.* 4.5.4). The effect size of the pre-test results

between the male and female participants indicates a medium effect for the following items: number correct ($d = 0.58$), percentile score ($d = 0.36$), t -score ($d = 0.48$), recognition of assumptions ($d = 0.34$) and drawing conclusions ($d = 0.40$). The effect size for the improvement of the male participants' t -score between the pre- and post-test, as calculated from the results in Table 4-11, is 0.39 and has a medium effect. The effect size that was calculated for the improvement of the male participants' percentile score is 0.90, recognition of assumptions is 0.86 and drawing conclusions is 0.96. These results are greater than 0.8 and are therefore practically significant. This indicates that the male participants have improved their critical thinking appraisal.

The Spearman's Rank-Order Correlation (*cf.* 4.5.4) was used to compare the WG³CTA results with the age of the participants. The results reported in Table 4-12 indicate no statistically significant correlation, which means that age did not have an effect on the WG³CTA pre-test and post-test results.

Table 4-12: Spearman's rank order correlation between the age differences of pre-service ESD teachers' WG³CTA pre- and post-test results

Age		Correlation Coefficient	p-value Sig. (2-tailed)
Number correct (/40)	Pre-test	0.094	0.493
	Post-test	-0.020	0.884
Percentile score	Pre-test	0.111	0.421
	Post-test	0.047	0.735
t -score	Pre-test	0.111	0.421
	Post-test	0.047	0.735
Recognition of assumptions	Pre-test	0.063	0.649
	Post-test	0.045	0.745
Evaluation of arguments	Pre-test	0.049	0.725
	Post-test	-0.106	0.441
Drawing conclusions	Pre-test	0.013	0.925
	Post-test	0.223	0.102

This ends the discussion of the third subsidiary research question about the influence of PBL on the development of the pre-service ESD teachers' critical thinking skills.

4.7 SUMMARY

The analysed research data was presented and discussed in this chapter. The quantitative and qualitative data sets were reported separately as proposed in the procedures for implementing the convergent parallel design (*cf.* 3.2.2.1). Attention was given to all three subsidiary research questions in an effort to finally answer the main research question. The

final chapter of this study discloses the findings and conclusive comments and expresses the limitations and contributions of this study.

CHAPTER 5 SUMMARY, FINDINGS AND RECOMMENDATIONS

5.1 INTRODUCTION

The preceding chapters in this study investigated the theoretical and conceptual framework of the concepts outlined in the title (Chapter 2), explained the research methodologies (Chapter 3) and presented the collected analysed quantitative and qualitative data (Chapter 4). The final chapter seeks to adjudicate the research question. This is accomplished by presenting the conclusions of the research data in relation to the theoretical framework. The chapter closes with a discussion of the limitations, contribution and recommendations of this study.

5.2 FINDINGS OF THIS STUDY

The research question endeavour to answer if implementing PBL in the module ESD has contributed to develop the pre-service ESD teachers' critical thinking skills. This question is answered by referring to the following three subsidiary research questions. Firstly, investigating the ways in which PBL can be implemented in ESD; secondly, determining the pre-service teachers' experience of PBL in ESD and lastly, resolving the influence of PBL on pre-service ESD teachers' critical thinking skills.

5.2.1 The implementation of problem-based learning in ESD

This paragraph discusses the first subsidiary research question, with reference to the literature: *"How can PBL be implemented in the teaching and learning of ESD?"*

Education plays a paramount role to advance sustainability in the world, as promoted by the UN Decade of ESD (UNESCO, 2005c:4; UNESCO, 2012:8) (*cf.* 2.2.1). According to the Global Action Plan (GAP) and the fourth SDG of Agenda 2030, teachers should be equipped with the knowledge and skills and develop the attitudes and values to become agents of change that endorse and champion ESD in their schools and communities (UN, 2015:21; UNESCO, 2014:20). Curriculum innovation in higher education institutions should therefore rethink the inclusion of ESD in pre-service teacher training programs, following a holistic approach (Álvarez-García *et al.*, 2015:82; Assadourian, 2017:4; UNESCO, 2017:8) (*cf.* 2.2.3). Including ESD in formal education in South Africa is a matter that is still heavily debated (Dreyer & Loubser, 2014:145; Mandikonza & Lotz-Sisitka, 2016:107). Reddy (2017:121) suggests that practical learning (work-integrated learning) and situational learning, as endorsed by the RP-MRTEQ, can be used to justify the inclusion of ESD in pre-service teacher training programs (*cf.* 2.2.3). Leal Filho *et al.* (2018:4) identified three

obstacles for implementing ESD in South African higher education institutions. One of the obstacles is the adversity of mobilising different subject lecturers to incorporate ESD in their subjects. According to a study compiled by Loubser (2015:99), the pre-service teachers also prefer that ESD is presented as a separate module in their curriculum. A literature review from studies in South Africa regarding the implementation of ESD in education faculty of higher education institutions, was compiled by Richter and De Sousa (2019:729). The researchers identified the principles, structures and stakeholders, as well as challenges to help institutions in realising ESD. The researchers advised that a champion or group of champions lead the transformation of advancing the priority action areas of the GAP at their institution. This effort will then train future teachers to champion ESD in their respective schools (*cf.* 2.2.3). According to Richter and De Sousa (2019:729), ESD can thus be successfully implemented in South African education faculties. From this discussion, it seems to be more successful to include ESD as a separate subject in the pre-service teacher training curriculum, than to include it in different subjects.

Loubser (2015:99) found that South African pre-service teachers lack adequate knowledge about EE and ESD (*cf.* 2.2.3). It is required of pre-service teachers to develop their problem-solving and critical thinking skills as well as work collaboratively, communicate their viewpoints and analyse information (Dreyer & Loubser, 2014:158). According to Elahi *et al.* (2014:539), EE contributed to develop pre-service teachers' critical thinking in their study compiled at a teacher training centre. EE is an interdisciplinary field that requires diverse skills and expertise, laying the foundation for developing these needed skills and understanding of the complexity of our environment in order to face the challenges of the 21st century (Clark *et al.*, 2020:381; Elahi *et al.*, 2014:535). It is furthermore important that realistic settings, which correspond with the students' life experiences, are used to enhance learning (Ertmer & Newby, 2013:56) (*cf.* 2.3). PBL is a teaching and learning strategy that uses real life problems and underlines the principles of constructivism (Savery & Duffy, 2001:1). In the constructivist classroom, teaching and learning strategies engage students to actively explore and think about complex issues (Ertmer & Newby, 2013:57). Social constructivism furthermore emphasises the zone of proximal development, in which peer collaboration and the involvement of knowledgeable individuals provide the required scaffolds to assist students in constructing knowledge (Vygotsky, 1978:126).

According to the International Implementation Scheme (IIS) of the UN-DESD (UNESCO, 2005a:31), one of the eleven key characteristics of ESD is to implement teaching and learning strategies that are student-centred and encourage the development of higher-order thinking skills. The priority areas of the GAP furthermore include the transformation of

learning and training environments where sustainability can be lived and experienced (UNESCO, 2014:18). Research commissioned by UNESCO (2017:21) as a result identified seven teaching and learning strategies that engage students actively to interact with each other and their environment and focus on real life issues (*cf.* 2.5.3). PBL is one of these seven strategies. Literature also endorse PBL as one of the preferable teaching and learning strategies in ESD (Dreyer & Loubser, 2014:149; Kwan & So, 2008:94; Shephard 2008:91; Steinemann, 2003:218) (*cf.* 2.5.3). PBL is a teaching and learning strategy that challenges students to acquire knowledge in order to solve a problem (*cf.* 2.5.1). Complex, ill-structured problems initiate the learning and the PBL process guides students to identify and investigate concepts that will assist in analysing the problem to resolve it (Hmelo-Silver, 2004:236). The discussion so far thus supports the introduction of PBL in the module ESD at the institution for this study. PBL can provide an answer in advancing the pre-service teachers' required knowledge about sustainable development issues through incorporating active learning, peer collaboration and scaffolding by the tutor in the social constructivist environment.

In designing the module ESD at the institution, an integrated PBL model was applied (*cf.* 3.4). The “*Seven Jump*” approach of the PBL process, that was developed by the Maastricht University (Schmidt & Moust, 2000:21) (*cf.* 2.5.1.2), was incorporated in the ESD module. Paragraph 3.4 of this study paid attention to the activities, work schedule and assessment criteria of the ESD module. The four PBL activities all incorporated ill-structured problems that challenged the participants to investigate complex environmental issues, comprehend the importance of EE and ESD and find creative ways to implement EE in their schools and the subjects they teach (*cf.* 3.4). The blended learning model at the institution for this study is ideal for implementing PBL, since it promotes online collaborative learning between the participants during the week, whilst the contact sessions on weekends allow for face to face meetings (*cf.* 3.4). Introducing the *Google Platform* supported the collaborative learning and greatly benefited the implementation of PBL in the module ESD (*cf.* 4.4). Technological development, the availability of information and access to free software is transforming the educational environment (Abeysekera & Dawson, 2015:4; Bishop & Verleger, 2013:3) (*cf.* 2.4.4). The flipped classroom allows for students to work at home and utilise time in the class for collaborative activities (McLaughlin *et al.*, 2014:237). Online PBL is an example of the flipped classroom. It allows the tutor to monitor students at home and provide the necessary scaffolds to guide them through the PBL process (Savin-Baden *et al.*, 2016:83). Class-time can then be utilised for group discussions and brain storming ideas (*cf.* 2.5.1.6). Students who are unfamiliar with online learning environments, might however find online

PBL challenging. It is therefore important that the tutor successfully creates a sense of belonging for the students in the digital environment (Barber *et al.*, 2015:62).

From this discussion it is evident that higher education institutions fulfil a pivotal role in promoting sustainability and to prepare graduates that will realise the UN's sustainable development goals (SDGs) and priority areas of UNESCO's GAP (Leal Filho *et al.*, 2018:2; Loubser, 2015:95; Mandikonza & Lotz-Sisitka, 2016:108; Shephard, 2008:87). This study therefore justifies the implementation of ESD as a separate module in the BEd curriculum at the institution and not just to integrate ESD in some of the modules. This study furthermore promotes the implementation of PBL, which is founded in a social constructivist framework, to engage pre-service teachers in active learning in order to develop the required knowledge, skills and attitudes that underwrite the outcomes of ESD (*cf.* 2.3; 2.2.4). This concludes the discussion about implementing PBL in the module ESD. The following paragraph pays attention to the second subsidiary research question, concerning pre-service teachers' experience of PBL in the module ESD.

5.2.2 Pre-service teachers' experience of problem-based learning in the module ESD

This paragraph discusses the findings of the second subsidiary research question: *"What are pre-service ESD teachers' experience of PBL, including their role as students and the role of the ESD tutor as facilitator in completing the PBL activities?"*

Inductive and deductive research methodologies was deployed in order to determine the pre-service ESD teachers' experience of PBL, as endorsed by the pragmatic design (Creswell & Plano Clark, 2018:38) (*cf.* 3.2.1). The discussion of the empirical data, with reference to the literature, addresses three aspects, namely the general aspects of the PBL experience, the PBL process and the PBL role players. Firstly, the general aspects of the PBL experience is explored.

5.2.2.1 Pre-service ESD teachers' experience of the general aspects of PBL

The pre-service ESD teachers overall regarded the general aspects of PBL as a positive experience (*cf.* 4.5.1; Table 4-2). The difference between male and female students regarding the general aspects of the PBL experience revealed no difference (*cf.* 4.5.4; Table 4-7), but considering age, the elder participants were more positive, compared to the younger participants (*cf.* 4.5.4; Table 4-8). It can be argued that the elder pre-service ESD teachers are more independent and mature and could therefore comprehend the scope of the advantages of PBL and adapt more easily to the PBL environment.

These favourable results towards the general aspects of PBL should be viewed against the background that it was the participants' first encounter with PBL, which was introduced in the ESD module for the entire semester (*cf.* 3.4). Initially, PBL was received with resistance by some of the participants, but as the semester progressed, they became more positive (*cf.* 4.5.1; Table 4-2). Proper training of students before implementing PBL for the first time is essential for its success (Wijnen *et al.*, 2017:4). The tutor implemented certain measures in this study to assist the participants in familiarising themselves with PBL at the beginning of the semester, for example the PBL video (*cf.* 3.4). It is furthermore influential to incorporate the necessary scaffolds, as highlighted in social constructivism, in the form of structure and guidance when implementing PBL and PBL online for the first time (Fukuzawa *et al.*, 2017:183; Schmidt & Moust, 2000:2; Verstegen *et al.*, 2016:27) (*cf.* 2.5.1.6; 2.5.1.5). Whilst completing the first PBL activity in this study, the tutor guided the participants with identifying and formulating the learning issues and applying scaffolds such as referring the pre-service teachers to relevant sources. The findings of this study corresponds with the students' experiences of PBL in the studies compiled by Golightly and Muniz (2013:9), Rakhudu (2011:84) and Wijnen *et al.* (2017:5) (*cf.* 2.5.1.5), in which the students also perceived PBL as a favourable teaching and learning strategy.

The results in this study especially exhibit a great agreement with the results from the study compiled by Golightly and Muniz (2013:9) with pre-service Geography teachers at a South African university. The PBL questionnaire that was developed and used by Golightly and Muniz (2013:9), was adapted and utilised in this study (*cf.* 3.6.1.2). In both studies, the highest scoring item is: *"I mastered new knowledge through PBL"*. Since PBL is a student-centred teaching and learning strategy introduced to the participants, the concern might exist in faculty that pre-service teachers will not learn sufficient subject content (Bonwell & Eison, 1991:4) (*cf.* 2.4.3). It is encouraging to note that more than 75% of the participants responded in the PBL questionnaire that they have mastered new knowledge (*cf.* 4.5.1; Table 4-2). The qualitative data confirmed that the participants perceived that they had developed new knowledge but also new skills. These skills include learning to work together as a member of a group, improving time management, planning more effectively and developing communication skills (*cf.* Figure 4.3). These soft skills that were developed are part of the sought after skills to prepare students for 21st century learning and the 4th industrial revolution (Cotet *et al.*, 2017:2) (*cf.* 2.5.1.3). Borhan (2014:77-78) and De Simone (2014:25) confirmed in their studies that PBL endorses solid discipline knowledge and engage students to analyse and present solutions to problems. In the study completed by Wijnen *et al.* (2017:5), more than half of the students responded that they had acquired a great deal of knowledge through PBL and they also studied on a more regular basis.

Working collaboratively is an important feature of social constructivism and can assist in preparing pre-service teachers to work with other teachers and parents and perform the varied roles expected of a teacher in today's inclusive classroom (Sezgin Selçuk, 2015:2) (*cf.* 2.5.2).

Even though most of the participants perceived the PBL experience as effective and meaningful, fewer participants responded that they preferred PBL above the traditional, lecture-based teaching strategies and even less agreed that PBL should be integrated in other modules. This finding also surfaced in the study compiled by Fukuzawa *et al.* (2017:180) (*cf.* 2.5.1.5). South African students are mostly exposed to traditional teaching strategies and still heavily rely on the lecturer to provide and explain the learning material (Golightly & Muniz, 2013:9). Rakhudu (2011:85) also reported that the students initially found it difficult to seek information by themselves and had to adapt to the new roles (*cf.* 2.5.1.5). The participants working hard for their grades to receive bursaries furthermore raised the concern that their mark for the ESD module depended on their group members. Assessing individual learning in the PBL environment is one of the challenges identified by Tandoğan and Akinoğlu (2007:74) (*cf.* 2.5.1.3). In order to incorporate assessment of individual learning in the module ESD, the pre-service teachers were assessed for their group work, as well as their individual participation and contribution in their tutorial groups by the tutor and fellow group members (*cf.* 3.4).

The second aspect regarding the pre-service teachers' experience of PBL in the module ESD focusses on the PBL process and is discussed next.

5.2.2.2 Pre-service ESD teachers' experience of the PBL process

The pre-service ESD teachers overall regarded the PBL process as a positive experience (*cf.* 4.5.2; Table 4-3). The female participants were more positive about three aspects of the PBL process compared to the male participants, which include the themes that were studied in the PBL activities, identifying and integrating the study materials and applying the assessment rubric (*cf.* 4.5.4; Table 4-7). The elder participants were more positive regarding the themes as well as the independent learning and workload, compared to the younger participants (*cf.* 4.5.4; Table 4-8).

One of the prominent aspects that emerged from the results and findings was that PBL is time consuming and enhances the workload of the participants (*cf.* 4.5.2; Table 4-3; Figure 4.5). This can be due to the unfamiliar aspect of PBL as a student-centred teaching and learning strategy. Many of the participants in this study are employed and attend to their

study obligations after hours, which means they have even less study time available compared to fulltime students at other universities (*cf.* 3.4). This correlates with the findings of Fukuzawa *et al.* (2017:177) and Rakhudu's (2011:86), in which students reported that they spend most of their time searching and analysing information (*cf.* 2.5.1.5). Golightly and Muniz (2013:12) recommended in this regard that tutors should carefully consider the number of themes to be studied in the module when implementing PBL (*cf.* 2.5.1.5). Fukuzawa *et al.* (2017:183) furthermore stressed the importance of scaffolding when introducing PBL for the first time. Shorter, weekly problems at the beginning of the module can also be advantageous to help students in familiarising themselves with the PBL process.

The participants in this study responded positively to the study material, assessment rubric and collaborative learning (*cf.* 4.5.2; Table 4-3; Figure 4.4). The pre-service teachers agreed that PBL encouraged them to identify the most important sources and to integrate the sources into their discussions. The participants were also of the opinion that the assessment rubric, which acted as a scaffold in the social constructivist setting, effectively guided them to monitor their progress and compile the PBL report. This was also confirmed in the study of Golightly and Muniz (2013:12). Collaborative learning in PBL, as endorsed by social constructivism, was also indicated as a positive experience (*cf.* Table 4-3; Figure 4.4). The participants could share their ideas and learn from each other as they interacted in discussions and completed the online report (*cf.* 4.5.2). According to the study compiled by Golightly and Van der Westhuizen (2018:152), online collaboration, with its sense of social presence, was identified as the most meaningful experience in the online PBL environment (*cf.* 2.5.1.6). Golightly and Muniz (2013:11) and Hmelo-Silver (2004:245) emphasised that tutors should provide the necessary guidance and support to students in the PBL environment (*cf.* 2.5.1.4). Students should furthermore have a firm foundation and understanding of collaborative learning to decrease frustrations within the PBL tutorial groups. In this regard, De Simone (2013:11) also confirmed the importance of collaboration in pre-service teacher training and argues that collaboration is a multifaceted skill that has to be taught to students (*cf.* 2.5.1.3). It will increasingly be expected from new generation teachers to work collaboratively in teams and introduce collaborative learning as they teach complex matter in their future classrooms. In the social constructivist classroom, the zones of proximal development especially, creates the space for practising and promoting collaborative learning (*cf.* 2.3).

The third and last aspect regarding the pre-service ESD teachers' PBL experience concentrates on the PBL role players, which is discussed in the next paragraph.

5.2.2.3 Pre-service ESD teachers' experience of the PBL role players

This study focussed on the tutor, group leaders and group members as the three main role players in the PBL environment.

The feedback from the participants regarding the conduct of the tutor during the PBL process were favourable. These findings correlate with the result from Golightly and Muniz (2013:13), Golightly and Van der Westhuizen (2018:150) and Salam (2018:236). Most of the participants in this study agreed that the tutor allowed them self-discovery; treated them equally and with respect; was available; encouraged them to except responsibility; and gave constructive feedback, as endorsed by social constructivism (*cf.* 4.5.3.1; Table 4-4). Facilitating the groups during the ESD tutorial sessions were challenging, since the duration and amount of contact sessions were limited, as explained in paragraph 3.4. After giving instructions, the tutor had a few minutes available per group. The tutor mostly relied on the comments given on the online *Google* documents to guide the groups during the week. De Simone (2014:19) and Masek and Yamin (2010:151) suggest that tutors should guide their students by posing questions to provoke further discussion and also provide links to sources when necessary (*cf.* 2.5.1.4). Thompson (2019:153) reported that the tutor offered suggestions to the students in the beginning to develop the learning issues. These measures are in line with the new reform in PBL, according to De Simone (2014:19). It enhances the students' success, reduces their anxiety and elevate their learning experience. Another challenge for the tutor in this study was ensuring the participation of all group members. The participants are new to the PBL environment and many participants are not in favour of working together in groups. Although most of the participants responded that the tutor facilitated participation, a few of the participants did not agree. It is important to note that this study was also the tutor's first encounter to facilitate PBL activities. With time the tutor will develop better facilitating skills. Masek and Yamin (2010:151) confirms that the tutor is responsible for creating an environment in which learning can occur smoothly and should assist the students when group conflict occurs. The useful tips for facilitating PBL tutorial groups, provided by Azer (2005:676), can be incorporated in this regard (*cf.* 2.5.1.4). Wijnen *et al.* (2017:2) furthermore stresses the importance of sufficient tutor training before implementing PBL in a faculty.

The pre-service ESD teachers were very positive about the conduct and contribution of the group leaders to steer their groups in completing the PBL activities (*cf.* 4.5.3.2; Table 4-5). The female participants especially were very positive about the role of the group leaders (*cf.* 4.5.4; Table 4-7). These results affirm that the group leaders played an important part in the successful implementation of PBL in the ESD module. The group leader's role was

to delegate the learning tasks and furthermore encourage and involve all the group members, as emphasised in the social constructivist environment. It was the group leaders' first encounter to act as a group leader in a PBL environment. The participants recorded that the group leaders treated them with respect and performed all their duties well. These outcomes also emerged in the study of Golightly and Muniz (2013:14), confirming that group leaders are effective and fulfils a crucial role in the PBL environment.

The response of the pre-service teachers to function as a member of a group, were indicated as positive experience. The participants responded that they respected one another's opinions in the groups, they supported each other and got on well together (*cf.* 4.5.3.3; Table 4-6). In the qualitative data, the majority of participants also indicated that the support and cooperation in the group was a positive experience (*cf.* 4.5.3.3). These responses should be viewed against the background that the participants were not allowed to choose their own group members. As discussed in the third chapter, three criteria were implemented by the tutor to divide the participants into the respective groups (*cf.* 3.4). The participants furthermore responded that they have learned to function as a member in a group through the PBL experience (*cf.* 4.5.1; Figure 4.3). The advantages of collaborative learning are also confirmed in the studies of Fukuzawa *et al.* (2017:182) and Rakhudu (2011:86) (*cf.* 2.5.1.5). Despite these positive experiences, some of the participants did complain about one or two group members that did not perform as expected, which heightened the frustration and group conflict in some of the groups (*cf.* 4.5.3.3). Positive solutions were however suggested and implemented by the participants, with varied successes (*cf.* 4.5.2; Figure 4.6). A minority of participants, who are not in favour of group work, had a negative attitude towards the PBL group activities. This can be due to the fact that the participants were not skilled in collaborative learning, as discussed in the previous paragraph (*cf.* 5.2.2.2). The problems encountered by the participants, as listed in Figure 4.5, also shed some light on this matter. The participants have busy schedules, they live far apart and not all members attended the contact sessions. Golightly and Muniz's (2013:15) findings confirm the negative attitude of some pre-service Geography teachers and suggested that the tutor should develop the participants' collaborative learning skills. This can be accomplished by implementing suitable scaffolds during the different phases of the PBL process, for example to increase the social presence of the tutor in the online PBL environment. Increasing the social presence of the tutor underlines the principles of social constructivism and can help to monitor and guide the groups and individual members, if necessary (*cf.* 2.5.1.4; 2.5.1.6). Training students in PBL before commencing a PBL module or program is crucial, as mentioned in paragraph 5.2.2.1 (Wijnen *et al.*, 2017:4). Students need to grasp the rationale behind PBL and understand their roles in the PBL environment.

This concludes the discussion of the second subsidiary research question about the pre-service ESD teachers' experience of problem-based learning. The third and last subsidiary research question deals with the influence of PBL on critical thinking skills and is discussed in the following paragraph.

5.2.3 The influence of PBL on pre-service ESD teachers' critical thinking skills

This paragraph discusses the findings of the third subsidiary research question: *"What is the influence of PBL on the perceptions of pre-service ESD teachers regarding the development of their critical thinking skills that include to recognise assumptions; evaluate arguments and draw conclusions?"*

The results of this study reveal that there is a discrepancy between the analysed data of the CT test instrument, that measured the participants' CT skills, compared to the PBL questionnaire and qualitative data, that determined the participants' perceptions of the development of their CT skills. The following discussion pays attention to the following three aspects: the quantitative results from the CT test instrument, the influence of PBL on CT development and the results from the PBL questionnaire and qualitative data which are discussed to reveal the pre-service teachers' perceptions regarding the development of their CT skills.

Firstly, the overall performance of the participants in the CT test instrument, the WG³CTA, is considered. The quantitative results from the WG³CTA in this study revealed that a few of the participants performed average to below average, but most of the participants performed well below average (*cf.* 4.6; Table 4-10). The sub-test sections of the WG³CTA revealed that the *"evaluation of arguments"* scored the highest, compared to the *"recognition of assumptions"* and *"drawing conclusions"*, that scored lower (*cf.* 4.6; Table 4-9). These results correlates with the results from the study compiled by Lombard and Grosser (2008:561) at a South African university with first-year pre-service teachers (*cf.* 2.6.3). In the study by Lombard and Grosser (2008:569), South African pre-service teachers' WGCTA results were compared to two norm groups from the United States of America, since no South African norm group exist. It included American Grade 12 high school learners and American pre-service teachers. The results of the South African first-year pre-service teachers was lower than both the norm groups. In the study compiled by Grosser and Nel (2013:5), the pre-service teachers also performed average to poor. Considering these results affirms that the South African educational system still fails to model creative and CT practises amongst its learners and students. Although CT development is one of the goals of CAPS at schools (*cf.* 2.2.2), it raises the question to

which extent this goal is achieved in the South African schooling system as well as in pre-service teacher training. This emphasises the need to focus more purposefully on developing CT skills of learners and students, as endorsed by several academics (Broadbear, 2003:4; Paul, 2005:28; Yen & Halili, 2015:43) (*cf.* 2.6.2). The results from the WG³CTA should furthermore be viewed against the background that the WG³CTA is an international instrument and some of the questions are set in a context that might not be familiar to the participants (*cf.* 2.6.3). The test is set in English and the Afrikaans first language users might have struggled with the English terminology and comprehension (*cf.* 2.6.3). In conclusion, it can also be argued that the higher education experience in totality is responsible for the development of students' CT skills (Perry *et al.*, 1996:77). The motivation and participation of the participants is also an important factor. Literature has revealed that not all students are naturally inquisitive and as a result require more training to become critical thinkers (Snyder & Snyder, 2008:92; Yen & Halili, 2015:43). Furthermore, many lecturers do not fully comprehend the scope of CT (Paul, 2005:27) and traditional, lecture-based teaching that focusses on content knowledge, is still the norm at the institution. These factors can also contribute and explain why the pre-service ESD teachers have not efficiently developed their CT skills.

Secondly, it is imperative to elaborate on the influence of PBL on the development of the participants' CT skills. In the pragmatic design of this study, a deductive methodology was utilised to determine if pre-service ESD teachers' critical thinking skills has improved after applying PBL as an interventional teaching and learning strategy (*cf.* 3.2.1). This method tests a hypothesis to acknowledge or reject the theory (Creswell & Plano Clark, 2018:37). In this study, the results from the WG³CTA indicates that overall, the participants' critical thinking skills have not improved after the PBL intervention in the ESD module (*cf.* 4.6; Table 4-9). The gender differences, however, reveal that the male participants' CT appraisal have improved between the WG³CTA pre- and post-test results, whereas the female participants' appraisal did not improve (*cf.* 4.6.1; Table 4-11). The age differences indicated no significant correlation between the older and younger participants (*cf.* 4.6.1; Table 4-12). An important aspect to consider, is the time frame of this study (*cf.* 3.4). Implementing PBL for one semester in only one module, is probably not sufficient to bring about the needed change. This is affirmed by one of the conclusions made by Masek and Yamin (2011:219), as discussed in paragraph 2.6.4. The studies compiled by Temel (2014:6) and Ulger (2018:10) had a similar outcome. Both studies utilised the CCTDI as instrument in a pre-test post-test research design after one semester (*cf.* 1.3.5). The results indicated no significant improvement in the critical thinking skills of the students. The study compiled by Sujanem *et al.* (2018:4) on the other hand, determined that PBL has contributed to develop

the CT skills of the school learners. The learners were tested after a year using an essay test as instrument (*cf.* 2.6.4). The literature review completed by Borhan (2014:79) identified a few studies that investigated the effect of PBL on pre-service teachers' skills and knowledge (*cf.* 2.5.2). Two of the studies focussed on pre-service teachers' higher order thinking skills, including critical thinking. These studies also concluded that PBL has contributed to improved pre-service teachers' critical thinking skills (Borhan, 2014: 81-82). Conflicting results are however confirmed in the literature reviews compiled by Kong *et al.* (2014:458) and Masek and Yamin (2011:215), as discussed in paragraph 2.6.4. The final conclusions from both literature reviews, however, confirm that PBL is an effective teaching and learning strategy that can effectively improve critical thinking skills. Identifying, analysing and assessing thinking to come to the proper conclusions is part of the process to improve critical thinking (Paul & Elder, 2014:2; Watson & Glaser, 2018:1). Literature furthermore reveals that critical thinking is a skill that can be improved when applying effective teaching and learning strategies (Facione, 1990:4; Perry *et al.*, 1996:77) (*cf.* 2.6.2). Enhancing critical thinking and other higher order thinking skills is a crucial educational goal in all curricula to prepare students to live in the fast-paced world of the 21st century (Yen & Halili, 2015:42). During the PBL process, students are challenged to analyse the problem, identify and research learning issues to propose appropriate solutions to the problem (Kek & Huijser, 2011:336; Schmidt & Moust, 2000:23). Thompson (2019:154) also confirmed that reflecting on how the learning issues is used during the PBL process, has encourage students to focus on and develop their CT. It is therefore clear why many educationists favour PBL as teaching and learning strategy to foster the critical thinking skills of their students (Kong *et al.*, 2014:464; Steinemann, 2003:218; Sujanem, 2018:5).

Lastly, the PBL questionnaire and qualitative results are considered to shed light on the participants' perceptions of the development of their CT skills. In the pragmatic design of this study, an inductive methodology was employed to interpret the qualitative data to give a broader view of the participants' experience of the development of their critical thinking skills (*cf.* 3.2.1). The quantitative results from the item in the PBL questionnaire and the qualitative results from the RLJ and focus-group interviews, reveal that most of the participants perceived that their CT skills have improved (*cf.* 4.6; Table 4-2). After completing the PBL activities, the participants responded in their reflective journals that they can study sources more easily to reach a logical conclusion, they understand the relation between ideas and they can approach problems more systematically (*cf.* Figure 4.7). Collaborating on the *Google Docs* gave participants the opportunity to assess their thinking, with comments made by the tutor and fellow group members. This is one of the elements of teaching and learning proposed by Broadbear (2003:7) to improve the CT skills of

students (*cf.* 2.6.2). In the study completed by Rakhudu (2011:86), the nursing students also responded that collaborative learning and reading through multiple resources in PBL have promoted their critical thinking skills.

From this discussion it is evident that the participants perceived that their critical thinking skills had improved despite the contradiction with the quantitative results obtained from the WG³CTA test instrument.

5.3 SUMMARY

The main research question of this study aimed to determine if implementing PBL as an intervention in the module ESD contributed to develop the pre-service teachers' critical thinking skills. Because of the findings from the standardised CT instrument, the pre-service ESD teachers' critical thinking skills have not improved. It can thus be stated that the PBL intervention was unsuccessful in fostering the pre-services teachers' critical thinking skills in the module ESD. Taking into account the PBL questionnaire and qualitative data, as discussed in the preceding paragraph (*cf.* 5.2.3), most of the pre-service ESD experienced that their critical thinking skills have improved. It can thus also be stated that most of the pre-service teachers perceived that their critical thinking skills had improved through the PBL experience in the module ESD. The triangulation between the quantitative and qualitative data, obtained from the mixed methods research design, therefore gives a broader and more in-depth picture of the phenomena that were investigated in this study.

5.4 LIMITATIONS OF THE STUDY

The following limitations of the study were identified by the researcher:

The duration of implementing PBL as an intervention in ESD was too short (Masek & Yamin, 2012:4; Temel, 2014:15) (*cf.* 2.6.4). Unfortunately, the module ESD is a single module in the third year of the BEd Intermediate Phase curriculum at the institution. Implementing PBL in other third- and fourth-year BEd modules could have had a more positive outcome with reference to the influence of PBL on the CT skills of the pre-service teachers.

The participants were unfamiliar with PBL when the semester commenced. The transition from a traditional, lectured-based teaching and learning strategy to PBL can be challenging to students (Fukuzawa *et al.*, 2017:182) (*cf.* 2.5.1.5). Although the participants received guidance regarding the teaching and learning strategy PBL, some of the participants were still uncertain about their roles and how to complete the first online PBL report (*cf.* 3.4). This

uncertainty could have affected the influence of PBL on the development of the pre-service teachers' CT skills.

The Watson-Glaser³ Critical Thinking Appraisal instrument that was applied for testing the participants' critical thinking skills is an international test. The language barrier and possible unfamiliar scenarios could have hindered some of the participants (*cf.* 2.6.3).

The study involved a relatively small number of participants ($n = 55$). Furthermore, convenience sampling was used, which means this study answers whether PBL was introduced successfully in the module ESD at this institution (*cf.* 3.5). The results describe the experience of the particular participants who took part in this study and can therefore not be generalised to all students in all contexts. Using a control group was however not possible in the circumstances at the institution.

5.5 CONTRIBUTIONS OF THE STUDY

The following contributions of the study were identified by the researcher:

Implementing the module ESD at this institution is in line with the UN SDGs that calls on all parties to contribute to protecting our environment to ensure a safe and prosperous world for all people. This study advances the third priority area of UNESCO's GAP, which describe the inclusion of ESD in pre-service teacher training. This study can be used by other higher education institutions to motivate or encourage the importance of including ESD in the curricula of pre-service teachers.

Compiling the module ESD, which incorporated PBL, provides a workable solution and an example to develop a similar module at other institutions. This study guide consists of three learning units, with the accompanying outcomes and assessment criteria, and includes a work schedule and 4 PBL activities.

In this study, PBL was implemented as teaching and learning strategy for one semester in the module ESD, as part of the BEd IF program at the institution. As far as the researcher could determine, this is the first time that PBL was introduced in the module ESD for pre-service teachers in South Africa. As far as the researcher could determine, this is also the first study to implement PBL for an entire semester in a pre-service teachers' module at a South African higher education institution. Introducing constructivist and social constructivist pedagogies is in line with the new education reform, not only for higher education institutions but also in secondary and primary schools. The numerous

advantages of PBL makes it a favourable teaching and learning strategy to explore and apply at more institutions in our country.

The study emphasised the importance of critical thinking as one of the higher order skills to be developed amongst pre-service teachers. Although PBL had no real influence on pre-service teachers' CT, it has contributed to create awareness amongst the pre-service teachers and challenged them to think critically about solutions for the problematical environmental problems that humanity is facing.

This study contributed to validate the Watson-Glaser³ Critical Thinking Appraisal as an instrument to measure critical thinking skills in the South African context. It further contributed to forming a future South African norm group for the WGCTATM.

The pre-service ESD teachers at the institution have being exposed to a PBL environment and had the opportunity to experience a student-centred teaching and learning strategy first-hand. They developed a variety of skills that they can apply in their school classrooms as future teachers.

5.6 RECOMMENDATIONS

The following recommendations can be made by the researcher after compiling this study:

Introducing ESD as a separate, compulsory module in all pre-service teacher training programs at the institution, as well as other teacher training institution in the country, is highly recommended. The importance of ESD can furthermore be advanced by providing short ESD courses to teachers as part of their in-service training.

Including a longer orientation period to prepare pre-service teachers properly for PBL can contribute to a more positive learning experience. Preparing participants and training tutors is paramount in the success of implementing PBL at an institution (Masek & Yamin, 2011:219; Pu *et al.*, 2019:8; Rakhudu, 2011:87). Pre-service teachers must understand how the roles of student and lecturer change as well as the PBL process, to fully cooperate from the beginning of the first PBL activity.

It will be advantageous to expose pre-service teachers earlier in the BEd program to PBL as teaching and learning strategy. PBL activities, with the necessary scaffolds, could be integrated in some of the first- and second-year BEd modules as well.

Measuring critical thinking skills over a longer period, for example between the first and final year of the BEd program, will give a better picture of the development of pre-service

teachers' critical thinking skills. Critical thinking is a skill that develops from the overall higher education experience (Perry *et al.*, 1996:77). Another study can therefore be suggested to measure critical thinking skills after applying PBL over several modules and years of an under-graduate program.

The training of lecturers to comprehend the scope of CT and to apply teaching and learning strategies that foster critical thinking, is also highly recommended. This will be advantageous for the development of the pre-service teachers' critical thinking skills and enable them to apply these acquired skills in their future classrooms, realising the goals of CAPS.

5.7 CONCLUSION

Literature reveals numerous research projects that investigated the success and experience of PBL as teaching and learning strategy in higher education institutions in various disciplines, including pre-service teacher training and in ESD. There are several international studies that compared PBL with traditional teaching methods to determine the development of critical thinking skills amongst students. Implementing PBL in South African higher education institutions and investigating its influence on higher order thinking skills, is however still in its developing phase. As far as the researcher could determine, this is the first study to expose pre-service teachers to PBL in the module ESD for an entire semester at a South African higher education institution. As far as the researcher could determine, it is also the first study in South Africa to apply the third edition of the Watson-Glaser Critical Thinking Appraisal as instrument to measure pre-service teachers' critical thinking skills and to measure the influence of PBL on the development of pre-service teachers' CT skills.

The results of this study revealed that the pre-service ESD teachers experienced PBL as challenging but also as an informative and a worthwhile learning experience. PBL proofed to be an effective teaching and learning strategy to incorporate in ESD and most of the participants perceived that it has contributed to develop their critical thinking skills. This study has been significant in emphasising the implementation of PBL in programs of higher education institutions in South Africa. Constructivist and social constructivist strategies are endorsed by academia and effective teaching and learning strategies play an important role in achieving the desired outcomes to prepare pre-service teachers for the challenges of the 21st century. This study accentuates the importance of critical thinking appraisal and to incorporate classroom practices that foster critical thinking skills.

This study furthermore contributes to highlight that the inclusion of ESD in pre-service teacher curricula is not an option, but a necessity. The environmental problems humanity is confronted with is forcing communities, including educationist, to rethink their contribution to provide achievable resolutions to promote and implement sustainable development. Future teachers should be confronted with the responsibility to live as stewards of God's creation and be equipped to guide their learners to think critically and succeed in becoming change agents.

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ANNEXURE A: LETTER OF ATTENDANCE FOR WORKSHOP ON QUALITATIVE DATA ANALYSIS WITH *ATLAS.TI* 8



Private Bag X1290, Potchefstroom
South Africa 2520

Tel: 018 299-1111/2222
Fax: 018 299-4910
Web: <http://www.nwu.ac.za>

AUTHeR
(Africa Unit for Transdisciplinary
Health Research)

Sanli Heystek
North-West University
Potchefstroom
2520

Potchefstroom, 12 June 2019

Dear Sanli Heystek

LETTER OF ATTENDANCE: QUALITATIVE DATA ANALYSIS WITH ATLAS.TI 8 (2 DAY WORKSHOP)

This letter serves as confirmation that you attended the two-day workshop on qualitative data analysis with ATLAS.ti 8 held by Dr Nicole Claasen 05 to 06 June 2019 at North-West University, Potchefstroom Campus.

The workshop programme included:

Introductory level (1st day)

- Basics of qualitative data analysis
- Advantages of computer-assisted qualitative data analysis software
- Preparing and organising data for analysis
- Interface and basic terms of ATLAS.ti
- Setting-up a project in ATLAS.ti
- Coding and building a code system in ATLAS.ti
- Creating networks, word clouds and word lists in ATLAS.ti

Advanced level (2nd day)

- Descriptive and conceptual levels of qualitative data analysis
- Using analytic memos
- Creating and managing semantic relations between codes
- Creating networks based non-semantic and semantic relations
- Querying data including the Query Tool, Code-Document Tables, Code Co-Occurrence
- Generating reliability using the Inter-Coder Agreement Measure in ATLAS.ti
- Using ATLAS.ti for a literature review

Yours sincerely,

A handwritten signature in black ink, appearing to be 'Nicole Claasen', written over a circular blue stamp.

Dr Nicole Claasen
ATLAS.ti certified senior professional trainer
AUTHeR, North-West University



ANNEXURE B: LETTER AND E-MAIL OF CONSENT FROM AROS ACADEMIC CURRICULUM COMMITTEE



Navorsingsprojek: GIFO311 Omgewingsopvoeding vir Volhoubare Ontwikkeling

24 Julie 2018

Dr Mome Diedericks

Mev. Sanli Reyneke

Hiermee gee Aros toestemming aan Mev. Sanli Reyneke om die module GIFO311 te gebruik as navorsingsprojek vir haar studies by die Noordwes Universiteit (NWU). Ons glo dat die studie 'n besondere bydra tot Aros se onderrig en leer gaan bied.

Baie sterkte

Dr Mome Diedericks

Akademiese Hoof

Sanli Reyneke

From: Chris-Mari van Zyl
Sent: Tuesday, 24 July 2018 16:22
To: Sanli Reyneke; Barry Richter
Cc: Morné Diedericks
Subject: GIFO311

Beste Prof Barry en Sanli,

Ek hoop dit gaan goed met julle?

Soos reeds gekommunikeer is die GIFO311 voorstel om vir jou studies te gebruik, goedgekeur deur die Navorsingskomitee en die AKK. Ek deel ook hiermee vir julle die stukkie uit die notule wat as bewys dien dat die voorstel goedgekeur is.

Indien daar enige verdere vrae is, is u welkom om my te kontak.

Hiermee die stukkie van die notule soos bespreek by die AKK:

GIFO311 vir 2019 (2018.05.24 – 4.6) (NVK 2018.07.17 – 5.6) (CVZ)

Mej Van Zyl gee toelating. Die saak is by die NVK-vergadering goedgekeur en na die AKK verwys vir goedkeuring.

Die studie behels die implementering van probleemgebaseerde leer in die ontwikkeling en aanbieding van die module Omgewingsopvoeding vir Volhoubare Ontwikkeling:

- 1) Die studiegids word verkort en geen leesbundel word voorgeskryf nie – studente sal self artikels soek.
- 2) Prof Aubrey Golightly sal 'n video maak om die beginsels van probleemgebaseerde leer aan studente te verduidelik.
- 3) Klasaanbieding sal hoofsaaklik bestaan uit fasilitering waar studente in groepe aan die projekte werk. Die studieleiers sal die dosent tydens die verloop van die semester monitor om te verseker dat die proses korrek verloop.
- 4) Assessering sal deur die semester plaasvind – studente sal in groepsverband aan 'n portefeulje werk, wat uit 4 projekte bestaan. Studente word weekliks deur die dosent en groepslede gemonitor en geassesseer vir hul deelname en bydrae tot die groepsprojek en klasaanbieding. Groepslede sal nie dieselfde punt vir die portefeulje ontvang nie – studente sal mekaar in groepsverband assesser ná afloop van elke opdrag. Dit sal bydra tot die deelname punt van elke student. Studente moet 'n deelname punt van minstens 40% behaal om die portefeulje saam met die groep in te mag handig. Die groepsportefeulje, met 4 projekte, sal aan die begin van die eksamen ingehandig word en as die eksamenpunt dien. Die modulepunt sal soos normaal bereken word: 50% vir deelname en 50% vir eksamen (portefeulje). Indien 'n student nie slaag nie, sal 'n tweede geleentheid gegee word dmv 'n individuele projek wat op die hereksamendatum ingehandig moet word.
- 5) Die volgende sal benodig word: 'n Etiese klaringssertifikaat vanaf NWU, 'n toestemmingsbrief van Aros en toestemming van die derdejaar GIFO-studente om aan die navorsingsprojek deel te neem.

Besluit:

- a) Die navorsingsvoorstel vir GIFO311 word goedgekeur.
 - b) Dit sal in die jaarboek ingewerk word dat daar nie 'n Senaatseksamen vir GIFO311 geskryf sal kan word nie en studente sal dus die module moet herhaal indien hul sou druipe.
- Dr Diedericks sal 'n amptelike toestemmingsbrief van Aros aan mev Reyneke beskikbaar stel.

ANNEXURE C: E-MAIL WITH PERMISSION FROM PEARSON TALENTLENS AND LETTER TO PARTICIPANTS

Sanli Reyneke

From: Sharp, Lucy <lucy.sharp@pearson.com>
Sent: Thursday, 20 September 2018 16:04
To: Sanli Reyneke
Subject: Using the Watson Glaser

Hi Sanli,

I have spoken with my manager and he has said that we can provide the tests for free - approximately 60-65 of the online version for your study :) Is this suitable?

We would not be able to give you permission to photocopy any of our test materials.

Also, an online version means the test would be automatically scored and you would get a report that you could give to each student who completes the test as well as the raw data.

Kind regards, Lucy

Good morning Lucy

I am not trained, but I will be assisted by the North West University Statistical Consultation Services.

I have studied the different test instruments available and contacted a few academics to assist me, and the WGCTA is the most suitable for the purpose of my study.

Unfortunately, with the Pound-South African Rand exchange rate the cost involved will not be affordable for me since I have no funding available for this research. I will have to look at alternative options.

Will you give me permission to use the original WGCTA test (80 questions) free of charge and make copies?

I look forward to hearing from you,

Sanli

Lucy Sharp

Talent Assessment Consultant

Pearson TalentLens
80 Strand,
London,
WC2R 0RL



Dear **Candidate**,

You have been invited by ***company name*** to complete an online psychometric instrument, the Watson Glaser Critical Thinking Appraisal as **part of the recruitment/development process for XXX role.**

Before completing the Watson Glaser, please read this information carefully:

- You will have **30 minutes** to complete the test once you start. Make sure you are in a quiet room, free from distractions, have a good internet connection and that you give yourself time to complete the questionnaire without being disturbed. We recommend that you complete the test on a desk-top computer, laptop or tablet – not a mobile phone. The test has 40 questions.
- Once you have clicked on the **Start button** the time will begin. **You will not be able to pause the test and come back to it once you have started.**
- Once you have reached the last question, click on **next** then click on the **finish** button. You will then be taken to the demographic questions (which are optional to complete). Whether you complete these questions or not you need to **proceed to the end of these** and click the **submit** button.
- You should complete the test on your own without assistance from others. You will be retested with another equivalent version of the test if asked to the later stages of the recruitment process.
- You will be given full instructions on how to complete the test once you have accessed the online testing website by clicking on the link below.

Why have I been asked to take the test?

You have been invited to complete the Watson Glaser Critical Thinking Appraisal test. Critical thinking is the ability to identify and analyse problems and seek and evaluate relevant information in order to reach appropriate conclusions. It is important for decision making and career success in general. **We use the test as part of our selection process to assess your suitability for the role.**

What will happen to my results?

Your results will remain strictly confidential and will only be seen by ***company name* recruitment team**. All results will be stored in accordance with the General Data Protection Regulation (GDPR). It is our policy to store all test results for six months, after which they will be made anonymous and used for monitoring and research purposes only.

Please contact **lucy.sharp@pearson.com** if you have any special requirements for completing the test.

When you're ready to complete the real test, click on the link below:

<https://login.talentlens.co.uk/v2/XBQBGZZVKZ>

ANNEXURE D: INFORMATION LEAFLET AND LETTER OF CONSENT FROM PRE-SERVICE ESD TEACHERS



Aros Student
Dickensonlaan 1180
Waverley
Pretoria

Privaat sak X6001, Potchefstroom
Suid-Afrika 2520

Tel: 018 299-1111/2222
Web: <http://www.nwu.ac.za>

Fakulteit Opvoedkunde

**(Omgewingsopvoeding vir Volhoubare
Ontwikkeling)**

14 Januarie 2019

Geagte Student

DEELNEMERSINLIGTINGSTUK EN TOESTEMMINGSVORM

Hiermee word u uitgenooi om deel te neem aan 'n navorsingsprojek wat vanjaar by Aros geloods word. Lees asseblief die volgende inligting noukeurig deur alvorens u dit onderteken. Dit is belangrik dat u ten volle verstaan waaroor die projek handel en wat u aandeel daarin gaan wees. U is welkom om vrae te vra en ook die navorser te kontak vir enige verdere navrae. Let wel dat u deelname ten volle vrywillig is en dat u op enige stadium kan onttrek indien u nie verder aan die navorsingsprojek wil deelneem nie.

Inligting van die navorsingsprojek:

TITEL VAN DIE NAVORSINGSPROJEK: Die implementering van probleemgebaseerde leer in opvoeding vir volhoubare ontwikkeling om kritiese denke te bevorder in voorgraadse onderwysstudente.

PROJEKTOESIGHOUER: Prof Barry Richter

KONTAKBESONDERHEDE: e-pos: Barry.Richter@nwu.ac.za

PROJEKHULPTOESIGHOUERS:

Dr Irene Muller, e-pos: 12765074@nwu.ac.za, tel: 016 910 3097

Prof Aubrey Golightly, e-pos: Aubrey.Golightly@nwu.ac.za, tel: 018 299 4729

NAVORSER: Sanli Heystek

KONTAKBESONDERHEDE: e-pos: sanli.heystek@aros.ac.za, tel: 012 332 3227/8

NWU NAVORSINGSETIEKKOMITEE VAN DIE FAKULTEIT VAN OPVOEDKUNDE

Kontakpersoon: Me Erna Greyling, e-pos: Erna.Greyling@nwu.ac.za, tel. 018 299 4656

Hierdie projek is goedgekeur deur die Navorsingsetiekkomitee van die Fakulteit Opvoedkunde van die Noordwes-Universiteit en sal in ooreenstemming met die etiese riglyne van die komitee uitgevoer word. Die navorser het toestemming verkry vanaf die Aros Navorsingskomitee en die Akademiese Kurrikulumkomitee om die projek te loods.

Waarom is ek gekies om aan die projek deel te neem?

Al die Aros derdejaar intermediêrefasestudente wat geregistreer is vir die module GIFO311 in 2019 en wat skriftelik toestemming verleen het, vorm deel van die navorsingsprojek.

Waaroor handel die navorsingsprojek?

In ons moderne samelewing word die mensdom gekonfronteer met komplekse omgewingsvraagstukke en -probleme. Die onus rus veral op onderwysinstellings om ons toekomstige onderwysers op te lei sodat die beginsels van omgewingsbewaring bevorder kan word op skoolvlak. In Suid-Afrikaanse skole is Omgewingsopvoeding vir Volhoubare Ontwikkeling nie 'n onafhanklike vak nie, maar moet in alle vakke aangespreek word. Dit beteken dat die beginsels van omgewingsopvoeding in al die vakke toegepas en geïntegreer behoort te word. Dit vereis dus dat onderwysstudente toegerus moet word met die nodige kennis maar ook die vaardighede om omgewingsprobleme te ondersoek en aan te spreek sodat hierdie beginsels ook uitgedra en toegepas kan word in die skole waar hul onderrig/gaan onderrig. Vir hierdie doel gaan daar in die module GIFO311 'n nuwe onderrig- en leerstrategie geïmplementeer word, naamlik probleemgebaseerde leer (PGL). Hierdie projek poog om vas te stel of die implementering van PGL as onderrigleerstrategie, studente se kritiese denkvaardighede asook probleemoplossingsvaardighede kan help ontwikkel. Studente se kritiese denkvermoë gaan daarom gemeet word aan die begin en weer aan die einde van die semester.

Wat is my verantwoordelikhede vir die projek?

Dit is belangrik dat u sover as moontlik die kontakssessies vir die semester bywoon en deelneem aan al die voorgeskrewe probleemgebaseerde leeraktiwiteite. U gaan 'n toets aflê om u kritiese denkvermoëns te meet aan die begin en weer aan die einde van die semester. U gaan deur die loop van die semester 'n reflektiewe leerjoernaal voltooi oor u ervaring en belewenis van PGL as onderrig- en leerstrategie.

Watter voordele hou die deelname aan die projek vir my in?

Die navorsingsprojek gee aan u die geleentheid om gratis deel te neem aan 'n internasionale toetsinstrument om u kritiese denkvermoëns te meet. Die blootstelling aan PGL gee aan u

die geleentheid om ervaring op te doen in 'n onderrig- en leerstrategie wat u ook as onderwyser in die klaskamer kan gebruik. Laasgenoemde voordeel sal ook voordelig wees vir studente wat verkies om nie aan die projek deel te neem nie.

Is daar enige nadele vir my om aan die projek deel te neem?

Nee, daar is geen ernstige risiko's verbonde daaraan om deel te neem aan die projek nie. U mag wel ongerief ervaar omdat u nie vertrouwd is met PGL nie en ook moontlike uitdagings gaan beleef met die groepwerk. Die tutors sal egter voortdurend beskikbaar wees om u te help en leiding te verskaf aan die groepe.

Word my inligting konfidensieel hanteer en word my identiteit beskerm?

Ja, al die data wat van die deelnemers ingesamel word, word streng vertroulik hanteer. Al die inligting word anoniem ontleed en gestoor en u identiteit sal op geen wyse openbaar gemaak word nie. Die data word dus op 'n niepersoonlike wyse gerapporteer wat beteken dat geen konneksie gemaak kan word met enige deelnemer nie.

Wat is probleem-gebaseerde leer (PGL)?

In die GIFO311 studiegids op bladsy 13 - 15 is 'n uiteensetting van PGL as onderrigleerstrategie. Daar is ook 'n opleidingsvideo op e-klas waarna u moet kyk alvorens u die eerste kontakssessie gaan bywoon.

Wat is die naam van die instrument wat gebruik gaan word om my kritiese denkvermoë te meet en waarom handel dit?

Dit is die *Watson-Glaser³ Critical Thinking Appraisal* wat deur Pearson TalentLens in die Verenigde Koninkryk uitgegee word. Die toets bestaan uit 40 meervoudigekeusevrae. Die toets word aanlyn afgelê en u het 30 minute geleentheid om dit te voltooi.

Daar is nie regte en verkeerde antwoorde nie. Dit is 'n toets wat kritiese denkvermoëns meet. Dit bepaal u vermoë om:

- aannames te identifiseer;
- argumente te evalueer; en
- gevolgtrekkings te maak.

Moet ek voorberei vir die toets?

Nee, u hoef nie enige voorbereiding te doen nie.

Gaan ek my uitslae van die toets ontvang?

Ja, u ontvang 'n volledige profielverslag na afloop van die toets wat die verskillende komponente van die uitslae uiteensit en verduidelik.

Wat gebeur met die uitslae na afloop van die toets?

U uitslae vorm deel van die data wat ingesamel en ontleed gaan word vir die navorsingsprojek. Al die uitslae word **anoniem** ontleed en dit word streng vertroulik hanteer.

Die inligting word verder volgens die 'General Data Protection Regulation' (GDPR) gestoor deur Pearson TalentLens vir 6 maande, waarna dit anoniem gemaak word en vir navorsingsdoeleindes gebruik kan word.

Wat is die prosedure vir die aflê van die toets?

U het **30 minute** om die toets te voltooi.

Sodra u op die *begin-knoppie* (**Start** button) gedruk het, begin u tyd. **U kan nie die toets stop of onderbreek nadat u begin het nie.**

Wanneer u die laaste vraag voltooi het, druk op *volgende* (**next**) en dan op *die einde-knoppie* (**finish** button).

Die toets neem u dan na die demografiese inligtingsvrae. Gaan deur tot aan die einde en druk op die *handig in-knoppie* (**submit** button).

U moet die toets op u eie aflê en u mag geen hulp van ander persone ontvang nie.

Die volledige instruksies oor hoe om die toets te voltooi word verskaf sodra u toegang verkry tot die aanlyn toets se webblad.

Waarvan moet ek nog kennis neem?

U kan die navorser/dosent vir die module GIFO311, Me Sanli Reyneke en die assistent, Me Martine van der Walt kontak indien u enige verdere navrae het.

'n Kopie van hierdie inligtingstuk en toestemmingsvorm is beskikbaar op e-klas.

Na die suksesvolle afhandeling van die projek, sal die resultate uiteengesit word in 'n artikel wat moontlik gepubliseer kan word. Al die studente wat deelgeneem het aan die projek sal per e-pos in kennis gestel word wanneer die artikel beskikbaar is.

Met dank, Me S. Heystek

VERKLARING VAN DEELNEMER

Hiermee gee ek, _____
(volle naam/-me en van), studentenommer _____,
toestemming dat ek gaan deelneem aan die navorsingsprojek vir die module GIFO311 by
Aros.

Ek onderneem om as deel van die module GIFO311 en die navorsingsprojek die volgende
te doen:

- kontakssessies by te woon en deel te neem aan al die voorgeskrewe module aktiwiteite;
- die PGL opleidingsvideo en inligting in die studiegids deur te werk; en
- die *Watson-Glaser³ Critical Thinking Appraisal* as voor- en na-toets af te lê.

Ek verklaar dat:

- ek hierdie inligtingstuk deurgelees het en verstaan wat van my verwag word in hierdie projek;
- ek die geleentheid gehad het om vrae te vra aan die navorser en dat my vrae beantwoord is;
- ek toestemming verleen dat my joernaal-inskrywings, uitslae van vraelyste en toetse en data wat ingesamel word deur onderhoude gebruik mag word vir die navorsingsprojek;
- ek verstaan dat my inligting vertroulik en konfidentsieel hanteer sal word en dat my identiteit op geen wyse openbaar gemaak sal word nie;
- ek verstaan dat my deelname aan die navorsingsprojek vrywillig is en dat ek nie gedwing was om daaraan deel te neem nie;
- ek verstaan dat ek op enige stadium kan onttrek indien ek nie verder aan die projek wil deelneem nie en dat ek op geen wyse benadeel sal word indien ek onttrek nie; en
- ek verstaan dat ek gevra mag word om die projek te verlaat indien die navorser dit goeddink of as ek nie my verantwoordelikhede nagekom het soos ooreengekom is nie.

Geteken te _____ (plek) op die _____ dag van _____
2019.

Handtekening van deelnemer

Handtekening van getuie

ANNEXURE E: PBL QUESTIONNAIRE

The questionnaire developed by Golightly & Munich (2013) for completion online in Afrikaans. For each item the 5 options to choose from includes:

(1- strongly disagree 2- disagree 3- neutral 4- agree 5- strongly agree)

- 1- stem glad nie saam nie
- 2- stem nie saam nie
- 3- neutraal
- 4- stem saam
- 5- stem heeltemal saam

PGL Ervaring / PBL Experience		
Algemene aspekte van die PGL ervaring <i>General Aspects of PBL Experience</i>	1. The PBL experience was effective and meaningful. 2. PBL motivates me to learn. 3. I prefer PBL above the traditional lecture-based teaching strategies. 4. I mastered new knowledge through PBL. 5. I perceive problems as challenges. 6. Initially I was negative regarding PBL but I became more positive as we progressed towards the solving of the problem. 7. PBL should definitely be integrated in other third and fourth year modules. 8. The PBL activities developed my critical thinking skills.	1. Ek het die PGL-ervaring effektief en betekenisvol gevind. 2. PGL motiveer my om te leer. 3. Ek verkies PGL bo die tradisionele lesing-gebaseerde onderrigmetode. 4. Ek het deur PGL nuwe kennis bemeester. 5. Ek beskou probleme as uitdagings. 6. Aan die begin was ek negatief oor PGL, maar ek het later meer positief geword soos ons gevorder het om die probleme op te los. 7. PGL behoort definitief in die ander derde- en vierdejaar modules geïntegreer te word. 8. Die PGL aktiwiteite het my kritiese denkvaardighede verbeter.
PGL Proses / PBL Process		
Temas <i>Themes</i>	9. The themes studied during the PBL activity was very interesting.	9. Die temas wat in die PGL aktiwiteite bestudeer was, is baie interessant.
Probleem-afbakening <i>Problem delimitation</i>	10. The delimitation of the problem is difficult.	10. Die afbakening van die probleem is moeilik.
Leersake <i>learning issues</i>	11. The group easily identified the learning outcomes (learning issues) in order to solve the problem.	11. Die groep kon die leeruitkomstes of leertake (<i>learning issues</i>) maklik identifiseer om sodoende die probleem op te los.
Samewerkende leer <i>Collaborative learning</i>	12. I had the opportunity to share my knowledge with the other students. 13. I find it to be effective when fellow students assist me with the mastering of skills and knowledge.	12. Ek het die geleentheid gehad om my kennis met ander studente te deel. 13. Ek vind dit effektief wanneer medestudente my ondersteun om vaardighede en kennis te bemeester.

	14. My interaction with fellow students enabled me to judge or value the views of my fellow students. 15. I experienced quality interaction with fellow students in terms of learning.	14. Die interaksie met medestudente het my in staat gestel om die sienings van ander studente te beoordeel. 15. Ek ondervind kwaliteit interaksie met medestudente in terme van leer.
Onafhanklike leer <i>Independent learning</i>	16. PBL will definitely assist me in becoming an independent, life-long learner.	16. PGL help my definitief om 'n onafhanklike, selfgerigte, lewenslange leerder te word.
Werkslading <i>Workload</i>	17. PBL enhances the workload of students.	17. PGL verhoog die werkslading van studente.
Studiemateriaal <i>Study material</i>	18. PBL encourages the integration of different study materials (sources) in order to find solutions to problems. 19. PBL enables you to identify the most important study materials from different resources.	18. PGL moedig die integrasie van verskillende studiemateriaal (bronne) aan om sodoende oplossings vir die probleme te vind. 19. PGL stel jou in staat om die belangrikste studiemateriaal uit verskillende bronne te identifiseer.
Assesserings- rubriek <i>Assessment rubric</i>	20. The assessment rubric for the PBL report effectively guided the group in the writing of the report. 21. The assessment rubric enabled group members to monitor their progress.	20. Die assesseringsrubriek van die PGL verslag het die groep effektief in die skryf van die verslag gelei. 21. Die assesseringsrubriek het groepslede in staat gestel om hul vordering te monitor.
PGL Rolspelers / PBL Role Players		
Tutor	22. The tutor allowed the students self-discovery. 23. The tutor was available to assist students outside of scheduled contact classes. 24. The tutor encouraged the students to accept responsibility for individual and collective learning. 25. The tutor facilitated participation by all group members. 26. The tutor guided the group by stimulating well thought-out discussion. 27. The tutor gave constructive feedback to individuals and to the group as a whole. 28. The tutor maintained a non-authoritative role during tutorial sessions. 29. The tutor treated all students as equals and promotes an atmosphere of mutual respect.	22. Die tutor het die studente toegelaat om self te ontdek. 23. Die tutor was beskikbaar en toeganklik om studente buite die geskeduleerde kontakssessies te help. 24. Die tutor het die studente aangemoedig om verantwoordelikheid vir individuele en samewerkende leer te aanvaar. 25. Die tutor het die deelname van al die groepslede gefasiliteer. 26. Die tutor het die groep gelei deur goed deurdagte bespreking te stimuleer. 27. Die tutor het opbouende terugvoer aan individue en die groep as geheel gegee. 28. Die tutor het gedurende kontakssessies 'n nie-gesaghebbende rol gehandhaaf. 29. Die tutor het al die studente gelykwaardig behandel en het 'n atmosfeer van wedersydse respek bevorder.
Groepleiers <i>Group leaders</i>	30. The different leaders for each of the PBL activities treated all the group members with the necessary respect.	30. Die onderskeie voorsitters (groepleiers) vir die verskillende PGL aktiwiteite, het telkens al die groepslede met die nodige respek behandel.

	31. The different leaders involved group members in meaningful discussions and communications. 32. The leaders encouraged group members to share their own opinions during group discussions. 33. The leaders delegated the learning tasks. 34. The leaders did not contribute anything to the group activities. 35. The leaders forced his opinions and views onto group members. 36. The leaders performed his/her duties effectively.	31. Die onderskeie voorsitters het groepslede in betekenisvolle besprekings en gesprekvoering betrek. 32. Die voorsitters het groepslede aangemoedig om hul opinies te deel tydens die groepbesprekings. 33. Die voorsitters het die leertake (<i>learning issues</i>) gedelegeer. 34. Die voorsitter het self niks bygedra tot die groepaktiwiteite nie. 35. Die voorsitters het hul menings en sienings op die groepslede afgedwing. 36. Die voorsitters het hul baie goed van hul taak gekwyt.
Groepslede <i>Group members</i>	37. Group members exhibited respect and understanding for one another's opinions and views. 38. All group members were well prepared for the tutorial sessions. 39. Group members helped me to understand the necessary concepts, ideas and study content towards the problem solution. 40. The PBL activities helped me to foster good interpersonal relationships with my fellow students. 41. The group listened to the concerns of the individual group members. 42. Group members negatively influenced one another regarding PBL activities. 43. The group members got on well together. 44. PBL enhances tension and frustration among students. 45. All group members reached out to one another in order to realize the outcomes on or before due dates.	37. Groepslede het respek en begrip vir mekaar se menings en sienings getoon. 38. Al die groepslede was goed voorbereid vir die kontakssessies. 39. Die groepslede het my gehelp om die nodige konsepte, idees en studie-inhoud te verstaan om die probleem op te los. 40. PGL het my gehelp om goeie interpersoonlike verhoudings met my medestudente te ontwikkel. 41. Die groep het na die bekommernisse van individuele groepslede geluister. 42. Die groepslede het mekaar negatief beïnvloed oor die PGL aktiwiteite. 43. Die groepslede het goed oor die weg gekom met mekaar. 44. PGL het spanning en frustrasie tussen studente verhoog. 45. Die groepslede het uitgereik na mekaar om die uitkomste voor of op die sperdatums te bereik.

ANNEXURE F: SEMI-STRUCTURED FOCUS-GROUP INTERVIEW QUESTIONS

The question that was used during the semi-structured interviews regarding pre-service ESD teachers' PBL experience.

PGL ERVARING in die algemeen:

1. Verduidelik in watter mate PGL jou geleer het om probleme op te los.
2. Verkies jy PGL as 'n onderrigleerstrategie in omgewingsopvoeding vir volhoubare ontwikkeling? Motiveer jul antwoorde.

PGL PROSES:

3. Watter een van die vier PGL aktiwiteite het jy die meeste geniet? Motiveer jul antwoorde.
4. Het die PGL aktiwiteite jou kennis van omgewingsopvoeding vir volhoubare ontwikkeling bevorder? Motiveer jul antwoorde.
5. Watter deel/fase van die PGL proses was vir jou die uitdagendste? Verduidelik waarom en hoe jul dit met die daaropvolgende aktiwiteite oorkom het.
6. Dink jy dat jul meer effektief geleer het deur saam te werk as lede van 'n groep as wat jy op jou eie sou leer? Motiveer jul antwoorde.

PGL ROLSPELERS:

7. Was die tutors beskikbaar om studente in PGL te ondersteun en te begelei? Motiveer jul antwoorde.
8. In watter opsigte het die tutors jul groep bygestaan in die oplos van die gestelde probleme?
9. Het die onderskeie groepleiers (voorsitters) vir die verskillende PGL aktiwiteite hul goed van hul taak gekwyt? Motiveer jul antwoorde.
10. Jul het in die groep geleentheid gehad om verskillende rolle in te neem. Verduidelik waarom dit goed of nie goed gewerk het nie.
11. Het die groepslede goed saamgewerk?
12. Is daar in die PBL tutoriale sessies geredeneer en selfs geargumenteer in die oplos van die gestelde omgewingsopvoedingsprobleme?

KRITIESE DENKE

13. Het die PGL aktiwiteite jou kritiese denke uitgedaag? Brei uit deur te verduidelik watter kritiese denkvaardighede jy moes inspan.
14. Tydens watter deel van die PGL proses moes jy kritiese denke toepas?
15. Dink jy jou kritiese denkvaardighede het verbeter na die voltooiing van die vier PGL aktiwiteite? Motiveer jul antwoorde.

16. Het die probleem-oplossende en kritiese denkevaardighede daartoe bygedra dat jy 'n beter begrip en insig ontwikkel het van omgewingsprobleme en hoe om dit op te los? Motiveer julle antwoorde.

ANNEXURE G: REFLECTIVE LEARNING JOURNAL QUESTIONS

Reflective learning journals will be compiled by students during the semester for each of the four PBL activities. Reflective questions include the useful points of Gibbs' Reflective Cycle (Peter, 2016):

1. Description: what happened during the completion of the PBL activity?
2. Feelings: what were you thinking and feeling prior, during and after the PBL activity?
3. Evaluation: what went well or badly during the PBL activity and what caused it?
4. Conclusion: what could you have done differently and what did you learn from this experience?
5. Action plan: if this occurs again, what can you do and how can you improve?
6. Critical thinking: Which critical thinking skills were developed whilst completing the PBL activities?

Guidelines:

- Write in the first person; make it your own.
- Let the words flow.

Hierdie vrae dien as riglyn om die reflektiewe joernaalinskrywings te voltooi vir elke PGL aktiwiteit:

1. Beskrywing: wat het gebeur tydens die voltooiing van die aktiwiteit?
2. Emosies: wat het jy gedink en ervaar voor, tydens en na afloop van die aktiwiteit wat jy saam met jou groeplede voltooi het?
3. Evaluering: wat was vir jou goed of wat was sleg tydens die voltooiing van die aktiwiteit en wat dink jy het dit veroorsaak?
4. Gevolgtrekking: wat kon jy anders gedoen het en wat het jy geleer uit die voltooiing van die aktiwiteit?
5. Aksieplan: hoe kan jy verbeter en watter voorstelle kan jy maak indien dieselfde probleem weer voorkom?
6. Kritiese denkvaardighede: Watter van die onderstaande kritiese denkvaardighede is bevorder in die uitvoer van die PGL-aktiwiteit? (Jy verstaan die verband tussen idees; jy kan die relevansie van argumente en idees bepaal en aannames identifiseer; jy kan argumente formuleer en beoordeel; jy kan teenstrydighede en foute in redenasies identifiseer; jy kan probleme op 'n sistematiese wyse benader; jy kan uit al die inligting tot 'n logiese gevolgtrekking kom; ensovoorts.)

ANNEXURE H: EXAMPLE OF RLJ CODING

1. Beskrywing: wat het gebeur tydens die voltooiing van die aktiwiteit? In die eerste kontakssessie het ons dadelik begin beplan en takies vir mekaar uitgedeel sodat ons die volgende week ons navorsing kon begin het. Die groep het in die eerste week stadiger gewerk omdat ons die verkeerde prentjie voor ons gehad het. Na die tweede kontakssessie kon ons onself herposisioneer en in die regte rigting navorsing doen. In die laaste week het almal mooi hard saam gewerk, alhoewel [REDACTED] soms weier gedink het as nodig.
2. Emosies: wat het jy gedink en ervaar voor, tydens en na afloop van die aktiwiteit wat jy saam met jou groeplede voltooi het? <u>Voor:</u> Ek was in die eerste week bietjie skepties oor ons groep omdat nie almal dieselfde idee gehad van wat die opdrag van ons verwag het nie. <u>Tydens:</u> Na die tweede kontakssessie het ek 'n duidelikheid gehad van wat van ons verwag word en ek kon lekker begin met my navorsing. Nadat ek 'n "templaat" vir ons groeplede opgestel het kon ons almal lekker saam werk. <u>Na:</u> Ons groeplede het in die laaste week baie mooi saam gewerk om die finale afronding aan die opdrag te doen. Ek het selfs omgewingsvriendelike stelsels in my leefstyl begin vestig.
3. Evaluering: wat was vir jou goed of wat was sleg tydens die voltooiing van die aktiwiteit en wat dink jy het dit veroorsaak? <u>Goed:</u> Ek het lanklaas so lekker in 'n groep gewerk waar almal hulle verantwoordelikhede nagekom het. Ek het goeie ervaring opgebou wat ek as onderwyser kan gebruik wanneer my leerders in groepe moet werk. My liefde, omgee en bewondering vir die natuur het toegeneem soos ek meer ondersoek ingestel het. <u>Sleg:</u> Nie almal is ewe aktief op die Google Docs nie (nie almal antwoord op die <i>comments</i> nie). Sommige lede werk tot laat in die aand en kan nie elke dag werk aan die opdrag nie. [REDACTED] luister nie dat 'n mens klaar praat nie, dan is sy nie op dieselfde bladsy as ons nie en doen dan haar eie ding.
4. Gevolgtrekking: wat kon jy anders gedoen het en wat het jy geleer uit die voltooiing van die aktiwiteit? Ek kon vroer begin het met my navorsing en meer oplossings genoem het. Stel 'n templaar vooraf op van hoe die opdrag moet lyk sodat almal net hoef in te vul. Daar is reeds baie omgewingsbestuurstelsels; skole, onderwysers, leerders en ouers moet net ingelig word en motivering gegee word vir die aanneming van so 'n stelsel.
5. Aksieplan: hoe kan jy verbeter en watter voorstelle kan jy maak indien dieselfde probleem weer voorkom? Begin in die eerste week om die verslag se templaar op Google Docs te laat. In die eerste week moet ek die opdrag deurgelees het en begin navors. Vir klasbesprekings moet ons groep punte neerskryf voor die tyd oor dit wat ons wil behandel sodat ons nie van die punt af dwaal nie.
6. Kritiese denkvaaardighede: Watter van die onderstaande kritiese denkvaaardighede is bevorder in die uitvoer van die PGL-aktiwiteit? Ek kan argumente formuleer en beoordeel; ek kan probleme op 'n sistematiese wyse benader; ek kan uit al die inligting tot 'n logiese gevolgtrekking kom.

13:10 Die...	◇ E-Pr-problem-work incorrect/i...
13:...	◇ *time-beginning
13:...	◇ E-Pr-emotion-negative/feel ov...
13:9 Ty...	◇ *time-during
13:2 N...	◇ E-Pr-emotion-enjoy
13:3 Goed...	◇ *time-end
13:...	◇ E-Pr-theme 1 EMS and ESD
13:...	◇ E-RP-group-cooperation
13:...	◇ I-learned-new behaviour
13:...	◇ #positive
13:...	◇ E-Pr-emotion-positive/feel good
13:...	◇ E-Pr-theme 1 EMS and ESD
13:...	◇ E-RP-group-cooperation
13:...	◇ I-PBL-experience in general
13:...	◇ #negative
13:...	◇ E-Pr-problem-communication
13:...	◇ E-Pr-problem-time managemen...
13:...	◇ E-Pr-Process Google Docs
13:...	◇ E-Pr-theme 1 EMS and ESD
13:5 Begin...	◇ E-Pr-Process Google Docs
13:...	◇ E-Pr-solution-planning
13:...	◇ E-Pr-solution-time management
13:...	◇ CT-jy kan argumente formulee...
13:...	◇ CT-jy kan probleme op 'n siste...
13:...	◇ CT-jy kan uit al die inligting tot...

ANNEXURE I: ESD MODULE PLANNING AND ESD STUDY LETTER WITH ASSESSMENT RUBRICS

Beplanning – GIFO311 2019

DATUM	ONDERWERP	BRONNE	ASSESSERINGS- OPDRAG	Punte	Gewigswaarde
Week 1	<u>Leereenheid 1 Omgewingsopvoeding in SA</u> • Opleiding in PGL • Groepwerk en fasilitering: Projek 1	Geen voorgeskrewe bronne. Aanbevole bronne beskikbaar in AROS	Klasdeelname en bydrae tot verslag	15	5%
Week 2	<u>Leereenheid 1 Omgewingsopvoeding in SA</u> • Groepwerk en fasilitering: Projek 1	Biblioteek: 1. Botkin, D.B. & Keller, E.A. 2014. <i>Environmental Science, Earth as a Living Planet</i> . Hoboken: John Wiley & Sons Inc. 2. Getis, A., Bjelland, M. & Getis, V. 2018. <i>Introduction to Geography</i> . 15de uitg. New York: McGrawhill Education. 3. Loubser, C.P. ed. 2017. <i>Environmental Education and Education for Sustainability, Some South African Perspectives</i> . 2de uitg. Pretoria: Van Schaik. 4. Miller, T.G. 2018. <i>Living in the Environment</i> , 19de uitg. Boston: Cengage Learning. 5. Peterson, J.F., Sack, D. & Gabler, R.E. 2017. <i>Physical Geography</i> . 11de uitg. Boston: Cengage Learning.	Leerjoernaal inskrywings	25	10%
Week 3	<u>Leereenheid 1 Omgewingsopvoeding in SA</u> • Terugvoer Projek 1		Aanbieding deur groep	30	10%
Week 4	<u>Leereenheid 2 Omgewingsprobleme</u> • Groepwerk en fasilitering: Projek 2		Klasdeelname en bydrae tot verslag	15	5%
Week 5	<u>Leereenheid 2 Omgewingsprobleme</u> • Groepwerk en fasilitering: Projek 2		Leerjoernaal inskrywings	25	10%
Week 6	<u>Leereenheid 2 Omgewingsprobleme</u> • Terugvoer Projek 2		Aanbieding deur groep	30	10%
Week 7	<u>Leereenheid 2 Omgewingsprobleme</u> • Groepwerk en fasilitering: Projek 3		Klasdeelname en bydrae tot verslag	15	5%
Week 8	<u>Leereenheid 2 Omgewingsprobleme</u> • Groepwerk en fasilitering: Projek 3		Leerjoernaal inskrywings	25	10%
Week 9	<u>Leereenheid 2 Omgewingsprobleme</u> • Terugvoer Projek 3		Aanbieding deur groep	30	10%
Week 10	<u>Leereenheid 3 Omgewingsopvoeding in praktyk</u> • Groepwerk en fasilitering: Projek 4		Klasdeelname en bydrae tot verslag	15	5%
Week 11	<u>Leereenheid 3 Omgewingsopvoeding in praktyk</u> • Groepwerk en fasilitering: Projek 4		Leerjoernaal inskrywings	25	10%
Week 12	<u>Leereenheid 3 Omgewingsopvoeding in praktyk</u> • Terugvoer Projek 4		Aanbieding deur groep	30	10%



Studiebrief

GIFO311

2019

1. ALGEMEEN

Beplan jou studies volgens die studiebrief sodra jy jou studiebrief ontvang het. Studente moet deurgaans deur die loop van die semester hierdie studiebrief deurgaans om seker te maak van die datums waarop toetse geskryf of opdragte ingehandig moet word.

Die dosent se e-posadres sal in die studiebrief verskyn, maar dit is beter om jou module te e-pos, hierdie e-pos word dan gestuur na die betrokke tutor van die module.

1.1. Kontakbesonderhede

Dosent	Akademiese assistent
Sanli Heystek sanli.heystek@aros.ac.za	Martine van der Walt gifo311@aros.ac.za

Die inhoud van hierdie studiebrief is belangrik. Let asseblief op na die werkskedule, toetse, teikendatums en ander belangrike inligting. Enige vrae en versoeke ten opsigte van die module moet met die dosent bespreek word. Afsprake moet asb. ook per e-pos gemaak word.

1.2. Slaagvereistes

U benodig 'n module punt van 50% om hierdie module te slaag.

1.3. Klasbywoning

Dit is belangrik dat alle kontaksessies bygewoon word, aangesien fasilitering van groepwerk tydens kontaksessies gaan plaasvind. Daar word van jou verwag om ten volle voorbereid te wees en om saam met jou groep te werk. As jy nie 'n kontakssessie kan bywoon nie, moet jy 'n mediese sertifikaat aan jou dosent verskaf.

1.4. Plagiat

Verwysings is 'n belangrike aspek in alle opdragte, aangesien navorsing oor die onderwerp gedoen moet word. Studente moet deur middel van verwysings bewys kan lewer dat die nodige navorsing gedoen is en dat die inhoud daarvan verstaan word.

Indien 'n student hom-/haarself skuldig maak aan swak akademiese praktyk of plagiaat, gaan die student 'n verpligte verwysingswerkswinkel moet bywoon.

Let wel dat die opdragpunt van die betrokke opdrag as nul gaan reflekteer tot die werkswinkel bygewoon is. Na bywoning sal die student se aangepaste punt beskikbaar gestel word. Indien die student nie die werkswinkel bywoon nie, ontvang die student nul vir die betrokke opdrag.

Vir meer inligting, raadpleeg die Aros Verwysingsgids of kontak die akademiese assistent van die module.

<i>Die onderstaande word gesien as swak akademiese praktyk of plagiaat:</i>
Geen in-teks verwysings in die opdrag nie,
Geen bronnelys in die opdrag nie,
Geen in-teksverwysing en bronnelys nie,
In-teks verwysing en verwysing in bronnelys stem nie ooreen nie.
Turnitin verslag dui aan dat te min parafrasering plaasgevind het, wat lei tot plagiaat (Baie inligting is net so uit bronne gekopieer of direk vertaal).
Twee studente wat dieselfde opdrag inhandig
Student wat 'n opdrag van 'n vorige jaargroep as hul eie inhandig

2. STUDIEMATERIAAL

Studiemateriaal
Daar is geen voorgeskrewe boeke en artikels vir hierdie module nie.
In die studiegids is aanbevole boeke en artikels gelys wat u kan gebruik.
Addisionele artikels sal ook op e-klas beskikbaar wees.

3. ASSESSERING

3.1. *Klasdeelname en bydrae tot PGL projek*

U word weekliks gemonitor deur die tutors en ontvang 'n punt vir klasdeelname en bydrae gelewer tot die groep se PGL verslag.

3.2. *Leerjoernaal inskrywings*

U gaan reflekteer oor die PGL proses deur leerjoernaal inskrywings te voltooi vir elke PGL aktiwiteit.

3.3. *Klasaanbieding*

U word saam met u groep geassesseer vir die klasaanbieding van jul PGL projek. Hierdie drie assesserings vorm saam die deelname punt vir die module.

3.4. *Self- en Portuurassessering*

Elke student voltooi die self- en portuurassesseringsrubriek na afloop van elke PGL aktiwiteit om hul eie bydrae asook die bydrae van die onderskeie groeplede te assesseer. Hierdie rubrieke word saam met die portefeulje ingehandig.

3.5. *PGL Verslae*

Die vier voltooide PGL verslae word ingehandig en deur die tutors geassesseer. Hierdie verslae word saamgevoeg en ingedien as die groep se portefeulje.

4. PORTEFEULJE

U benodig 'n deelname punt van minstens 40% om die portefeulje saam met u groep in te handig. Die portefeulje bestaan uit die finale verslae van die vier PGL aktiwiteite. Elke student se individuele punt vir die portefeulje word bereken deur die self- en portuurassessering in ag te neem.

5. MODULEPUNT

Word bereken deur jou portefeulje punt en deelname punt in verhouding van 50:50.

6. DEELNAMEPUNT

Die deelnamepunt sal soos volg bereken word:

Assessering geleentheid	Gewig
Klasdeelname en bydrae tot verslag van PGL aktiwiteit 1-4	20%
Leerjoernaal inskrywings van PGL aktiwiteit 1-4	40%
Klasaanbieding van PGL aktiwiteit 1-4	40%
Totaal van deelnamepunt	100%

7. WERKPROGRAM

Ons werkprogram vir die semester is as volg:

Week	Datums van klasse	Leereenhede	Assessering geleentheid
1	1/2 Feb.	1. Omgewingsopvoeding in SA	klasdeelname
2	8/9 Feb.	Groepwerk	klasdeelname
3	15/16 Feb.	Klasaanbieding	PGL Aktiwiteit 1
4	22/23 Feb.	2. Omgewingsopvoeding vir volhoubare ontwikkeling	klasdeelname
5	1/2 Mrt.	Groepwerk	klasdeelname
6	8/9 Mrt.	Klasaanbieding	PGL Aktiwiteit 2
7	15/16 Mrt.	2. Omgewingsopvoeding vir volhoubare ontwikkeling	klasdeelname
8	5/6 Apr.	Groepwerk	klasdeelname
9	12/13 Apr.	Klasaanbieding	PGL Aktiwiteit 3
10	3/4 Mei	3. Omgewingsopvoeding in praktyk	klasdeelname
11	10/11 Mei	Groepwerk	klasdeelname
12	17/18 Mei	Klasaanbieding	PGL Aktiwiteit 4

8. ASSESSERINGSRUBRIEKE

Die volgende rubrieke gaan gebruik word vir die assesseringsgeleenthede:

Assesseringsrubriek vir PGL Aktiwiteit 1 (Omgewingsbestuursplan)

Groep: _____

KRITERIA	PUNTE	UITSTEKEND	GOED	REDELIKE POGING	ONVOLDOENDE
Afbakening van die probleem	4	Baie goeie en volledige afbakening van probleem. (4)	Bevredigende afbakening van die probleem. (3)	Afbakening van die probleem toon leemtes. (2)	Swak en vae afbakening van die probleem. (1)
Formulering van die leerdoelwitte	8	Leerdoelwitte is volledig en baie goed gedefinieer. (7-8)	Leerdoelwitte is bevredigend gedefinieer. (5-6)	Leerdoelwitte is nie volledig en goed gedefinieer nie. (3-4)	Leerdoelwitte is swak gedefinieer en onvolledig. (1-2)
Die omvang en kwaliteit van die navorsing; ontleed en beskrywing van die probleem	20	Buitengewoon goeie beskrywing van die waarde van omgewingsopvoeding wat 'n baie goeie begrip van die probleem toon. (16-20)	Bevredigende beskrywing van die waarde van omgewingsopvoeding wat 'n goeie begrip van die probleem toon. (11-15)	Die beskrywing van die waarde van omgewingsopvoeding kon verder ontwikkel word aangesien leemtes in die begrip van die probleem voorkom. (6-10)	Swak beskrywing van die waarde van omgewingsopvoeding wat tot 'n swak begrip van die probleem aanleiding gee. (1-5)
Identifisering en aanbevelings van moontlike oplossings vir die probleem	12	Volledige en buitengewoon goed-geformuleerde oplossings en aanbevelings vir die probleem is gemaak. Goeie, werkbare omgewingsbestuurstelsel is ingesluit. (10-12)	Volledige en goed geformuleerde oplossings en aanbevelings is vir die probleem gemaak. Omgewingsbestuurstelsel is ingesluit. (7-9)	Slegs sekere oplossings en aanbevelings is van toepassing op die probleem. Omgewingsbestuurstelsel is onduidelik of nie gepas nie. (4-6)	Swak geformuleerde oplossings en aanbevelings van die probleem is gemaak. Omgewingsbestuurstelsel ontbreek. (1-3)
Die gebruik van resente literatuur, bronne en data	8	Die gebruik van resente wetenskaplike bronne en data is uitstekend. (7-8)	Die gebruik van die bronne en data is goed. (5-6)	Daar kon van meer resente bronne en data in bespreking gebruik gemaak word. (3-4)	Te min bronne en resente data is gebruik. (1-2)
Bronverwysings en bibliografie	4	Bronverwysings in die bespreking is op goeie akademiese standaard. Die bibliografie is volledig en korrek. (4)	Bronverwysings is meestal korrek in die bespreking aangehaal. Bronne is korrek in die bibliografie aangehaal. (3)	Van die bronne is nie korrek of glad nie aangehaal nie. Nie al die bronne is in die bibliografie gelys nie of is foutief gelys. (2)	Daar is glad nie na bronne verwys nie. Of die bronne is nie korrek aangehaal nie. Die bronne word ook nie in die bibliografie verwys nie. (1)
Skryfvaardighede	4	Goeie akademiese taalgebruik kom voor. (4)	Akademiese taalgebruik kom voor. (3)	Akademiese taalvaardigheid kort aandag. Spelfoute kom algemeen voor. (2)	Die taalgebruik is nie op standaard nie. Te veel spelfoute kom voor. (1)
TOTAAL	60				

Assesseringsrubriek vir PGL Aktiwiteit 2 (Waterbesoedeling)

Groep: _____

KRITERIA	PUNTE	UITSTEKEND	GOED	REDELIKE POGING	ONVOLDOENDE
Afbakening van die probleem	4	Baie goeie en volledige afbakening van probleem. (4)	Bevredigende afbakening van die probleem. (3)	Afbakening van die probleem toon leemtes. (2)	Swak en vae afbakening van die probleem. (1)
Formulering van die leerdoelwitte	8	Leerdoelwitte is volledig en baie goed gedefinieer. (7-8)	Leerdoelwitte is bevredigend gedefinieer. (5-6)	Leerdoelwitte is nie volledig en goed gedefinieer nie. (3-4)	Leerdoelwitte is swak gedefinieer en onvolledig. (1-2)
Die omvang en kwaliteit van die navorsing; ontleed en beskrywing van die probleem	20	Buitengewoon goeie beskrywing van die oorsake en gevolge van waterbesoedeling wat 'n baie goeie begrip van die probleem toon. (16-20)	Bevredigende beskrywing van die oorsake en gevolge van waterbesoedeling wat 'n goeie begrip van die probleem toon. (11-15)	Die beskrywing van die oorsake en gevolge van waterbesoedeling kon verder ontwikkel word aangesien leemtes in die begrip van die probleem voorkom. (6-10)	Swak beskrywing van die oorsake en gevolge van waterbesoedeling wat tot 'n swak begrip van die probleem aanleiding gee. (1-5)
Identifisering en aanbevelings van moontlike oplossings vir die probleem	12	Volledige en buitengewoon goed-geformuleerde oplossings en aanbevelings vir die probleem is gemaak. Baie goeie aanbevelings is gemaak om plaaslike owerheid en onderwysers te betrek. (10-12)	Volledige en goed geformuleerde oplossings en aanbevelings is vir die probleem gemaak. Die rol van plaaslike owerheid en onderwysers is uiteengesit. (7-9)	Slegs sekere oplossings en aanbevelings is van toepassing op die probleem. Die rol van plaaslike owerheid en onderwysers toon leemtes. (4-6)	Swak geformuleerde oplossings en aanbevelings van die probleem is gemaak. Die rol van die plaaslike owerheid en onderwysers is vaag of ontbreek. (1-3)
Die gebruik van resente literatuur, bronne en data	8	Die gebruik van resente wetenskaplike bronne en data is uitstekend. (7-8)	Die gebruik van die bronne en data is goed. (5-6)	Daar kon van meer resente bronne en data in bespreking gebruik gemaak word. (3-4)	Te min bronne en resente data is gebruik. (1-2)
Bronverwysings en bibliografie	4	Bronverwysings in die bespreking is op goeie akademiese standaard. Die bibliografie is volledig en korrek. (4)	Bronverwysings is meestal korrek in die bespreking aangehaal. Bronne is korrek in die bibliografie aangehaal. (3)	Van die bronne is nie korrek of glad nie aangehaal nie. Van die bronne is nie in die bibliografie gelys nie of is foutief gelys. (2)	Bronverwysings ontbreek of is foutief. Die bronne word ook nie in die bibliografie verwys nie. (1)
Skryfvaardighede	4	Goeie akademiese taalgebruik kom voor. (4)	Akademiese taalgebruik kom voor. (3)	Akademiese taalvaardigheid kort aandag. Spelfoute kom algemeen voor. (2)	Die taalgebruik is nie op standaard nie. Te veel spelfoute kom voor. (1)
TOTAAL	60				

Assesseringsrubriek vir PGL Aktiwiteit 3 (Aardverwarming)
Groep: _____

KRITERIA	PUNTE	UITSTEKEND	GOED	REDELIKE POGING	ONVOLDENDE
Afbakening van die probleem	4	Baie goeie en volledige afbakening van probleem. (4)	Bevredigende afbakening van die probleem. (3)	Afbakening van die probleem toon leemtes. (2)	Swak en vae afbakening van die probleem. (1)
Formulering van die leerdoelwitte	8	Leerdoelwitte is volledig en baie goed gedefinieer. (7-8)	Leerdoelwitte is bevredigend gedefinieer. (5-6)	Leerdoelwitte is nie volledig en goed gedefinieer nie. (3-4)	Leerdoelwitte is swak gedefinieer en onvolledig. (1-2)
Die omvang en kwaliteit van die navorsing; ontleed en beskrywing van die probleem	20	Buitengewoon goeie beskrywing van die oorsake en gevolge van aardverwarming wat 'n baie goeie begrip van die probleem toon. (16-20)	Bevredigende ontwikkelde beskrywing van die oorsake en gevolge van aardverwarming wat 'n goeie begrip van die probleem toon. (11-15)	Die beskrywing van die oorsake en gevolge van aardverwarming kon verder ontwikkel word aangesien leemtes in die begrip van die probleem voorkom. (6-10)	Swak ontwikkelde beskrywing van die oorsake en gevolge van aardverwarming wat 'n swak begrip van die probleem aanleiding gee. (1-5)
Identifisering en aanbevelings van moontlike oplossings vir die probleem	12	Volledige en buitengewoon goed-geformuleerde oplossings en aanbevelings vir die probleem is gemaak. Gepaste maatreëls deur die regering en bydraes van individue is voorgestel. (10-12)	Volledige en goed geformuleerde oplossings en aanbevelings is vir die probleem gemaak. Maatreëls deur die regering en bydraes van individue kom voor in die verslag. (7-9)	Slegs sekere oplossings en aanbevelings is van toepassing op die probleem. Maatreëls deur die regering en bydraes van individue toon leemtes. (4-6)	Swak geformuleerde oplossings en aanbevelings van die probleem is gemaak. Maatreëls deur die regering en bydraes van individue ontbreek of is baie vaag. (1-3)
Die gebruik van resente literatuur, bronne en data	8	Die gebruik van resente wetenskaplike bronne en data is uitstekend. (7-8)	Die gebruik van die bronne en data is goed. (5-6)	Daar kon van meer resente bronne en data in bespreking gebruik gemaak word. (3-4)	Te min bronne en resente data is gebruik. (1-2)
Bronverwysings en bibliografie	4	Bronverwysings in die bespreking is op goeie akademiese standaard. Die bibliografie is volledig en korrek. (4)	Bronverwysings is meestal korrek in die bespreking aangehaal. Bronne is korrek in die bibliografie aangehaal. (3)	Van die bronne is nie korrek of glad nie aangehaal nie. Van die bronne is nie in die bibliografie gelys nie of is foutief gelys. (2)	Daar is glad nie na bronne verwys nie. Of die bronne is nie korrek aangehaal nie. Die bronne word ook nie in die bibliografie verwys nie. (1)
Skryfvaardighede	4	Goeie akademiese taalgebruik kom voor. (4)	Akademiese taalgebruik kom voor. (3)	Akademiese taalvaardigheid kort aandag. Spelfoute kom algemeen voor. (2)	Die taalgebruik is nie op standaard nie. Te veel spelfoute kom voor. (1)
TOTAAL	60				

Assesseringsrubriek vir PGL Aktiwiteit 4 (Omgewingsopvoeding in praktyk)
Groep: _____

KRITERIA	PUNTE	UITSTEKEND	GOED	REDELIKE POGING	ONVOLDENDE
Afbakening van die probleem	4	Baie goeie en volledige afbakening van probleem. (4)	Bevredigende afbakening van die probleem. (3)	Afbakening van die probleem toon leemtes. (2)	Swak en vae afbakening van die probleem. (1)
Formulering van die leerdoelwitte	8	Leerdoelwitte is volledig en baie goed gedefinieer. (7-8)	Leerdoelwitte is bevredigend gedefinieer. (5-6)	Leerdoelwitte is nie volledig en goed gedefinieer nie. (3-4)	Leerdoelwitte is swak gedefinieer en onvolledig. (1-2)
Die omvang en kwaliteit van die navorsing; ontleed en beskrywing van die probleem	20	Buitengewoon goeie beskrywing van die KABV vereistes en die konsep volhoubare ontwikkeling wat 'n baie goeie begrip van die tema toon. (16-20)	Bevredigende beskrywing van die KABV vereistes en die konsep volhoubare ontwikkeling wat 'n goeie begrip van die tema toon. (11-15)	Die beskrywing van die KABV vereistes en die konsep volhoubare ontwikkeling kon verder ontwikkel word aangesien leemtes in die begrip van die tema voorkom. (6-10)	Swak beskrywing van die KABV vereistes en die konsep volhoubare ontwikkeling wat tot 'n swak begrip van die tema aanleiding gee. (1-5)
Identifisering en aanbevelings van moontlike oplossings vir die probleem	12	Volledige en buitengewoon goed-geformuleerde oplossings en aanbevelings vir die probleem is gemaak. Baie goeie praktiese les wat omgewingsopvoeding integreer is ingesluit. (10-12)	Volledige en goed geformuleerde oplossings en aanbevelings is vir die probleem gemaak. Goeie les wat omgewingsopvoeding integreer is ingesluit. (7-9)	Slegs sekere oplossings en aanbevelings is van toepassing op die probleem. Omgewingsopvoeding les is redelik toepaslik. (4-6)	Swak geformuleerde oplossings en aanbevelings van die probleem is gemaak. Omgewingsopvoeding les is nie toepaslik nie of ontbreek. (1-3)
Die gebruik van resente literatuur, bronne en data	8	Die gebruik van resente wetenskaplike bronne en data is uitstekend. (7-8)	Die gebruik van die bronne en data is goed. (5-6)	Daar kon van meer resente bronne en data in bespreking gebruik gemaak word. (3-4)	Te min bronne en resente data is gebruik. (1-2)
Bronverwysings en bibliografie	4	Bronverwysings in die bespreking is op goeie akademiese standaard. Die bibliografie is volledig en korrek. (4)	Bronverwysings is meestal korrek in die bespreking aangehaal. Bronne is korrek in die bibliografie aangehaal. (3)	Van die bronne is nie korrek of glad nie aangehaal nie. Van die bronne is nie in die bibliografie gelys nie of is foutief gelys. (2)	Daar is glad nie na bronne verwys nie. Of die bronne is nie korrek aangehaal nie. Die bronne word ook nie in die bibliografie verwys nie. (1)
Skryfvaardighede	4	Goeie akademiese taalgebruik kom voor. (4)	Akademiese taalgebruik kom voor. (3)	Akademiese taalvaardigheid kort aandag. Spel- en taalfoute kom algemeen voor. (2)	Die taalgebruik is nie op standaard nie. Te veel spel- en taalfoute kom voor. (1)
TOTAAL	60				

Self- en portuurassessering van bydraes in PGL Aktiwiteit 1 / 2 / 3 / 4

(Ontwikkel deur Crowe| C.M.)

Naam:

Groep:

Assessering van die groep: Ken 'n punt uit 10 toe vir jou groep se samewerking om die aanlyn PBL aktiwiteit te voltooi: (10) groep werk baie goed aanlyn saam aan die aktiwiteit te voltooi. (5) groep werk gewoonlik goed saam, met probleme van tyd tot tyd. (0) groep kan glad nie aanlyn saamwerk om die PBL aktiwiteit te voltooi nie.	
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Dui 'n punt van 0 (swak) tot 10 (baie goed) aan in elke ry vir jouself asook al die lede in jou groep. Jou assessering moet wees oor die uitvoering en prestasie van groeplede in die voltooiing van die aanlyn PBL aktiwiteite en is daarom gerig op bewyse wat jy gesien en gehoor het.

Vul jou naam in die eerste kolom en daarna die name van jou groeplede:	self					
Leierskap (10) Verskaf rigting, het ander geïnspireer. (5) Gewillige volgelinge (0) Het groep gefrustreer, die vordering vertraag en ander gekritiseer.						
Samewerking (10) Het gereeld met die ander saamgewerk, het bygedra tot die groepwerk. (5) Het saamgewerk met die nodige aanmoediging so nou en dan. (0) Het selde 'n bydra gelewer, meestal alleen gewerk, moes gedwing word om saam te werk anders het hy nie saamgewerk nie.						
Inisiatief (10) Kom op met goeie idees wat ander gehelp het, het probleme opgelos. (5) Aanvaar ander se idees en help om dit te verbeter. (0) Kritiseer ander se idees, maar gee nooit sy eie idees nie.						
Houding (10) Positief, moedig ander aan tot beter werk. (5) Neutraal, werk goed saam met die groep sonder entoesiasme of 'n gebrom. (0) Negatief, kla oor die projek, en werk onwillig saam met die groep.						
Poging (10) Werk baie hard aan die take soos toegedeel deur die groep of op sy/haar eie. (5) Werk redelik hard, gegewe ander modules en verpligtinge. (0) Het glad nie hard gewerk nie, take is nie gedoen nie of was nie-bevredigend nie.						
Navorsing (10) Het baie addisioneel gepubliseerde artikels, kontakte of internet-webbladsye gevind en wat baie die PBL projek gehelp het (5) Het slegs die toegedeelte materiaal gelees en het die kennis effektief gebruik. (0) Het geen materiaal oor die PBL projek gelees nie, en het op ander staat gemaak vir inligting.						
Kommunikasie en geskrewe verslag (10) Het groot dele van die verslag georganiseer en geskryf. (5) Het sy/haar gedeelte bygedra tot die skryf van die verslag. (0) Het min tot geen bydra gelewer in die skryf van die verslag nie.						
Individuele take (10) Het alles op sy/haar eie gedoen, het ook ander gehelp. (5) Het meeste gedoen, met miskien die hulp van ander. (0) Het of min van dit gedoen of die meeste was gekopieer.						
Begrip van die aanlyn PBL-aktiwiteit (10) Uitstekende begrip van die PBL-aktiwiteit en het dit effektief met groeplede gedeel. (5) Redelike begrip van die PBL-aktiwiteit getoon en dit effektief gebruik. (0) Min of kunsmatige begrip van die PBL-aktiwiteit getoon, en het op groeplede staat gemaak.						
Totaal uit 100:						

Assesseringsrubriek: Klasaanbieding van PGL Aktiwiteit 1 / 2 / 3 / 4**Groep:**

Kriteria	Punte toekenning
Die aanbieder: Aanbieder is goed voorberei; is gemaklik en praat duidelik. Naam van aanbieder:	/10
Klasaanbieding skyfies: Skyfies is netjies, kreatief en duidelik sigbaar; dit bevat slegs die hoofpunte. Daar is moeite gedoen met die voorbereiding van die skyfies.	/10
Terugvoer: Goeie bevindinge en oplossings word aangebied; dit word op 'n logiese wyse verduidelik en uiteengesit.	/10
Totaal:	/30

Assesseringsrubriek: Leerjoernaal van PGL Aktiwiteit 1 / 2 / 3 / 4**Naam:****Groep:**

Kriteria	Punte toekenning
1. Kort beskrywing van wat gebeur het tydens die voltooiing van die projek.	/5
2. Beskrywing van wat jy gedink en ervaar het terwyl jy die projek saam met jou groeplede voltooi het.	/5
3. Evaluering van wat vir jou goed en wat sleg was tydens die projek.	/5
4. Gevolgtrekking oor wat jy anders kon gedoen het.	/5
5. Aksieplan voorstelle oor wat jy kan doen as dit weer voorkom.	/5
Totaal:	/25

Assesseringsrubriek: Klasdeelname & bydrae PGL Aktiwiteit 1 / 2 / 3 / 4**Naam:****Groep:**

Kriteria	Punte toekenning
Klasdeelname en bydrae tot PGL aktiwiteit – week 1.	/5
Klasdeelname en bydrae tot PGL aktiwiteit – week 2.	/5
Klasdeelname en bydrae tot PGL aktiwiteit – week 3.	/5
Totaal:	/15

Baie sterkte met jou studies.

Vriendelike groete, **Sanli Heystek**

ANNEXURE J: LIST OF DOCUMENTS AVAILABLE ELECTRONICALLY

This following documents are available electronically. Follow the link to the *Google Drive* folder and send a request email to review the content.

<https://drive.google.com/drive/folders/1Ka0jdOGXhSyEP90al2BjUSo1-EURyKgh?usp=sharing>

Code list RLJ and focus-group interviews (FGI) (*Atlas.ti8* report)

ESD Study Guide

FGI quotations group 1 and 2 (*Atlas.ti8* report)

FGI recording group 1

FGI recording group 2

FGI transcription group 1

FGI transcription group 2

PBL tutorial video

RLJ quotations activity 1 (*Atlas.ti8* report)

RLJ quotations activity 2 (*Atlas.ti8* report)

RLJ quotations activity 3 (*Atlas.ti8* report)

RLJ quotations activity 4 (*Atlas.ti8* report)

Tutor observational field notes PBL activity 1-4