TOWARDS A FRAMEWORK TO ENHANCE ENTRY-LEVEL NATIONAL DIPLOMA STUDENTS' LEARNING OF COMPUTER PROGRAMMING - EFFECTS OF GUIDED INQUIRY LEARNING

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By

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I, Jose Lukose, student number 201110185, hereby declare that I am fully aware of the University of Fort Hare's policy on plagiarism and I have taken every measure to comply with the policy.

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ABSTRACT

Research reports using global data show that the failure rates in introductory programming courses average about 32%. This study assessed the effect of elements of Guided Inquiry Learning (GIL) on enhancing academic performance of first year students in Introduction to Computer Programming course. As learners from schools join the university and enrol for different courses, they find the sudden transformation quite challenging. This makes it more challenging for first year university students, especially in difficult courses such as Introduction to Programming. As times change with advances in technology, the traditional ways of presenting information during teaching–learning interface may not address students' needs. Lecturers and university stakeholders make efforts to address these challenges by proposing innovative teaching ways. One of the common approaches that have been used profitably in other science and engineering programmes is GIL. It is a form of inductive collaborative learning approach where students are presented with a challenge which challenges them to accomplish the desired learning outcomes in the process of responding to the posed challenge. The strategies in GIL include, among others, learning teams who participate in intra- and inter-learner interactions besides lecturer-learner interactions, linking theory and practical information cementing skills and problem solving strategies, scaffolding information, blended learning by integrating both traditional and technology-assisted learning, inquiry activities such as initiating investigations, gathering data, and critiquing evidence to come up with evidence-based solutions. The objective was to apply GIL to this module and observe if there were gains in students' academic performance. This study was located in the pragmatic paradigm using action research design and a mixed method approach. The sample consisted of first year students enrolled for Introduction to programming which was a year-long course (two semesters) at a South African university. The population consisted of the only 49 students who were registered for the module under focus. A group of 20 students were considered for the whole year in the GIL experiment. Although it would have been ideal to have experimental and control groups with same number of students, that was not possible in this study, because only 20 out of the 49 who were willing to be included in the experimental group. The present researcher employed three of these GIL strategies in teaching the module Introduction to Programming to the experimental group while another colleague continued with traditional teaching in the control group. Care was taken to limit the insider outsider conflict. Both groups were assessed by the same assessment tools at the same times. Results from these assessments together with focus group interviews provided the core data for this study. Both quantitative and qualitative analyses were carried out on the data, statistical analysis (mainly, chi-Square and t-test) for the former and thematic analysis for the latter. Results indicated gains in the experimental group such as enhanced motivation, interaction, intra-group social cohesion, creativity and provided students the confidence to share knowledge and skills with their peers and keep everyone focused on the course contents. These gains are reflected in higher year marks and pass rates than those in the control group as the analysed data indicate. A study that will pilot the GIL framework in several universities with different teaching modes and large classes are recommended.

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LIST OF ACRONYMS

AR	: Action Research
CL	: Cognitive Load
CS	: Computer Science
CSE	: Computer Science Education
DEV1120	: Development software 2
DP	: Duly Performed
GIL	: Guided Inquiry Learning
HE	: Higher Education
HEI	: Higher Education Institution
ICT	: Information and Communication Technology
IT	: Information Technology
NDIT	: National Diploma: Information Technology
PAR	: Participatory Action Research
SD	: Standard Deviation
ZPD	: Zone of Proximal Development

CONTENTS

CHAPTER ONE

INTRODUCTION AND MOTIVATION FOR THE STUDY

1.1 Introduction

The challenges facing tertiary students and lecturers in terms of teaching and learning have been well documented (Goujon, Haller, & Kmet, 2017; Johnson, Becker, & Hall, 2015; Ndulu, 2004; Papastergiou, 2008; Salmi, 2003). However, such challenges are different from one discipline or course to the other. Researchers have indicated that instructional material and/or learning experiences have a strong impact on how the learning process takes place among learners and lecturers (Manavathu & Zhou, 2012; Ambrose & Lovett, 2014). Learning content could be disseminated in various ways such as through face-to-face tutorials, standalone computers, or through online learning management systems with networked computers that can be accessed from anywhere at any time. It is important to understand how different learning approaches have been used and applied. This research selected one of the most feared courses by first year students, namely Introduction to Computer Programming as reported by many studies (Bennedsen & Caspersen, 2007; Chetty & Westhuizen, 2015; Derus & Ali, 2012; Gomes & Mendes, 2007; Pillay, 2003; Watson & Li, 2014). This study assessed the effect of elements of Guided Inquiry Learning (GIL) on enhancing academic performance of first year students in Introduction to Computer Programming course. As learners from schools join the university and enrol for different courses, they find the sudden transformation quite challenging. This makes it more challenging for first year university students, especially in difficult courses such as Introduction to Programming. As times change with advances in technology, the traditional ways of presenting information during teaching–learning interface may not address students' needs. Lecturers and university stakeholders make efforts to address these challenges by proposing innovative teaching ways. One of the common approaches that have been used profitably in other science and engineering programmes is GIL. It is a form of inductive collaborative learning approach where students are presented with a challenge which challenges them to accomplish the desired learning outcomes in the process of responding to the posed challenge. The strategies in GIL include, among others, learning teams who participate in intra- and inter-learner interactions besides lecturer-learner interactions, linking theory and practical information, cementing skills and problem solving strategies, scaffolding information, blended learning by integrating both traditional and technology-assisted learning, inquiry activities such as initiating investigations, gathering data, and critiquing evidence to come up with evidence-based solutions. The details on the research background, problem statement and research objectives are outlined in the next sections.

1.2 Background

This section provides the research background and the context under which the research was conducted.

Students at entry to level 1 study at a Higher Education Institution (HEI) are considered as entry-level students. Programming skills are complex computer skills required to perform computer programming. Computer programming (often called programming) is the process of developing and implementing various sets of instructions to enable a computer to do a certain task. Programming is an important course taught in higher education Institutions as part of the curriculum of the undergraduate programmes in Computer Science (CS) and Information Technology(IT) disciplines.

Commonly offered as a first year core subject, introductory programming subjects have an alarming failure rate (Bennedsen & Caspersen, 2007; Costa et al., 2017; Iqbal Malik & Coldwell-Neilson, 2017; Koulouri, Lauria, & Macredie, 2015; Malik & Coldwell-Neilson, 2017; Sheard & Hagan, 1998; Watson & Li, 2014). Innovation and Technology in Computer Science Education (ITiCSE) working group in 2001 assessed the programming ability of an international population of first year CS students from several universities (McCracken et al., 2001). According to this study, majority of entry-level programming students found it difficult to grasp the fundamentals and foundation level programming concepts at their early stages of learning (programming), and they performed poorly on a set of common program-writing problems.

In the university where the study was conducted, the Department of Information Technology enrols students in a common three-year National Diploma: Information Technology (ND:IT) programme. Courses offered in year one of the National Diploma act as the foundation of their studies. From their second year of studies they start specializing in different areas of IT. The core subject, Development Software 1 (DEV1120) is an introductory programming course offered for all first year learners enrolled for this programme. The purpose of this course is to equip learners with a solid understanding of the basic principles of programming which apply to all computer programming languages. Learners are taught how to analyse problems and how to write algorithmic solutions using pseudocode and the VB.Net (Console Application) programming language. Learners are introduced to the concept of the Program Development Cycle and taught how to use the tools associated with each stage. ("Learner Guide - Development Software 1 (DEV1120)," 2016)

Over the past several years this course had an alarming failure rate. Since 2010, an average of 51.44% of students has been failing in this introductory programming subject. The assessment of this subject consists of four written tests of incremental difficulty and an end of the year final examination. Average marks scored in these four tests is calculated to generate a student's year mark. The average year mark (termed in South Africa as Duly Performed mark - DP) averaged between 39.06 and 57.03 with an average of 46.51 for the past five years. Learners are not allowed to write the final examination, should they fail to accumulate a minimum 40% of year mark (DP). Those who qualified for the final examination averaged a 53.51% examination mark for the past five years. This shows the depth of the problem. A great proportion of the students who enrol at this institution have very little or no prior knowledge of basic computer skills. Difficulties in learning programming concepts by entry-level programming students force them to run away from the Development Software specialization of the ND: IT programme. Over the years, the registration team has been reporting that the students are reluctant to choose this specialization.

1.2.1 Difficulty in learning to program

The way in which the learners in the first year of their university studies (for this study- the entry-level programmers) are introduced to learning programming and the factors that affect the successful outcome need to be considered and analyzed before considering a solution to this problem. There have been several studies conducted to find the root of the problem (Alqadi & Maletic, 2017; Chetty & Westhuizen, 2015; Craig, Smith, & Petersen, 2017; Derus & Ali, 2012; Gomes & Mendes, 2007; Horton & Craig, 2015). In an attempt to benchmark program reading skills of new programmers, researchers found that many such students could not read and understand program code (Lister et al., 2004). Understanding of programming poses many challenges for first year students, as a large number enter Information and Communication Technology (ICT) programmes with little or no prior knowledge (Falkner & Munro, 2009). McCracken et al. (2001) sees learners' inability to solve problems as a contributing factor in learning programming. This was further echoed by Falkner and Munro (2009) through their observation, "novice computer science students are required at an early stage to develop a diverse range of skills: problem analysis, problem solving, code development and testing" (p.65). Programming is problem solving intensive. Learners need to move away from the conventional way of learning they have been practising in the (familiar) school environment. With the study to find problems faced by beginning programmers, Affleck and Smith (1999) found that the main problem faced by students with "learning to program is accessing prior knowledge and adopting an approach to study that will go beyond memorizing explicit knowledge to constructing implicit knowledge necessary to apply and transfer the domain concepts to new situation" (p. 7). This poses a new challenge to the learners who start a programming course in Higher Education (HE). They are coming from a familiar academic setting where they were studying topics that were familiar, comfortable and which they were studying for some years (Jenkins, 2002). They have been practising tried, tested and trusted learning skills at school level. Then, they are confronted with totally new topics that demand more than those habitual learning skills. This poses a critical challenge to them. According to Jenkins (2002), some less obvious skills such as life skills may also pose a challenge to the entry-level learners as they will be facing some of the most challenging materials in their programming course in their first years of university life. Some later studies have concurred with this assessment (Bain & Barnes, 2014; Gomes, Santos & Mendes, 2012). This is the time when they are going through a transition as they adapt to the all-new way of life and study at a non-familiar environment of university.

Entry-level programmers may potentially have the intellectual capacity to program, but this itself may not be enough to learn to program successfully. The learning styles play a vital role in producing a successful programmer. Learning styles can be classified into deep and surface learning (Gibson, 2002). Surface learning is characterized by entry-level programmers memorizing concepts in the hope of future use, whereas deep learning requires the comprehension of the effects of programming concepts so that those concepts can be applied in future new situations. Programming by nature often requires application of the existing knowledge in new situations. Thus it is important that the programmers engage in deep learning as opposed to surface learning.

1.2.2 Skills in Learning to Program

Learning to program is a multi-skilled task. It requires learning a number of different skills and processes. Core skills that entry-level programmers require to learn during an introductory programming course are:

- Forming a problem representation;
- Planning a solution to a given problem;
- Translate the problem representation into an algorithm;
- Convert the algorithm into program codes specific to a given programming language;
- Debug and test the program to see if the program exhibits the expected behaviour.

The most difficult ones among these are the first three and out of these three the most difficult is translating the problem representation into an algorithm. Jenkins (2002) stressed on the importance of having a correct and efficient algorithm as the basis of any coding. Given a correct algorithm, the other processes are essentially mechanical. Lecturing students on syntax does not make any difference when they have no clue as to where and how to apply them in the program (Jenkins, 2002). Thus the core act of learning to programming is learning the art of transforming the problem in the problem domain into a logical algorithm which can be implemented through any programming language.

Traditional (and the present) introductory classes in Computer Science and Information Technology (CS & IT), tend to focus on syntax and semantics, and the problem solving process is seen as one of the immediate success factors. Falkner and Munro (2009) state that "if we hide the problem solving process away as something we do between lectures, then students stand little chance of learning from us" (p.67). Our approach should consist of exposing, and forming learning communities around the problem solving process.

1.2.3 Approaches to Computing Education

Science including Computer Science (and programming) is traditionally taught deductively. Typically, the instructor begins with theories (syntax and semantics) and then progresses (in most cases) to the application of those theories. Programmers are required to do much more than recalling the syntax and semantics, substituting values and finding answers. In their daily operations, students will be required to communicate fluently, observe and analyse complex problem situations, to be able to work in a group, etc. Universities should aim to develop such skills among the learners for them to become industry-ready once they graduate. To achieve this, a combination of teaching and learning methods accommodating different learning styles are necessary. Several authors have reported on the inadequacy of 'chalk and talk' approach in enhancing understanding and state that it only promotes passive learning (Betihavas, Bridgman, Kornhaber, & Cross, 2016; Brandsteidl, Mayerhofer, Seidl, & Huemer, 2012; Giannakos & Vlamos, 2010; Hake, 1998; O'Flaherty & Phillips, 2015; Saeed, 2018). According to Gibson (2002), a constructivist view of learning and a consequent move away from the traditional 'chalk and talk' teaching methods will benefit the student through recognition and development of his/her multiple intelligence. He goes on to say that, "traditional teaching methods are ineffective and, in any case, neither encourage nor measure student understanding even when teachers think otherwise" (p. 466).

Several authors have reported on the inadequacy of passive learning (Cremasco, Lima, Martins, Duarte, & Montrezor, 2016; Magana, Vieira, & Boutin, 2018; Michel, Cater, & Varela, 2009; Riley & Ward, 2015; Smith, 2014; Stewart, 2014). Passive learning is likely to fail since each student in a classroom constructs new knowledge in a different manner as each of them brings different cognitive frameworks into the classroom (Ben-Ari, 1998). He further observes that learning must be active and through guidance by the teacher and feedback from other students in order for students to construct knowledge. Constructivists believe that discovery of facts alone does not constitute effective learning, but construction of viable mental models is also significant (Ben-Ari, 2001). The role of a teacher is to actively guide the student in this effort. Students learn by constructing their own versions of reality rather than copying and absorbing what is presented by the teacher. Prince and Felder (2006) observe that the inductive instructional methods such as inquiry learning, problem-based learning, project-based learning, case-based learning, discovery learning and just-in-time teaching all share many common features as they are all learner-centred (student-centred) and constructivist methods. They came up with a table with the features and defining characteristics of these methods which is given in Table 1.1. These methods almost always involve students discussing questions and solving problems in class (active learning), where most of the work is being done in groups (collaborative learning). Today, promoting active learning among students to improve their conceptual understanding and thinking skills is seen as one of the major goals of science and technology education (Pundak, Herscovitz, Shacham, & Wiser-Biton, 2009).

Table 1.2

Common inductive instructional methods and their features adopted from Prince and Felder (2006).

Method → **Feature ↓**	**Guided Inquiry**	**Problem-Based**	**Project based**	**Case-Based**	**Discovery**	**Just-in-Time**

Questions or problems provide context for learning	1	2	2	2	2	2
Complex, ill-structured, open-ended real-world problems provide context for learning	4	1	3	2	4	4
Major projects provide context for learning	4	4	1	3	4	4
Case studies provide context for learning	4	4	4	1	4	4
Students discover course content for themselves	2	2	2	3	1	2
Students complete and submit conceptual exercises electronically; instructor adjusts lessons according to their responses	4	4	4	4	4	1
Primarily self-directed learning	4	3	3	3	2	4
Active learning	2	2	2	2	2	2
Collaborative/cooperative (team-based) learning	4	3	3	4	4	4

Note: 1-by definition, 2-always, 3-usually, 4-possibly

Source: (Prince & Felder, 2006, p. 124)

1.3 Problem Statement

Entry-level students struggle to grasp an early understanding of programming, which can lead to frustration and eventually surrender (Horton & Craig, 2015; Petersen, Craig, Campbell, & Tafliovich, 2016; Shuhaidan, Hamilton & D'Souza, 2009). Difficulties in learning to program and high failure rate from introductory programming modules are a global phenomenon and not unique to any specific sector or creed of the population (Bennedsen & Caspersen, 2007; Horton & Craig, 2015; Watson & Li, 2014). Bennedson and Casperson (2007) also argued that low retention rates are often experienced in CS schools and students' inability to learn programming acts as a major contributing factor for this phenomenon. Using global data, Bennedsen and Caspersen (2007) reported that the failure rates in introductory programming courses averaged about 33% and Watson and Li (2014) concurred by reporting a similar figure of 32%. Two large scale global research studies conducted by ITiCSE working groups (McCracken et al., 2001) and (Lister et al., 2004) tested entry-level university students' common program-writing problems. First study assessed the programming ability of students by testing them on common program-writing problems and reported that students struggled to achieve an average above 30% on their assessments. Second one attempted to study the code-reading and tracing skills of entry-level students and observed that approximately 25% of the students were guessing the solutions.

Large numbers of learners entering CS programs with little or no prior experience of programming face many challenges for their level one university study. They are required to develop a diverse range of skills at an early stage of their studies in order to excel in programming tasks such as problem solving, problem analysis, design, logical sequence formation, code writing, testing and integrating all these skills fall within the software development cycle/process. Falkner and Munro (2009) observe that lack of performance in programming is having an impact on other facets of students' lives including their confidence in studies, overall programme progression and other factors such as (student) engagement and retention.

The problem is that, over the years as a programming lecturer and as an academic administrator the researcher has observed that entry-level students face difficulties in performing academically well in programming courses. The data under sub section 1.2 earlier support this observation. Additionally, there is no standard guiding model or framework that is currently available for lecturing introduction to programming. Pedagogical issues related to teaching and learning computer programming for entry-level students in HE in a rural setting, is an under-researched area in South Africa. In an attempt to solve this problem, this study adopted a pragmatic approach to deal with entry-level Higher HE students' challenges in learning computer programming skills. There could be several pragmatic approaches to solve this problem. But the one that was attempted through this study was GIL. GIL follows a form of collaborative inductive learning approach. The strategies in GIL include, among others, learning teams who participate in intra- and inter-learner interactions besides lecturer-learner interactions, linking theory and practical information cementing skills and problem solving strategies, scaffolding information, blended learning by integrating both traditional and technology-assisted learning, inquiry activities such as initiating investigations, gathering data, and critiquing evidence to come up with evidence-based solutions. The methods chosen for this study has not been widely used in computer programming education.

1.4 The research question

In order to address the problem, the following research question was proposed:

How can the Guided Inquiry Learning (GIL) be applied in teaching Introduction to Programming course to enhance academic performance of entry-level students at HEIs?

The sub-questions posed were:

1. What would be the differences in academic achievement between students taught traditionally and those taught using GIL approach?
2. What would be the effect of GIL approach on student's confidence, motivation and communication skills related to introduction to programming?
3. What would be the strengths and weaknesses of GIL in the learning and teaching context of introduction to programming course?

1.5 Objectives of the research

The specific research objectives of this study were to:

- Compare and Contrast the differences in achievement between students taught traditionally and those taught using GIL approach;
- Evaluate the effect of GIL approach on students' confidence, motivation and communication skills related to introduction to programming;
- Assess the strengths and weaknesses of GIL in the learning and teaching context of introductory programming course.

1.6 Significance of this study

There is general agreement in the current literature that learning to programme is a difficult task (Jenkins, 2002; Teague & Roe, 2008; Yang, Hwang, Yang, & Hwang, 2015; Malliarakis, Satratzemi, & Xinogalos, 2017). Most (if not all) of the students enrolled for this course had a disadvantaged background and were therefore battling even more with the totally new and unfamiliar topics that demand more than those habitual learning skills they were familiar with in their school environment. Thus, these students might benefit from an investigation into improved teaching methods. This study is significant in that it can encourage ND: IT students to develop an interest and positive attitude towards computer programming. They can be better prepared for their future career as a computer programmer. A different approach to address the shortcomings of present traditional methods lays a foundation and builds a proper framework for future reference.

Insights gained from this study can benefit students doing programming courses in other levels. This study is also significant because it contributes to developing the teaching and learning of computer programming, as well as to enhancing professional development of learners. Computer programmers and software developers are expected to have the skills to solve novel, complex and multidisciplinary problems in the fast changing world. So it is important that universities and other higher learning institutions produce CS/IT graduates who are capable of identifying, structuring and solving complex problems. If GIL is found to be productive in the teaching-learning context then a solution to the problem, i.e. improving student performance and producing graduates better prepared for employment by industry will be welcomed by the wider community. In addition, this will have the potential to address the high dropout rate among the CS/IT students. The study adds to the body of research on programming pedagogies. Apart from the understanding gained and resultant pedagogical issues, the academic sector should benefit from the proposed GIL framework.

1.7 Research methodology

The section provides a summarised version of the research methodology that was used. More details on the research methodology will be presented in Chapter 3. The research design used for this study is Action Research (AR) within a case study. AR is an iterative research methodology that involves the subjects of the research as active participants - the research is done with, rather than on, the participants (Carr & Kemmis, 1986). According to them action researchers see the development of theory or understanding as a by-product of the improvement of real situations, rather than application as a by-product of advances in `pure theory'. In other words, AR is research directed towards the improvement of practice.

Falkner and Munro (2009) observe that, AR is an appropriate research methodology for use when a problem has been identified, an initial plan has been constructed and further strategies may be employed depending upon the success, or impact, of the initial strategy. It brings together researchers and subjects and enables them to work closely to bring social change (Auriacombe, 2016). According to Bryman (1989), relationship between the researcher and the subjects takes place within the framework of the conceptualized AR design. In this study, the relationship is between the students doing the course coded as DEV1120 and the researcher as the lecturer. AR can be categorized into four types (Avison, Lau, Myers, & Nielsen, 1999):

- AR focusing on change and reflection
- Action science trying to resolve conflicts between espoused and applied theories
- Participatory Action (PAR) emphasizing participant collaboration; and
- Action learning for programmed instruction and experiential learning.

This study used PAR which was the appropriate one to test the impact of intervention, to reflect on and to take necessary remedial action.

In this study, the relationship is between the students doing the course coded as DEV1120 and the lecturer who is also the present researcher. The researcher participates in this study as the lecturer teaching the subjects, i.e., acts as the change agent.

1.7.1 Study site

The university where the study was conducted, has four campuses. The course DEV1120 is offered only at two sites and the research was done at one.

1.7.2 Population and sample

The population for this study was all students enrolled for the course DEV1120 at this study site (N=49). The sample for this study was chosen based on the convenience sampling approach. Because of the nature of the programme and the study site, the population and the sample were the same who were then divided into an experimental group and a control group based on their consent to be grouped into the former. The number of students who participated in the experimental group and control group were 20 and 29 respectively. It would have been ideal to have equal numbers in both groups, nonetheless only 20 signed the informed consent. As such the researcher did not have freedom to get equal numbers in both groups. Out of the 20 students who agreed to participate with this study, one dropped out of the course and the entire programme. This made the effective sample 19.

1.7.3 Method of data collection.

The types of data gathering techniques that were used in to collect data in this study were analysis of students' scripts for four formative assessments and one summative assessment and open-ended focus group interviews.

1.7.4 Data analysis

In quantitative data analysis, researchers use techniques to convert data to a numerical form and subject it to statistical analysis (Rubin & Babbie, 2007). Reducing data into an interpretable form that enables the researcher to study the research problem and draw conclusions is the main purpose of quantitative data analysis. Statistical analysis provide procedures for assembling, classifying, tabulating, and summarising numerical data for the purposes of obtaining meaning or information (Monette, Sullivan, & DeJong, 2013).

Qualitative analysis is usually based on interpretive philosophy that aims at examining meaningful and symbolic content of data. In other words, it tries to establish how participants make meaning of a specific phenomenon (Nieuwenhuis, 2010a). The aim of qualitative data analysis was to interpret and make sense of what was in the data.

The study generated both Quantitative and Qualitative data. Quantitative data were analysed using appropriate statistical data analysis methods such as t-Test and Chi-Square test. Qualitative data were analysed using thematic content analysis.

1.8 Delimitations

The socio-economic background of the students was not considered for this study, though they were recognized as factors that may have an influence on their academic performances. Both experimental and control groups were selected from the same campus. Though care was taken to avoid contamination effects, since control group could still interact with experimental group, this effect could not have been eliminated completely. Unique campus culture where the study was conducted may also have influenced the results of the study in non-obvious ways.

1.9 Outline of chapters

The dissertation consists of five chapters summarised as follows:

Chapter 1: This chapter discusses the background to the study, the rationale and significance of the study, research questions and sub questions and the objectives of this study.

Chapter 2: In this chapter a critical review of the theoretical framework and the literature related to this study is included. This includes related literature on teaching and learning approaches. The literature covers both traditional and modern teaching approaches and models.

Chapter 3: This chapter covers the methodology used to conduct this study. The modes of enquiry as well as the population and sample are discussed. A detailed description of the intervention process and the instruments used to assess the students are explained. This is done by outlining the specific methods and techniques which were considered appropriate for this research.

Chapter 4: In this chapter, data collection, data analysis and interpretations are discussed. Findings from the data collected and its meaning to computer programming education will be discussed in detail.

Chapter 5: This chapter draws research conclusions and proposes recommendations from the results of this study. Through this chapter, based on the conclusions and recommendations, an innovative Guides Inquiry Learning framework is proposed to address entry-level Higher Education Students' challenges on learning computer programming skills within the context of this study.

1.10 Definitions of operational terms

Guided Inquiry Learning: "…practices that promote student learning through guided and increasingly independent investigation of complex questions and problems. Rather than teaching the results of others' investigations, which students learn passively, instructors assist students in mastering and learning through the process of active investigation itself" (Lee, 2004, p.9).

Inquiry Learning: It is a " learning process that uses questions and problems to provide contexts for learning" (Prince & Felder, 2006, p.127) where "students learn content as well as discipline-specific reasoning skills and practices by collaboratively engaging in investigations" (Hmelo-Silver, Duncan, & Chinn, 2007, p.100)

Computer Programming OR Programming: "The process of developing and implementing various sets of instructions to enable a computer to do a certain task. These instructions are considered computer programs and help the computer to operate smoothly" ("computer-programming", 2018).

1.11 Summary

In this chapter the study was introduced and its background was portrayed. An overview of computer programming education and the need to address the challenges faced by introductory programming students were given. The research problem, research question and the sub-questions were stated and objectives of the study were identified. Significance of this study and a brief overview of the research methodology employed in conducting the study were given. The chapter concluded with a section containing definitions of operational terms used in the study.

The next chapter will present the theoretical framework for the study followed by a review of the pertinent literature.

CHAPTER TWO

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Introduction

The first chapter introduced the study. An overview of Introductory programming education and challenges faced by entry-level students in learning to program were given. GIL was proposed as an attempt to address the difficulties faced by entry-level students doing programming (DEV1120). The research question, objectives of the study and the perceived significance of the study were formulated and presented. A brief overview of the research methodology and the delimitations were presented thereafter.

This chapter reviews the theoretical framework, the pertinent literature related to this study, and how the theory is appropriate for this study. The chapter unpacks different teaching experiences, approaches, techniques, models and challenges facing tertiary institutions. Programming is central to CS and cognate disciplines and courses in programming are offered as part of the core syllabus CS and IT Departments in Higher Education Sector. There have been several studies conducted in the past to analyze the performance of entry-level computer programming students.

2.2 Theoretical framework

Oxford dictionary 2018 defines theory as “a supposition or a system of ideas intended to explain something, especially one based on general principles independent of the thing to be explained. It is a set of principles on which the practice of an activity is based” (“Theory”, 2018). Theories carefully outline the precise definitions in a specific domain to explain why and how the relationships are logically tied so that the theory gives specific predictions.

Theory is a carefully outlined precise definitions of a specific domain that explains why and how relationships logically tied together for it to give specific predictions (Wacker, 1998). It is a “statement of relationships between units observed or approximated in the empirical world" (p. 364). Oxford dictionary 2018 defines framework as "A basic structure underlying a system, concept, or text" ("Framework", 2018). A framework entails concepts put together based on their relevance and the research problems that provides a frame of reference for the research (Devi, Das, Das, & Khandelwal, 2017). An understanding of the phenomena under study and its assumptions and philosophical views are broadly presented through the theoretical and conceptual frameworks (Devi, Das, Das, & Khandelwal, 2017). The theoretical framework for this study is based on Vygotsky's social constructivism and sociocultural theories and Bandura's Social cognitive theory.

2.2.1 The constructivist approach

The origin of constructivism dates back to the time of Socrates who observed the importance in teachers and students engaging in discussions to interpret and construct the knowledge by asking questions (Hilav, 1990 as cited in Amineh & Asl, 2015). In behaviourism, knowledge is treated as 'a thing' which can be acquired. Constructivism rose to prominence in educational theory as a response to behaviourism which emphasised stimuli and response-based learning and resultantly placed the responsibility of learning on the student (Jones & Brader-Araje, 2002). The constructivist argument dispels the knowledge acquisition phenomenon and views the learner as an active cognising agent who actively constructs what and how he/she knows by organising experiential encounters (Husen & Postlethwaite, 1989). Davis, Maher and Noddings (1990) state that learners have their own toolkits for constructing knowledge and advise that the teacher's and community's role is to provide the challenge, support and setting that will encourage the construction. Constructivism informs that knowledge is not passively acquired and neither is it the discovery of ontological reality. It is actively built by the cognising subject through organising and adapting to the experiential world (Husen & Postlethwaite, 1989). Constructivism as a theory extends beyond teaching and learning (Brooks, 1999), and as Fosnot, (1996) noted, constructivism is both a 'paradigm' and a 'theory'.

It has attracted debate from both those who oppose it and amongst those who subscribe to its tenets. As a result there are many strands within the constructivist school and many sub-disciplines are emerging (Kenny, 2010). Instead of thinking about constructivism as a universally agreed concept, scholars rather conceive constructivism as a set of paradigms subscribing to the notion that reality is actively constructed or ‘brought forward’ by the observer (Riegler, 2012). The mind can put together the ideas it has and can make new ones (Lock, 1947). This view emphasises that constructivism is about the mind creating knowledge. It is a cognitive process.

Constructivism assumes that learners construct their knowledge individually and collectively using their own toolkits. The purpose of the environment is to provide the background on which the construction must thrive (Davis, Maher, & Noddings, 1990). This view implies that constructivism is a mind-based phenomenon with the environment providing the basis on which the mind creates knowledge.

Constructivism is a theory about knowledge and learning, where knowledge is a non-objective temporal dynamic which is constructed through social and cultural developmental processes. Brooks (1999) believe that constructivism extends beyond teaching and learning. It is a philosophical position on knowledge indicating that constructed knowledge is an ever-changing temporal phenomenon brought about by and through prevailing social and cultural processes.

According to Vygotsky (1978), every function in the child’s cultural development appears twice, on the social level and then on the individual level. That is between people (inter-psychological) and then within the child (intra-psychological) himself/herself. This applies equally to voluntary attention, to logical memory, and to the formation of concepts. He further observes that all the higher functions originate as actual relationships between individuals.

This is explained by Wertsch, (1979) as learning originates in group processes between and among individuals (inter-psychological) as ‘higher mental’ functions that move to the individual’s ‘intra-psychology’ through mechanisms set by the individual’s mental processes. The relationship between the individual and the social context is observed by Liu & Matthews, (2005) as twofold - *the mind is not independent of the social and the social (collective) is greater than the sum of the individuals*. The authors explain that firstly, the mind is not independent of the social because learning is conceived as historically and culturally driven through the internalisation of the social conceptual system into new individual conciousness but the individual is still able to “stand above the social collective because of the ability of the mind to generate personal understandings” (p. 39). Secondly, individual consiousness and the collective are connected through a historically negotiated *collective-subjectivity* in which individuals bring to the group a personal contribution, and as interchange occurs, the collective becomes larger and qualitatively different from the sum of the individuals (Liu & Matthews, 2005).

There seems to be many forms of constructivism that exists. Good (1993) identified many forms of constructivism in the literature such as cognitive, contextual, dialectical, empirical, humanistic, information-processing, methodological, moderate, Piagetian, post-epistemological, pragmatic, radical, rational, realist, social, sociocultural and socio-historical. But the two principal schools of thought within constructivism for classroom practice are cognitive constructivism (also referred to as individual or personal constructivism) and social constructivism (Powell & Kalina, 2009).

2.2.2 Piaget’s cognitive constructivism

Jean Piaget, the prominent figure of the twentieth-century psychology, is considered as the one who introduced the major theory of cognitive development (Barrouillet, 2015). According to Piaget’s theory of cognitive development, humans must construct their own knowledge rather than giving them information which they understand and use immediately (Piaget, 1953). Piaget’s cognitive constructivism focuses mainly on the individual and how an individual constructs knowledge (Powell & Kalina, 2009). As a cognitive constructivist, Piaget asserts the importance of mind in learning and attempted to explain the development of cognitive structures in learners (Schcolnik, Kol, & Abarbanel, 2016).

Piaget, the stage theorist, explains that the children’s cognitive development occures through the process of assimilation and accommodation when going through the four stages of development (Semmar & Al-Thani, 2015) namely, sensorimotor, preoperational, concrete operational and formal operational (Powell & Kalina, 2009). These stages are depicted through the Table 2. 1.

Table 2.1

Piaget's four developmental stages

Stage	Age Range	Description
Sensorimotor	0-2 years	Coordination of senses with motor response, sensory curiosity about the world. Language used for demands and cataloguing. Object permanence developed
Preoperational	2-7 years	Symbolic thinking, use of proper syntax and grammar to express full concepts. Imagination and intuition are strong, but complex abstract thought still difficult. Conservation developed.
Concrete Operational	7-11 years	Concepts attached to concrete situations. Time, space, and quantity are understood and can be applied, but not as independent concepts
Formal Operations	11+	Theoretical, hypothetical, and counterfactual thinking. Abstract logic and reasoning. Strategy and planning become possible. Concepts learned in one context can be applied to another.

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Piaget uses assimilation and accommodation to describe the interplay of mind and the environment the individual lives-in (Schcolnik, Kol, & Abarbanel, 2016). According to Piaget, learners use their own cognitive structures to interpret the environment by assimilating the new information into the existing knowledge. Assimilation is the process of adding the new knowledge into the existing cognitive framework. Accommodation occurs when the subjects change their own existing cognitive framework to incorporate/accommodate the new information or knowledge. In learning, when the subject processes the new information to fit into what is already in the memory, these adjustment processes take place. An equilibrium occurs when new ideas can fit into the existing schema whereas the disequilibrium occurs when the new set of knowledge fail to fit into the existing schema. Disequilibrium is the state of being uncomfortable that forces the subject to adjust his/her existing schema by mastering the new knowledge (accommodation) to bring balance or equilibrium (Powell, 2006).

Therefore, when a learner organises previous knowledge structure with new information and experiences learning takes place. This occurs at different rates for each individual learner. Each individual gets knowledge and learns at his/her own pace. A teacher has to be cognizant of these factors when conducting a constructivist classroom.

2.2.3 Constructivist learning theory

Constructivism learning theory is defined as construction of new knowledge, centred on a learner's previous experience. Studies agree that constructivism learning theory concentrates on knowledge construction based on a learner's previous experience (Modritscher, 2006). Constructivist learning theory is different from other traditional educational theories. When learners can use what they are learning in real world settings, they hold on to what they have learnt for a longer period of time. Constructivist learning theory allows the learner to place value on learning environment, rather than learning environment imposing value on the individual.

Several people have used models of instruction informed by constructivist theories to implement emerging technologies into instruction. A research example of a constructivist learning theory being integrated in the real world with real outcomes, together with mobile technology was carried out using "The Virus Game" (Collella, 2000). Learners partook in a simulation game that demonstrated the spread of a virus.

2.2.4 Constructivist implication on pedagogy

Constructivists understand that learners are beings who bring personal and unique dimension into the classroom based on their array of experiences. This dispels the *tabula rasa* notion, by realising that learners "bring with them a rich array of prior experiences, knowledge, and beliefs that they use in constructing new understandings" (Jones & Brader-Araje, 2002, p. 3). The preconceptions, tied to experience, filter and affect learning and understanding. As exemplified in Rubba's, (1992) learning cycle, constructivists need to expose the learners' knowledge gaps ('which they bring with them') in order to create a 'cognitive' conflict that should lead to the process of constructing the solution.

The social theory by Vygotsky referred to earlier and has gained widespread acceptance in educational pedagogy is the notion of the Zone of Proximal Development (ZPD) which Vygotsky defined as the "the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peer" (Vygotsky, 1978). The ZPD informs the role of educators, education technology and peers in the learning processes. Teachers are seen as providing adult guidance necessary to lift learner competences from actual development model to a higher level of capability. Discussion and collaborative works are also seen as facilitating learning development.

On being a constructivist teacher, Brooks (199) advises that the constructivist teachers accept and encourage student initiatives and autonomy where students are encouraged to frame their own questions and allowed to find answers thus making them responsible for their own learning. In this way they become problem solvers but more importantly problem finders as well. An idea reinforced by (Taber, 2006) who emphasised that learning is something done by the learner, not what is imposed on the learner.

These encourage learners to generate own abstractions and understandings from real-life phenomenon. The use of cognitive terminology such as 'classify', 'analyze', 'predict', and 'create' in assessments and tasks affect the way they think and become their action (Brooks, 1999).

In constructivist environments, student responses drive lessons, shift instructional strategies, and alter content. This is not to be confused with dereliction of the teacher's leadership role but as Brooks (1999) advise that educators must encourage teaching moments to 'coalesce' around learners' topical issues. Constructivist teachers inquire about students' understanding of concepts before sharing their own understandings of those concepts. This encourages learners to develop their own understandings as opposed to taking meanings from the teacher. Dialogue with the teacher and other learners is encouraged. Social interaction reinforces own convictions and offers an opportunity to learn from others. Educators encourage students' inquiry by asking thoughtful, open-ended questions and encouraging students to ask each other questions.

2.2.5 Vygotsky's social constructivism theory

Vygotski was a social constructivist and he believed that learning takes place first on an interpersonal level through interaction with others, that is transformed into an intrapersonal one, which is internalized by the individual (Vygotsky, 1978). Understanding, significance and meaning are created through interactions with other human beings (Amineh & Asl, 2015). This makes learning a social and collaborative activity. He introduced the notion of Zone of Proximal Development (ZPD) to explain learning and development. Vygotsky (1978) defines ZPD as "the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p. 86). According to him, learning creates the internal proximal development, it awakens a variety of internal developmental processes that are able to operate only when the learner is interacting with people in his/her environment and in cooperation with his/her peers. Once these processes are internalized, they become part of the learner's independent developmental achievement. According to Balakrishnan and Claiborne (2012), research on the significance of collaboration for expanding the individual's ZPD shows enhancements in an individual's understanding through interaction with others grappling with similar problems. In other words, ZPD became known as a collaborative activity between learners or with adult (facilitator/guide)-learner dyad on any task that challenged the learner(s) (Gredler, 2012).

According to Kim (2001), social constructivism is based on specific assumptions about reality, knowledge and learning. These assumptions are detailed below:

Reality: Reality is constructed through human activity as opposed to the belief that it exists in advance. Properties of the world or the group are invented by members of the society together and not by an individual alone (Kukla, 2013).

Knowledge: For social constructivists, knowledge is a human product which is constructed socially and culturally. Interactions with others and with the environment result in individuals creating meaning.

Learning: For social constructivists, learning is a social process (Vygotsky, 1978). Through social activities, interactions and collaborations meaningful learning occurs within individuals.

Social constructivist theory of learning proposes that students must be active participants in their own learning – through conversations and exchange of ideas with teachers and other students – that help them reach new horizons of understanding (Harkness, 2009). Students co-construct their knowledge through collaboration on meaningful tasks and by doing so they make connections to their own prior knowledge and refine their thinking. Thus learning is not experienced as transfer of knowledge from one head (donor/teacher) to the other head (learner), rather learner actively constructs his/her own knowledge. Active teaching and learning methods are based on social constructivism as opposed to behaviorism. Behaviorism is a teacher-centered approach that promotes teacher-centered classrooms, lectures and passive reception of materials (Land & Jonassen, 2012)

But a teacher should not attempt direct communication of concepts from his/her head to the head of a student (Gredler, 2012). According to Vygotski (1978), this practice is educationally fruitless and this results in a meaningless acquisition of words that actually hides a vacuum.

2.2.6 Vygotsky's sociocultural theory

Vygotsky's Sociocultural or sociocultural theory argues that the environment in which one operates defines one's personalities and characteristics (Vygotsky, 1994:352). According to the sociocultural theory, the environment comprises the membership or being belonging to a specific social group, living in a specific historical period under the specific historical circumstances. The main aspects such as historical development, the composition of ones' personality and the structure and the behaviour all build up to the social evolution. The theory further argues that based on their culture and history, people actively realize and change themselves (Vygotsky, 1979). In his views learning is a social process and which could be influenced by the background. Participation in cultural and historically created environments such as family, peer groups and in institutional contexts such as schooling and social activities contributes towards human developments (Lantolf, Thorne, & Poehner, 2015). The theory indicates that learning is a necessary and universal aspect of the process of developing culturally organized, specifically human, psychological functions (Vygotsky 1979:91).

Vygotsky (1994, p.176) also states that “environment that one is has a greater impact on the personal developments that one gets in life”. Vygotsky (1994) concludes by stating that “due to capitalism, the development of material production simultaneously brought with it the progressive division of labour and the constantly growing distorted development of the human potential” (p. 78). The main points to pick up will be considering the environment which the learners and the course that this research focuses on are from.

Vygotsky‘s sociocultural theory consists of three important factors about human development and human learning. Firstly, Vygotsky accepts that human development and learning does not occur in isolation, but within a social network or relatives, society and the broader environment. The other factor the theory explains is that learning is developmental and that leaners, need guidance and assistance in the learning process for career development (Vygotsky 1979). Several other researchers like Killen (2000, 2005), Laird et al. (2005) and Strydom and Mentz (2010) have supported the same idea. The final factor according to this theory to be considered is the differences in socio-economic and political power that have impact on the consequences of capitalism. To support this, Bourdieu‘s (1993) research on the field of cultural production is also applicable to this factor.

2.2.7 Constructivism and GIL

According to Powell & Kalina (2009), the founding father of social constructivism Lev Vygotski, believed in social interaction and regarded it as an integral part of learning. As the students complete activities in a group, the internalization of knowledge occurs for each individual at a different rate according to their own experience. Constructivits use inquiry to facilitate learning. According to Powell and Kalina (2009), the goal of an educator is to create an inquiring and accepting atmosphere that leads to each student reaching his or her full potential through effective guidance. GIL involves (classroom) practices that promote students' learning through guided and increasingly independent investigation of questions and problems. Rather than teaching results of other's investigation (passive learning), instructors guide students in mastering and learning through active investigation. It may involve, ability to identify problems, analyse problems, generate possible solutions and select best solution with appropriate justification (Lee, Greene, Odom, Schechter & Slatta, 2004).

Peng, Su, Chou and Tsai (2009) argue that, "learning takes place through collaboration and meaningful negotiation in the learning community that takes the form of conversation among learners" (p. 179). According to Jonassen, Peck and Wilson (1999), constructivism philosophy of learning places meaning making at the heart of it.

2.2.8 Bandura's social cognitive theory

Bandura (1986) explains that "human functioning as a model of triadic reciprocality in which behavior, cognitive and other personal factors, and environmental events all operate as interacting determinants of each other" (p. 18). The description gives rise to the name social cognitive theory. This description resonates with Bransford et al.'s (1999) five areas of learning and IIleris's (2002) three dimensions of learning. Bandura (1986) defines the nature of human beings in terms of five basic capabilities, namely symbolizing capability, forethought capability, vicarious capability (observation and modelling), self-regulatory capability and self-reflective capability. Symbolizing capability refers to human beings' capacity to use symbols. Through these people process and transform transient experiences into internal models that serve as guides for future action (Bandura, 1986). He further explains that " human being's behaviour is regulated by forethought where, people motivate themselves and guide their actions anticipatorily" (1986, p. 19). Vicarious capability is people's ability to learn by observing others (Bandura, 1986, p.19). Self- regulatory capability is derived from "how human beings motivate themselves based on their internal values and self-evaluative feedback to their own actions" (Bandura, 1986, p. 20). Lastly, self-reflective capability is human being's ability for reflective self-consciousness. It allows human beings to analyse their experiences and to reflect on their own thought processes. By reflecting on their experiences and on what they know, they can obtain basic knowledge about themselves and the world around them (Bandura, 1986, p.21).

Bandura (1986) explains learning as largely an information-processing activity in which information about the structure of behaviour and about environmental events is transformed into symbolic representations that serve as guides for action. He is of the opinion that "most human behaviour is learned by observation through modelling" (p. 47) (vicarious capability). This implies that when we observe others, we form rules of behaviour, and on future occasions this coded information serves as a guide for our own actions. There is a clear link between one's culture and history towards one's behaviour. For learning to be effective, there is a need to observe the behaviour of others (family members, peers, lecturers and role models) in order to determine how to act and what could work for each individual.

2.3 An overview of education

Education has been in existence for a long period as old as human existence on earth. After spending years at primary schools attaining basic education, people later move on to acquire secondary education and later tertiary education (Okpala, 2014). However, people continue to learn in different ways on a daily basis. Across all continents, education is vital for social, economic and personal changes. It has been recognised as one of the most powerful tool in ensuring national development (Coleman, 2015; Fägerlind & Saha, 2016; Halliday, Kern, Garrett, & Turnbull, 2018). This means that there is need for high quality of education in any institution. This is one of the reasons why countries have always budgeted large amounts for education. Today, education still remains a global concern in all nations because of the intellectual power it creates and which governs all facets of life. Basic education is an important phase in a learner's education when the learner lays the foundation for future educational opportunities and lifelong skills. The knowledge and skills acquired during learning is pivotal in a human being's career development.

There is ongoing debate on which type of education is more important than the other. Any attained education is always very important, whether at primary, secondary or tertiary level. Okeke (2014) argues that education is also an important tool that is used to bring about knowledge economy and societies' values, and self-centeredness of nations. As pointed out by Aminu (2013) education is an essential resource that a nation can hope for in its economic, social and human resources. The human resources constitute the human capital.

Researchers have explained the significance of education in different ways, for example as "the total process of developing one's capability and ability through knowledge, skills and understanding values for all activities of life" (UNESCO, 2014, p.122). Education can be one of the instrumental influences of one's life choices, decision making and way of living (Bano, 2015). This section has provided the general understanding of education and its concerns. The next sections describe how one acquires it. However, it is appreciated that whatever education one gets before reaching higher education is very critical. The remaining sections in this chapter align with how the education and the different approaches applied could enable Guided Learning Inquiry.

2.3.1 Understanding how to learn

People are different and learn differently due to individual differences originating from nature and nurture. In order for one to implement any specific teaching approach, there is a need to consider a variety of approaches. This is very important especially in HE, as most of the learners are reaching the adulthood, which may have a strong influence on how they learn. To fully comprehend the nature of GIL and how it can be acquired, a credible starting point is to explore how students learn as explicated in pedagogic theory. One has to consider the background, behaviour and nature of the course and the student when understanding how learners learn. As pointed out by Ertmer and Newby, learning theories of behaviourism, cognitivism and constructivism have dominated and shaped pedagogical literature historically and currently (Ertmer & Newby, 2013). Behaviourism refers to learning with observable actions in response to some external stimuli (Harasim, 2012; Ertmer & Newby, 2013). Behaviourists do not focus on understanding the nature of knowledge nor the underlying mental and cognitive processes involved in learning (Winn, 1990). According to Harasim (2012) behaviourism failed to explain most of the social behaviours since for behaviourist scientists, it does not count what they cannot see or measure.

On the other hand cognitivist learning theories emphasise and interrogate how information is received, organized, stored, and retrieved by the mind (Ertmer & Newby, 2013). This means that learning is not centred on what learners can do but on what they acquire and the manner in which their mind acquires it (Jonassen, 1991a). Cognitivists focus on how the mind creates meaning from the cues it receives. Cognitive Information Processing (CIP) or in other words how students process information mentally is the major theme of cognitivist learning theory (Harasim, 2012). Constructivism, on the other hand, tries to remedy behaviourism's peripheral approach to learning which emphases stimulus-response based learning as well as cognitivism's obsession with the mind by taking into account the learners' cognition and the influence of the greater social context by including the beliefs, knowledge, and skills that they bring with them (Jones & Brader-Araje, 2002).

Constructivism realises that the mind accepts and filters cues from the environment and produces its own reality (Jonassen, 1991b), as a result acknowledging the roles of both the environment and the cognitive by emphasising the interaction between the two (Ertmer & Newby, 2013). It stresses on the active involvement of student with teacher and peers in creating(constructing) knowledge (Harasim, 2012). When compared to other competing schools of thought, constructivism can be seen as belonging to the philosophical divide consistent with relativism and in opposition to other paradigms such as realism, objectivism or positivism (Bodner & Geelan, 2001). Whereas positivists and realists subscribe to the notion that reality and truth are objective and independent of the means of knowing them (Rorty, 1991). Relativism, to which constructivism is aligned, acknowledges the existence of a real world but doubts whether a truly objective and unbiased world can be ascertained. It further argues that observational choices of an individual are influenced by the beliefs, theories hypotheses and background of that individual (Bodner & Geelan, 2001) to such an extent that von Glasersfeld (1995) called the notion of truly independent observations a myth.

In summary, understanding an individual's background, beliefs, culture and overall characteristics play an important role in understanding how one learns. The research shall be built on this notion and such understanding will be considered later in the thesis in assisting to formulate the GIL model. The next section presents the specific challenges learners face in the introductory courses of Programming

2.4 Overview of Programming courses

Computer programming teaches learners to design, develop, and manage computer programs with the objective of instructing a computer to carry out specific activities in order to yield the desired intention as required by the developer. Programming requires skills in the application and management of computer applications in use. Various researchers argue that understanding and the learning to code is regarded as one of the challenging tasks (Robins, Rountree & Rountree, 2003; Gomes & Mendes, 2007). The overall performance in programming courses is fairly poor, however in some cases some learners master it faster than the others (Jenkins, 2002). Quite a few find programming a bit easy and manage to pass. According to Winslow (1996), programming needs critical thinking and translation of abstract concepts into real-life application which is not easy for many learners. Those students who are a bit slow in understanding abstraction always find learning programming difficult both theoretically and practically (Winslow, 1996; Minelli, Mocci & Lanza, 2015).

Following an earlier study by Benedsen and Caspersen (2007), Watson and Li (2014) analysed the failure rates in introductory programming courses across the world. The revised study provided results on programming course literature. The data set containing the pass rate data included 161 introductory programming courses from 51 institutions across 15 different countries. The mean percentage of non-passing students (failure rate) of Introductory Programming courses across the globe between the years 1979 and 2013 is given in Figure 2.1 (Watson & Li's 2014). Their study indicated a mean global pass rate of 67.7%, which corroborates with finding of the first study, 67% by Bennedsen and Caspersen (2007). The mean global failure and dropout rate is 32.3%. It is important to note that though there have been increased number of tools made available including technology assisted learning tools to support Introductory programming courses over the years, there have been no significant improvement in the pass rate of these courses over time (Watson & Li's 2014).

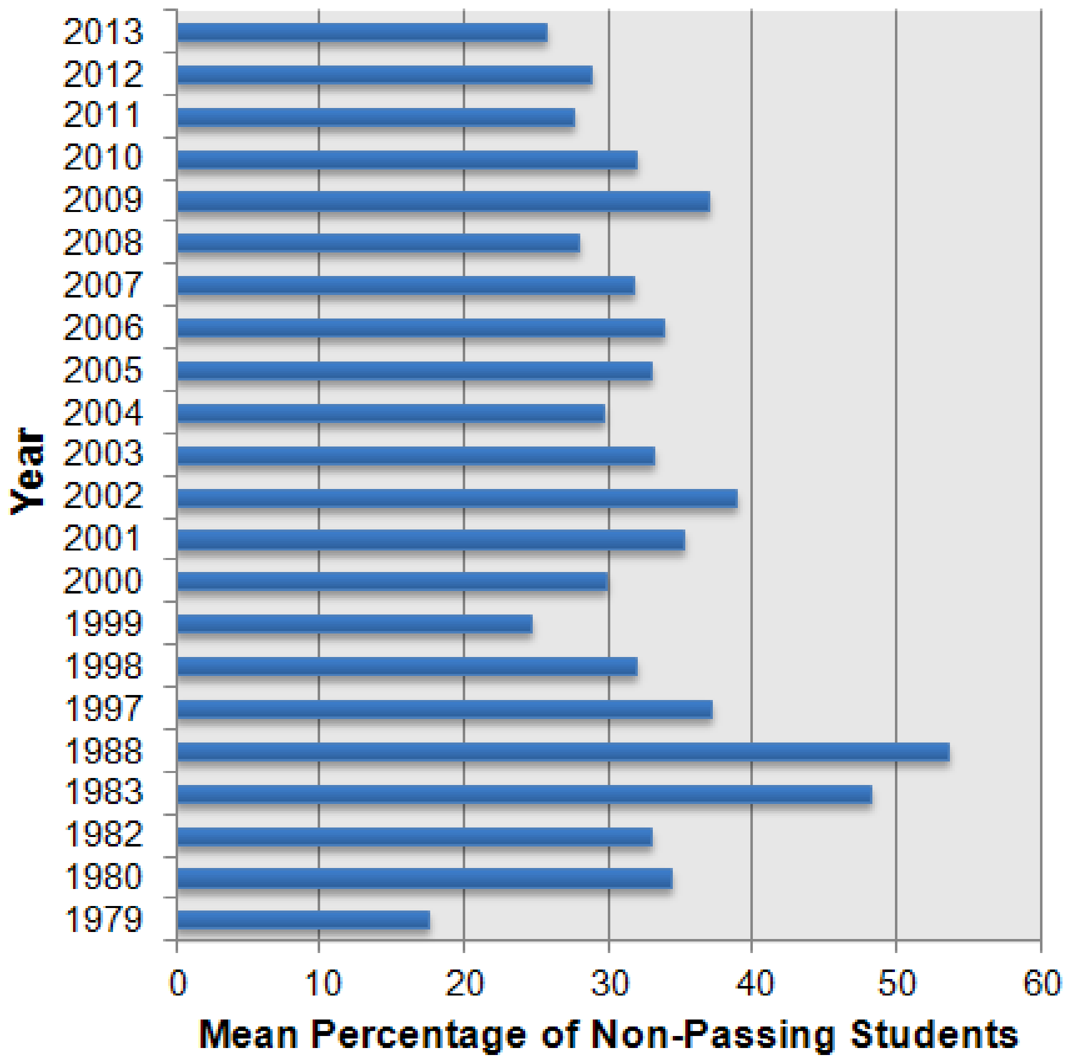

Figure 2.1: Mean global percentage failure rate of Introductory Programming courses by year *(Watson and Li, 2014)*

The mean percentage of non-passing students (failure rate) of Introductory Programming courses by country is given in Figure 2.2 (Watson & Li's 2014). The mean failure rate in South Africa is 44% which is considerably higher than the global mean failure rate.

Figure 2.2: Mean percentage failure rate of Introductory Programming courses by the Country

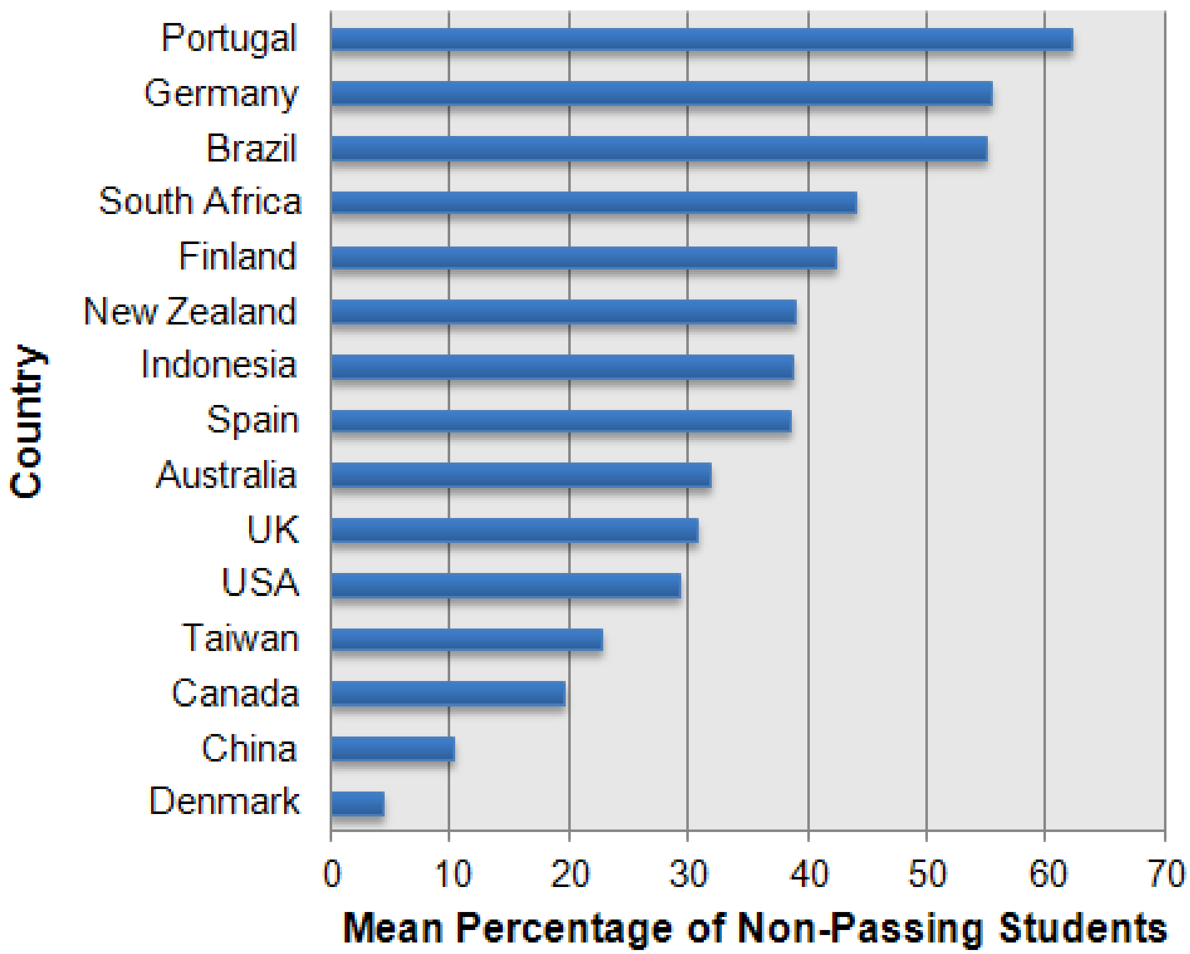

Figure 2.2: Mean percentage failure rate of Introductory Programming courses by the Country *(Watson and Li, 2014).*

2.4.1 Challenges and factors influencing learning programming

Low pass rates in Introduction to programming have been common for decades. Majority of the learners find computer programming difficult to understand and pass for the first time (Tinto, 1975; Roddan, 2002; Robins, Rountree & Rountree, 2003; Bergin & Reilly, 2005; Kinnunen & Malmi, 2008; Derus & Ali, 2012; Schoeman, 2015). Introductory programming failure rate among students is high worldwide, including in South Africa. The failure rate remains a subject for investigation due to a high number of students who find learning to program difficult. Most tertiary institutions experience higher failure rates in programming courses globally, averaging under 35% (Bennedsen & Caspersen, 2007; Watson & Li, 2014). Many researchers indicated the difficulties experienced in introductory programming, with very few learners finding it an interesting course (Hagan, Sheard & Macdonald, 1997; Eckerdal, 2006; Ben-Ari, 2016; Dasuki & Quaye, 2016). Faced with these challenges the Higher Education sectors all over have been innovative and proposing approaches to enhance and support the teaching and learning of programming. This Section provides more details on specific challenges facing learners in programming.

2.4.2 Learning difficulties among entry-level programmers

Learning introductory programming courses is considered to be difficult by students. Bergin and Reilly (2005) observe that “it is well known in the Computer Science Education (CSE) community that students have difficulty with programming courses and this can result in high dropout and failure rates” (p. 293). Two large scale research studies conducted by ITiCSE working groups assessed the programming ability of entry-level students across several Universities from different countries and reported on students’ difficulties. Through the first study, the working group tested 217 students from four universities on a common set of program-writing problems. Majority of students performed poorly than expected (McCracken et al., 2001). Students struggled to achieve an average above 30% on assessments administered among them as part of the study. The average general evaluation score for all exercises, across all universities was 22.89 out of 110 points. Through this multi-national study, they further observed that the students in introductory programming courses do not know how to program at the expected skill level across all universities and that makes this a universal problem.

With the later study, the ‘Leeds working group’ (Lister et al., 2004), attempted to study the code-reading and tracing skills of entry-level programmers. Again majority of the students failed to perform well. Approximately 25% of the students appeared to be performing in a level consistent to guessing. So difficulty in learning to program and high attrition rate among the entry-level higher education students is a global phenomenon.

2.4.3 Factors affecting learners on programming

The way in which learners in the first year of their university studies enrolled for undergraduate programmes in the field of CS or in a cognate field (entry-level computer programmers) are introduced to learning programming and the associated factors impacting on the successful outcome needs to be considered and analyzed when determining the features, which potential teaching and learning strategy should have.

A broader assessment of the factors impacting the ability to learn to program is essential to come up with a comprehensive plan for students’ success in programming. The varying results highlight the complex nature of what really affects students’ ability to succeed and supports the notion that learning to program is a complex matter to comprehend (Matthíasdóttir & Geirsson, 2011).

Understanding of programming poses many challenges for first year students. Ability to read and understand what a piece of code does was observed by Perkins and Martin (1986) as an important skill required by new programmers. Entry-level programmers are often seen to be having difficulty in grasping the foundation level programming concepts early in their studies, leading to grief and frustration and ultimately surrender (Shuhaidan et al., 2009). They often carry this conceptual baggage and that hinders their ability to understand concepts in their further levels of studies.

McCracken et al. (2001) stated that earner’s inability to solve problems as the major contributing factor in their difficulties to learning to program. This was also echoed by Falkner and Munro (2009) with their observation “entry-level computer science students are required at an early stage to develop a diverse range of skills such as problem analysis, problem solving" (p. 25) . Programming involves intensive problem solving skills and strategies. Study of algorithmic problem solving is considered to be at the core of learning computer programming (Lishinski, Yadav, Enbody, & Good, 2016; Sheth, Murphy, Ross, & Shasha, 2016). Huggard and Goldrick (2009) note that learners even fail to know where to begin their solution when faced with programming problems. While the McCracken group reported on entry-level programming students' poor problem solving skills (McCracken et al., 2001), the Lister Working group reported that students even lack in knowledge and skills that are precursor or pre-requisite to problem-solving such as reading and understanding the code and tracing or tracking skills (Lister et al., 2004). They also identify close tracking and tracing skills as a critical filter that allow detecting programming errors with understanding.

With the study to find problems faced by beginning programmers, Affleck and Smith (1999) found that accessing prior knowledge and adopting an approach to study that will go beyond memorizing explicit knowledge to constructing implicit knowledge necessary to apply and transfer the domain concepts to new situation are the main issues faced by them. These pose a new challenge to the learners who start a programming course in higher education.

D'Souza, Hamilton, Harland and Muir (2008) observe that programming poses early learning challenges to students with little or no programming background. A large number of students enter ICT programmes with little or no prior knowledge (Falkner & Munro, 2009). Many students face programming courses for the first time in their student life. They do not see any form of continuity in this course, from the courses they are familiar with and experienced with in their school days. In addition, the complexity and the set of skills it requires them to learn pose a greater challenge in the early days of their university life. Lack of preparation, lack of previous exposure to computers and the level of complexity are some of the inherent problems with entry-level programming courses (Gonzalez, 2006). Learners need to move away from the conventional way of learning they have been practising in the (familiar) school environment. They are coming from a familiar academic setting where they were studying topics that were familiar, comfortable and were studying for some years (Jenkins, 2002). They have been practising tried, tested and trusted learning skills. Then, they are confronted with totally new topics that demand more than those habitual learning skills. This poses a critical challenge to them. According to Jenkins (2002), some less obvious skills such as life skills may also pose a challenge to entry-level learners as they will be facing some of the most challenging materials in the programming course during their first years of university life itself. This is the time when they are going through a transition as they adapt to the all-new way of life and study at a non-familiar environment of university life. This aggravates the problem.

In general, abstraction is a fundamental concept in programming (Or-Bach & Lavy, 2004). According to Bennedsen and Caspersen (2006), abstraction and abstract thinking are crucial components for learning computer programming. But abstract concepts of programming is very challenging for entry-level students in particular for those with little programming background (Gonzalez, 2006). Difficulties with the abstract concepts of knowing how to model a solution to a problem, decompose it into manageable and code able subcomponents or sub-problems then conceive a hypothetical error situation to test and figure out mistakes constitute a major issue faced by entry-level students (Esteves, Fonseca, Morgado, & Martins, 2011). They even fail to understand the very basic concepts such as variables, data types and memory addresses since these abstract concepts do not have direct analogies in real life situations (Miliszewska & Tan, 2007). Through the inter-university, multi-national study among students doing introductory programming courses, Mc Ckacken et al. (2001) note that abstracting the problem to be solved from the problem domain/description was the most difficult part for the students and more importantly this issue was found to be the most obvious similarity among students across all Universities. They further observed that, if they had successfully completed year one introductory programming course, then it was not their programming skills rather their knowledge was that enabled them to succeed.

Individual domains including personal factors may influence the successful outcome of students learning to program. A student’s motivation in engaging in activities pertaining to learn programming and his/her capabilities to complete them can better describe these personal factors (Carbone, Hurst, Mitchell, & Gunstone, 2009). The difficulties they find in learning to program in their early days of university life affect students' motivation level. Lack of skills affects students' confidence and motivation in a negative direction (Carbone et al., 2009; Rahman, Anuar, & Said, 2018; Settle, Vihavainen, & Sorva, 2014). According to Kinnunen and Malmi (2006), low level of motivation is one of the major reasons why students drop out of IT courses. Without motivation, there may not be any reason to 'succeed' in programming. Entry-level students may have the potential intellectual capacity to create programs, but that in itself may not be enough to learn programming successfully. As Zimmerman (1995) observes, even though students may possess the intellectual capacity, if they are poorly motivated, they may still fail to learn to program. Course assessment results may not reflect the true ability of learners, if they are not motivated enough to do well as was confirmed by Teague (2009) through the study conducted to determine the extent to which the personal factors such as motivation and confidence affects students learning to program.

Figure 2.2 summarises the factors influencing the learning difficulties entry-level students generally face in learning to program. It is now clear that students need to learn a number of different skills and processes in learning to program, thereby requiring deep learning (meaningful learning) to take place among learners to succeed in programming.

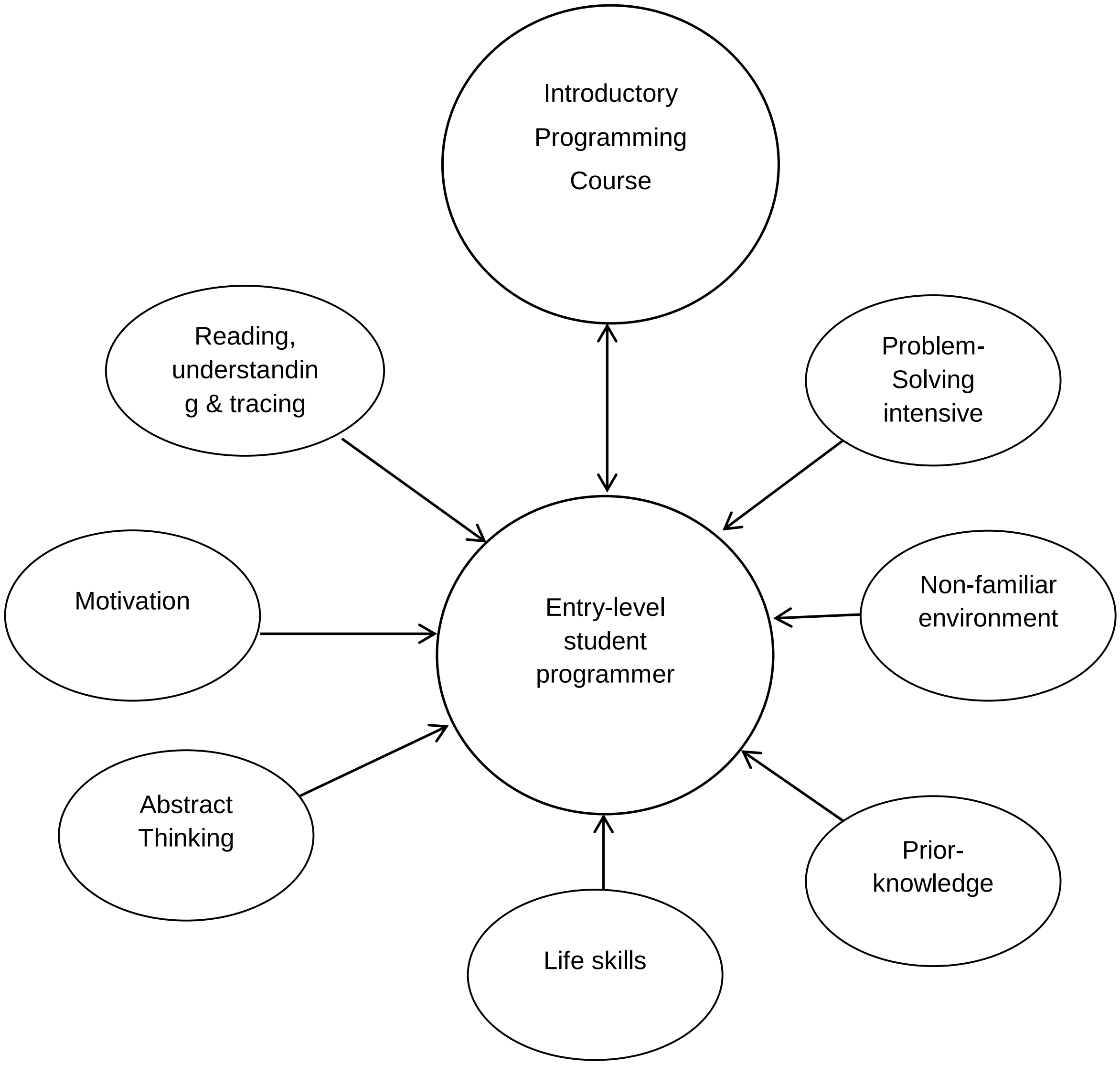

Figure 2.3: Factors impacting on entry-level students' ability in learning to program (*Source: Researcher)*

2.5 Meaningful learning

Research done in computing education explains that learning can occur in two different ways – surface learning (superficial learning) or deep learning (meaningful learning) (Jenkins, 2002; Mayer, 1981). Surface learning is a peripheral and noncommittal approach to learning associated with rote learning or done with a 'just getting over with it' attitude (Biggs & Tang, 2007). It does not seek to formulate connections or logical links between phenomena, it rather treats concepts in isolation whilst accepting and memorising knowledge uncritically (Millis, 2010). According to Lublin (2003) the primary intention of students who take a surface approach to learning is not to become interested or to understand the subject, but rather their motivation is to jump through the necessary learning material to score the mark, or the grade, or attain the qualification. They learn to repeat what they have learned and tend to memorise concepts for the purposes of assessments. Surface learning does not link incoming or new knowledge with the existing knowledge and it replaces one set of knowledge with another without understanding it (Hay, 2007). In approaching learning tasks, surface level learning aims at avoiding failure rather than understanding the key concepts, their connectedness and relationship to broader contexts (Bowden & Marton, 1998). Thus they fail to apply the knowledge in a new novel situation. Surface learning is characterized by entry-level learners memorizing programming concepts for the purpose of future use.

Students who take a deep approach to learning actively seek to understand the material/the subject and vigorously interact with the content (Lublin, 2003). They make use of evidence, inquiry, take a broad view of the subject matter, relate ideas to one another and connect with the existing knowledge. Irrespective of the strategies they use, deep learning is characterized by learners' quest to search for understanding (Case & Marshall, 2009). Deep learning facilitates deeper understanding of programming concepts among learners and prepares them to apply these concepts in the future implementation of solutions. Programming by nature requires analysing, designing and implementing solutions for the given problem domains.

Meaningful learning or deep learning, is a process where the learner augments the existing knowledge with new knowledge learned from new material by forming connections between them (Bransford, 1979). According to Cognitive Load Theory (CLT), human cognitive architecture consists of limited working memory or short-term memory, which interacts with a relatively unlimited long-term memory. The existing knowledge which is in the long-term memory is called schema and the process of extending it via connecting it to the new information stored in the short-term memory is called assimilation. A schema is essentially a mental framework for understanding and remembering information (Kirschner, Kirschner, & Pass, 2009) . It is this cognitive construct that puts together elements of information based on the way they will be dealt with or used. For example, contents of subject matter are organized into these schemas in the long term memory and these schemas determine how the new information interacting with them should be dealt with (Sweller, 1994).

Short-term memory is a temporary, limited capacity working space that holds and manipulates information under consideration. This is used for all conscious activities. On the other hand long-term memory has unlimited storage capacity which is organized and keeps a permanent record of everything that one has learnt without conscious efforts.

Figure-2.4 provides a general framework for the process of meaningful learning of technical information (Mayer, 1981).

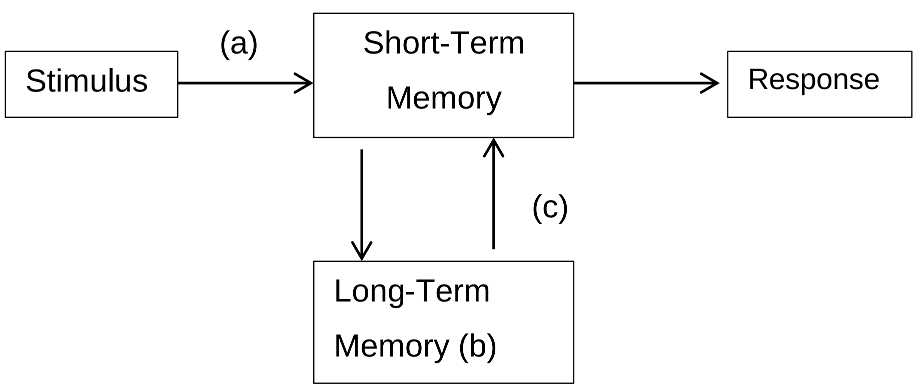

Figure 2.4: Framework for the process of meaningful learning *(Mayer, 1981)*

Programming is a technical activity and in order for meaningful / deep learning to occur during the learning of this highly technical information, the following steps need to take place (Mayer, 1981):

1) Reception: New technical information from outside enters the human cognitive system. Learner must pay attention to it in order for this incoming information to enter the short-term or the working memory (arrow ‘a’ indicates this in figure-2.4).

2) Availability: learner must have appropriate prerequisite concepts or schemas in long-term memory to use in order for the assimilation of the incoming information with the appropriate schema to take place (box ‘b’ indicates this).
3) Activation: learner actively uses this prerequisite knowledge from long-term memory during learning so that the new information is connected to it, thus facilitating assimilation (arrow ‘c’ from long-term memory to short-term memory indicates this).

Thus in meaningful learning, learner allows new material into his/her short-term memory, searches long-term memory for appropriate prerequisite knowledge (schema) and transfers it into short-term memory so that it can be connected with the incoming information, causing assimilation. This results in “ideational scaffolding” (Ausubel, 1968) and fosters deeper understanding. Meaningful learning will not occur, if any of these steps are omitted. In that case, learner will be forced to learn each piece of new information separate by rote learning (surface learning).

Both surface learning and deep learning let new information to be stored in long-term memory. Surface learning is useful to learn specific programming constructs such as syntaxes, operator precedence etc. (Jenkins, 2002). But as discussed earlier, meaningful learning fosters understanding which in turn enables the learner to use the learned information in problem-solving tasks that is different from what is explicitly taught (Mayer, 1981) and this is what a programmer, be it an expert or an entry-level programmer is expected to perform in his/her quest to create solutions to the given problem domains. In other words, deep learning enables learner to transfer the learning to new novel situations and to new problem areas (Jenkins, 2002), whereas the new information learned through surface learning cannot be transferred to new situations (Mayer, 1981). Thus the instructional designers should always be wary of the cognitive load the learners are exposed to, since the short-term memory carries the risk of being overloaded, in particular when they are required to perform complex tasks such as problem solving.

2.5.1 Cognitive load

Short-term memory or the working memory is the only memory that can be monitored and is used to perform all conscious activities. But it has got a limited capacity and can only handle seven plus or minus two items or elements of information at a given time (Miller, 1956). Since the instructions and tasks impose a cognitive load on a learner, instructions must be designed to make sure that the Short-term memory is capable of handling them. This load should not exceed the limited capacity of this working memory.

Cognitive load (CL) is dependent upon the inherent nature of the subject (intrinsic cognitive load) and the way in which the subject is presented to the learner (extraneous and germane cognitive loads) (Kirschner, 2002). Intrinsic CL occurs as a result of performing the task at hand. A highly complex task would yield higher intrinsic load. Poorly designed instructions generally result in generating extraneous cognitive load to the working memory. When unnecessary information is fed with the important knowledge constructs, this unnecessary information also occupies (the limited) working memory slots but fails to contribute towards learning the task at hand. Consciously connecting new information with what is already known is the process which yields germane cognitive load. This directly contributes towards learning and schema construction. It is important that, in order for learning to occur, the total load generated by all three of them should not exceed the capacity of the working memory.

According to cognitive load theory, conventional instructional methods fail to consider the limitations of working memory in designing instructions (Kirschner et al., 2009). Intrinsic cognitive load cannot be reduced, since it is generated as a result of the intrinsic information/knowledge emanating from the material being dealt with or the task being performed whereas the extraneous and germane CL depend on the instructional design. If part of the working memory is freed by lowering extraneous CL with effective instructional design, then learners can be encouraged to engage in conscious cognitive processing directly relevant to learning, that is, germane CL.

For example, if an entry-level programmer is required to actively engage in the syntax of a programming language while attempting to learn an algorithm, then that results in generating more extraneous cognitive load. Since, the intrinsic CL cannot be reduced due to the limited capacity of the working memory, learner fails or partially fails to connect the new information with what is already known (schema). In other words, assimilation of knowledge does not take place. This means, creation of germane CL is severely compromised. Deep or meaningful learning does not occur in such circumstances.

Therefore, in order for meaningful learning to ocur while learning to program, it is important to minimize the cognitive load placed on the entry-level programmer by reducing the extraneous cognitive load. This can be achieved by not overloading the learner with information not directly related to the material or the task at hand.

Meaningful learning only occurs under certain conditions. Even though all such conditions are in place, there is no guarantee that meaningful learning can still occur. Students learning styles will have a greater impact on it. Kolb's learning cycle deals with this aspect of meaningful learning.

2.5.2 Kolb's learning cycle

Knowing and being able to take advantage of students' learning styles can help instructors prepare them better for the real world (Nilson, 2010). According to him "Kolb portrays the process of meaningful learning as a series of events that integrates the functions of feeling, perceiving, thinking and acting" (p. 230).

In Kolb's Learning Cycle (Kolb, 1976, 1984; Konak, Clark, & Nasereddin, 2014) learning takes place in four-stages as illustrated in Fig- 2.5. According to Kolb, for a learner to be effective, he/she should be able to directly involve in concrete experiences (concrete experience - CE), reflect and observe on these experiences (reflective observation - RO), create concepts and integrate these observations into theories (abstract conceptualization - AC) and use these theories to make decisions and solve novel, new problem scenarios presented to them (active experimentation – AE). A learner moves through the four phases of this cycle. These four stages accommodate different learning styles of learners and allow them to comprehensively investigate the topic under discussion through different activities and views (Konak et al., 2014).

An experimental study conducted by Kamis and Topi (2007) to improve the technical problem solving capabilities of learners learning computer network sub-netting found that individuals traverse through the entire cycle starting and ending with concrete problem solving activities that maximize their performance. They further observe that “observing a trainer performing a computer skill, abstracting the skill symbolically, practicing it mentally, and testing one’s abstract conceptualization through hands-on practice improve computer skills” (p.3). Through a similar study in a different context they conclude “if one becomes stuck when solving technical problems, Kolb’s cycle serves as an elegant reference for becoming unstuck” (Kamis & Kahn, 2009, p.109)

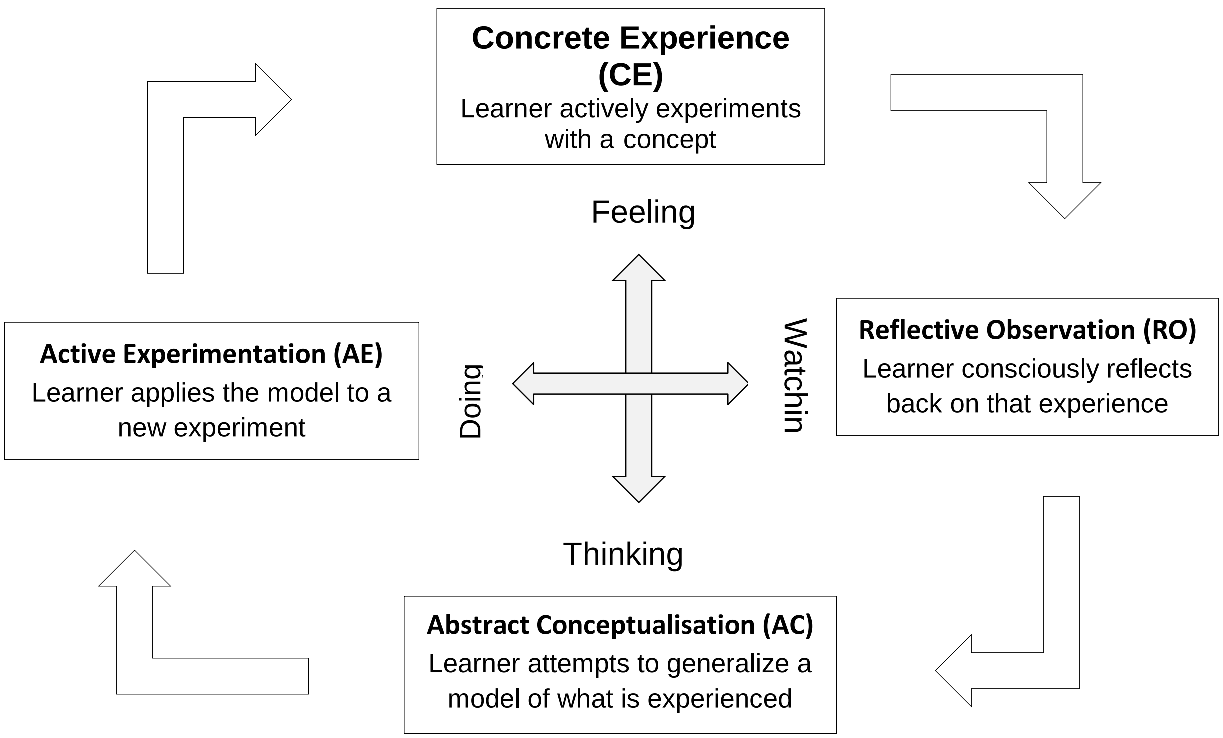

Figure 2.5: Movements through Kolb’s Learning Cycle *(Konak, Clark & Nasereddin, 2014)*

Research has shown that active approaches to learning programming work better (Hwang, Shadiev, Wang, & Huang, 2012; Whittington, 2004). Among the active learning approaches, GIL is closely related to Kolb’s learning cycle (Konak et al., 2014). In this active student centred approach, learners work in small teams and are expected to work on inquiry based activities designed to encourage them to construct their own knowledge rather than receiving it from traditional lectures led by instructors (Douglas & Chiu, 2012; Hu, Lang, Kussmaul, Mayfield, & Pirmann, 2014). Instructors act as facilitators in this mode of learning.

Konak, Clark and Nasereddin (2014) conducted an empirical study to address the challenges of providing students with hands-on learning experiences in information security using virtual computer laboratories. Through their study they observed that, students who performed hands-on activities designed following Kolb's learning cycle exhibited higher level of competency development, showed increased interest and gained deeper understanding of the subject matter. They further observed that more comprehensive students learning was achieved, when the activities were designed following inquiry-based framework.

2.6 Students' motivation, confidence and communication skills and their academic performance

The general definition of motivation as indicated by Breen (1999) is "the nature of an individual's internal forces and the extent to which they define external goals and direct the individual towards them" (p.1). However, there is less research that has been conducted on determining and measuring student motivation.

Motivation comes from or is experienced from different sources for different students. According to Round (2005) the common source of motivation is determined by the course interest. In a study by Round (2005), majority of the students mentioned that they are motivated to 'continue doing' their course, despite the difficulties that may be experienced knowing that they are preparing for the future job opportunity. Findings from the same study show that students who achieve everyday academic motivation like their courses, have self-academic confidence and have understanding of the academic environment (Round, 2005). Such students will have understood the university culture and background and received proper orientation.

2.6.1 Students' motivation

Several studies have been undertaken on student motivation and the different factors that important on them. A summary of these factors are mentioned by Round (2005) and Breen (1999) and are summarised as follows:

- Students are motivated if they have interest in the course;
- If they get high marks in the course;
- If the course they are doing will lead to a good future job opportunity;
- University background and success;
- Good learning environment;
- High quality lecturing staff

It is argued by Dooley (2004) that motivation affects students' academic success, confidence and the level of communication among them. The common types of motivation are:

Intrinsic motivation and extrinsic motivation. Intrinsic motivation is about the behaviour performed in order to experience joy and happiness, such as the interest of studying a particular course (Winn, 2002). ***Extrinsic motivation*** is about performing a behaviour as a means to an end, that is, to receive a final incentive for example passing a course (Winn, 2002). With extrinsic motivation, the learner is motivated to study so that in the end, will get a certain prize or reward.

Round (2005) has further explained student motivation in terms of the following:

- Entry motivation – this involves the joining and selection of a particular university;
- Daily motivation – involves all the activities surrounding the course work functions. All the tasks involved during the learning process.
- Future motivation – where one is motivated to obtain something at the end for example a degree or a good job.

Mäkinen et al (2004) indicated that motivation is linked to the commitment that students put in a subject. This could be through in class or out of class socialization among students. Additionally, Nevill and Rhodes (2004), mentioned ‘satisfiers’ and ‘dissatisfiers’ which affect students. In a certain study, students indicated that the following factors affected their satisfaction:

- Wiliness to achieve academic success;
- Interest in a good employment opportunity;
- Self-motivation to learn;
- Approachable and friendly academics
- Good interaction with peers and fellow students

Again, Nevill and Rhodes (2004), indicated the following d*issatisfiers*

- Academic versus personal life balance;
- The learning environment and resources available;
- Stakeholders’ comments on university students
- Issues involving financial advice
- Using different assessment strategies
- other students’ views of university life

The satisfiers and dissatisfiers play an important role in understanding motivation. In summary, it is clear that motivation brings in confidence in students and the required joy and interest. Literature available supports that motivated students become more confident in their courses and are likely to perform better than those less motivated ones.

2.6.2 Students’ confidence

According to Jones and Thomas (2001) self-confidence refers to “the assurance that a person has in his or her own abilities, towards conceptualized in the academic areas” (p.3). The Oxford English Dictionary (1989) explains confidence as ‘having strong belief, firm trust, or sure expectation; feeling certain, or fully assured, ‘self-reliant, bold; sure of one-self and having no fear of failure’. Literature is clear on that confidence differs between individuals in the same situation (Sander et al, 2000). Additionally, their levels of confidence differ for people in different situations. For example, one can be highly confident in a familiar setting, and at the same time lose confidence in an unfamiliar and challenging environment (Sander et al, 2000). The research focuses on academic confidence, rather than the general confidence.

Academic confidence is conceptualised as being how students are different in having a 'strong belief and firm trust' of what their institution has to offer (Jackson, 2003). Academic confidence is based on four sources: mastery, vicarious experience, verbal persuasion and physiological states (Round, 2005). The researcher further argues that academic confidence, therefore, is proposed as an interlink between one's inherent capabilities, his/her learning techniques and the resources afforded by university (Round, 2005). This means that students who are having academic confidence are likely to interact and communicate with one another more, as they understand the role and significance of communication for academic achievements. This leads to a further discussion on communication.

2.6.3 Students' Communication skills

There is significant amount of literature on the role of communication for university students. Since in most cases learners come from different high schools with different background, it is clear that communication becomes a challenge. In most rural schools of South Africa, English is used as a second language yet is the main language of communication at universities. Communication is a vital part of our daily routines (Bygate, 1987). Communication involves the components such as writing, reading, talking and listening.

Through communication, students learn from each other and acquire different skills, their confidence will grow and, become more motivated (Dornyei & Thurrell, 1994). To increase students' communicative skills, different communication mechanisms should be identified. Other researchers have investigated communication strategies (Bygate, 1987; Dornyei & Thurrell, 1994). The types of communication strategies include - Writing skills through paraphrase or approximation; use of nonverbal skills like gestures; requesting for effective feedback and seeking for repetition and further clarification.

When students have communicative competence, they grow in academic confidence. Therefore, communicative strategies at universities should be targeted towards increasing students' competence and activities that they do.

It is evident that the terms motivation, confidence and communication are well linked and lead to one goal for students especially in their early stages at universities. Students become more comfortable and confident to interact and enjoy learning if they are exposed to good communication platforms.

2.7 ICTs in education

In a fast changing world, education is vital for a person to be able to have access to and apply information. It has come to a stage where it is no more a luxury to access or use information but it is an asset indispensable for development. Regrettably, many third world nations, particularly Africa, are still lagging behind in the application and use of ICT (Ijiga, 2014). This makes it difficult to consider the emerging approaches. Meanwhile, it is observed that research has been carried out on the uses of ICTs by teachers mainly in their specific areas of specialisation. Most of these studies were carried out in advanced nations where there is already a predominant use of ICT, with enough resources and materials for their maintenance (UNESCO, 2013). Unequivocally, the use of ICTs for pedagogy has immense advantages. This is so because it allows them to exhibit knowledge of the prospects and effects of their uses for teaching and learning in the context of curriculum; to plan, implement, and manage learning and teaching in an open and elastic learning environment (UNESCO, 2013). The usage of ICTs has led to the development of electronic learning applications as detailed in the following sections.

2.7.1 E-Learning

ELearning encompasses all electronically supported learning and teaching whether it be termed computer based training (CBT), Internet based training (IBT) or Web Based training (WBT). What it simply means is that learning is facilitated through the use of the internet and computers. The researchers define eLearning as the teaching and delivering of teaching material through the use of ICT. ELearning can be learner-paced or instructor led (Maher Alghali & Roesnita, 2014; Bora & Ahmed, 2013). ELearning has gained popularity and has been adopted by many educational institutions because it provides effective quality education and it is also supported because of:

- ease of access - this means that students can enrol for training and they are able to access educational resources without being physically present in the instructor's location. This also implies that learning materials and courses can be accessed at the student's convenience and not at the instructor's local time (Muhammad & Abdulrahman, 2015).
- group based collaboration – learners interact amongst themselves to brainstorm and share ideas
- flexibility – joining discussions or bulletin boards at any time
- self-paced learning - students learn at their own pace
- universal dimensions of knowledge and
- improved response to meeting deadlines

Although eLearning has many good elements, it has some disadvantages such as the fact that learners learn in isolation without physical interaction with other students or the instructor. Furthermore, some practical exercises cannot be done using eLearning, take for example, agricultural lab activities. Moreover, managing eLearning software might prove to be a challenge and it might be also difficult for students to master.

Most educational institutions have adopted the use of eLearning in their day-to-day teaching and learning activities. This comes with a lot of challenges that are grouped by Maher Alghali and Roesnita (2014), as financial, individual, knowledge management, support and technological challenges. Under these 6 categories, 24 challenges were identified (Maher Alghali & Roesnita, 2014).

2.7.2 Technology as a cognitive tool

This emphasises the notion about learning, a constructive activity involving careful cognitive efforts, and the use of technologies as cognitive learning tools instead of an instructional medium. It connotes a substantial departure from customary conceptions of technologies that were used for routine learning through activities such as routine drills and practice. Thus, the principal difference between customary learning applications of technologies together with their usage and using learning technologies and tools to facilitate constructive learning environment is that the traditional view assumes media as carriers of information and learners as passive recipients rather than active constructors of knowledge.

The literature on the use of computer systems as a cognitive tool has developed in the last two decades. ‘Mindtools’ is another term that represents more or less the same thing as ‘cognitive tools’. Cognitive tools are technologies that assist learners to engage in and enable cognitive processing thereby bringing about knowledge construction. The tool of technology is not one of a physical nature but rather a cognitive nature being used as an engager, as well as an enabler of thinking and knowledge formation (Jonassen, Peck & Wilson, 2002). They increase the cognitive powers of human beings through thinking, problem solving and learning. Jonassen (2012) points out that the role of a cognitive tool is to extend the learner’s cognitive functioning during the learning process, and to engage and enable critical thinking and higher-order learning. Mindtools help learners to grow into critical thinkers.

Cognitive tools are technologies that students interrelate and think within knowledge construction, aimed to bring their proficiency to the performance which is part of the combined learning system (Kim & Reeves, 2007). According to Jonassen et al. (2012), learners do not learn directly from technology. The part technology plays in instruction is to engage the students more actively in the thinking process and handling information which in turn facilitates the learning process.

2.7.3 Mobile learning technology

Keegan (2005) focuses on mobility in the definition of mobile learning technology, defining it as the provision of education and training using PDAs, palmtops, handhelds and smart phones (devices easy to carry and use everywhere and anytime) . Keegan (2005) eliminated the use of the laptop from mobile learning technology, thus restricting mobile learning technology to those devices which are portable, ubiquitous and flexible in order to provide a wide range of social contexts (Pachler, Bachmair & Cook, 2010).

Mobile learning technology is the ability to obtain or provide educational content on mobile devices. Educational content talks about digital learning resources which consist of any form of content or media made accessible on a personal device. Mobile learning technology using handheld computers is in its early stages in terms of technologies and pedagogies. As a result, there is still some dispute between industry campaigners in what manner mobile learning technology ought to be defined: in terms of devices and technologies; with regard to the mobility of learners together with the mobility of learning, and with regard to the learners' experience of learning using mobile devices.

Some researchers and educational administrators view mobile learning technology as the immediate offspring of e-learning. Pinkwart, Hoppe, Milrad, & Perez, (2003) for instance, defines e-learning as learning facilitated by digital automated tools and media, and by comparison, mobile learning technology as e-learning which utilises mobile devices and wireless transmission.

2.7.4 Open Online Communities of Practice (OOCoP)

OOCoP refers to the state when knowledge sharing in CoPs no longer takes place exclusively within the boundaries of the organisations. Members of CoPs are considered relatively stable. Early researchers acknowledge that these members of a CoP do not have potent interactions with members of other CoPs, therefore it is considered to be closed (Anderson, 1999; Roy, 2011). To the contrary, members of OOCoPs demonstrate significant interactions with members of other CoPs. The social interactions made possible through OCoP facilitate sharing of tacit knowledge (Baker-eveleth & Eveleth, 2005). Through OOCoP, such “open” setups tend to widen the horizons of social interactions, thereby enabling the sharing of tacit knowledge on a cross-organisational level.

Additionally, in an OOCoP members can join irrespective of their qualification(s) or personal profile. Such OCoPs can be classified as Open or Public (Roy, 2011). The OCoP for Computer Studies teachers in Namibia therefore falls under this category. Careful and well-protracted use of technological tools such as Web 2.0 that allows users to become content-generators is obviously of paramount importance for OOCoPs.

An OOCoP can provide instant help, expertise, long-term apprenticeship in a safe social setting, and perhaps most importantly, emotional support for teachers isolated from their technological peers (Hanson-smith, 2013). Breu et al. (2008) outline the benefits to educators through the use of ICT. Information can easily be shared with administrators and teaching teams to increase communication about students and expedite decision-making regarding interventions and teaching strategies.

2.7.5 Technological E-Learning challenges

These come in the form of infrastructure, localisation, presentation and interface design, resource management and speed bandwidth as highlighted by (Maher Alghali & Roesnita, 2014). Maher Alghali and Roesnita (2014), note that local infrastructure is not effectively used because resources are not used to full capacity all the time. Resources are used at full capacity only during certain peak periods like examination times. This means that institutions are investing a lot of money into infrastructure that is not used at full capacity most of the time. This leads to scalability challenges. When there is a need to increase the capacity of the infrastructure, higher education institutions need again to carry the cost implications of the upgrade. This means that more finance has to be pumped onto the e-Learning system in addition to what it normally receives and that should also adequately support financial obligations the institution has to meet on a regular basis.

2.7.6 Other examples of technologies in teaching

Assistive and adaptive technologies such as recommender systems are exploited in an effort to determine the suitable learning materials for each individual learner. The study addresses the issue of how individual differences within e-learners at universities and other social settings can be addressed when designing, developing and delivering e-learning material. Graf and List (2005) define adaptivity as the automatic adjustment of the content or interface to suit an individual learner's needs. In the context of this work, an adaptive framework is a structure that enables an e-learning system to be able to provide content that is at an appropriate cognitive level to a particular learner without compromising on the need to achieve common pedagogical goals. Adaptivity may be single point, that is, results of a diagnostic test are used to determine adaptation, or it may be continuous adaptation, where continuous data mining is used to provide real-time adaptation (Brown, 2015). The term differentiated teaching will be used to refer to teaching in an e-learning environment that focuses on the academic achievement of each individual student, taking into account their educational, historical and social backgrounds while at the same time taking into consideration the learner's interests and learning ability (Gynther, 2016).

The increased use of web-based learning platforms has resulted in information overload; thus making it difficult for e-learners to identify the best suitable information required in their studies (Pedro et al., 2014). Because of this situation, researchers found it ideal to devise techniques that enable e-learners to sift out unwanted information (Manouselis, Drachsler, Verbert a Duval, 2012). Such techniques often make use of recommender systems. Recommender systems are systems that use information retrieval principles to identify content that meets a users' preferences, thus allowing for personalisation and adaptivity of content to take place (Elahi, Ricci, & Rubens, 2016). Recommender systems are generally classified into content filtering, collaborative filtering or probabilistic modelling technique-based systems (Sharif & Afzal, 2015). According to Sharif and Afzal (2015), a content-based filtering recommender system generates recommendations based on historical activities of a learner such as key-word search or other online activities; while collaborative filtering recommendation algorithms rely on mining data from a user’s social contacts under the assumption that a learner is likely to like the same material as his/her friends or other influential people use within his/her social group. Both content-based and collaborative filtering techniques suffer from the “cold start problem”, that is, it is difficult to make a recommendation for a new user who does not have a social or personal history within the system (Ricci, Rokach & Shapira, 2011). This has seen the rise of model-based recommender systems that uses probabilistic inference to come up with matches to a user’s preferences (Gorakala & Uselli, 2015).

2.7.7 Social media and learning

“The trend and direction of utilizing SNSs such as WhatsApp, Facebook, Twitter, or YouTube for education is to use as a tool for sharing collaboration, posting comments, which leads to the development of teaching and learning management” (Treepuech, 2011).

Treepuech (2011) further pointed out that students generally have more satisfaction with teaching and learning management by SNSs as compared to the traditional system, even though teaching and learning management by SNSs is appropriate for a smaller group of students.

Academic institutions have started making significant investment in computing and internet infrastructure hoping that this investment would result in extensive use of knowledge resources on the web leading to significant increase in productivity of students and teachers and enhance the learning experiences (Bharali, Kaur & Pradeep, 2012). At the same time, concerns are raised among teachers and parents that these investments may not result in anticipated goals of increased productivity and quality.

Greenhow, Robelia and Hughes (as cited in Valetsianos & Navarrete, 2012) pointed out that SNSs can facilitate interaction, communication, and collaboration, which caused it to be prominently featured in discussions pertaining to the use of technology to support and strengthen educational activities.

Learners enjoy and appreciate the social learning experience offered by the combination of online social network and traditional teaching. They also easily support one another in the learning process and see enhancement in their learning experiences as a result of social interactions (Valetsianos & Navarrete, 2012).

According to Ratneswary and Rasiah (2013), using social networks creates a more positive and less-threatening learning environment which enhances learners' engagement and learning experience while creating a stronger relationship between each other and with their teachers. Ratneswary and Rasiah (2013) further stated that social networking provides a rich team-based learning environment to share learners' creativity in a virtual medium to further enhance learner-centred learning. In the process, learners also gain communication skills, team work skills, interpersonal and intrapersonal skills, leadership skills, time management, discipline-specific knowledge and digital literacy skills.

2.7.7.1 WhatsApp as an e-learning/m-learning tool

Most countries' education systems support the utilization of ICT in the classroom. A steady but noticeable progress has been made in the use of ICT in the classroom thereby putting more emphasis on learners and the learning process. Mobile learning has developed as one of the tools used in the classroom environment. Mobile phones remain the main platform for mobile learning due to an innovative opportunity mobile phones provide in the learning process (Kumar, Lian & Vasudevan, 2016).

WhatsApp is an instant messaging application that allows smartphone users to send and receive a variety of media: texts, photos, videos, documents, and location, as well as voice calls (WhatsApp, 2018). Learners use both texting and instant messaging and it was found that many educational institutions are eager to use instant messaging applications for educational purposes (Abaido & El-Messiry, 2016).

WhatsApp is obviously not a teaching tool on its own but rather a tool to facilitate communication as well as distributing educational resources to learners. Moreover, education is all about communication. One of the commonly used features of WhatsApp is the option to create a group, add participants and share information in different ways in the group. The person who created the group/ Administrator of the group has administrative rights of adding and removing participants to/from the group. Everyone in the group receives a notification for every message posted by participants. All these features add a potential for learners to be active in the learning process and boost informal communication between learners and teachers concerning subject matter. It also brings out a sense of belonging in learners as well as breaking down the wall of fear between teachers and learners. The same findings about WhatsApp were revealed in a study by Awada (2016), where it was concluded that WhatsApp application helped in creating an anxiety reduced learning environment thereby increasing students' sense of belonging. Bouhnik and Deshen (2014) indicated that learners tend to take their academic work seriously on a social platform like WhatsApp where other learners are due to the urge to impress one another.

2.7.8 A Model for framing learning technology

Koole (2006) and Koole (2009) developed the Framework for the Rational Analysis of Mobile Education (FRAME). One of the aims of FRAME is to help educators and learners assess the effectiveness of various mobile devices used in distance learning. The other aim is to guide the development of future mobile devices. Thirdly, the aim is to help the development of learning materials designed for mobile learning technology and finally to specify teaching and learning strategies for mobile learning technology.

The Framework for the Rational Analysis of Mobile Education (FRAME) was adjudged to be the first theoretical model to describe learning as a process for bringing together mobile technologies, human learning capacities and social interaction (Koole, 2006). The FRAME model which can be seen below is represented in a Venn diagram.

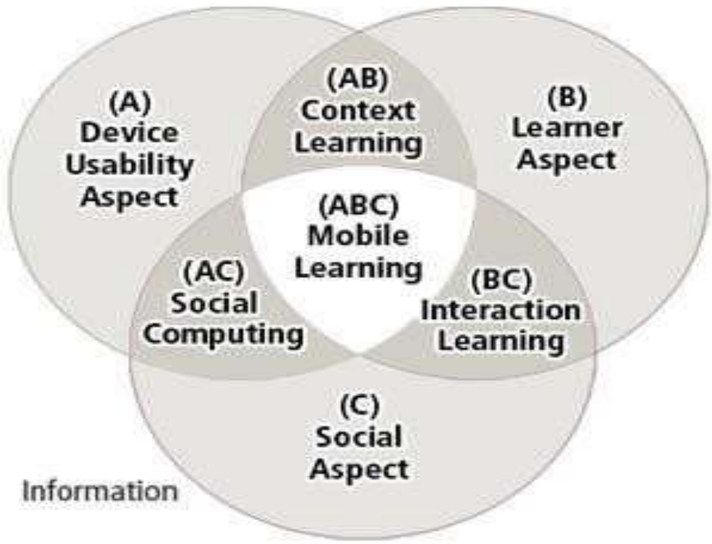

Figure 2.5: Model for Framing Mobile learning technology (FRAME) *(Koole,2006)*

The FRAME is modelled towards the information context and this context can be internal or external. The components of the Venn diagram are: 1) the device usability aspect: which refers to characteristic (e.g. physical, technical and functional) description of mobile devices 2) the learner aspect: this is the learner's attribute (e.g. cognitive abilities, memory and prior knowledge) 3) The social aspect: the process of interaction and co-operation between learners.

From the diagram above, one can deduce that the interactions that exist between the device usability aspect (A) and the learner aspect (B) create a very flexible learning environment. This can be found in the context learning intersection (AB). The social computing intersection is found between device usability aspects (A) and the social aspect (C). This is the communication environment which exists between users. The combination of the learner aspect (B) and the social aspect (C) leads to the interaction learning intersection (BC). This is the area that represents the instructional and learning theories. A closer look at the intersection region which has to do with the combination of the attributes of the three aspects explains the mobile learning technology process (ABC).

2.7.8.1 A Framework for sustainable mobile learning technology in educational institutions

Ng and Nicholas (2013) created a framework to ascertain the findings and actions investigating mobile learning technology in an Australian Secondary School. This is basically a person-centred model involving stakeholders (such as management and leadership, teachers, learners, technicians and community). The framework is aimed at using PDAs to explore the different influences on the sustainability of mobile learning technology programmes in schools. Sustainability of ICT in education is made up of five components. They are:

i) Economic sustainability: funds being available in institutions for the provision of a long term ICT programme

ii) Social sustainability: this covers mobile learning technology projects on a wider community scale. This includes parents, political leaders and mobile companies

iii) Political sustainability: this has to do with institutional policies and leadership roles to adopt a mobile learning technology programme that will last the test of time.

iv) Technological sustainability: this is when decisions are taken on the technology tools that will be used for the programme.

v) Pedagogical sustainability: this defines the teaching and learning practices. It looks at the various roles and interactions between teachers and learners so as to bring about learning with mobile devices.

For mobile learning technology to be sustainable, Ng and Nicholas (2013) explained three human related issues. One of them is the provision of suitable devices and also other technological devices; not forgetting to ensure that there is constant maintenance and technical support. This will build positive attitudes in learners and teachers towards the programme. Secondly is the need to open effective channels of communication which will enhance feedback. This will remove confusion and stress among the mobile learning technology team, and finally is the need to enhance the level of trust among stakeholders.

2.7.8.2 A conversational framework for the effective use of learning technologies

According to Laurillard (2002), four main aspects of the teaching-learning process are in existence and that diverse educational media can be analysed (and used) in terms of these dimensions. This framework can be considered as both a learning theory and a practical framework for designing educational environments. Higher education, according to Laurrillard (2002), is much about acquiring "ways of seeing the world". The associated pedagogic strategy has to consider different forms of communication and associated mental activities, that is, discussion, adaptation, interaction, and reflection. The main roles of mobile technology in supporting the 'conversational learning' are therefore: Providing an environment to enable conversation and Enabling learners to build models in order to solve problems

2.8 Guided Inquiry Learning (GIL)

Traditional ways of collecting, structuring and presenting topics/information do not meet the needs of the students in the ever increasing/demanding dynamic environment. This has led to several reform initiatives. The results of a survey conducted to study the progress of learning by first year programming students in a collaborative learning environment by Teague and Roe (2008) indicate that, learning in a collaborative environment becomes a social process where students learn by working with others. They further observe that through collaborative learning, students are interactively engaged in the subject material, observing each other's approaches to problem solving, keeping each other focused on the task, and being encouraged to verbalise issues and decisions along the way. McKinney and Denton (2006) conducted an empirical study in the School of Computer Science and Information Sciences, University of Alabama where the students in an introductory programming course were exposed to collaborative learning environments such as team-based problem solving and pair programming. They observe that early use of collaborative learning benefits include deeper learning, developing skills wanted by industry, higher retention, higher achievement, higher course success rates, higher interest and higher sense of belonging. These benefits were enjoyed by all students but were important for first year students who were at risk of leaving the discipline.

Falkner and Munro (2009) applied a range of collaborative learning techniques within an introductory CS (programming) course in the School of CS, University of Adelaide, Australia to address specifically problem solving skills over a three year period. Their attempt to integrate collaborative learning activities with cooperative problem solving processes, involving students in small groups working through a set of small problems impacted both on the social aspect of the course and the problem solving skills. Students were able to quickly develop a peer group. They observed increased student confidence and perception of ability, and increased student ability to complete problem solving activities. Students also reported that they felt more comfortable in asking questions and arguing their positions in their groups than they felt in larger classes.

According to Prince and Felder (2007), in GIL students are presented with a challenge (such as a question to be answered, an observation or data set to be interpreted, or a hypothesis to be tested) and they accomplish the desired learning in the process of responding to that challenge. Enquiry/Inquiry Based Learning is a form of inductive collaborative learning. Khan and O'Rourke (2004) give guidelines to establish an appropriate environment for GIL. According to them such an environment requires:

- a clear starting point: a starting point and stimulus for learning can be an intriguing problem or an interesting case study or a real-life project.

- resources to support learning: these can include specific time-tables sessions, such as interactive lectures and workshops, laboratories, field works, resources and peer-assisted study schemes.

- peer support: IBL is ideally suitable for collaborative student team-working. Operating in small groups with the guidance of a facilitator, students learn to take responsibility for specific lines of inquiry to facilitate the scope of the research. Presence in the group of a number of students will generate a diversity of potential responses to the material and a range of perspectives.

- facilitation: Facilitation is important to bring the learners back on course, when they wander from the main thrust of the problem/inquiry.

Lee (2004) states that IBL promotes “the ability to formulate good questions, identify and collect appropriate evidence, present results systematically, analyse and interpret results, formulate conclusions and evaluate the worth and importance of those conclusions”. It also involves the ability to identify problems, examine problems, generate possible solutions and select the best solution with appropriate justification. These are seen as critical skills required to be mastered by entry-level programmers. Prince and Felder (2006) state that “Inquiry learning is the simplest of the inductive approaches and might be the best one for inexperienced or previously traditional instructors to begin with”.

According to Hanson (2006), Process Oriented Guided-Inquiry Learning uses learning teams and guided-inquiry activities to develop understanding, questions to promote critical and analytical thinking, problem solving, reporting, metacognition and individual responsibility. These are all very critical in developing programming skills among both entry-level and experienced programmers.

Gaddis and Schoffstall (2007) found through their study that inclusion of guided-inquiry learning experiments in organic chemistry laboratory courses improved students’ conceptual understanding . Several studies conducted on implementation within chemistry have proved the effectiveness of GIL (Farrel, Moog, & Spencer, 1999; Gaddis & Schoffstall, 2007). Several common, and important, outcomes observed in all these assessments of implementations are: more students successfully complete the courses; students’ mastery of content is at least as high as in traditional instructional methods; and students generally prefer the approach to traditional methods. However, whether these outcomes will also hold true when GIL is implemented in programming courses is not well known.

GIL can be implemented in different ways. A few successful models include replacing essentially all lectures with GIL sessions (Farrel et al., 1999). Another model is replacing part of the lecture sessions with GIL sessions each week (Lewis & Lewis, 2005).

Douglas & Chiu (2009) used the former approach for an Introduction to Materials class from engineering discipline at a large university. Preliminary examination of the transcripts for the interviews suggests that students did recognize the benefits of working in groups, such as establishing critical thinking, learning cooperative skills and retaining the content knowledge. However, the use of guided inquiry in this setting had minimal benefit due to the expectations of the students. Use of guided inquiry in this context showed no benefit to student performance, and students were less satisfied with the class.

The latter approach was employed by Lawis & Lewis (2005) in a general chemistry course based on conventional lectures which was reformed by combining peer-led team learning with a guided-inquiry approach. The experimental group was found to perform better than the control group overall, in spite of experiencing one fewer lecture each week.

GIL gives educators enough flexibility to adapt to the environment where it is implemented. The researcher would like to propose a variant of GIL which is more aligned towards the latter approach to suit with the domain of Development Software 1 class in the year 2016, since the latter approach does not lose the importance of instructors' presence with the students. The former approach, as observed through the study discussed earlier (Douglas & Chiu, 2009), leaves the students in a vacuum. Given the disadvantaged socio-economic background of our learners, they would require the guidance of an authority figure walking with them during the process of learning.

2.9 Critical literature analysis

There are different approaches that are used for teaching and learning. It is evident that teachers have adopted and experimented with so many approaches to accommodate the different learners' needs. The literature presented in the two chapters shows that there are traditional and modern approaches. These include implementing and applying certain theories and also introducing emerging teaching technologies. The Chapters cover all the possible teaching approaches including those making use of technologies. It is also common that learners have different backgrounds and different learning needs. The majority of research studies related to teaching pedagogies have yielded positive results in some cases, especially in those institutions that have access to better teaching and learning facilities. Most of these researches were carried out in advanced countries where there are adequate facilities to conduct experiments on these studies, but it may be difficult to apply the same in low resource areas. Academic institutions in most countries particularly in developing countries, however, are in the early phase of emerging learning adoption, characterised by patchy and uncoordinated provision and use, some enhancement of the learning process, some development of mobile learning technology, but no profound improvements in learning and teaching (Balanskat, Blamire & Kefala, 2006). Thus the trends of adoption and acceptance of new teaching approaches always face resistance in many places. As a result, introducing a new teaching approach is easier for those institutions that have more resources and manpower.

Despite the positive and different efforts made by academics to enhance learning, it is clear that teaching Introduction to programming is not very easy. This is indicated by very low percentages of pass rates and high numbers of dropouts in CS and IT courses. The current models and teaching approaches that have been implemented in teaching Programming courses are well documented. Some approaches have worked well and yield to better results in Programming courses, however the pass rate in this course remains very low. The success stories come where GIL has been well documented. Researchers have produced processes, techniques and guidelines to implement GIL and in some cases positive results have been witnessed and yet in some cases it is not clear. Additionally, the literature available has provided different approaches, models, frameworks, theories and technologies that have been adopted to support teaching. However, many of these suggestions and solutions have weaknesses and may not be applicable in all environments.

The research considers the GIL and applies this approach in teaching Introduction to Programming. What is still lacking from current literature is a standard generic framework that could be considered when using GIL. Therefore, it is necessary to design a GIL framework that is sustainable and applicable, thereby making teaching and learning of Introduction to Programming a success in previously disadvantaged universities in South Africa.

2.9 Summary

The chapter has provided insights on the general education and learning process. The chapter explains challenges facing learners especially in learning programming. Different factors that affect learning and make it difficult to teach programming are exposed. The success rates and high failure rates in programming are reported. Possible ways and techniques commonly used to enable teaching and learning programming are explained. The chapter provides sufficient literature on the research. The available theories, learning approaches and models all provide the required information for the research. There is evidence that there is no one approach that works well for all the environments. Therefore, before introducing the GIL approach, it is crucial to consider the literature on current teaching and learning models and both traditional and modern approaches.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The previous chapter discussed the theoretical framework of this study, its attributes and how it informed the study. The pertinent literature that formed the basis to answer the research questions was also reviewed.

This chapter focuses on the research design and methods employed in this research. The research paradigm is discussed to indicate the theoretical assumptions underpinning the operations of this study. The research design employed is a case study using AR. The research approach was mixed method approach, comprising of experimental research and focus group interviews.

3.2 Research Paradigm

This subsection describes a number of research paradigms and at the end of the section it says which research paradigm was adopted in this research. Thomas Kuhn (1962) first used the term paradigm to introduce the concept, philosophical way of thinking. The research paradigms symbolise a worldview which describes, for its holder, the nature of the world, the individual’s place in it, and the variety of potential relationships to that world and its parts (Guba & Lincoln, 1994). Cohen, Manion and Morrison (1994) describe research paradigm as the philosophical intent or motivation for undertaking a study. This view is also held by Mackenzie and Knipe (2006) who state that the intention, motivation and expectations of research are established through the selection of a paradigm. Johnson and Christensen (2008) observe research paradigm as "a perspective held by a community of researchers that is based on a set of shared assumptions, concepts, values, and practices" (p. 33). They go on to say “it is an approach to thinking about and doing research" (p. 33). Thus identifying the research paradigm of the study is the major starting point of any study (Brady & Gilligan, 2018) because they provide the beliefs and guides the researcher in deciding on what to be studied, how the study should be conducted and how the results should be analysed (Kivunja & Kuyini, 2017).

Lincoln and Giba (1985) states that paradigm has four constructs: epistemology, ontology, methodology and axiology. Epistemology is the study of the nature of the knowledge and its justification (Schwandt, 1997). It aims to construct the knowledge by eliciting the nature of the knowledge and relationship between the knower and the known (Kivunja & Kuyini, 2017). According to Slaving (1984), the sources of that knowledge are intuitive knowledge, authoritative knowledge, logical knowledge and empirical knowledge. Epistemology guides the researcher in deciding how to go about in uncovering the knowledge within the social context the study is undertaken.

According to Scotland (2012), ontology is concerned with assumptions the researcher makes about the nature of reality. It is the philosophical study of being and nature of reality. Philosophical assumptions are important in making meaning of data the researcher gathers (Kivunja & Kuyini, 2017).

Methodology is the strategy or plan of action that is supported by the choice and use of particular methods (Crotty, 1998) in conducting the investigation and that includes research design, methods, approaches and procedures to find out something. Axiology refers to the ethical issues to be considered when conducting the investigation (Kivunja & Kuyini, 2017).

It should be noted that every paradigm is based upon its own ontological and epistemological assumptions which can never be empirically proven or disproven (Scotland, 2012). Scotland goes on to assert that every paradigm has its own epistemological and ontological views thus having differing assumptions of reality and knowledge which is reflected through the methodology the particular paradigm uses in conducting the investigation. Though there have been many paradigms evolved in the past two to three decades, there is now a general consensus among the educational researchers about the major paradigms applicable to educational research. Candy (1989), one of the leading researchers in the field suggested three main taxonomies namely, Positivist, Interpretivist and Critical paradigms for educational research.

Researchers such as Tashakkorimand Teddlie (2003) proposed another one, pragmatic paradigm which borrows elements from all these three of them.

3.2.1 Positivist Paradigm

Positivist philosophy was first proposed by the French philosopher Auguste Comte. He observes that experimentation, observation and reasoning is the basis for understanding human behavior (Comte 1856). Positivist scientific method in its purest form involves a process of experimentation to explore observations and answer questions (Kivunja & Kuyini, 2017). The four foundational elements of positivist paradigms are: its epistemology objectivism, its ontology realism, its methodology experimental and its axiology beneficence. A positivist approaches the world impartially with the aim of discovering absolute knowledge about an objective reality because positivists believe that discoverable objective reality exists independent of the researcher (Cohen et al., 2013). Experimental methodology employs a research that manipulates one or more variable/s to understand whether the change in the variable causes change in another variable (Smith & Heshusius, 1986). Beneficence axiology requires that research should aim in benefiting research participants and humanity in general (Mertens, 2014). These underpins the methods used by positivist researchers. Since positivist methodology aims to explain relationships, they attempt to elicit cause and its influence over the outcome and thus the research generally follows deductive approaches. Positivist research commonly involves empirical testing, random sampling, controlled variables and control groups to collect verifiable evidence (Scotlant, 2012).

3.2.2 Interpretivist paradigm

Understanding the subjective world of human experience is the major endeavor of Interpretivist paradigm (Guba & Lincoln, 1989). The main tenet of this approach is that the research must be observed from within the environment through direct experience of the people (Mack, 2010) making the research subjective in nature. It further believes that reality is socially constructed. Interpretivist paradigm assumes a subjectivist epistemology, relativist ontology, naturalist methodology and balanced axiology (Kivunja & Kuyini, 2017). Researchers make meaning of data out of their own interpretation informed by their interactions with the participants and thus making meaning subjective. Relativism holds the view that reality is subjective and differs from person to person. In otherwords the situation studied has multiple realities and through interactions between and among researchers and subjects, these realities can be explored and meaning made out of them. Researcher acts as a participant observer in collecting data through interviews, discourses or through reflective sessions in a naturalist methodology (Carr & Kemmis, 1986). Balanced axiology assumes that outcome of the research reflects the values of the researcher in trying to produce a balanced report of findings (Kivunja & Kuyini, 2017). Interpretive methods elicit understanding and insight of behavior and explain actions from the perspectives of participants but never dominate participants. This research commonly involves open-ended interviews, focus groups, open-ended questionnaires, and/or open-ended observations to collect evidence (Scotlant, 2012).

3.2.3 Critical paradigm

Critical paradigm seeks to address the political, social and economic domain and related issues (Kivunja & Kuyini, 2017). The assumed epistemology of this paradigm is subjectivism which has the basis in real world phenomena. The ontological position is of historical realism with the view that reality is shaped by social, political, cultural and ethnic values (Guba & Lincoln, 1994). Methodology is dialogic and the axiology is that seeks to respect cultural norms that exists within the society (Kivunja & Kuyini, 2017).

3.2.4 Pragmatic Paradigm

Pragmatic paradigm has arisen with the argument that the truth of the real world cannot solely be accessed through a single scientific method. Some philosophers start arguing that there is a need of a world view that seeks to use all appropriate methods to study the phenomenon at hand (Biesta, 2010; Mark & Charles, 2010; Tashakkori & Teddlie, 2003). They started looking at approaches that lets the researcher to use a combination of methods to shed light on the phenomenon at hand. This resulted in proposing mixed methods as a pragmatic way to understand human behavior (Kivunja & Kuyini, 2017) and hence Pragmatic paradigm. Pragmatism is not solely aligned to any of the philosophies, rather the research focuses on the ‘what’ and ‘how’ of the research problem (Creswell, 2003). According to Creswell (2003) research problem is the central point of the investigation/study and the researcher tends to apply all approaches to understand this problem. Researcher seeks to choose data collection and analysis methods that are likely to give insight into the research question, without showing any specific loyalty to any alternative paradigm (Mackenzie & Knipe, 2006). The epistemological assumption of this paradigm is relational. It assumes the ontology non-singular realty, methodology mixed methods and value-laden axiology (Kivunja & Kuyini, 2017).

This research resides under the paragmatic paradigm taking a pragmatic philosophical stand. Pragmatic philosophy refers to the application of both qualitative and quantitative data depending on the objectives of the study. This study involved experimenting with a new teaching approach (GIL) to address the learning difficulties associated with learning an introductory programming course. Quantitative data were collected and analysed using statistical methods considering positivist philosophy. In this research the researcher interacted with the learners to know the exact challenges learners faced in learning Introduction to Programming. Focus group semi-structured interviews were conducted and analysed in an interpretivist theoretical framework to understand how the new approach to learning Introductory Programming course impacted on the participant's attitude towards learning computer programming. The study thus does not solely align with either positivist or interpretivist philosophies. The best suitable philosophical approach for the study is pragmatic paradigm.

Table 3.1

Research methods used in this study - overview

Research component	**Existing options**	**Applicable research method(s) for this study**
Research paradigms	Positivist, Interpretivist, Critical, Pragmatic	Pragmatic

Reasoning approaches	Inductive , Deductive	Inductive and Deductive
Research strategy	Experiment, Survey, Case study, Grounded theory, Ethnography	Case study
Research approach	Qualitative, Quantitative, mixed-methods	Mixed
Data collection Tools and Techniques	Literature, Interview Questionnaires, Observations, Focus groups Experiment, etc.	Literature review Focus Group interviews Experiment
Sampling	Purposive sampling Convenience sampling Simple random sampling etc.	Convenience sampling
Data analysis and triangulation	Descriptive statistics, Framework analysis, Interpretive analysis, Theoretical analysis, etc.	Descriptive statistics for quantitative data Interpretive (thematic) analysis for qualitative data

3.3 Research approach

The research considers a mixed method approach. With the mixed methods approach to research, researchers incorporate methods of collecting or analysing data from the quantitative and qualitative research approaches in a single research study (Creswell, 2003; Johnson & Onwuegbuzie, 2004; Tashakkori & Teddlie, 2003). That is, researchers collect or analyse not only numerical data, which is customary for quantitative research, but also narrative data, which is the norm for qualitative research in order to address the research question(s) defined for a particular research study. As an example, in order to collect a mixture of data, researchers might distribute a survey that contains closed-ended questions to collect the numerical or quantitative data and conduct an interview using open-ended questions to collect the narrative, or qualitative data.

The correlation of both the qualitative and quantitative data assisted the researcher to understand the application of GIL. This study makes use of both quantitative and qualitative methods within a case study. According to Leedy and Ormrod (2010) research methodology is the general approach the researcher takes in carrying out the research project. There are two main types of research methods – quantitative and qualitative methods (Muijs; 2011). According to Creswell (2003) qualitative method employs different knowledge claims, strategies of inquiry and methods of data collection and analysis. Kaplan and Maxwell (2005) states that the goal of “qualitative research is understanding issues or particular situations by investigating the perspectives and behavior of the people in these situations and the context within which they act” (p. 30). In other words, qualitative research helps in understanding a phenomenon from the points of view of the participants in its particular context. Qualitative methods are better suited in this study as the researcher is intending to analyse how the chosen approach in learning and teaching addresses the entry-level higher education of students’ challenges on learning computer programming.

The learner guide for this course ("Learner Guide - Development Software 1 (DEV1120)," 2016) prescribes that students have to complete four mandatory formative assessments and a final summative assessment during the course of the year. Students were interviewed using an open-ended focus group interview strategy to find out what their views on using GIL in classroom environment are and how they impacted on their learning and skills development. To avoid the research bias, an insider/outsider position for the interviewer was established. The researcher did not conduct the interview thus maintaining enough distance and objectivity for necessary research validity.

On the other hand, quantitative approach was also used. This involves the collection of data so that information can be quantified and subjected to statistical treatment in order to support or refute alternate knowledge claims (Creswell, 2003). According to Creswell (2002) quantitative research originated in the physical sciences, particularly in chemistry and physics. Three historical trends pertaining to quantitative research include research design, test and measurement procedures, and statistical analysis. Quantitative research also involves data collection that is typically numeric and the researcher used mathematical models as the methodology of data analysis.

There are three classifications of quantitative research: descriptive, experimental and causal comparative (Leedy & Ormrod, 2001). They further observe that “The descriptive research approach is a basic research method that examines the situation as it exists in its current state”. Descriptive research involves the identification of attributes of a particular phenomenon based on an observational basis, or the exploration of correlations between two or more phenomena. During the experimental research, the researcher investigates the treatment of an intervention into the study group and then measures the outcomes of the treatment. The three types of exploratory research approaches are pre-experimental, true-experimental, and quasi-experimental (Leedy & Ormrod, 2001).

Research methodology is essentially the procedure by which the researchers go about achieving the research objectives and eventually its contribution. Table 1.2 lists some of the existing research options and the selected research methods for this research. Besides the research using mixed method approach, majority of the data collected was qualitative in nature. For qualitative data the interpretive research paradigm is adopted.

The research approaches considered were based on the research question, how can the GIL be applied in teaching Introduction to Programming course to enhance academic performance of entry-level students at HEIs? The final product of this thesis which is a response to the research question is a framework for implementing Guided Inquiry Learning.

3.4 Research design

Terre Blanche, Durrheim and Painter (2006) state that the research design is a plan of action that acts as bridge between research questions and the actual implementation of the research, which details the conditions for collection and analysis of data. The research design used for this study is AR within a case study. AR is an iterative research methodology that involves the subjects of the research as active participants - the research is done with, rather than, on the participants (Carr & Kemmis, 1986). According to them action researchers see the development of theory or understanding as a by-product of the improvement of real situations, rather than application as a by-product of advances in `pure theory'. In other words, AR is research directed towards the improvement of practice.

Falkner and Munro (2009) observe that, AR is an appropriate research methodology for use when a problem has been identified, an initial plan has been constructed and further strategies that may be employed depending upon the success, or impact, of the initial strategy. Bryman (1989) states that “action research can reasonably be conceptualized as a research design which entails a particular framework within which the relationship between the researcher and the subjects take place” (p. 149). In this study, the relationship is between the students doing the course DEV1120 and the researcher as the lecturer. AR can be categorized into four types (Avison, Lau, Myers, & Nielsen, 1999):

- AR focusing on change and reflection
- Action science trying to resolve conflicts between espoused and applied theories
- Participatory Action Research (PAR) emphasizing participant collaboration; and
- Action learning for programmed instruction and experiential learning.

The chosen category for this study is PAR (refer Section – 3.8.1)

As discussed above, the study employs AR within a case study. The case study method enables a researcher to closely examine the data within a specific context. In most cases, a case study method selects a small geographical area or a very limited number of individuals as the subjects of study. Case studies, in their true essence, explore and investigate contemporary real-life phenomenon through detailed contextual analysis of a limited number of events or conditions, and their relationships. (Yin, 1984) defines the case study research method as:

> an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used. (p. 29).

Case study research, through reports of past studies, allows the exploration and understanding of complex issues. It can be considered a robust research method particularly when a holistic, in-depth investigation is required. Recognised as a tool in many social science studies, the role of case study method in research becomes more prominent when issues with regards to education (Gulsecen & Kubat, 2006), sociology (Grassel & Schirmer, 2006) and community based problems (Johnson, 2006), such as poverty, unemployment, drug addiction, illiteracy/learning, etc. are raised. One of the reasons for the recognition of a case study as a research method is that researchers are becoming more concerned about the limitations of quantitative methods in providing holistic and in-depth explanations of the social and behavioural problems in question.

3.4.1 Case study research method used in this study

Through case study methods, a researcher is able to go beyond the quantitative statistical results and understand the behavioural conditions through the actor’s perspective. By including both quantitative and qualitative data, the case study helps explain both the process and outcome of a phenomenon through complete observation, reconstruction and analysis of the cases under investigation (Tellis, 1997). This aligns very well with the current study where a specific course on introduction to programming offered by an academic Department under a specific higher education institution in South Africa is considered

3.4.1.1 Admission criteria to NDIT and general socio-academic background of students entering HEIs in SA

Scores applied by the faculty where this NDIT programme is offered at the selected university for placement of the 2016 intake of students are given in the Table 3.2.

Table 3.2

Admission Point Score (APS) in 2016 for NDIT applications at the selected university

Level	Percentage	Symbol	Status of achievement	APS
7	90 – 100%	A+	Outstanding achievement	9
7	80 – 90%	A	Outstanding achievement	8
6	70 – 79%	B	Meritorious achievement	7
5	60 – 69%	C	Substantial achievement	6
4	50 – 59%	D	Moderate achievement	5
3	40 – 49%	E	Adequate achievement	4
2	30 – 39%	F	Elementary achievement	1
1	0 - 29%	G	Not achieved - Fail	0

Source: Hidden – to conform with anonymity (2016)

The year the data was collected, in order to meet the admissions requirements to the NDIT programme, applicants were required to meet the following minimum NSC achievement ratings:

1. 4 (50% to 59%) in English (as a home language or first additional language) AND

2. 3 (40% to 49%) in Mathematics OR 5 (60% to 69%) in Mathematics Literacy

NSC curriculum in South Africa, allows secondary school learners to opt for either (traditional) Mathematics or Mathematics Literacy as part of their studies. “Mathematics

Literacy is a simplified curriculum designed to teach everyday uses of Mathematics" (Marais & Bradshaw, 2016, p. 339). The underlying principles usually associated with the curriculum of traditional Mathematics at secondary school level are not conveyed through Mathematics Literacy curriculum.

Though South Africa can claim a rich history, much of this is marred by the exploitation of the majority sections of the population through the apartheid (*racial segregation*) era. Many parts of South Africa in particular the rural areas are still under-developed as compared to the urban areas. This is the result of the restrictions imposed by the apartheid era government over peoples of colour in choosing where they could live. They were not allowed to live in urban and its suburban areas. The public schools that they were allowed to enter were underfunded. They were given substandard education. Though the current South Africa is a democratic country, the lasting effects of apartheid are still visible in these areas. Still many schools in rural areas of South Africa are heavily underfunded and characterised by overcrowded classrooms with lack of qualified and experienced teaching staff and as a result some of these schools cannot even offer subjects such as Mathematics or Physics (Marais & Bradshaw, 2016). These schools still fail to afford computer laboratories and skilled teachers who could teach courses in ICT.

NSC curriculum offers two ICT related subjects namely, Computer Applications and Training (CAT) and Information Technology (IT) as optional subjects as part of students' secondary school education. CAT curriculum encompasses skills development in supporting end-user applications requirements and daily workplace productivity with computers. The suitability of this curriculum to support learning programming courses at university level is questionable. IT curriculum encompasses skills development in learning techniques and procedures to solve problems through logical and computational thinking, electronic transmission, access, and manipulation of data and information ("Curriculum and assessment policy statement Grade 10-12", 2011). The curriculum of this course has the potential to prepare students well for further studies in programming at tertiary institutions.

3.5 Description of population and sampling

The population for this study consisted of all the students enrolled for the course Development Software 1 (DEV1120) which is offered at year level-1 of the programme National Diploma: Information Technology (NDIT) at this selected university. NDIT programme is offered at two sites of the university about 100 kilometers apart from each other and this study was conducted at one site where the researcher had access.

National Senior Certificate (NSC) results (equivalent to Grade 12), are converted into points for each NSC subject to calculate the Admission Point Score (APS). An additional interview and/or other assessments may also be taken into consideration in determining the total APS. In order for an applicant to be considered for admission to a programme, APS obtained by applicants must meet the required APS that is set by the university for the specific programme.

3.5.1 Sampling

According to Goba, Balfour and Nkambule (2011) there are limitations for experimental design when applied in educational settings. Random selection of participants is often not practical in educational research as researchers are not often allowed to disturb the normal teaching. Through a study of postgraduate education research in South Africa, Goba, Balfour and Nkambule (2011) observed that in the period between 1995 and 2004, majority of studies (56%) used convenience sampling not random sampling in education research. Sample for this study was chosen based on convenience sampling approach.

3.5.1.1 Convenience sampling

Convenience sampling is a type of non-probability sampling in which, participants are selected from the target population that meet certain criteria such as accessibility, geographical proximity and willingness to participate (Etikan, Musa, & Alkassim, 2016).

Marshall and Rossman (2006) state that a sample selection should be planned around practical issues, such as the researcher’s comfort level, ability to fit into some role during participant observation, and access to a range of subgroups and activities. Students registered for the course, Development Software 1 (DEV1120) under the programme, NDIT at the site where the study was conducted meets the specific criterion of this study. This course is offered at the entry-level of the Higher Education study levels for these learners. This course is an Introductory programming course. Though DEV1120 is offered at two sites, the researcher had only access to the site where this study was conducted. The total population was 49 students enrolled for this course. 20 learners were selected using by way of informed consent. Though it would have been ideal to have 24 students selected to be part of the experimental group, only 20 students voluntarily agreed to participate in the research. The students consisted of males and females of age ranging between 18 and 22 years. Out of the 20 students, one dropped out of the course and the entire programme. This made the effective sample 19. The remaining 29 students formed part of the control group for the quantitative analysis. The limitation of this sample was the non-agreement by any of the students to continue being part of the study and the presence of learners with prior computer programming learning experience at school level which was not the case as explicated through the Table 3.5.

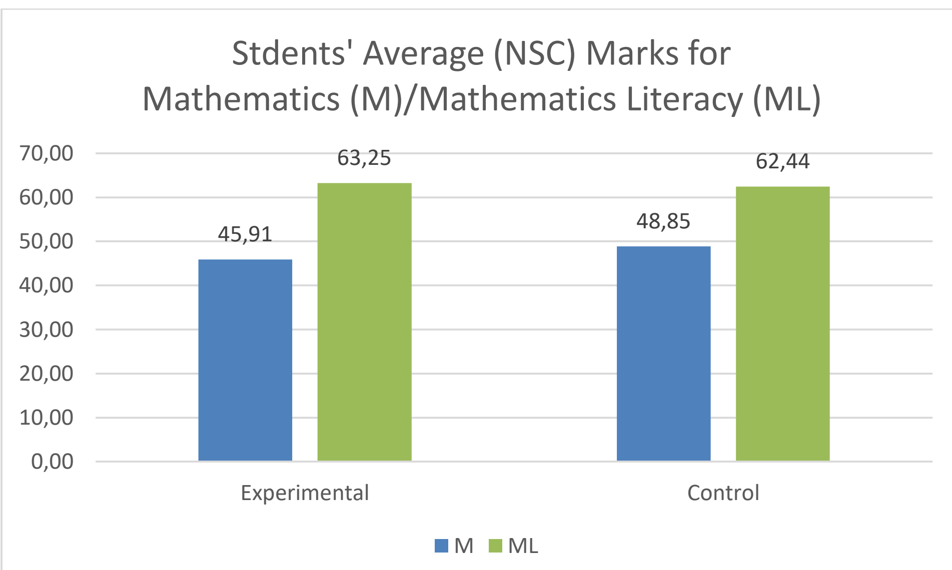

Figure 3.1: Students' average Mathematics(M) / Mathematics Literacy(ML) scores based on their NSC certificates

11 out of 19 students from the experimental group did Mathematics at school level and the rest (8) did Mathematics Literacy. 20 out of 29 students from control group did

Mathematics at school level and the rest (9) did Mathematics Literacy. The average mark of students who did Mathematics at school for the experimental group is around 45 and control group had a similar average of 48. The average mark of students who did Mathematics Literacy at school level for experimental group was about 63 and control group had a similar average of 62. Only 4 students from experimental group and 5 students from control group had done Physical Science at school level.

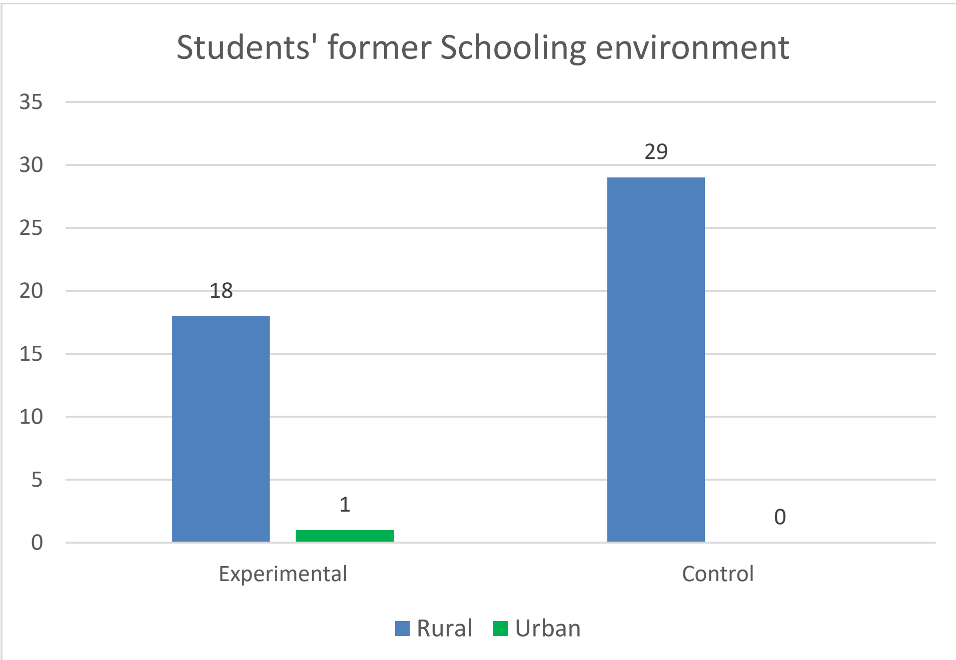

Figure 3.2: Students' former schooling environment (Rural vs Urban)

All students from the control group hail from a rural background and all except one from the experimental group were from schools in rural settings. Thus, almost all of them were from a similar educational and social background.

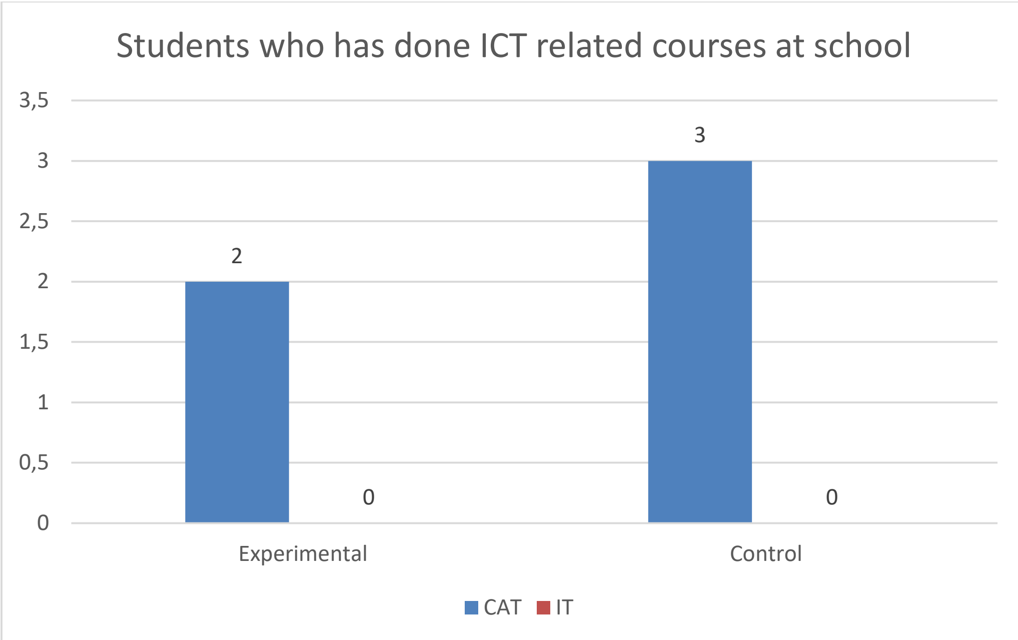

Figure 3.3: Students with ICT courses at NSC level

Out of the 19 students from the experimental group only two had done CAT and none had done IT. Out of the 29 students from the control group only three had done CAT and none had done IT at school level. This indicates that no student from both the groups had prior programming learning experience at school level.

3.6 Data Collection Instruments

Mixed method approach allows the researcher to collect both quantitative and qualitative data. The learner guide for the course, DEV1120 ("Learner Guide - Development Software 1 (DEV1120)," 2016) prescribed that students had to complete four mandatory formative assessments and a final summative assessment during the course of the year. Results of all these assessments formed part of the quantitative data for this study. There are many data collection methods under the qualitative paradigm. Some of these are observation, interviews, focus group interviews, document and audio-visual materials (Creswell, 2013). Under each of these methods is a variety of options for consideration. The suitable method selected for this research was focus group interviews.

3.6.1 Formative assessments

Four formative assessments in varying complexity were conducted on all the modules in the syllabus. The duration of tests 1, 2 and 3 was 90 minutes and test 4 120 minutes (2 hours). These tests were designed to test the students' ability to interpret, analyse, design a solution through logical sequence formation, and write pseudo code following certain number of steps. Students were required to explain their understanding of certain aspects of the syllabus. The focus of these tests was not just on their ability to perform analytical and problem solving skills but also on the conceptual knowledge of the course and the application thereof. The aim of these questions was to teach them not just to do something without knowing the reason or its significance. These assessments tested their conceptual knowledge regarding the specific topics/modules from the syllabus. Structuring the questions in this way, the researcher expected to be able to determine whether the students understood basics of programming concepts and were able to identify and use appropriate methods to get to the solution.

3.6.2 Summative assessment

A summative assessment was written on the entire syllabus. The duration of this examination was 180 minutes (three hours). The examination followed a similar structure as of the formative assessments that tested the factual and conceptual knowledge on the entire syllabus and the ability to interpret problem domain, analyse it, design a solution through logical sequence formation, and write pseudo code following certain number of steps.

3.6.3 Focus group interviews

The distinct feature of focus group interviews are that the discussion is focused on a particular topic, where debate and even conflicts are encouraged and the group dynamics assists in gathering data (Nieuwenhuis, 2010b). Data was generated by interactions between group members. Semi-structured group interviews were sought after for their ability to allow the researcher to have control over the line of questions (Creswell, 2013); meaning, the interviewer had the liberty to prompt for further clarity based on the point of discussion. Semi-structured, open-ended questions in this case, allowed the respondents to elaborate on their responses. Given that this research employed multiple focus groups, interview guides helped to maintain consistency in data collection and enhanced comparability of responses between different group interviews conducted. Participants presented their views and experience while hearing from others. In responding to each other, participants reveal more of their own frame of reference on the subject of study (Finch & Lewis, 2003). The interview questions were designed to gather qualitative data detailing the learner experience. They were asked to explain what did and did not work for them and why and the reason for them. They were asked to identify the skills they learned through the intervention and how well they were able to apply these skills.

3.7 Reliability and Validity

"Reliability and validity are tools of an essentially positivist epistemology" (Winter, 2000, p. 10). This section starts with describing issues around the reliability and validity around quantitative part of the study. Trustworthiness of the qualitative part of the study and the measures taken to ensure trustworthiness will be discussed at the latter part of this section.

3.7.1 Reliability

Reliability is defined as "the extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable" (Joppe, 2000 as cited in Golafshani, 2003). Another definition is "reliability means that measurements made are consistent and that if the same experiment is performed under the same conditions, the same measurements were obtained" (Melville & Goddard 1996, p. 12). Consistency in producing similar results when repeated measurements are done on the same phenomenon is considered as the reliability factor of an instrument. Cronbach's alpha is a commonly used statistic to ensure reliability of an instrument (Taber, 2017). It determines the internal consistency of the instrument. If the items are strongly correlated with each other, their internal consistency will be high and alpha coefficient will be close to one and considered as highly reliable, whereas the alpha coefficient will be close to zero if the items are poorly formulated and do not correlate. In an educational research, the Cronbach's alpha coefficient value reaching 0.70 is considered as a sufficient measure of reliability (Taber, 2017). For this study, Cronbach's alpha was calculated and t-test and chi-squared tests were conducted.

Table 3.3

Cronbach's alpha of the instrument

Reliability Statistics	
Cronbach's Alpha	N of Items
.883	7

3.7.2 Validity

Validity is the measure that an instrument measures what it is supposed to measure (Black & Champion, 1976). There are two aspects of validity: measure the concepts accurately and measure what they intend to measure (Winter, 2000). It refers to the appropriateness, meaningfulness, and usefulness of the measurement. There are two strand of validity: internal validity and external validity.

3.7.2.1 Internal validity

Internal validity is concerned with ensuring that cause of the results or findings of the research is the phenomena under investigation and not any other unaccounted factors (Winter, 2000). According to Leedy and Ormord (2005) carefully controlled experimental design is the way to draw acceptable conclusion on the cause and effect relationship. Random selection of participants and assigning them to groups and having a control group maximize internal validity. Internal validity is concerned with controlling extraneous variables and outside influences that may impact the outcome. This can be addressed through avoiding possible threats to internal validity.

3.7.2.1.1 Threats to internal validity

History: Events that occur during the study that may affect the dependent variable. If such an event only affects one of the groups, then the outcome of the study cannot be ascribed to the manipulation of independent variable. Events affecting both the groups participated in this study were similar except the intervention done on the experimental group.

Maturation: Natural changes, biological or/and psychological changes that takes place within the participants can impact on their behaviour and consequently the findings of the study. Maturation threat in this study was minimal since the study was concluded relatively over a short period of time – 10 Months. Besides this, participants in both groups matured at a similar rate.

Selection: If the selection of participants into two groups is not done randomly or if there are significant differences in sizes between the experimental and control group, then the results of the study could be biased. There was no significant difference in the size composition between the two groups.

Experimental mortality: This occurs when participants fail to complete the study due to variety of reasons. This can affect statistical comparison and final conclusion. Experimental group had a mortality of 10% and control group had none which is ignorable as the remaining number of participants were acceptable.

Diffusion of treatment: This occurs when participants from experimental and control group can communicate with each other. Participants from experimental group may share values of the new teaching and learning approach they are experiencing with the other group members and this may ‘contaminate’ them. Since both experimental group and control group were learning at the same campus, controlling this threat was not easy. However, researcher believes that the approach (intervention) used in this study to enhance programming skills is not an easy approach to replicate without the presence of an expert facilitator.

3.7.2.2 External validity

This refers to the degree or extend to which the findings can be generalized to the entire population (Vos, Strydom, Fouche & Delport, 2014). According to them to a certain extent generalisability of the study can be ensured through controlling external threats to the validity.

3.7.2.2.1 Threats to external validity

Multiple-treatment interference: If there are multiple independent variable in an experiment, then particular combination and ordering of treatment could be the cause of change in dependent variable. The same ordering and combination is required to generalize the findings in an outside setting. This was not the case in this study.

Unrepresentative sample: Though a truly representative sample is always desired, it is not often easy. However, this study had the entire students registered for the course in the accessible campus as the sample. Forty percentage of them voluntarily and randomly were selected to be in the experimental group and the rest in the control group.

3.7.3 Trustworthiness (qualitative rigour)

The extent to which credibility, transferability, dependability and confirmability are achieved is the measure of trustworthiness in qualitative study. (Lincoln & Guba, 1985). According to them, prolonged engagement and persistent observation results in credible findings. The researcher as the participating change agent was personally involved with the sample twice a week for 120 minutes over a period of ten Months. Constant interactions and observations took place during these sessions of problem solving to guide and assist the GIL groups.

Providing accurate, detailed, and complete description of the context and the participants involved in the study to the reader can improve transferability of the study (Ary, Jacobs, Sorensen, & Razavieh, 2010). Section - 3.5 of this report Population and sample describe the population and how the sample was selected for this study. Section - 3.8.2 of this report details how the intervention was carried out and how the researcher was involved in the study. Focus group interview were conducted with semi-structured open-ended questions by a person who served as an insider-outsider to improve dependability of the study process. Participants were participating voluntarily and could withdraw at any time if they wished to do so. Data transcripts (verbatim) were created from the recorded audio and were made available to check accuracy of what they have said. Having in-depth methodological descriptions to ensure integrity of the research findings in turn achieves confirmability (Shenton, 2004). This chapter provides in-depth methodological descriptions of the research process conducted and how data was collected and analysed.

3.8 Data collection procedure

There are several approaches to doing AR and this research adopts the Mixed-Methods Sequential Explanatory Design as recommended by Ivankova, Creswell and Stick (2006) where both quantitative and qualitative techniques are applied in the same research. Mixed method approaches are adopted in situations where qualitative or quantitative techniques, in isolation, would not address the problem fully and uses the combined strength of both to create a more robust understanding of the problem (Tashakkori & Teddlie, 1998)). The method gives guidelines on the priorities or weights given to the quantitative and qualitative data collection and analysis as well as the sequence of the data collection and analysis. It illustrates the stage/stages in the research process at which the quantitative and qualitative data are connected and where results are integrated. The method was successfully applied to analyse Doctoral students' persistence in an educational leadership programme offered by the University of Nebraska–Lincoln. In an African context, Bati, Gelderblom , & Van Biljon, (2014) used the Mixed-Methods Sequential Explanatory Design method to evaluate the effectiveness of a newly designed blended learning approach in teaching computer programming skills to novice programmers on a large scale. This study finds the application by Batia, Gelderblom, & Biljon (2014) dimension consistent with the desired confirmatory and explanatory process required at the implementation stage of the new deep learning blended learning framework.

Ivankova, Creswell, Stick, (2006) present a six point signposted sequential process for carrying out AR using the Mixed-Methods Sequential Explanatory Design comprising of (*1) Quantitative Data Collection, (2) Quantitative Data Analysis, (3) Connecting Quantitative and Qualitative; (4) Qualitative data Collection; (5) Qualitative Data Analysis, (6) Integration of Qualitative and Quantitative Data Analysis.*

This study used participatory AR which is the appropriate one to test the impact of the intervention, to reflect on and to take necessary remedial action.

3.8.1 Participatory Action Research (PAR)

AR is a participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human purposes (Reason & Bradbury, 2001). It seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concerns to people, and more generally the flourishing of individual persons and their communities. This study will be PAR as the researcher (change agent) is part of the study being the lecturer responsible for the course DEV1120. The purpose of this study is to develop and implement an intervention in an attempt to enhance the programming skills of entry-level programming students doing the course DEV1120. For this purpose, the researcher proposes a process using a variant of GIL. The intervention was reviewed and evaluated to improve the manner in which each module of DEV1120 is presented to the learners.

3.8.1.1 Intervention process (PAR process)

The intervention process employed to enhance entry-level programmers' programming skills using GIL is explained below:

3.8.1.1.1 In-Class intervention

The classroom was designed in such a way that it promoted team work. The class room consisted of round table and each table could accommodate up to five students. Students were then divided into smaller groups of four to five students. Round table seating arrangement enabled them to communicate effectively with one another. In addition, arranging the classroom in this manner assisted them to become acquainted with each other and collaborate easily on tasks.

A typical class session started with the lecturer introducing new course material. In other words, lecturer introduced the basic programming concepts, principles and theories pertaining to the topic in the course DEV1110. Students listened and took notes. This took between 20-30 minutes of a 120-minute session. This laid the foundation for the topic under discussion and enabled the students to follow the explanations without being lost as such they could then build further on it by reading reference material and discussing it with peers.

The lecturer gave an example applying GIL principles: Problem was given for which a solution was to be formulated. The procedure then followed an analysis of the problem by asking questions (inquiring) on and about the problem scenario. Answers to these questions were expected to make the process more understandable or may lead to other questions. Following-up on all the new questions would eventually give answers to all the unknown information in the problem. This resulted in students understanding the problem, as well as what was required to be determined and the steps to follow in order to find the solution.

The lecturer provided new problems to the groups. Students (group members collectively) were required to formulate the programming solution using GIL approach. Students collaborated with one another. Since classroom was arranged with round tables; lecturer could freely walk around the venue. This enabled lecturer to observe, listen, encourage discussion and provide guidance where required, to each group. In other words, lecturer acted as a facilitator who made sure the group members did not go off the problem domain in their efforts to formulate the solution through inquiry (discussions).

In addition, a GIL guide was given to students. Learning modules were arranged in this guide with module outcomes, explanation for the topics covered through the specific module with an example problem scenario with possible questions that they could ask themselves to guide them in understanding and the solving the problem. Guide also provided more exercises (problem scenarios) to practice using GIL approach.

None of these listed interventions were applied for students who were part of the control group. They were taught using the traditional chalk-an-talk approach.

3.8.1.1.2 Out-of-class intervention

Students were given problems to solve in the form of home works. Though students were expected to find solutions alone while they were out of class room environment, a virtual collaborative group environment was created through a social networking platform (WhatsApp in this study) to facilitate the GIL environment. Groups of four to five students were created over WhatsApp replicating the classroom groups. Students in groups were encouraged to engage on discussions through these virtual groups as they would do in the classroom environment. Since lecturer was part of these groups; lecturer could observe, encourage discussions and guide them where required.

3.8.2 Insider outsider position to focus group interviews

Insider/outsider status of a researcher is the extent to which the researcher is being part of the group that is researched or not (Gair, 2012). He goes on to observe that an ‘insider’ is a researcher who personally belongs to the group that is being researched while ‘outsider’ is not a member of that group. The insider/outsider position was considered to conduct focus group interviews of students in order to avoid bias. If the focus group interviews were conducted by the researcher who was also the lecturer who carried out the intervention, then there would have been an authority disposition. This might have led students to give answers out of fear of being judged. The relationship that was developed between the researcher and the students throughout the year might have influenced their responses. Students might have felt that the researcher/interviewer would want to hear favourable answers (whether true or not).

The insider position – Enough distance and objectivity might not be maintained, if the interview is being conducted by someone who is considered as an insider (Brannick & Coghlan, 2007). There is also this possibility of insider ignoring part of the data if they take-for-granted the research context (Hayfield & Huxley, 2015). But the familiarity of being an insider might be beneficial since they are more aware of the research context and that enable them to keep the participants on top of the research agenda while trying to elicit information from them (Hayfield & Huxley, 2015). The focus group interviews for this study was conducted by a lecturer who is stationed at a campus which is about 100 kilometres away from the site where the study was conducted. This lecturer had previous experience in teaching Introductory Programming courses for entry-level students. The interviewer was therefore well-equipped in terms of understanding the research context. In this context, the interviewer was an insider and this allowed the interviewer to be natural and highly disposed to get honest response.

The outsider position – Taking an outsider's position gives the researcher a more objective view of the reality (Xu, 2017). This allows one to conduct the interviews with no preconceptions or any vested interest (Ritchie, Zwi, Blignault, Bunde-Birouste, & Silove, 2009). Hayfield and Huxley (2015) observe that because of the interviewer's outsiders' perspective, an interviewer who is considered as an outsider may be able to make observations and notice features that an insider may overlook. However, there is also this opposing argument that an outsider may not be able to understand, or accurately represent, the experiences of the participants, since they are alien to the context of the study under which it took place (Ryan, 2015).

Since the interviewer has had experience in teaching Introductory programming course beforehand, he understood the context of the study very well. Not being part of the DEV11P0 group who underwent the intervention allowed the interviewer to ask questions without pre-empting what the responses could be. Interpretations of the interviewer over the responses were from a neutral position and follow-up questions were guided purely by the responses from the participants to the questions asked. In this context the interviewer was an outsider. This finally resulted in interviews that were being conducted by someone who qualified both as an insider and outsider giving more validity to the collected data.

3.9 Data analysis

Data analysis includes grouping and summarising information to establish meaning and maintain evidence (Schoenbach, 2014). Quantitative data was analysed using descriptive statistical methods. T-tests and chi-Square tests were conducted using the statistical analysis software SPSS version 24 to measure the significance of the findings.

Qualitative data analysis is usually based on interpretive philosophy that aims at examining meaningful and symbolic content of data. In other words, it tries to establish how participants make meaning of a specific phenomenon (Nieuwenhuis, 2010a). The aim of qualitative data analysis is to interpret and make sense of what is in the data. According to Nieuwenhuis (2010a), there are a number of data analysis strategies such as hermeneutics, content analysis, conversation analysis, discourse analysis and narrative analysis. The strategy that was more appropriate for this study was thematic content analysis.

A content analysis approach significantly aided revelation of criteria for evaluations in this research through categorising according to themes the key concepts that emerged from literature. Themes were identified which translated into criteria for evaluation or integration. Furthermore, content analysis was applied to the qualitative data collected through focus group interviews. The information from the interviews was classified according to themes identified from literature though additional themes were also emerged. The process of theming was repeated following the Jabareen (2009) framework construction steps, until there were no newer themes emerging from the data. The interpretation of the data through the interpretivist paradigm was not sufficient to generalise the analysis. The Moment of Translation lens from the ANT (Actor Network Theory) aided in interpretation and positioning the findings under various categories.

An interpretive approach was applied in making sense of the collected data. An interpretive approach or a research that took an interpretive approach is normally inductive in nature and typically adopts a qualitative approach in data gathering (Gray, 2009:36). In this research, an inductive approach is considered to understand the collected data and subsequently design the framework. The key process for formulating the final framework will be based on the steps outlined in the figure 3.1.

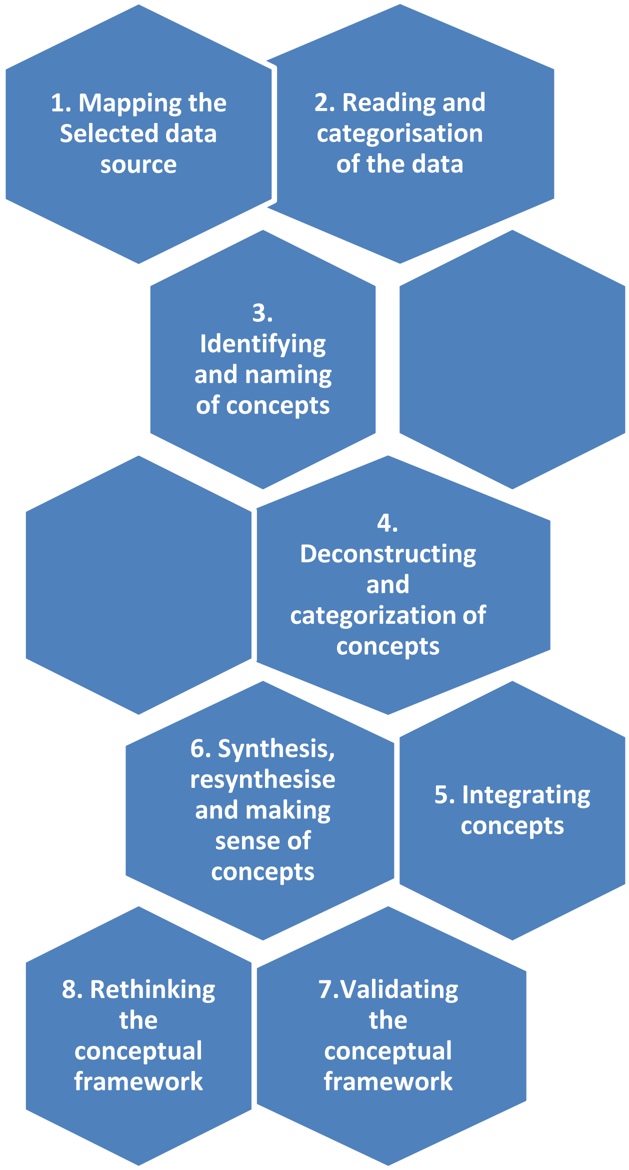

Figure 3.4: Steps in developing the conceptual framework *(Jabareen, 2009)*

3.9.1 Selecting ANT Moment of Translation (MoT) lens for data analysis

Data analysis was done after the lenses of the Actor network theory (ANT) moment of translation. The ANT is popular for its ability to provide a rich and dynamic way of bringing together the socio-technical and non-technical aspects of the organisation

(Wickramasinghe et al, 2011). ANT is specifically suited for the analysis since it considers society and organisations as a set of agents, and the agents interact to form heterogeneous networks (Law, 1999; Tatnall & Gilding, 2005; Cresswell et al., 2010).

3.9.2 Content analysis

According to Spencer, Ritchie and O'Connor (2003) in content analysis content and context of documents are analysed: themes are identified with the researcher focusing on the way the theme is treated or presented. Content analysis is an inductive and iterative process where researcher looks for similarities and differences in the text that would corroborate or disconfirm theory. Texts generated through focus group interviews were analysed to find out whether the emerging conclusions and findings through data collected from different sources corroborate.

3.10 Ethical consideration

Hammersley and Traianou (2012) observe the following as the most common ethical concerns relevant to social research on its participants:

- Minimising Harm: Does the research cause any harm such as financial, reputational etc to the people being studied and/or to others and how this could be justified or be avoided?
- Respecting Autonomy: Research participants should be allowed to make their own decisions in deciding whether or not to participate in the research.
- Protecting Privacy: When the research report is made publicly available, what should and what should not be made public and how is the confidentiality of participants' information maintained?
- Offering Reciprocity: Should the participants be rewarded for the time spend and efforts that they made for the research and if so how?
- Treating People Equitably: No one that the researcher comes into contact with in the course of the research should unjustly be favored or discriminated against.

Harm is not merely a matter of physical harm but many other aspects including emotional and social harm (Guillemin & Gillam, 2004). Respecting autonomy checks whether the research process show respect for people in the sense of allowing them to make decisions for themselves, notably about whether or not to participate. According to Guillemin and Gillan (2004), informed consent is at heart of an interpersonal process between researcher and participant, where the prospective participant comes to an understanding of what the research project is about and what participation would involve and makes his or her own free decision about whether, and on what terms, to participate. The participants in this research were informed of the purpose of the research and the methods of instructions which they will be subjected to in advance. The participants (sample) were selected on the basis of voluntary participation through a consent form. Thus there is no perceived harm and violation of participants' autonomy with this research.

All data collected from participants in this study was treated with utmost confidentiality. This study is conducted as part of the participants' learning requirements for achieving the qualification and is aimed at enhancing their skills level. The perceived outcome of this study is for the mutual benefit (reciprocal) of all participants involved in the research. National Diploma: Information Technology classes are predominantly homogenous and intervention is aiming to benefit all participating students. Thus equity concerns are minimal in this study.

To adhere to the Institution's mandatory research ethical procedures in conducting research, the researcher obtained ethical clearance (approval) from the Institutional Research Ethical Clearance Committee of the Institution where the researcher is registered as a student. To adhere to the mandatory research ethical procedures in conducting research with the stakeholders of the Institution, the researcher obtained ethical clearance (approval) from the Institutional Research Ethical Clearance Committee of the Institution where the research intervention took place.

3.11 Summary

This chapter described the overall research strategy employed by this study. The research paradigm, design and approach were discussed. Population sampling methods, data collection instruments, validity and reliability issues, data collections procedures analysis and ethical considerations were also discussed. Next chapter will present the data collected throughout this study and provide a detailed report on the results obtained during the collection of data. Those data will be interpreted, analysed and presented in this coming chapter.

CHAPTER FOUR

DATA ANALYSIS, INTERPRETATION AND DISCUSSION

4.1 Introduction

The previous chapter outlined the specific methods that this research used for the study. This chapter focuses on presenting the results from the participants. Findings from test performances and focus group are presented in this chapter to establish the influence of GIL on student performance, communication skills, confidence, motivation, advantages and disadvantages. Quantitative data was mainly used to ascertain GIL's effect of student performance. Focus groups were used to establish GIL's effect on communication skills, confidence, motivation and associated advantages and disadvantages. This chapter also used findings from focus groups to establish GIL's effect on student performance.

4.2 Data presentation

This section explains how the data was analysed and presented. As shown in the sections that follow, figures and tables were used to present quantitative data. On the other hand, qualitative data was included in this chapter as it was captured.

4.2.1 Overview of data analysis

The results presented are based on the implementation of the GIL in teaching Introduction to Programming course. There were two groups of participants: Control group and experimental group. Students who were taught through the usual traditional teaching and learning approach referred to as the control group during the results presentation. Control group had 29 participants. Students who were taught through the GIL approach were referred to as the experimental group and this group had 20 students initially. However, one dropped out of the course and the studies completely. So the experimental group had 19 participants. In terms of gender distribution, 60% were male and 40% represented female participants.

The quantitative analysis was done to compare the performances in all the assessments given during the course and later the final examination. SPSS was used for data analysis. At the same time, content analysis was also used.

Quantitative data analysis was used to provide a solution to the problem at hand. The problem has been to find an appropriate solution to address high failure rate in an Introduction to Programming course. This was done by applying the GIL approach. Additionally, results were to answer the sub research question one stated below (see page 84).

4.2.2 Population and demographic data

The frequency table shows the participants distribution both in real numbers and as a percentage. Table 4.1 shows the numbers of the participants. The experimental group represented the learners who were involved and engaged using GIL. On the other hand, the control group was the learners who did the course in the traditional method.

Table 4.1
Total population of the participants

Group					
		Frequency	Percent	Valid	Cumulative
Valid	Experimental	19	38.8	39.6	39.6
	Control	29	59.2	60.4	100.0
	Total	48	98.0	100.0	
Missing	System	1	2.0		
Total		49	100.0		

It was important to view the results based on the gender. This was to show if GIL approach had an effect on gender. The total number of males and female students are indicated in the Gender Table 4.2.

Table 4.2:

Distribution of participants by gender

Gender Distribution					
Experimental Group					
		Frequency	Percent	Valid Percent	Cumulative
Valid	Male	11	55.0	57.9	57.9
	Female	8	40.0	42.1	100.0
	Total	19	95	100.0	
Missing	System	1	5.0		
Total		20	100.0		
Control Group					
		Frequency	Percent	Valid Percent	Cumulative
Valid	Male	16	55.2	55.2	55.2
	Female	13	44.8	44.8	100.0
	Total	29	100.0	100.0	
Missing	System	0	0.0		

Total		29	100.0		
Overall					
		Frequency	Percent	Valid Percent	Cumulative
Valid	Male	27	55.1	56.3	56.3
	Female	21	42.9	43.8	100.0
	Total	48	98.0	100.0	
Missing	System	1	2.0		
Total		49	100.0		

Table 4.2 shows that the gender distribution was slightly skewed towards males in both experimental group and control group. This was in accordance with the overall gender distribution of students who were registered for the Introduction to Programming course (DEV1120) at the time of the study.

4.3 Findings from quantitative data

These are the findings obtained after an analysis of all the assessments that were given to the learners. The data include marks for the formative assessments - Test one, two, three and four. These marks were computed to form the year mark (DP) for examination admission. Then there is the summative assessment –examination marks. The final mark is computed as follows: Both year mark and examination mark must have a sub-minimum of 40%. If a student fails to achieve these separate sub-minimum marks, then he/she fails in the course. The final mark is computed by taking 40% of the year mark and 60% of the examination mark. At the end of the course, using this formula, the overall final marks of the students were also calculated. Quantitative data was based on the marks that were captured from the experimental and control groups.

RQ1: What are the differences in achievement between students taught traditionally and those taught using GIL approach?

Associated hypothesis were:

H_0: GIL approach, as opposed to traditional approach, used for teaching introductory programming course for entry-level students at HEIs, has no effect on their course achievements

H_0: GIL approach, as opposed to traditional approach, used for teaching introductory programming course for entry-level students at HEIs, has a positive effect on their course achievements

The study gathered data to establish the influence of different teaching approaches on student performance. The intervention started from the very beginning of the academic year. Four formative assessments and a summative assessment were used to evaluate the influence of teaching approach on student performance. A detailed representation using various relevant statistical techniques on quantitative data generated throughout the study and the resultant analysis on them are presented through the following sections.

4.3.1 Frequency tables for assessments (Overall course performance analysis)

The statistics of each of the assessment is given in the next tables. The overall performance for each of the assessments is given in Tables 4.4 – 4.10

4.3.1.1 Analysis of Test 1

Table 4.3

Test 1 Pass rates

Test1					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Pass	44	89.8	91.7	91.7

	Fail	4	8.2	8.3	100.0
	Total	48	98.0	100.0	
Missing	System	1	2.0		
Total		49	100.0		

Generally, the pass rate of the first test was good with only 8.2% failure rate.

4.3.1.2 Analysis of Test 2

Table 4.4

Test 2 Pass rate

Test2					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Pass	27	55.1	56.3	56.3
	Fail	21	42.9	43.8	100.0
	Total	48	98.0	100.0	
Missing	System	1	2.0		
Total		49	100.0		

The Test 2 results show that overall pass rate was only 56%. There was an increase in failure rate by 35% compared to the Test 1.

4.3.1.3 Analysis of Test 3

Table 4.5

Test 3 Pass rate

Test3					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Pass	33	67.3	68.8	68.8
	Fail	15	30.6	31.3	100.0
	Total	48	98.0	100.0	
Missing	System	1	2.0		
Total		49	100.0		

There was an improvement on Test 3 by just above 10% from Test 2.

4.3.1.4 Analysis of Test 4

Table 4.6

Test 4 Pass rate

Test4					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Pass	33	67.3	68.8	68.8
	Fail	15	30.6	31.3	100.0
	Total	48	98.0	100.0	
Missing	System	1	2.0		
Total		49	100.0		

The performance of Test 4 is almost similar to Test 3. However, for Test 4 it was just slightly lower, though the number of students was one less during Test 4.

4.3.1.5 Analysis of year mark (DP - admission to examination)

Table 4.7

Students who achieved Admission to Examination (DP)

Admission to Examination					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	36	73.5	75.0	75.0
	No	12	24.5	25.0	100.0
	Total	48	98.0	100.0	
Missing	System	1	2.0		
Total		49	100.0		

About 75% of the students qualified for the final examination from the course based on their yearlong performance (DP). This is a significant improvement from the previous year's students' performances. Percentage of students who qualified for the final examination ranged between about 56 and 64 with an average of about 61% for the past five years. The intervention through GIL approach on experimental group seems to have contributed to this significant overall improvement. See section 4.3.2 for the detailed students' performance comparative analysis between control group and experimental group.

4.3.1.6 Analysis of examination pass rate

Table 4.8

Examination Pass rate

Exam Mark					
		Frequency	Percent	Valid Percentage	Cumulative Percentage
Valid	Pass	31	63.3	86.1	86.1
	Fail	5	10.2	13.9	100.0
	Total	36	73.5	100.0	
Missing	System	13	26.5		
Total		49	100.0		

The examination results show that the pass rate was very good. It should be noted that only students who achieved the status admission to examination based on their yearlong performance (DP) were allowed to write final examination. Overall, a quarter of the population failed to achieve this status, thus they were not allowed to write the final examination. Table 4.7 does not include the number of the students who failed to obtain admission to examination.

4.3.1.7 Analysis of Final Result /Achievement

Table 4.9

Final Result / Achievement

Final Result				
	Frequency	Percent	Valid Percent	Cumulative Percent

Valid	Pass	32	65.3	66.7	66.7
	Fail	16	32.7	33.3	100.0
	Total	48	98.0	100.0	
Missing	System	1	2.0		
Total		49	100.0		

The final results for the course shows that the overall pass rate was good. This includes the number of students who failed to obtain admission to examination as well. The overall pass rate was approximately 67%. This is a significant improvement from the previous year's overall pass rate as discussed in Chapet-1. It should be noted that a very good pass rate achieved in the experimental group has contributed to improving the overall achievement obtained for the course.

To show the comparisons between the two Groups, cross tables were generated, chi-Square tests were conducted and bar charts were generated. The findings are summarised in the following tables and figures.

4.3.2 Cross Tables, chi-Square test analysis and bar charts for Assessments

4.3.2.1 Analysis of Test 1

Table 4.10

Test 1 Comparisons on Pass rates of two groups

Crosstab					
			T1		Total
			Pass	Fail	
Group	Experimental	Count	19a	0a	19

		% within Group	100.0%	0.0%	100.0%
		% within T1	43.2%	0.0%	39.6%
		% of Total	39.6%	0.0%	39.6%
	Control	Count	25_a	4_a	29
		% within Group	86.2%	13.8%	100.0%
		% within T1	56.8%	100.0%	60.4%
		% of Total	52.1%	8.3%	60.4%
Total		Count	44	4	48
		% within Group	91.7%	8.3%	100.0%
		% within T1	100.0%	100.0%	100.0%
		% of Total	91.7%	8.3%	100.0%
Each subscript letter denotes a subset of T1 categories whose column proportions do not differ significantly from each other at the .05 level.					

Table 4.11

Chi-square for Test 1

Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.859[a]	1	.091		
Continuity Correction[b]	1.338	1	.247		
Likelihood Ratio	4.267	1	.039		

Fisher's Exact Test				.142	.122
Linear-by-Linear Association	2.799	1	.094		
N of Valid Cases	48				
a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 1.58.					
b. Computed only for a 2x2 table					

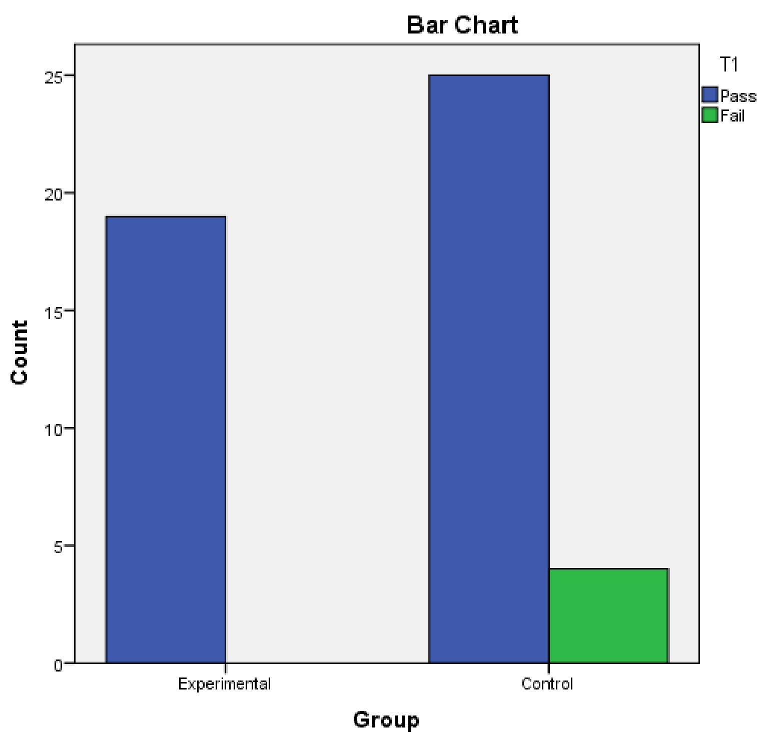

Figure 4.1: Bar chart - Test 1 performance for each groups

Decision and conclusions for Test 1 Performance:

The value of the test statistic is 2.859. Since the p-value ($p=0.091$) is greater than our chosen significance level ($\alpha = 0.05$), we do not reject the null hypothesis. Rather, we conclude that there is not enough evidence to suggest an association between group (teaching methods) and whether a student pass or fail. Based on the results, we can state the following:

- No association was found between group (teaching methods) and whether or not students pass or fail (*chi-square* = 2.859, *p* = 0.091).

However, all students (100%) from experimental group passed test-1 as compared to twenty-five (86.2%) from the control group.

4.3.2.2 Analysis for Test 2

Table 4.12

Test 2 Comparisons on Pass rates of two groups

Crosstab					
			T2		
			Pass	Fail	Total
Group	Experimental	Count	18a	1b	19
		% within Group	94.7%	5.3%	100.0%
		% within T2	66.7%	4.8%	39.6%
		% of Total	37.5%	2.1%	39.6%
	Control	Count	9a	20b	29
		% within Group	31.0%	69.0%	100.0%
		% within T2	33.3%	95.2%	60.4%
		% of Total	18.8%	41.7%	60.4%
Total		Count	27	21	48
		% within Group	56.3%	43.8%	100.0%
		% within T2	100.0%	100.0%	100.0%
		% of Total	56.3%	43.8%	100.0%

Each subscript letter denotes a subset of T2 categories whose column proportions do not differ significantly from each other at the .05 level.

Table 4.13

Test 2 Chi-square on Pass rates of two groups

Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	18.929[a]	1	.000		
Continuity Correction[b]	16.429	1	.000		
Likelihood Ratio	22.031	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	18.534	1	.000		
N of Valid Cases	48				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.31.					
b. Computed only for a 2x2 table					

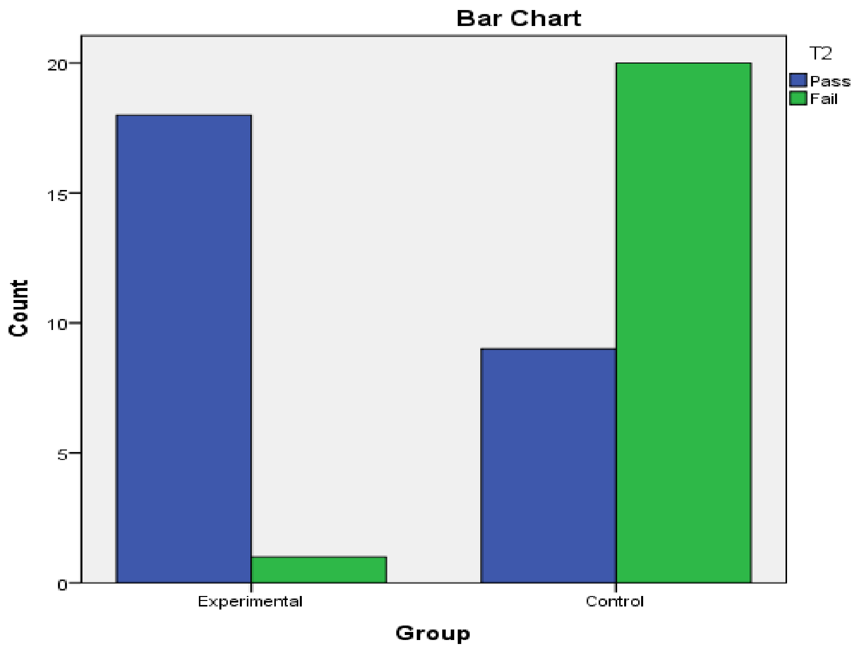

Figure 4.2: Bar chart - Test 2 performance for each groups

Decision and conclusions on Test 2 performance:

The value of the test statistic is 18.929. Since the p-value (p=0.000) is less than our chosen significance level *α* = 0.05, we can reject the null hypothesis, and conclude that there is an association between group (teaching methods) and whether or not students pass or fail. Based on the results, we can state the following:

- There was a significant association between group and whether or not students pass or fail (*chi-square* = 18.929, *p* =0 .000).

18 students (94.7%) from the experimental group passed the tests as compared to only nine (31.0%) students from the control group. The very high failure rate in the control group has significantly contributed to the overall drop of about 35% in pass rate for test-2 as compared to test-1.

4.3.2.3 Analysis of Test 3

Table 4.14
Test 3 Comparisons on Pass rates of two groups

Crosstab					
			T3		Total
			Pass	Fail	
Group	Experimental	Count	16_a	3_a	19
		% within Group	84.2%	15.8%	100.0%
		% within T3	48.5%	20.0%	39.6%
		% of Total	33.3%	6.3%	39.6%
	Control	Count	17_a	12_a	29
		% within Group	58.6%	41.4%	100.0%
		% within T3	51.5%	80.0%	60.4%
		% of Total	35.4%	25.0%	60.4%
Total		Count	33	15	48
		% within Group	68.8%	31.3%	100.0%
		% within T3	100.0%	100.0%	100.0%
		% of Total	68.8%	31.3%	100.0%

Each subscript letter denotes a subset of T3 categories whose column proportions do not differ significantly from each other at the .05 level.

Table 4.15

Test 3 Chi-square on Pass rates of two groups

Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.499[a]	1	.061		
Continuity Correction[b]	2.409	1	.121		
Likelihood Ratio	3.714	1	.054		
Fisher's Exact Test				.110	.058
Linear-by-Linear Association	3.426	1	.064		
N of Valid Cases	48				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.94.					
b. Computed only for a 2x2 table					

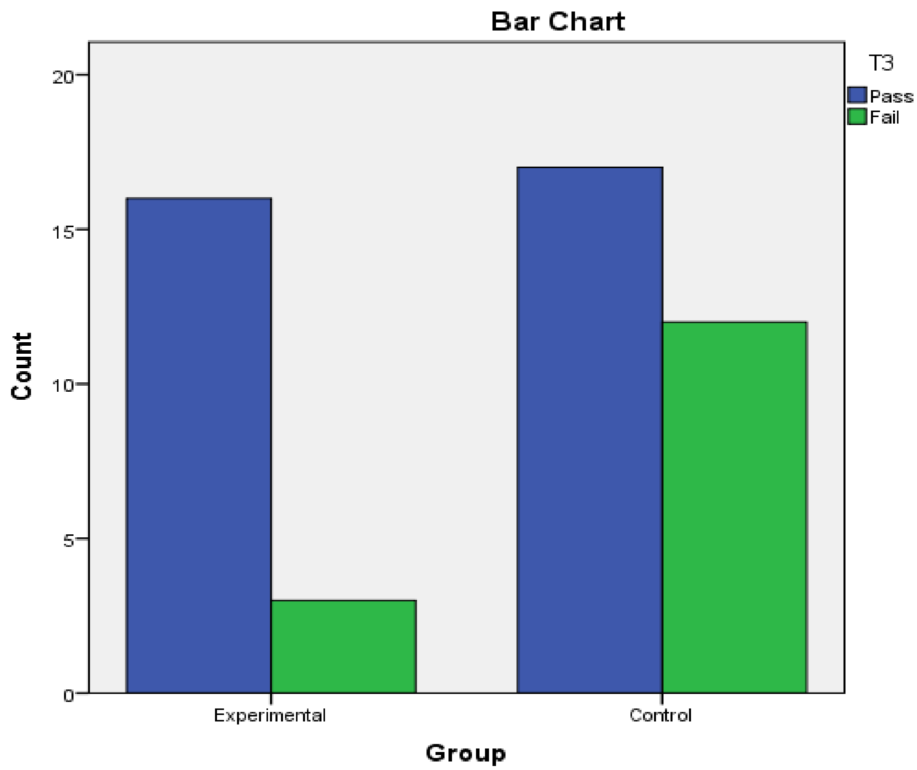

Figure 4.3: Bar chart - Test 3 performance for each groups

Decision and conclusions for Test 3 Performance:

The value of the test statistic is 3.499. Since the p-value (p=0.061) is greater than our chosen significance level (α = 0.05), we do not reject the null hypothesis. Rather, we conclude that there is not enough evidence to suggest an association between group (teaching methods) and whether a student pass or fail. Based on the results, we can state the following:

- No association was found between group (teaching methods) and whether or not students pass or fail (*chi-square* = 3.499, *p* = 0.061).

However, 16 students (84.2%) from experimental group passed test-3 as compared to only 17 (58.6%) from the control group.

4.3.2.4 Analysis of Test 4

Table 4.16

Test 4 Comparisons on Pass rates of two groups

Crosstab					
			T4		
			Pass	Fail	Total
Group	Experimental	Count	18a	1b	19
		% within Group	94.7%	5.3%	100.0%
		% within T4	54.5%	6.7%	39.6%
		% of Total	37.5%	2.1%	39.6%
	Control	Count	15a	14b	29
		% within Group	51.7%	48.3%	100.0%
		% within T4	45.5%	93.3%	60.4%
		% of Total	31.3%	29.2%	60.4%
Total		Count	33	15	48
		% within Group	68.8%	31.3%	100.0%
		% within T4	100.0%	100.0%	100.0%
		% of Total	68.8%	31.3%	100.0%

Each subscript letter denotes a subset of T4 categories whose column proportions do not differ significantly from each other at the .05 level.

Table 4.17

Test 4 Chi-square on Pass rates on two groups

Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.885[a]	1	.002		
Continuity Correction[b]	7.984	1	.005		
Likelihood Ratio	11.621	1	.001		
Fisher's Exact Test				.002	.001
Linear-by-Linear Association	9.679	1	.002		
N of Valid Cases	48				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.94.					
b. Computed only for a 2x2 table					

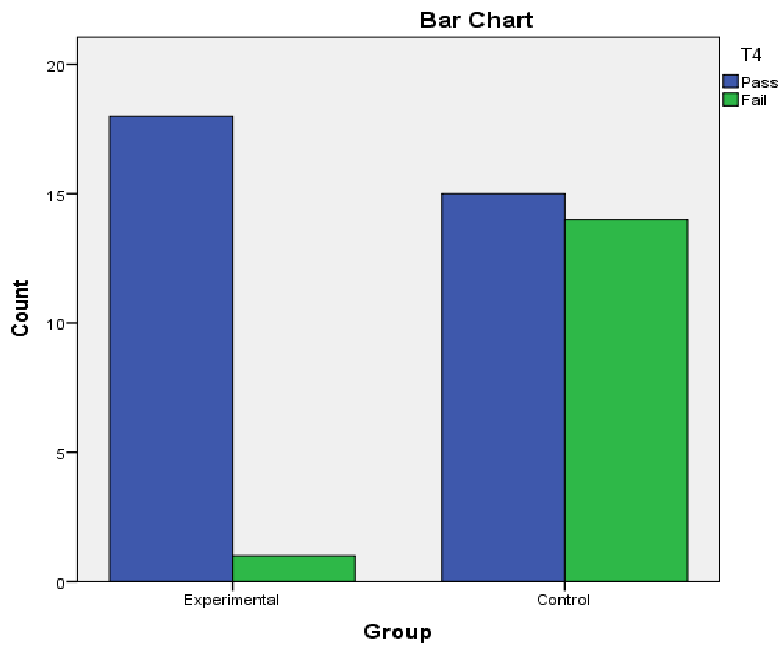

Figure 4.4: Bar chart - Test 4 performance for each groups

Decision and conclusions on Test 4 performance:

The value of the test statistic is 9.885. Since the p-value (p=0.002) is less than our chosen significance level α = 0.05, we can reject the null hypothesis, and conclude that there is an association between group (teaching methods) and whether or not students pass or fail. Based on the results, we can state the following:

- There was a significant association between group and whether or not students pass or fail (*chi-square* = 9.885, *p* =0 .002).

18 students (94.7%) from the experimental group passed the tests as compared to only 15 (51.7%) students from the control group.

4.3.2.5 Analysis of year mark (Examination Admission)

Table 4.18

Admission to Exams Comparisons on Pass rates on two groups

Crosstab					
			AdExam		Total
			Yes	No	
Group	Experimental	Count	19a	0b	19
		% within Group	100.0%	0.0%	100.0%
		% within AdExam	52.8%	0.0%	39.6%
		% of Total	39.6%	0.0%	39.6%
	Control	Count	17a	12b	29
		% within Group	58.6%	41.4%	100.0%
		% within AdExam	47.2%	100.0%	60.4%
		% of Total	35.4%	25.0%	60.4%
Total		Count	36	12	48
		% within Group	75.0%	25.0%	100.0%
		% within AdExam	100.0%	100.0%	100.0%
		% of Total	75.0%	25.0%	100.0%
Each subscript letter denotes a subset of AdExam categories whose column proportions do not differ significantly from each other at the .05 level.					

Table 4.19

Admission to Examinations (DP) Chi-square on two groups

Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	10.483[a]	1	.001		
Continuity Correction[b]	8.392	1	.004		
Likelihood Ratio	14.648	1	.000		
Fisher's Exact Test				.001	.001
Linear-by-Linear Association	10.264	1	.001		
N of Valid Cases	48				
a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.75.					
b. Computed only for a 2x2 table					

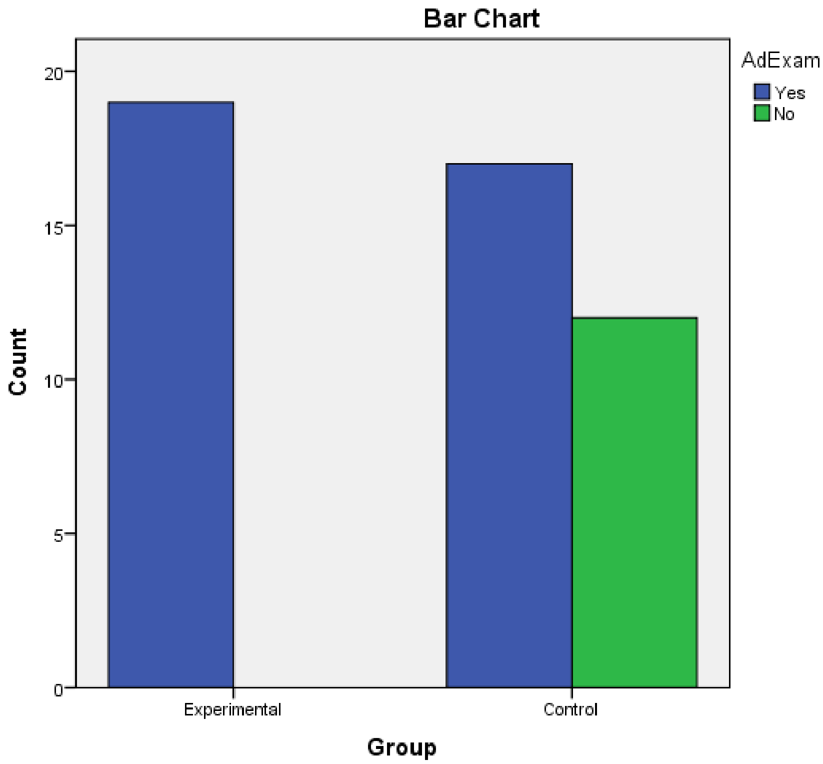

Figure 4.5: Bar chart –Admission to examination (DP) for each groups

Decision and conclusions on Duly Performed (DP) marks:

The value of the test statistic is 10.483. Since the p-value (p=0.001) is less than our chosen significance level α = 0.05, we can reject the null hypothesis, and conclude that there is an association between group (teaching methods) and whether or not students pass or fail. Based on the results, we can state the following:

- There was a significant association between group and whether or not students pass or fail (*chi-square* = 10.483, *p* =0 .001).

All students (100%) from the experimental group to qualified for the final examination based on their performances throughout the academic year while only 17 (58.6%) of the students from the control group which was taught using traditional approach managed to qualify for the final examination. From the control group, though a staggering percentage (41.4%) could not even qualify for the final examination, this is in line with the previous years' statistics as discussed in Chapter-1. This resulted in them failing the course without even writing the final examination.

4.3.2.6 Analysis of Final Results

Table 4.20

Comparisons on Final Results (Pass/Fail rates) of two groups

Crosstab					
			FinalResults		
			Pass	Fail	Total
Group	Experimental	Count	17_a	2_b	19
		% within Group	89.5%	10.5%	100.0%
		% within FinalMark	53.1%	12.5%	39.6%
		% of Total	35.4%	4.2%	39.6%
	Control	Count	15_a	14_b	29
		% within Group	51.7%	48.3%	100.0%
		% within FinalMark	46.9%	87.5%	60.4%
		% of Total	31.3%	29.2%	60.4%
Total		Count	32	16	48
		% within Group	66.7%	33.3%	100.0%
		% within FinalMark	100.0%	100.0%	100.0%
		% of Total	66.7%	33.3%	100.0%
Each subscript letter denotes a subset of FinalMark categories whose column proportions do not differ significantly from each other at the .05 level.					

Table 4.21

Final Results Chi-square on two groups

Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	7.361[a]	1	.007		
Continuity Correction[b]	5.760	1	.016		
Likelihood Ratio	8.150	1	.004		
Fisher's Exact Test				.011	.007
Linear-by-Linear Association	7.208	1	.007		
N of Valid Cases	48				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.33.					
b. Computed only for a 2x2 table					

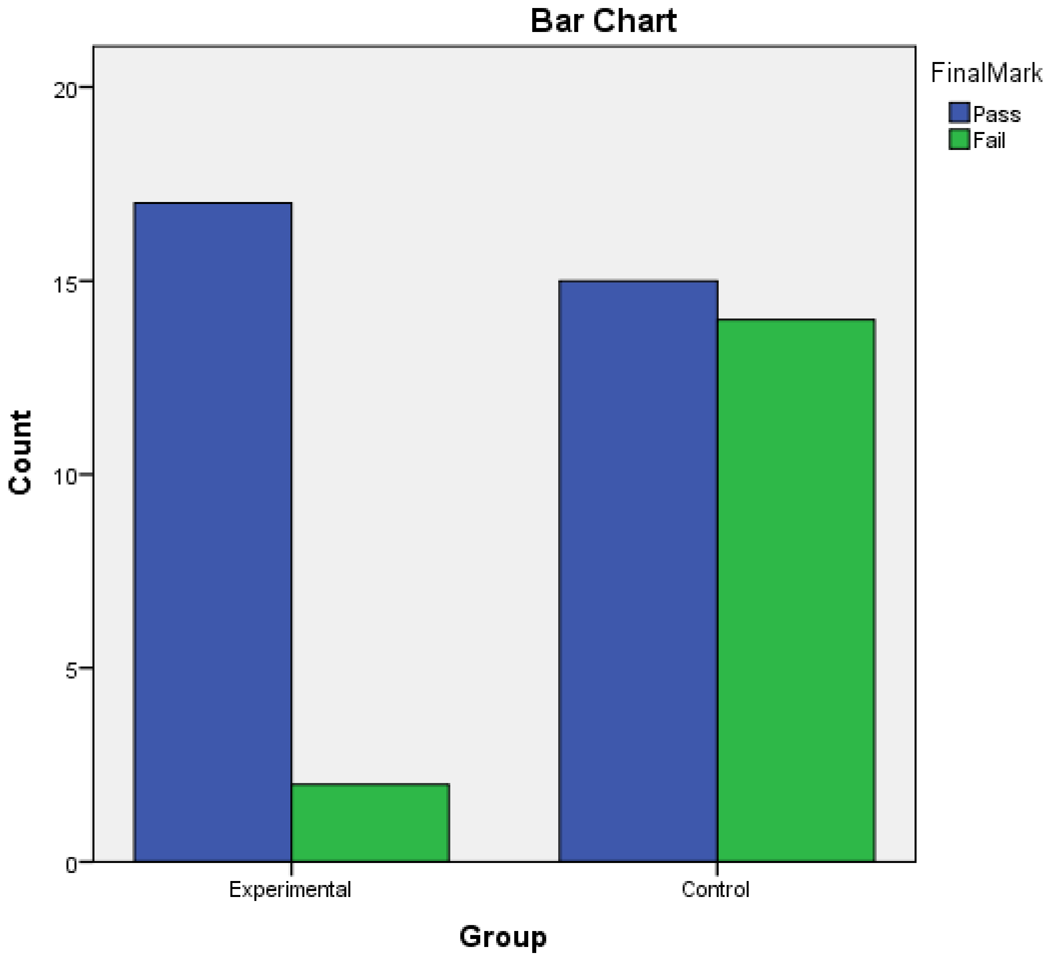

Figure 4.6: Bar chart – Final Results (Overall Pass/Fail) for each groups

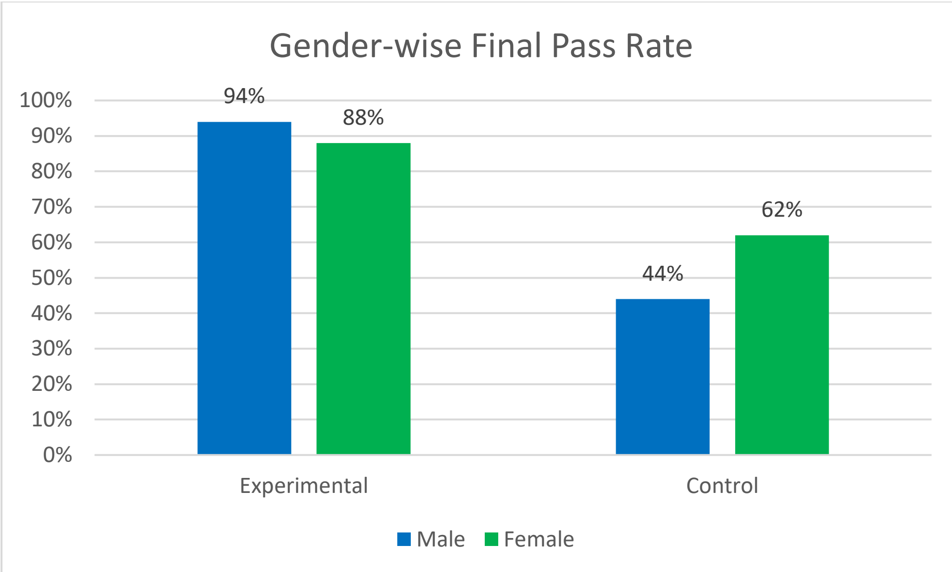

Figure 4.7: Bar chart – Final Results (Gender-wise Pass rate) for each groups

Decision and conclusions on Final Results:

The value of the test statistic is 7.361. Since the p-value (p=0.007) is less than our chosen significance level *α* = 0.05, we can reject the null hypothesis, and conclude that there is an association between group (teaching methods) and whether or not students pass or fail. Based on the results, we can state the following:

- There was a significant association between group and whether or not students pass or fail (*chi-square* = 7.361, *p* =0 .007).

Only two students (10.5%) failed to complete the course successfully from the experimental group as compared to fourteen (48.3%) students from the control group. Close to ninety percentages (90%) of students learning through the GIL approach completed the course successfully as compared to almost fifty-two (52%) students taught using traditional teaching approach.

Only one student each from each of the gender groups failed to complete the course successfully from the experimental group. So there is no significant difference in the pass rates between the male and female students who were learning through the GIL approach. But, 62% of the female students from the control groups completed the course successfully as compared to the 44% of the male students from the same group.

It could also be concluded from the findings that GIL approach in this case worked very well in preparing the students for examination admission as indicated by the 100% examination admission for the experimental group. However, not all the tests show a significant performance difference by the experimental group. For example, Test 1 and 3 performances do not show that GIL was significantly more effective than the traditional approach. On the other hand, the overall performance in all the assessments of the students under the experimental group was better than those under the control group. Students' final achievement results show a welcoming 37.8% difference between the groups taught with GIL approach and traditional approach in favor of the experimental group.

To further check whether the GIL was effective to enhance the students' performance, a t-test was performed. This was to show further, the significance of GIL approach on the performance of students enrolled for the Introductory Programming course.

4.3.3 T-Test Analysis

Table 4.22

Summary of Tests and average marks – Group Statistics

Group Statistics					
	Group	N	Mean	Std. Deviation	Std. Error Mean
Test1	Experimental	19	65.39	6.680	1.533
	Control	29	63.97	15.729	2.921
Test2	Experimental	19	57.37	16.480	3.781
	Control	29	34.07	25.386	4.714

Test3	Experimental	19	56.21	16.301	3.740
	Control	29	46.34	29.472	5.473
Test4	Experimental	19	58.32	16.101	3.694
	Control	29	33.79	22.132	4.110
DP	Experimental	19	59.53	11.187	2.567
	Control	29	45.10	20.106	3.734

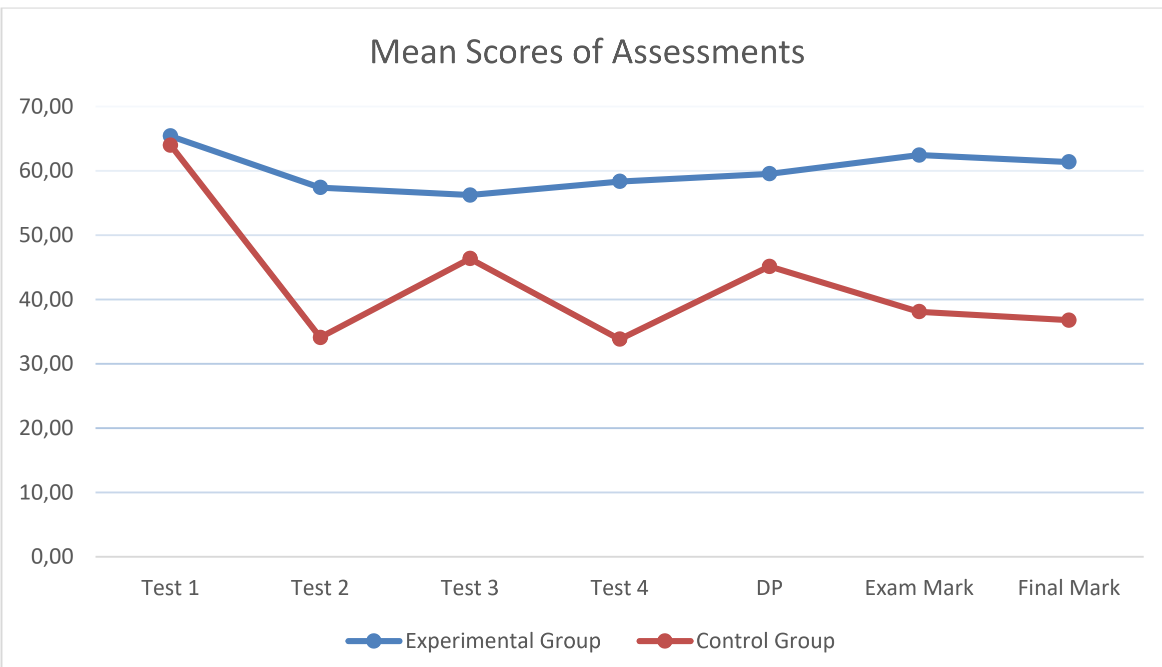

Figure 4.8: Mean Scores (%) of assessments - Experimental versus control groups

Table 4.23 ***Calculate t-test results for all assessments – The Independent Samples Test***

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Test1	Equal variances assumed	13.292	.001	.374	46	.710	1.429	3.826	-6.272	9.131
	Equal variances not assumed			.433	40.737	.667	1.429	3.298	-5.233	8.092
Test2	Equal variances assumed	2.117	.152	3.536	46	.001	23.299	6.590	10.034	36.565
	Equal variances not assumed			3.856	46.000	.000	23.299	6.043	11.136	35.463
Test3	Equal variances assumed	11.758	.001	1.329	46	.190	9.866	7.424	-5.078	24.810
	Equal variances not assumed			1.488	44.994	.144	9.866	6.629	-3.485	23.216
Test4	Equal variances assumed	4.185	.047	4.156	46	.000	24.523	5.900	12.647	36.399
	Equal variances not assumed			4.438	45.412	.000	24.523	5.526	13.396	35.649
DP	Equal variances assumed	10.642	.002	2.845	46	.007	14.423	5.070	4.218	24.628
	Equal variances not assumed			3.183	45.062	.003	14.423	4.531	5.298	23.548

The highlighted in yellow assessments shows the assessments were there was a statistically confirmed significance between the GIL and the traditional approach among the two groups. Table 4.23 depicts an independent-samples test which compared the means between experimental and control student's performance in tests and DP. Levene's test for homogeneity of variance (homoscedasticity) was used.

Decision and conclusions based on the Groups statistics and t-test:

The summary of the t-test results that shows the significance of GIL is shown in Table 4.23. This test verified that the assumption of equal variances holds in Test 2 and does not hold in the rest of other samples. Significant differences in means between the groups were noticed in Test2 (p=0.001), Test4(p=0.000) and DP (p=0.003).

On average, students' performance was not significantly different in test one and three. However, student performance was significantly different in test two and four. Even though the performances were not significantly different, the average test one mark shows that students taught using GIL performed slightly higher (65.30) than the control group (63.97). Similarly, test three average mark shows that the experiment group performed well on average (56.21) than the control group (46.34). Even though test one and three's average mark is not significantly different for both groups, it is encouraging to note that the standard deviation for the experiment group was small (6.68) compared to that of the control group (15.73) for test one. Though slightly greater, the standard deviation of the experimental group (16.30) in test three was close to half that of the control group (29.47). This implies that, while both groups performed well especially in test one, GIL closely and collectively improved the performance of all the students when compared to the traditional teaching approach. Table 4.22 shows the details of the marks.

In addition, findings from test two and four show that the experimental group performed significantly better than the control group. For example, the average test two marks for the experimental group is 57.4 compared to that of the control group which is 34.07. Similarly, test four showed a significantly high average mark for experimental group (58.32) compared to that of the control group (33.79). For Test 1 and 3, there is no significant difference as per the p-value, though the average for these two tests was still higher for the experimental group. But it should be noted that the standard deviation was always lower for the experimental group than the control group (ref. Table 4.3). The lower standard deviation implies that the experimental group was generally performing at the same level. As was the case with test one and three, the experimental group's standard deviation for test two is smaller (16.48) when compared to that of the control group (25.39). A similar type of result was found on test four as the experimental group had a smaller standard deviation of 16.10 compared to that of the control group that was 22.13. There were no common outliers and the mark differences for the assessments among the experimental groups were almost in the same range. We maintain our argument that GIL collectively improves the performance of students with minimum outliers as students help each other understand the subject during the learning process. This argument is supported by the number of students who failed in class tests. For example, none (0%) in the experimental group failed test one as compared to four (13.8%) from the control group. Only one (5.3%) student from the experimental group failed test two compared to twenty (69.0%) from the control group. Twelve (41.4%) students from the control group failed test three compared to three (15.8%) from the experimental group. Lastly, nearly half of the students (48.3%) failed test four from the control group compared to one (5.3%) from the experimental group.

Performances from in class tests were extended to their Duly Performed (DP) marks. Results show that, all 19 (100%) students from the experimental group got at least a 40% of the DP that gave them admissions to the final examination. However, just above 50% of the control group got at least a 40% final examination admission. The rest of the students failed to qualify for the examination admission.

The group summary clearly indicated that throughout all the assessments, the experimental group was generally performing well. In this case the average mark for the experimental group on all assessments was higher as shown through Table 4.21 and Figure 4.7.

These findings corroborate with the results obtained through chi-Square analysis as explained through section 4.3.2

In terms of performance, the overall pass rates of GIL and traditional learning approach were 89% and 52% respectively for university introductory programming course. Watson and Li (2014) reported that the global pass rate for programming courses as 67.7% which is significantly lower than the one found for the experimental group of this study. Furthermore, the same authors reported South Africa’s overall failure rate as approximately 45% for the same course and the finding for the control group in this study with 48% is close to their findings and hence confirmatory of that of Watson and Li (2014). The average year mark obtained by the students in experimental group and control group were 59.53% and 45.10% respectively. This supported the findings by another researcher from the same institution who experimented with a with a similar approach in an Engineering programme (Louw, 2012). The author reported that the class average improved to 55% when students were taught using guided inquiry based learning approach as compared to the 46% when students were taught using traditional methods.

In conclusion, GIL approach, as opposed to Traditional Approaches, used for teaching entry-level students doing computer programming had a positive effect of their course achievements. Thus the null-hypothesis (H_0) is rejected.

4.4 Qualitative data analysis, interpretation and discussion

Focus group interviews were conducted with the participating students. These interviews were done with students to find out more about their own experience throughout the year learning the Introductory Programming course using GIL approach. 18 learners participated in the focus groups. There were two groups with 5 participants each and the other two groups with 4 participants each.

Students responses (see Appendix E) are included (verbatim) to indicate what their opinions and experience were with regard to GIL. Thematic analysis was conducted over the collected data. The formulated themes are presented here as a way to answer the sub research questions. Each theme is presented starting with researcher's summary followed by quotes from students illustrating examples of responses from different focus groups.

Sub research question 1: What would be the differences in academic achievement between students taught traditionally and those taught using GIL approach?

To address research sub question 1, different themes were qualitatively derived. The themes were based on the findings from focus group interviews and supported by relevant literature. The researcher also applied own analysis to formulate the themes.

The following themes emerged:

Group Sessions helped understand the subject content better

Students were asked to give their opinion on group sessions as part of the GIL approach. They all overwhelmingly supported the idea of having a group learning environment. Difficulty in understanding the subject content and applying them are viewed as one of the major challenges faced by entry-level programming students by many researchers (Bergin &Reilly, 2005; Derus & Ali, 2012; Schoeman, 2015; Shuhaidan et al.,2009). There was a consensus among them that the peer assistance through group sessions helped them understand the subject content better and clearer.

Responses from students as given below in verbatim prove this:

> FG1 P1: *"May be we won't understand the way the educator explains the things whereas if it is from your peer make more sense. I think it is a really good idea. It works for me, my opinion"*
>
> FG1 P3: *"And I think it worked because, now I can understand things easier with my fellow students.."*
>
> FG1 P4*: "As my fellow classmates has said - it has helped me a lot because we communicate with group members and understand more complex things than may be the teacher just explains…"*
>
> FG1 P2: *"It sounds better sir, when it comes from your group mates. If your lecturer may be it was faster a little bit when it was presented in the class sir, then your group mates will explain it to you in a better way.."*
>
> FG3 P3: *"Interactions within the class mates..its really helped because sometimes that person understand the question more, like an advocate that member can explain to others like when we are done with the lecture. Then like it will help us understand more."*

Group session experience assisted students while doing their home works alone

Entry-level students are required to develop a diverse range of skills such as problem analysis and problem solving at an early stage of their studies (Falkner & Munro, 2009), but studies have proven that students even fail to know where to begin with in attempting to get to the solution (Huggard & Goldrick, 2009). Students used their group session experiences and approaches when they were doing their home works. The questions they asked and were being asked during the group sessions worked as a 'guide' on how to analyse the problem. Though there was no fixed rule, through their responses it was evident that they learned to approach a problem scenario systematically questioning themselves to understand and analyse the problem to get to (even) alternate solutions. The following students' responses ascertain this conclusion:

> FG1 P1: *"..during the group discussions I would like, we will first analyse the problem. What is it that we want to solve and how can we solve it? Then, I list the alternative way on how to solve it and then I choose the most appropriate one. When I am alone – like…firstly, I have to identify the kind of a problem that I want to solve. Look for the solutions then choose the best one…then okay, vary them then choose the best one. It helped me to fully analyse what is it that I want to solve and how can I solve it"*

> FG1 P5: *"If you have a problem sir….when you are alone…. If you ask the right questions to yourself like we did in the groups and follow the process on how to come up with the solutions mostly by answering those questions asked...then you will solve the problem, sir. Yes…it was totally different from how I used to solve any problem before…"*

> FG1 P3: *"To me personally it helped me, because it taught me that in any problem there will be a solution. If only you follow the right steps and ask the right questions... yah firstly, you have to know what is your problem. Then try to find a way to solve your problem. You ask questions like what is the output expected, what input is needed to get there, like that… So personally it helped*

me, because now I know in each and every problem there will be a solution at the end"

FG2 P2: *"…before I approach any question, I am trying to use the skills during discussions. Ask myself many questions…to analyse the problems lists all steps in how to solve the problem and find most effective ways to solve the problem"*

FG2 P4: *"Before, when I am trying to code, when I was writing programs, I just write write write and get lost. But now, I ask to me first and I write down all objectives, all the inputs, write things that are row, come up with..what do I say trying to come up solutions"*

FG3 P1: *"Now you know which questions to ask yourselves to analyse".*

FG3 P4: *"When you are working alone, now you are able to ask yourself some questions, and from experience of the group, now that you are alone, you will think you ask yourself some questions. It will help me to have the conversations with myself, because you are trying to understand the problem in a different way….and then probably you want to come up with two things because you are being used to working as a group. Now you are a single person, you want to find out if there can be more ways, because programming is not that something that is done in one way ".*

From some of the above listed responses it is clear that GIL sessions have given students the belief that there is a solution to every problem and engaging themselves in conversation through asking critical questions themselves, could eventually lead them to a solution.

Appreciated alternative problem solving approaches

The study of algorithmic problem solving is at the core of learning computer programming and it is well documented that entry-level students struggle in mastering problem solving skills (Lishinski, Yadav, Enbody, & Good, 2016; McCracken et al., 2001; Sheth, Murphy, Ross, & Shasha, 2016). Students have stated that they learned to acknowledge and appreciate the fact that there are different ways to solve a problem as different individuals could approach a given problem scenario differently. Groups sessions have taught them that a given problem scenario can be solved in different ways, as their peers in the group came up with their own way of solving the problem. Following responses from students provide valuable insight into this:

> FG 3 P2: *"(GIL) has a positive impact because programming is not always done in a single way. Like for example, I just see how the class members found the problem in different ways, for example you got a question and you argue in the first way, but he gets it in the other way, but you still get the same answer. So you get to see how there are different ways"*

> FG 3 P3: *"(GIL) taught us that problems are not solved only in one way. That there are different ways.. So at the end of the day you need to understand that if you do it this way, some other person can do it the other way, and they are not fault, so you need to think of the optimal way of doing it to get the great answer"*

> FG2 P5: *"When we put in our possible solution to a problem, group will come up with the best possible answers to that problem."*

> FG2 P3: *"we are working as a group, we come up with different solutions.."*

> FG1 P2: *"we've all come up with different solution on how to solve the problem then we look the most appropriate or the most correct way or the one that will be easier for us to understand…., the most appropriate one that will help us to be able to solve even related problems to that one"*

Students tend to follow the solutions that are given by lecturers and fail to look for different ways of solving a problem in a typical traditional teaching environment. The active learning environment inspired them to come up with their own ways of solving the problem. This in turn improved their problem solving skills. Students constructed their own solutions rather than acting as receivers of ideas from the lecturer.

Social networking platform to facilitate GIL sessions (out of classroom)

Features made available through the virtual groups that are found in social networking platforms such as WhatsApp have the potential to make learners active in the learning process, boost informal communication between learners and teachers and create an anxiety reducing environment (Awada, 2016; Bouhnik & Deshan, 2014). As part of the study, a social networking platform (WhatsApp in this study), was used to facilitate GIL environment among the students while they were out of the classroom environment. Groups of 4 to 5 students were created over WhatsApp replicating the classroom groups and they were encouraged to engage in discussions through these groups. Students found this so effective and used it extensively to their benefit while away from classroom. Responses from the interviews as given below suggest that the experiment to create GIL environment over virtual space has attracted the new digital generation students.

> FG1 P1: *"…there is no better way to educate a young mind in this generation now, than using social network. Cause, if you put something educative on social network, it will spread, it will be viral. Everyone will learn about it. And, cause, now life now is about technology and everything. So, if it is out there, spreading, more chances are that young adults, as us, will learn about it – enriching our minds and learning everything. So it helps with that for me.."*
>
> FG1 P2: *"..WhatsApp helped a lot, because wherever you are - you are always with your phone. So, it is easier to solve a problem on WhatsApp"*
>
> Interviewer asks as a follow up question to this focus group: "I want to understand Whatsapp use better. So did you continue your group sessions on from class on Whatsapp?"
>
> Then the students responded as follows:
>
> P2: *"Yes"*
> Followed by:

P3: *"Even the home works, when you have homework and you are at home, no one is there to discuss. So you talk to your mates…question.. and people will know how to respond and question over the phone..on Whatsapp…you know, that's how it works."*

P2: *"..when you're doing homework sir then, if….let's say we are doing a flow chart sir ,then you're trying to do it then you post it on Whatsapp. Then, you let them to see you, what you were…to see the way you're doing it sir then they will comment that if you were wrong to do that then it is done in these ways"*

FG2 P2: *"There was this WhatsApp group was created. When we do the home work, we type it and post. It helped. My group mates and I discuss…and lecturer did tell us if we were doing completely opposite through WhatsApp and post questions. In a way it was a classroom there in WhatsApp..it helped"*

FG2 P5: *"When we put in our possible solution to a problem, group will come up with the best possible answers to that problem"*

FG2 P4: *"When we come up with problems that we can't solve, then ask them (group) through WhatsApp, then they can come up with hints.."*

FG2 P3*: "Even now, the WhatsApp groups, even now I can go, you can still do your work. Then you capture by a camera, then you send it, those guys see a problem there or see any errors, then we will react"*

FG3 P2: *"Yah at home for instance if you struggling like the stuff and all, before you go to the class like you whatsapp your questions to your group members and class mates can all help you to get to the answer".*

FG4 P1: *"We had some WhatsApp groups. We do communicate with others like when we have those lazy moments of hours at home, hei I am not sure about this question like, then we go to WhatsApp and discuss like don't you know this and that. In that way my group members help me on continuing or making sure that my answer is in the right track".*

Sub research question 2: What would be the effect of GIL approach on students' confidence, motivation and communication skills related to Introduction to Programming?

Participants were asked in their focus group interviews to indicate how GIL had enabled them to be confident, motivated and improve on their communication skills. Several questions were asked during the interviews to answer sub research question 2. Discussions in focus groups showed that students' confidence and communication skills were improved due to GIL teaching approach. They further indicated that the group sessions motivated them to continue with learning programming not only with the Introductory course but also with future advanced programming courses.

The following themes emerged from focus group interviews that addresses the sub research question 2:

Generated self-belief and confidence among students to write computer programs that work.

Subjective personal experience which contributes towards students' level of confidence does play a major role in their decision to continue with the CS/IT degree (McDowell, Werner, Bullock, & Fernald, 2006). At the end of the academic year, almost all the students indicated that they believed themselves, in their own abilities to write computer programs that work. They have achieved the confidence in writing programs, which is the essential ingredient any student should have in order to be successful. They indicated that the GIL approach had enabled them to gain this confidence. The following responses from students prove this:

> FG1 P1: *"..I think I can do it…. I can do programming. I haven't faced any problem that I can't solve at the moment (in programming), but I'm not saying I know everything but then again, I haven't faced a problem that I can't solve"*

> FG1 P3: *"Based on the classworks, tests and the..everything that we have done so far.., yes, I can do it"*

FG2 P1: *"I can say sir, I can write the program that works. Because, with the skills that I have now with those group sessions, yes, I can"*

FG2 P4: *".. I tell you now now, that I can do a program, all that works, and if it does not work, I will go and check my errors. Yes.."*

FG2 P2: *"I tell you because the lecturer taught me like this, and I gained skills from groups, peers. So the skills that I have I can apply them. So I can write programs"*

FG3 P1: *"(we know we can) Because we are doing it. We do it in different ways. Students know, do it in different groups.."*

FG3 P4*: "And I know I can do (program). And now we know that we have a lecturer who communicates with us. He would let you write the program ..and now we are confident enough to say. Because we know that he didn't do it for us, but we did it ourselves, and just helped and guided here and there. So that's why we can say that, we actually have no problem".*

FG3 P2: *"As we say, when you write program, sometimes, when you first write, it is not like perfect. You always catch-up. You always like catch-up on those small errors, to make it perfect. You write it, then you run it. You see those minor mistakes, you correct them"*

FG4 P1: *"Yes. Obviously. I mean in a sense that I am confident that I could write a program that runs.."*

FG4 P1: *"I am confident that I can write programs.."*

Over the years' studies have found that entry-level students lack in confidence because their attempts to write computer programs fail often. GIL approach in teaching Introductory Programming has given the students who participated in this study the confidence and self-belief that they can successfully write computer programs.

Built strong foundation

The major aim of any introductory course is to build a strong foundation in the specific field of study among students and create a sense of confidence to continue learning/growing in the same field (McDowell, Werner, Bullock, & Fernald, 2006). Studies have shown that learning difficulties associated with Introductory Programming courses are a major contributing factor for many entry-level students choosing not to continue with programmes in CS and other cognate fields (Costa et al., 2017; Koulouri, Lauria, & Macredie, 2015; Sheard & Hagan, 1998; Watson & Li, 2014). Students who participated in this study overwhelmingly acknowledged and believed that they had attained a strong foundation in computer programming through this course. They believed that they could nurture their skills in programming through the strong foundation that they achieved currently. This is evident from the responses of the students as given below:

> FG1 P1*: "I have learned the basics - yes – now, like the foundation is there – it's going to be stable. Now I just need to…. the kick basically, learn more and you know finish everything.."*

> FG1 P4: *"Now, I can weigh my ability as a programmer….okay…the basics are there and I can tackle to do a programme, ….and with the basics that I got in programming, for sure, I can tackle doing the programme."*

> FG2 P5: *"I am not perfect, but we are heading towards where we are supposed to be. Because we are first year students and still have a lot to learn. So far we are on the right path where we need to be as programmers"*

> FG2 P4: *"…I can say at this stage of study, I have sound background".*

> FG3 P2: *"First year is the beginning. Teaching up the basics, and I think what the most important thing is to know the basics, and you can make anything from there. I think we got the basic side strong. Strong basics we have, therefore we can learn anything else, that would make programming easier once you know the basics".*

FG3 P4: *" … programming has been introduced to me this year, and we only learned the few things as the basics. So I think from now on, its good on my level. Now as I go forward, it is going to be perfect"*

FG3 P3: *"..we have got some background of programming. So for like for example if I have to learn C++ next year, I will understand better from what I learned through the group work and my lecturer this year"*

Grew in confidence to express themselves in front of others

GIL approach and the group sessions enabled students to gain confidence in themselves and as a result, they believe they are able to stand in front of others and express themselves. Following student responses in verbatim asserts this view:

FG1 P3: *"It (GIL sessions) helps in terms of confidence, because in terms of confidence, being confident about what you think about that particular thing that we are doing and in terms of debating… I have learned to stand up for something that I have said"*

FG1 P1: *"So, socializing with people makes you learn more and makes you more comfortable. … you feel less pressure, more confident. and yeah and when you are in your group obviously its gonna be a competition for everyone…then you like give your opinion and learn to argue your opinion. So you like eventually get strong in with giving your opinion with others.."*

FG2 P5: *"..But the way that this group thing had helped us, that everyone became confident in themselves, and they were able to project themselves, were able to interact when there is a discussion and they were able to..like, how can I put this.."*

FG2 P2: *"I prefer reading than talking. these group discussions helped me a lot. Because now, I have gained confidence, I can talk with people and collaborate with them"*

FG3 P4: *"Also then to be confident, because you said that the answer is like this, they would ask questions how did you go about it to find certain answer, so you have to be confident explaining your views to them so that you get the feedback so that you can interact and explain how you get to the result".*

FG3 P3: *"So like, if I am not too sure, like some people are not sure of like themselves, but it is like now everyone will be doing and will be confident even to showing the answers to the friends. Like this is the way I am doing it. If your way is correct or my way is correct..you interact, you opened it".*

FG4 P3: *"…so in future, you can speak in front of many people. So confidence"*

It is evident from these responses that, that they were able to express themselves in front of others and even learned to defend their arguments. These are critical skills they will require to be successful in their future prospective workplaces

Improved problem solving skills

Entry-level students are required to master their problem solving skills in order to be successful in Introductory Programming courses (Lishinski, Yadav, Enbody, & Good, 2016; McCracken et al., 2001). Studies have shown that failure to acquire these skills at the early stage of their university life force them to drop out of this course (Morgado & Barbosa, 2012; Yadin, 2011). Students have indicated that GIL approach employed in teaching this Introductory Programming course had improved their problem solving skills and gave them confidence in continuing with the programme. Assessments made through the themes drawn from student responses such as 'GIL helped in understanding the problem domain better', 'improved analytical skills and 'group sessions assisted student while doing home works' are clear indicators that the GIL has improved substantially students' overall problem solving skills.

Group sessions encouraged/motivated to prepare well for the class

Lack of motivation at the early stages of their study is viewed as a contributing factor by many authors to students failing to pursue programming courses in their later stages of studies (Rahman, Anuar, & Said, 2018; Settle, Vihavainen, & Sorva, 2014).

In a typical GIL class, after the introduction of the new topic, students were given fresh challenges such as problems to solve or discuss the topic further. Students were also given homework to prepare for the next class. Students were expected to participate in discussions in the form of inquiring and answering. Most of the students indicated that this mode of practice motivated them to do the homework and encouraged them to prepare well for the next class, so that they would not feel left behind from the fellow group members. This was evident from their responses such as the following:

> FG1 P1: *Group sessions "motivated me in such a way to wake up every day and be able to come to the class, because we have got so lot in common and we have got so much to do like…while we are trying to solve a problem….when we are trying to solve the problem, like we discuss first and then see which one is better than other one. So, it was more of like of a competition, but in a good way. So, that motivate us, that motivate me, in particular to be able to come and return"*
>
> He goes on to say *"..It's good, it's exciting and it's also challenging, because obviously everyone is gonna try to be better than someone else. So, people work harder to impress the group basically"*
>
> FG1 P3: *".. working with other people could improve your way of learning, and in that we felt comfortable when we were with each other"*
>
> FG1 P4: *"Group works for me sir, they motivate me in a way that uhm…obviously I don't want to be like, the one that contributes the least. So, I want to be the one on top like, I want the spotlight on me. So, it will make me wanna work harder than everyone else so…and knowing that maybe this certain person works hard, so it means I have to put in times two the effort and work harder so that I can have the spotlight.. and I'm sure they will have the same mentality to work harder than me. So, it motivates me in that way..that yeah. I want to be better than like, everyone else. Everyone wants to be a winner. No one wants to be a loser."*
>
> FG2 P5: *"… let's say during the class, in a couple of questions of which one understand it properly and one answers correctly. So seeing the peers get the*

answers right, kind of motivates the person to prepare for the next lecture, so that, you have no fears of left behind in any way, that's how it the kind of motivate, the groups"

FG2 P4*: "..it motivated in that everyone in the group debate. In the discussion part. So no one just sit down and listening. So I will prepare for myself, so that I can add, contribute to the discussions. Yah… this is what I can add on"*

FG2 P2: *"It helped a lot because I know I am going to class. I am going to meet other students, that is for them to help me. If I understand the question or the problem. So I have to go them and ask the questions. Then you have to contribute, all of us."*

FG2 P1: *"It will be the place where I go back at res or at home, I won't just rest and do nothing. I have to work, so that I go back there (class).."*

FG3 P4: *"when we working as a group, you have your fault and your group members tell you your fauls and when we arrive at home then you can attend to those faults preparing for the next class. So that when you come for your next class, you will be familiar for and both understanding"*

FG3 P3: *"…getting the answer right and getting back to a position that could persuade, so that you belong to them with your understanding so when you come to the group like for example you explain to them. That is the motivation for you to tell what you understand to your group.."*

FG4 P2: *"Ok… it comes to bit of competition between us as groups. Yah. You know if you are in a group with Apiwe, you know, ok Apiwe is good that I will improve myself so that I can be also in his standard. I am in a competition with him, yah its good"*

It is evident through these responses from the students that the group sessions motivated them to prepare well and even encouraged them to engage on healthy competition academically while maintaining cordial relationships among themselves.

Changing role of a lecturer in the classroom– From solutions provider to a guide/facilitator

Traditional teaching and learning in the classroom creates a passive learning environment where the teacher/lecturer passes information to the students hoping that they would receive the information/knowledge that they are passing on (Kikuchi et al., 2016). In a GIL approach, the teacher is no longer the 'provider' of information or solutions, rather a guide who makes sure learners do not deviate from the required task and invokes their thinking by asking thought provoking questions (Khan and O'Rourke, 2004). Though students were not used to this kind of a learning process, their responses as given below show they appreciated this new learning environment and acknowledged this assisted them in improving their own learning skills:

> FG1 P3: *"fortunately enough, our teacher, does not spoon feed us. He let us to think on our own and ask us more questions but not give the solutions, and that helped us to analyse the problem better, because we know that we have to come up with a solution"*
>
> FG2 P2: *"..the other thing sir..the lecturer goes around and check what we are doing sir. But he never give us answer.. but ask us more questions and at first I couldn't understand this, because we always get answers from tachers. But later I realise that it was good. It forced me to think and find solutions. Now I ask similar questions to myself when I get a problem to solve and get to the answer easily*".
>
> FG4 P4: *"..it is also good for us to ask (the lecturer) if you don't understand the question"*
>
> FG4 P2: *"I think if we are all confused about certain problem, we will call the lecturer so that he can guide us in the right way and that's where we kind of ok..ok "*
>
> FG4 P1: *"Actually he (lecturer) hasn't really given us the answer. He guides*
>
> FG4 P2: *"Yes he (lecturer) guides us. Yah"*

This way of learning was a complete departure from the traditional learning environment the students were so used to. But they appreciated the benefits that this brought to them. They see themselves as the solution generators rather than seeing themselves as the solution seekers.

Helped students cope with the new challenges and expectations of being in HE

Entry-level students enter higher education sector not knowing the challenges and expectations of the new environment. This in itself is a major stumbling block in coping with the new environment during the early days of their university life. The non-familiar HE environment coupled with the demands of a non-familiar subject area such as the one offered through Introduction to Programming have the potential to discourage these learners further and add more pressure on them (Jenkins, 2002). Many studies have identified this as one of the reasons contributing towards high attrition rates among entry-level programming students (D'Souza, Hamilton, Harland & Muir, 2008; Jenkins,2002). But the collaborative learning environment created through GIL approach in this study has proven to be effective in addressing these challenges. Students' responses as given in verbatim below confirm this:

> FG1 P1: *"..socializing with people makes you learn more and makes you more comfortable…. Socialising with them…and yeah…. it will help you with your pressure basically because if your peers are there you will have less pressure"*
> *FG1 P4: "The fact that we are interdependent with each other help us when we are in groups. So that you know that you need him as well as he needs you so It helped us like, to communicate well, try and explain to each other our maybe fears and expectations at varsity. Our strains or how far like or how you would like to take our careers in IT and as ….it helped us to be more comfortable with each other; to know our weaknesses and to know who got our backs"*
>
> FG2 P5: *"Hm I for one, when you come from my school straight into the University, you kind of feel that you don't belong either.…But having a group to interact with in the class, that kind of made the person feel that if they don't go to school they will miss out on a lot, but when you are here, you just enjoy yourself, because you are having a good company. And it is said that there are*

many activities which happen in the University, but having a group to help you to through certain things you don't really succumb to the peer pressure of the things that happen in and outside of the University."

FG2 P4*: " (GIL environment) helped me .. because, when I came here the first day, I didn't know anyone. I would just sit here alone, and when the group started, I start chatting to the guys, and get being friends, and now I am confident, and get undepressed easy"*

FG3 P4*: "it happened to me as a surprise. Because when I came here I expected to feel that loneliness for quite some time, because I don't know people, and I don't know who will approach me first, I don't know who to approach. So working as a group, now we didn't have an option, but to interact. Interacting as a group really helped, because now interacting and then we created some relationships in between the groups so that we can talk and interact with our own idea. So it reduced the fear I had"*

FG3 P1: *"Yah..when you arrived, you are bit nervous. To communicate to people. But in the groups, everybody is speaking same as you is. So there isn't too much pressure. Because after a while, you feel like talking to one of your own people"*

FG4 P3: *"…it has lowered the level of pressure you had, because you were like, ok I am on my own.. you just always constantly thinking about it. It worries you in the fact that you lose focus when you are by yourself. Then in the group, there is less pressure on you. You are more relaxed to work and interact with others".*

GIL improved oral communication skills

Programming/software development at the industry/workplace is often not done as a solitary process. There is always a group working on a specific objective but individuals are allocated with sections of the major task (Anewalt & Polack, 2017). So communication skill is an important soft skill a programming graduate must possess (Zarb, Hughes, & Richards, 2014). Considering the disadvantaged background the students are hailing from, the graduates coming out of the institutions such as where this study was conducted face communication skills as a major challenge in their success. Students indicated that GIL sessions had not only assisted them in mastering the course content, but also developed them in other areas. They were encouraged to participate in group sessions with ‘strangers’ who became peers, that in turn gave them confidence in expressing themselves in front of other people. This was evident through the following responses from students:

> FG1 P1: *“It helped a lot in terms of oral and presentation, and being able to listen to each other…being able to express what you feel, because each one of us get a chance to speak what she/he thinks about a particular problem. So, it impacted us to be able to communicate with each other, to give each other a chance and be able to communicate well - not having miscommunication or whatsoever.”*

> FG1 P3: *“It helps in terms of confidence, because in terms of confidence, being confident about what you think about that particular thing that we are doing and in terms of debating hope? I have learned to stand up for something that I have said. Now I am able to stand in front of people and talk, without being scared or something”*

> FG2 P5: *“Well you get different kinds of people, you get people out there, socialising people. Then there are people that are kind of shy. But the way that this group thing had helped us, that everyone became confident in themselves, and they were able to project yourselves, were able to interact when there is a discussion…”*

> FG2 P2: *“I prefer reading than talking. these group discussions helped me a lot. Because now, I have gained confidence, I can talk with people and collaborate with them”*

> FG3 P3: *“some of us English is not our first language it is our second language. As we engage in our group it improved our communication skills. Some of us are shy, we are not able to speak out. But now we can speak out fluently and could put our idea across so that everyone present could hear you”*

FG3 P3: *"It also improves your listening skills, like when someone discusses, you have to pay attention to them and give them the chance to put their idea across, and this will like at the end of the day if those same people to listen to you have to listen as well."*

FG4 P4*: "Some people, we did not have good communication skills, but when we were in groups, we managed to get some benefits. We are not scared (now)."*

FG4 P1: *"Some of us come here from rural areas or whatever schools. So we come over here not confident of our English. When we are in class, we need to speak English. Like when we communicate, we need to speak in English most. So we are more fluent now. Speaking with our friends, when we are in a group, when I say some wrong words, obviously they are going to laugh me for a while, then after a while they are going to correct me, no dude, this is not the way you suppose to say, this is supposed to say in this way. In that sense, it influenced my vocabulary, improved my oral sense, and made me more fluent with my English and whoever we are communicating with"*

Most of the students hail from the rural parts of South Africa with schools that are characterised by lack of facilities both in terms of skilled and experienced teachers and infrastructure due to the legacy of the apartheid system. Students openly admitting that their language proficiency was not up to the standard and then seeing themselves improving on their communication skills and gaining confidence in the language of instruction at the university (English), which is the most commonly used language at their future workplace/s as well is encouraging.

Transformation from being an introvert to expressing oneself freely.

Communication and conversations among students themselves are influenced by the personality traits of students such as being an introvert or extrovert. Studies have shown that extrovert students tend to be more successful than the introverts (Overbaugh & Lin, 2006). Being able to communicate well is an enabler to be successful once these students are at their future workplace since software development industry by nature involves group work (Anewalt & Polack, 2017). GIL approach in teaching the Introductory Programming course has assisted the introvert students to come out of their shells and express themselves freely. The following responses from students as given below indicate this:

> FG1 P2: *"…basically, first thing is because… I am not talkative Sir. I am a shy kind of a person. This too helped me to develop an interest, to educate myself to work and give me a chance to talk Sir".*

> FG2 P5: *"Well you get different kinds of people, you get people out there, socialising people. Then there are people that are kind of shy. But the way that this group thing had helped us, that everyone became confident in themselves, and they were able to project yourselves, were able to interact when there is a discussion and they were able to how can I put this.. but basically what I am saying is, everyone eventually became comfortable themselves and with the group and we were able to interact each other, helped in communications"*

> FG2 P4: *"From my side, I am a shy person to talk. I get confidence through talking to both group members and then talking to a class. My confidence grew as time goes. Now I can say I am bit confident myself. I can talk in front of many too"*

> FG3 P3: *"..for some of us English is not our first language it is our second language. As we engage in our group it improved our communication skills. Some of us are shy, we are not able to speak out. But now we can speak out fluently and could put our idea across so that everyone present could hear you"*

> FG4 P1: *"…now some of the people that were reserved at the beginning of the year are now interacting with us, and we are in a group and each and every one of us knows the other person in our class"*

> FG 4 P2 (pointing at another student): *"..I saw him in the beginning of the year, you know he was not like present, he was reserved, he was shy in the way, but now, it's a different story".*

All: (laugh)

P2: *"He participates even more than anyone else now. You get to improve you know".*

P3: *"I think; I was very quiet at the beginning of the year. I didn't like raising my hands and answering questions. Through the interactions, I became more open".*

Sub research question 3: What would be the strength and weakness of GIL in the learning and teaching context of Introduction to Programming course?

Data was gathered to identify the strengths and weaknesses of adopting GIL approach in teaching an Introductory Programming course for students. Students have indicated several benefits they have gained by learning this course through GIL approach. Most of the students even indicated that they prefer to learn other courses using GIL approach.

The following themes were emerged from focus group interviews that addresses the sub research question 3.

Entry-level students' transition into an all new environment of a HEI

One of the major challenges faced by entry-level students is the sudden transition from a familiar schooling environment to an all new HEI environment. Many authors have cited that students' struggles in coping with the new environment during their early days of university life coupled with the challenging demands of Introductory Programming courses demotivate them and result in many students surrendering or dropping out (D'Souza, Hamilton, Harland & Muir, 2008; Jenkins,2002). But the collaborative environment created through GIL sessions enabled them to make friendships with 'strangers' so easily and that assisted them in engaging the subject matter with confidence. This is evident through the following responses:

FG1 P3: *"It created a strong friendship from very beginning..yah of the year. I had people who call sisters because we were so relaxed when we were with each other.."*

FG1: P1: *"It also built chemistry within us as students because . Now, let's say we have break or recess, and we are just chilling, we are just talking, let's say we are talking about something else whereas when we are going to class. You go to a person, knowing that person. So, you understand them and you know… So…chilling and doing group works, also like she said, builds friendships and everything…yeah"*

FG1 P3: *"The interaction amongst us was the best because, as they said, we've got the chance to know each other better, to know like, our strong points and weaknesses are when it comes to programming. So we know as a group, when it comes to maybe to floated? maybe he's good on this and she's good on this so when the problem come we know who can explain it better to us…"*

FG2 P5: *".. we got to know each other and became easier for us to interact and share ideas and scenarios. Yah"*

FG3 P2: *"Everyone tend to talk like if we are stuck with something. Everyone is gonna give their opinion and discuss it, come to an answer and then we do it".*

FG4 P2: *"We learned to. Learned from our differences, we didn't come to the class knowing each and every one of us. We didn't know each other, but when we were in groups, sat down and got to experience how Amos is like, got to see how Apiwe is like, how interactive he is and how he deals with us, and what not.."*

GIL helped in understanding the problem domain better

Programming is inherently problem solving intensive. Problem solving is one of the major challenges the entry-level programming learners are faced with. Studies have shown that entry-level students even fail to understand the problem scenario and what it demands from them in full and that eventually results in them failing to come up with a solution to the problem at hand (Lishinski, Yadav, Enbody, & Good, 2016; Lister et al., 2004; McCracken et al., 2001). Majority of the students have indicated that GIL sessions have assisted them in decomposing the complexity of the questions and the problem scenario through different views expressed of the scenario by way of peer discussions. This is evident through their verbatim responses as given below:

> FG3 P4: *"…before there was Inquiry learning, we didn't approach the problem, I myself I didn't approach the problem, I just look at the question and attack it. But after this learning, I learned the approach of approaching a problem…"*

> FG3 P3: *"And when you are solving a problem.... first you have to read and understand the question before you try to do anything, make sure you understand the question, if you don't read and understand the question, problem is that you have 90 percent of the chance of answering something else. So we discuss between ourselves and clarify issues in the problem..yah that way…"*

> FG4 P1*: "…there is like different minds over here. So the way she understands the problem, is different from the way I understand the problem. So with me in a group, with other students, we gonna come back as a group and try and break it down. Obviously in her understanding she is gonna tell me something I didn't understand in my understanding. And in that way we gonna find a solution for us to tackle the problem"*

> FG4 P3: *"I think it (GIL approach) had a positive impact. Certain students might misunderstand the question, or let us say we didn't understand it at all. But when we are in a group, we get to explain to each other in different ways and ask questions and come up with a solution that we all going to understand and so that a person can see, … And it is better that way, because we did it all together. Yah, so it makes it more easier to understand when people are explaining it to you"*

GIL improved students' analytical skills

One of the critical skills required in mastering problem solving is the ability to critically analyse the problem scenario. Studies have shown that demand of such higher level skills at early stages of learning to program demotivates entry-level students and eventually leads them to surrender (Gomes & Mendes, 2007; Lishinski, Yadav, Enbody, & Good, 2016). Majority of the students appreciated the collaborative active environment created through GIL sessions and how it improved their analytical skills. This is evident through their responses as given below:

> FG1 P1: *".. unlike when you are on your own, you are just given a problem and you just pre-assume that maybe it needs this and that and then you just do it the way you think it is and maybe that's not the correct way. But when you are in a group like, we analyse it better and we try to figure it out…. what is the more complex or the more appropriate solution to try to solve the particular problem. Then we came up with different ideas and then we vary them and choose the correct one."*

> FG1 P2: *"when we are in our groups we analyse problems and try to come up with different ways to solve this problem.."*

> FG2 P4: *"…when we are there as a group, someone will be not understand the certain part, then he will ask me to explain to him or her, then I will see that I made a mistake when I explain it to him/her. And we can try and analyse problem thoroughly, and broke it down to smaller pieces, then solve it."*

> FG2 P2: *"… when we are working with the problem scenario in the group, we first start by asking ourselves questions…try to figure out scenario better..we ask questions to my group members…we break the problem into sections by answering my friend's and my questions..then…yes…that way..*

> FG2 P5: *"Getting to elaborate on what he has said, you are able to break down the question into pieces, just so that you could see, what input is needed in the sort of problem we are dealing with, output and processing all of that. So that we cannot just rush into things, because, that's where you get thing wrong. So*

it kind helps to read the question over and over to be understood it fully, then answer the questions"

FG2 P2: *" if we are doing the pseudocode, we ask questions like, what are the objectives, the inputs and outputs. So we don't just go through the question, and write it down without asking questions. So it helped a lot"*

FG3 P4: *"when were doing the problem, they would seem to be big… he would first ask us some questions regarding the input then what we need to accept then output and in that manner we would analyse the problem more easily and then get to the solution more easily"*

FG4 P2: *" Ok, at first me personally, when I see a problem, I analyse it ok this is how I can do it. But when we sat with the group, then we discuss it and we explain it, and understand it and analyse it in a different way than I did it before. Rather than quickly judging the problem, and say I can't do it, its hard, I sit down and understand it in different sections, so that I can understand"*

FG4 P1*: "..I used to look at a problem as a whole, but in groups we put it into sections and make it more easier and we combine the work as a whole. That way you solve the problem easier".*

Adopting GIL in other courses

Generally, students feel that it would be beneficial if GIL could be adopted as a teaching approach in other courses. They indicated that with other courses (taught using traditional teaching methods) there was no opportunity for group interactions and they did not have much of an opportunity to share ideas with one another. The following responses from students indicate that they believed the GIL approach could benefit them in many other courses:

FG1 P1*: "It will be perfect if we can adopt it (GIL) to our other courses as well…. if we can do it in other courses as well it can be better on how we understand other course material"*

FG2 P5: *"I think it would be very helpful in other courses. Because, in development software, there is a kind of bond amongst the students and the lecturer whereas in other courses, there isn't that bond whereby one can really feel free to ask questions and interact with the lecturer and other students. If were to adopt it to other courses, it would be easier for us to ask questions if we don't understand certain aspects of the work. It would definitely improve our marks as a whole"*

FG3 P4: *"…the way that we use it in learning this subject, we are not only using it in Development software, but also using that approach in other subjects".*

From the responses it is clear that though GIL was not introduced in other courses, students used the experiences they gained through this course and created their own groups in other courses.

Inquiry as a way to analyse problem scenario

Once a problem was given to be solved, they started analysing the problem scenario by asking questions among themselves. Answering these questions eventually lead to better understanding and analysing the problem scenario. This way of analysis has improved their analysis skills. Accurate analysis of the problem scenario is the precursor to an accurate solution. The following student responses as given below in verbatim confirm this:

FG1 P1: *"..We are given a problem there. Our first step is to - what is our output. We have to check what should be the final result of this problem. And When we get to that point where, okay, - in this problem we want this, to be the output so Now, as a group we are going to discuss how do we move from problem to output. So, basically how do you move from input to output? So, we will ask questions.."*

FG1 P2: *"we explain sir, explain what is needed. What is actually asked here sir. Then we explain to all of us, then everyone understands then you…so that we can all be able to contribute, sir. Come up with What you are thinking about this"*

FG2 P2: *"We read it may be three or four times and ask ourselves some questions. What is required, what are the inputs for this, what are the processing needs to be done to get to the required answer?"*

FG2 P1: *"What is important is in one understand the question. Just analyse it and say what is expected from us?"*

FG3 P2: *"What we do that we ask ourselves first questions, when we find answers to that questions, then we will find answers to subsequent questions we ask ourselves. We ask ourselves questions and try to answer and find other questions to get what needs to be found, accepted.."*

FG4 P3: *" … (we) read through the question thoroughly and make sure that we all understand what the question requires of us..we start asking questions sir…then someone try to answer like how he thinks what is required..then keep asking till we understand everything about the problem and requirements sir…."*

Students way of understanding and analysing the questions at hand was inquiry. Inquiry inspired the thought process and that led to subsequent queries and trying to get answers to their own queries led to the clear understanding and analysis of the problem scenario.

GIL Weaknesses

Despite the different benefits identified by students of using GIL, it was observed that such an approach can have negative effects on students. Such disadvantages include depending on others and that, GIL may not be applicable to other courses. Themes that emerged to this effect are:

Dependency syndrome

Some students felt that they might end up failing to work on their own. Instead, they would prefer to work with others in groups. This could be due to the fact that some students might see groups sessions as a way of getting others to work for them. This sentiment was not shared by many students, but very few of them concurred with this view. Few responses gathered from students suggest this tendency as given below:

FG3 P5: *"When I am in the group, if I don't understand this section, some people will explain it to me then I will get the answers. But when I am alone, I just become hard. Because I am used in doing it as a group. Getting different options, etc"*
FG4 P3: *"..it is also negative in the fact that, when you are alone, you tend to underestimate yourself and you find it harder to work alone".*

FG4 P2: *"You get lazy. You get bored when you are alone. You used to be in the group. You used add on to your knowledge, you add it to them. And when you are at home alone doing it, you just get lazy like if Amos was here, I will probably doing this, and you just settle, ok I will probably do it in the class"*

GIL may not be applicable to other courses

Though most of the students felt GIL could benefit them in other courses, very few of them felt that GIL may not be applicable in other courses. There seems to be a perception that GIL can work well in a practical or a technical subject that involves problem solving and/or calculations. The following responses from a few students point towards this view:

FG3 P4: *"I don't think it would do great for me in other subjects because Development Software is programming and it not theory. Some other subjects are theory, whereby you have to read and understand what you are reading and then. You just know the answers, there is one way of answering. So we won't have something to interact with others"*
This view was challenged by other students from the same focus group though.

FG4 P4: *"I think, it could help but I don't think for every other subjects. Subjects like for system software for example. It is just basically questions, and you just have to study and read. The more you read the more you understanding. So I don't think it would be of much help there, in that sense"*

FG4 P3: *"Yah some people prefer being studying alone, like for system software. But in IT skills, where there is like calculations, I am sure it will help. We are not very good at Maths"*

This view can be down to the fact that; GIL was only tested on a programming course.

4.5 Summary

This chapter presented results obtained during the collection of data. A summary of the biographical data was given. Data collected were analysed and presented to establish the influence of GIL on student performance; motivation, confidence and communication skills, and respective advantages and disadvantages. In terms of performance, GIL yielded an 89% pass rate while the traditional learning approach had a 52% overall pass rate. GIL's pass rate is above the global pass rate of 67.7% for programming courses as established in the literature review of Chapter two. The traditional teaching method had a higher failure rate (48%) compared to the mean global failure and dropout rate of 32.3%. South Africa's failure rate is approximately 45%, a percentage that is close to the one found in this study. This finding suggests that GIL can help improve students' performance in Introductory Programming courses.

The literature review of Chapter two identified different reasons for students to fail. Of interest is a finding that GIL managed to address some of the core factors contributing to students' failure. GIL not only assisted the students in understanding introductory programming concepts and principles but also in applying this knowledge in problem solving. These were supported by both the quantitative and qualitative data collected. GIL approach motivated students, enhanced their confidence and assisted them in improving their communication skills. GIL helped students adjust to university life as the pressure of being in a new environment was to a good extent was alleviated through the introduction /exposure to the group sessions at their early stage of university studies.

In the next chapter, the findings will be discussed and interpreted, a proposed conceptual framework to implement GIL approach in similar context will be presented and recommendations for further study will be proposed.

CHAPTER FIVE

Conclusion, Recommendations and Achievements

5.1 Introduction

Through the previous chapter the collected data were presented, interpreted and analysed. This chapter concludes the research work on the framework for GIL in teaching Introduction to Programming at a university in South Africa and provides the research conclusions. The chapter outlines how each of the research objectives stated in Chapter one were achieved. Scientific, methodological and substantive reflections that conclude the research work are discussed in this chapter. A few challenges were encountered during the completion of this work, and it is stated in this chapter. Finally, the recommended framework to the academic stakeholders as well as further research work is provided. The frameworks add to the research contribution as it provides a clear step by step process on how other academic lecturers could learn and adopt the GIL in other courses.

5.2 Summary of Findings

The motivation for the development of the framework produced in this study arises from the fact that most developing countries face challenges regarding the integration of new learning approaches that are followed in developed countries. Though many lecturers in these countries do attempt to introduce the new teaching approaches, but with little success in many cases. What is lacking is the clear process on how to implement new teaching strategies. In fact, there is no procedure available to advise on how to apply GIL when teaching Introductory Programming courses. Findings show that GIL approach prepared the learners better than the traditional teaching technologies. The experimental group on GIL performed better and had higher average marks in all the assessments. All the learners under the GIL experimental group were able to qualify for examination admission. In this study it is clear that GIL proved to have a positive impact on learners doing Introduction to Programming course. Both qualitative and quantitative results show that the learners were motivated, confident and gained better communication skills during the course.

The research conclusion is based on how it has addressed and achieved the research questions and the objectives.

5.3 Conclusions from empirical research

The researcher was involved in teaching and has experience in the academic sector. Besides, the researcher has taught the course under consideration for a number of years. So in summarizing the empirical research findings, there is reference to the observations and experience from the researcher. Findings clearly show that the students who were engaged under the GIL had an overall better performance than the control group. As indicated in Chapter 4, in figure 4.7 on the mean scores, the average marks for the experimental groups were higher in all the assessments. In Test one and three the average differences between the two groups was smaller. It was the smallest in Test one where for the experimental group the average mark was 65% and for the control group 64%. This could be due to the students in the experimental group still adjusting to the GIL approach. It could also be considered as an important conclusion that, for GIL to be successfully implemented, there is need to invest time in understanding the learners and for the lecturers to clearly have the proper guidance on how GIL should be applied.

Additionally, despite there being no statistical significance for Test one between experimental and control groups, it is clear on Table 4.9 that all the learners in the experimental group passed the test. The four who failed come from the control group. An almost similar observation is found regarding Test three where only three out of 19 within the experimental group failed while 12 out of 17 failed within the control group (ref. Table 4.13). To support this, findings from the focus groups show that learners were confident and self-motivated to write their own programs using the skills obtained through GIL approach.

5.4 Conclusions from literature review

Considering the current literature, it is evident that the education system is very complicated and there are different approaches in teaching and learning. But, there is no one size fits all approach. It is evident that learners find it difficult to master introductory programming skills though lecturers and researchers have made efforts to address these challenges. Despite all the efforts and existing best teaching approaches, Introduction to Programming at HEIs remains one of the most failed courses in CS and IT related fields. Figure 2.1 in Chapter 2 shows the statistics on learners' performance and failure rate on Introductory Programming courses globally. The global programming non-pass rate is close to 35% and in South Africa alone it is an average of 45%.

Based on the conclusions from the empirical research and literature review, it is clear that results from the assessments and the statistics as explained in Chapter 4 show that GIL worked. To further summarise the findings and the overall study, the indicated research questions are revisited. These are the originally mentioned questions in Chapter 1.

5.5 Conclusions based on Research Questions

In order to address the problem mentioned above the research questions were proposed as follows:

The main research question was:

How can the Guided Inquiry Learning (GIL) be applied in teaching Introduction to Programming course to enhance academic performance of entry-level students at HEIs?

The main research question was read in line with the main research objective, which was to: Design a novel framework using a variant of GIL to enhance programming skills and performance among learners. In this final Chapter, it is also clear that both the main research question and objectives were achieved. Later in this chapter, the proposed framework shows how the main objective and question were addressed.

Sub research questions necessary to support the main research question were:

1. *What would be the differences in academic achievement between students taught traditionally and those taught using GIL approach?*

This was addressed by the collected assessment results and the themes that emerged through focus groups interviews. Statistical data analysis as indicated in Chapter 4, shows that there is a significant difference between the learners that were engaged using GIL and the one taught using traditional approach. The performance of the experimental group was far better than those in the control group. As indicated through Table 4.20; the final achievement result for the experimental group was almost 90% as compared to the control groups' pass rate of less than 52%. Achievement results obtained by experimental group is much higher than both the global and South African average achievement rates of 67.7% and 55% respectively as reported by Watson and Li (2014) for an Introductory Programming course. It was evident that the overall performance also improved as indicated by the final pass rate of almost 67% for both groups (combined), which is higher than the average pass rate of other previous years (46.88%) as was reported in Chapter 1 of this dissertation. This should be attributed to the high pass rates achieved by the experimental group.

These findings are corroborated through the following themes emerged from the focus groups interviews indicated through section 4.4

a. Group sessions helped understand the subject content better
b. Group session experience assisted students while doing their home works alone
c. Appreciated alternative problem solving approaches
d. Social networking platform to facilitate GIL sessions

As evident through the themes listed above, students overwhelmingly agreed that the GIL approach in teaching the Introductory Programming course assisted them in understanding the underlying theories and principles of the course and improved their problem solving skills.

2. *What would be the effect of GIL approach on student's confidence, motivation and communication skills related to introduction to programming?*

The terms motivation, confidence and communication are well linked and lead to one goal for students which is their success in the academic course as explained through the literature in chapter two. Motivation affects students' success. Receiving a final incentive such as passing a course is an indicator of learners' extrinsic motivation (Winn, 2002). Final pass rate for experimental group (90%) was far better than that obtained by the control group (52%). This is an indication that students who participated with the study were motivated in GIL approach in teaching Introduction to

Programming course. Findings of another researcher from the same institution who experimented with a similar approach in an Engineering programme (Louw, 2012) corroborated this.

Through communication, students learn from each other and acquire different skills and their confidence will grow and become more motivated (Dorneyi & Thurrel, 1994). The qualitative findings from the focus groups proved that the learners were motivated and confident after engaging in this new way of teaching and learning. It was found that when students were more actively involved in the learning process, they learned new concepts easier and understood the work better. This view was corroborated by many researchers who studies on active learning (Charlevoix, Strey, & Mills, 2009; De Weck, Young, & Adams, 2003). The following themes that emerged from the focus group interviews as given under Section 4.4 indicated that GIL approach resulted in improved confidence, motivation and communication skills among the students:

a. (GIL approach) generated self-belief and confidence among students to write computer programs that work
b. Built strong foundation
c. Grew in confidence to express themselves in front of others
d. Improved problem solving skills
e. Groups sessions encouraged / motivated to prepare well for the next class
f. Changing role of a lecturer in the classroom – From solutions provider to a guide/facilitator
g. Helped students cope with the new challenges and expectations of being in a HEI
h. GIL improved oral communication skills
i. Transformation from being an introvert to expressing oneself freely

Similar researches conducted by other researchers also support the findings from this study (Louw 2012; Shatila, 2007).

3. *What would be the strengths and weaknesses of GIL in the learning and teaching context of Introduction to Programming course?*

Both quantitative and qualitative results show the summary of the strengths and few weaknesses of the GIL. The most important one to highlight is the strengths, which include better performances among the learners under the experimental group. Student performance throughout the year was measured through four formative tests and a summative examination and the final result indicated that adopting GIL approach improved performance as compared to the traditional approach. The statistical results in Chapter 4 show the differences. For example, the mean scores of all assessments throughout the year for experimental group were higher than that of control group. The standard deviation calculated of mean scores of assessments were all considerably less than that of the control group as indicated through Table 4.22. These factors indicated that GIL approach not only improved the average performance of the entire experimental group but also closely and collectively improved the performance of all students as compared to the traditional teaching approach. These findings corroborated with the findings of a similar study conducted by Louw (2012).

Additionally, the focus group qualitative results also show that the experimental group learners were very confident and motivated to go out and share what they have learnt. The participants showed that they had gained from learning in groups and recommended if GIL could be applied in other courses as well. The following themes that emerged from the focus groups interviews as indicated through Section 4.4, corroborate the quantitative findings:

a. (GIL enabled to cope with the challenges of) entry-level students' transition into the all new environment of a HEI
b. GIL helped in understanding the problem domain better
c. GIL improved students' analytical skills
d. (Recommends) adopting GIL in other courses
e. Inquiry as a way to analyse problem scenarios

However, focus group interview responses also revealed some of the weakness of this approach. The following themes that emerged indicate the weaknesses of this approach:

a. (Students') Dependency syndrome
b. GIL may not be applicable in all the other courses

5.6 Achievements

The study has managed to apply the GIL in teaching an Introduction to Programming course. The learners were grouped and those considered to be part of the experimental group were targeted for the research. The researcher was able to design the GIL process and share with the learners. Positive findings and results came out of the research and the learners performed better and learnt better under the GIL approach. A conceptual framework that guides how GIL could be considered in teaching and learning in similar context is proposed.

The other achievements of the research are summarised based on the research objectives.

The main aim of this research is *to design a novel framework using a variant of Guided Inquiry Learning (GIL) to enhance programming skills among the entry-level programming students doing National Diploma: Information Technology at a university in the Eastern Cape Province of South Africa.*

The specific research objectives of this study are to:

- Compare and Contrast the differences in performance between students taught traditionally and those taught using GIL approach;
- Evaluate the effect of GIL approach on students' confidence, motivation and communication skills related to introduction to programming
- Assess the strengths and weaknesses of GIL in the context of students from historically disadvantaged background.

The results explained in chapter 4 and summarised in this chapter show that the set research objectives were achieved. The study managed to achieve the objectives. The main objective is addressed by the proposed conceptual GIL framework.

The sub objectives are achieved by the quantitative and qualitative data analysis as shown in Chapter 4 and summarized above in this chapter.

5.7 Limitations of the study

The notable limitations of the study are summarised in bullets form:

- Only one course was considered using GIL;
- One stream was also used for the data collection;
- The experimental group was not too big – as only 20 participants were involved;

5.8 Recommendations

The research proposes the following recommendations. These are targeted towards the university stakeholders.

- Revisit the curriculum assessment strategy
- Train lecturers on understanding modern teaching approaches such as GIL
- Redesign lecture rooms to accommodate group discussion

Finally, a recommended framework that could guide other academic personnel to implement GIL is proposed

5.9 Framework formulation

In proposing the framework, the whole research process and many findings from the study are considered. Firstly, the GIL process is outlined. The proposed framework is based on the following procedure:

- Consideration of current literature on teaching approaches;
- Consideration of the theoretical framework that has been mentioned in Chapter 2;
- Description of how GIL was applied in this study;
- Analysis of the different approaches on teaching and learning in deriving the major components of the framework;

Considering the nature of the research question and objective, there is a need to describe what a framework entails and to provide understanding as to what kind of a framework is proposed. The final product in this research is *a conceptual framework* and not a theoretical framework. However, a theoretical framework formed part of the process of deriving the final framework. It was necessary to align the research work with the selected underpinning theory to achieve one of the research objectives, hence the theoretical framework. As defined by Jabareen (2009) a conceptual framework is a network or a plane of linked concepts. A conceptual framework is something that is constructed, not found. It incorporates pieces that are borrowed from different sources, but the structure, the overall coherence, is something that the researcher builds (Maxwell, 2005). A conceptual framework is flexible by nature, it is modifiable, it puts emphasis on understanding instead of extrapolation (Jabareen, 2009). In this case for example, academics could be guided by the proposed framework and there is flexibility in introducing and applying GIL. The proposed GIL framework is also flexible in that it looks into the contradictions or gaps that are found in existing views and how the current research can make an original contribution to the body of knowledge. The proposed conceptual framework for adopting GIL in this research is developed following the steps outlined in the sections below.

5.9.1 Drawing up the framework components

The following steps were important in drawing up the proposed conceptual framework.

Mapping the selected data source

For a comprehensive process and to attain applicable output, selection of a data source in this research was based on the sources of data identified by Maxwell (2005). These are researchers’ own experience and knowledge, existing theory and research and piloting and exploratory research. Maxwell described these as the ‘sources modules’ that can help in the construction of a conceptual framework.

The researcher's own experience and knowledge in the phenomenon

As a researcher, I cannot distance myself from the research. Also, I possess ample experience and knowledge gained from real-world views of the academic sector and the university under consideration. Consequently, my experience and views are applied in the formulation of the research problem and the proposed conceptual framework in this research.

Existing theory and research

This research relied comprehensively on a review of literature on best teaching and learning practices. The theory in this case refers to a broader than it’s usual meaning in discussions of research methods. It is a structure that is intended to represent or model something. A useful theory provides a framework for making sense of what might seem not related to pieces of data or irrelevant to one another or to the research questions. In this case, the ANT helped to understand the academic sector and the identification of actors and their interest in ensuring the success of GIL. It was important to identify all actors that could participate in the GIL implementation as it helps to ensure inclusivity and alignment of processes to university goals.

Piloting and exploratory research

A pilot research or GIL experiment was conducted prior to the inception of the actual output to establish the best fit methods and strategy for the research. The pilot research led to the involvement of the research group referred to as the experimental group in this study. Focus group interview were carried out to gather the relevant data.

5.9.2 Analysis of the Guided Inquiry Learning

It was important to understand the GIL common processes and structure before proposing the framework components.

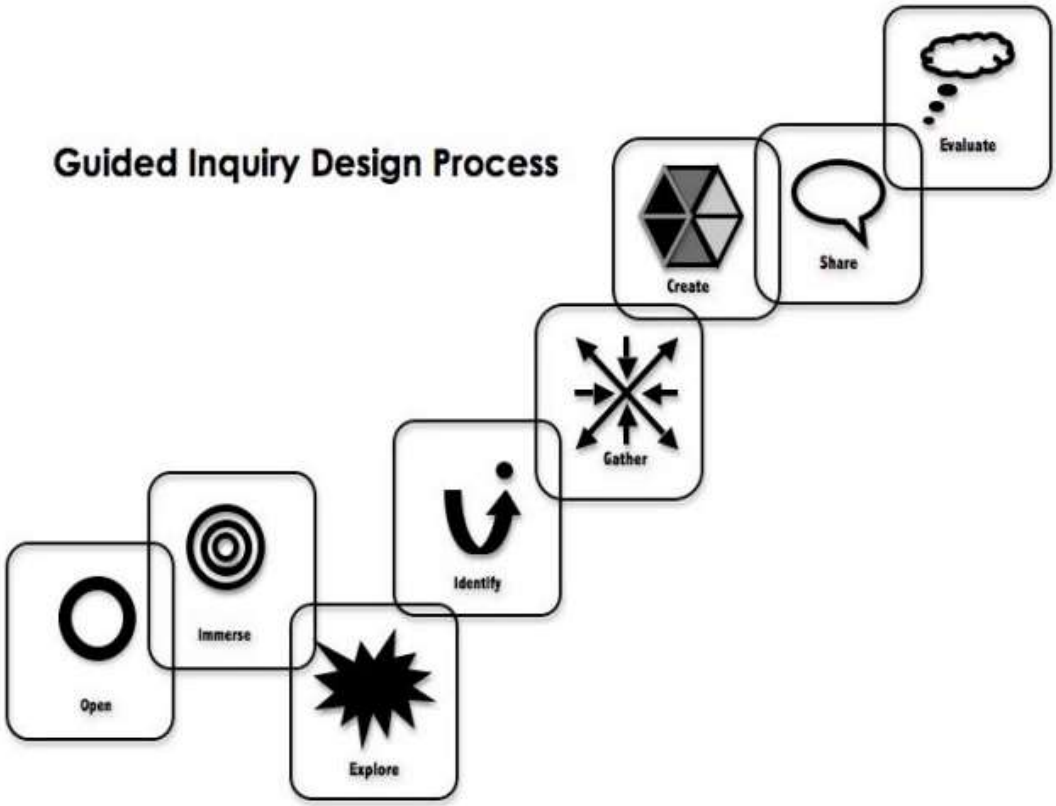

Figure 5.1: The GIL approach *(Kuhlthau, Maniotes & Caspari, 2007)*

Six Principles of GIL

- Learners are actively engaged and always have time to reflect;
- What learners know is used as the bases for further learning;
- Creative thinking is encouraged;
- Learners possess different ways and skills to learn;
- Social interactions are powerful for learners to understand concepts;
- Instructions and experience are required for learners to learn for development.

Before proposing the GIL framework, it is necessary to consider the guided inquiry process. This process helps in understanding how the GIL works and could be implemented.

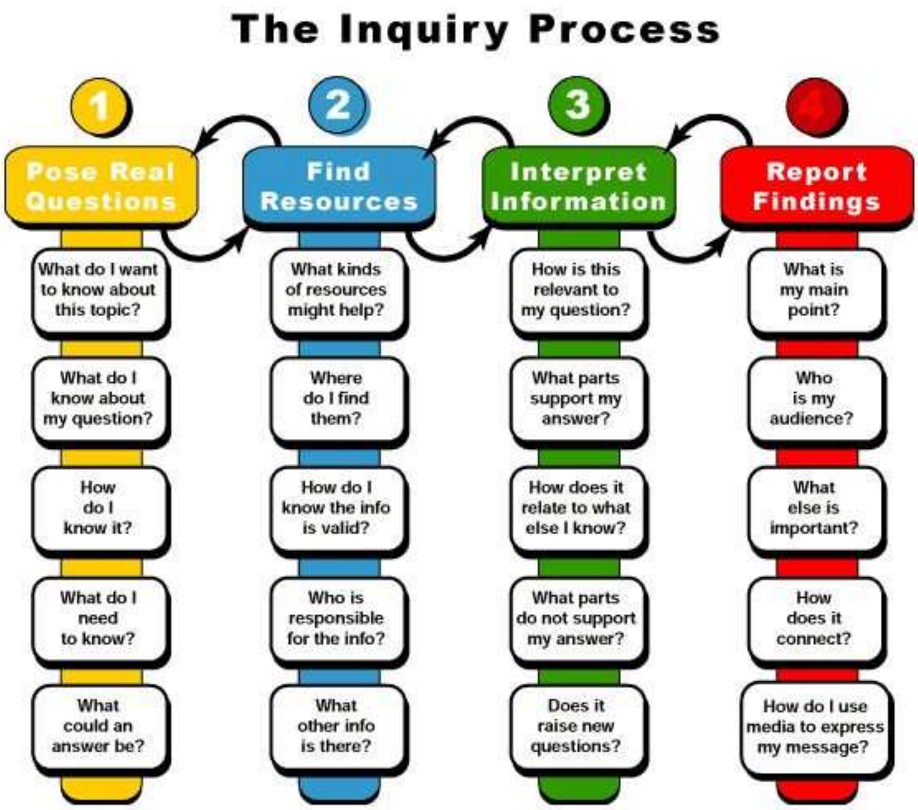

Figure 5.2: The GIL process (*Cross, 1996)*

5.9.3 Proposed Framework

5.9.3.1 Broad Applied Strategy

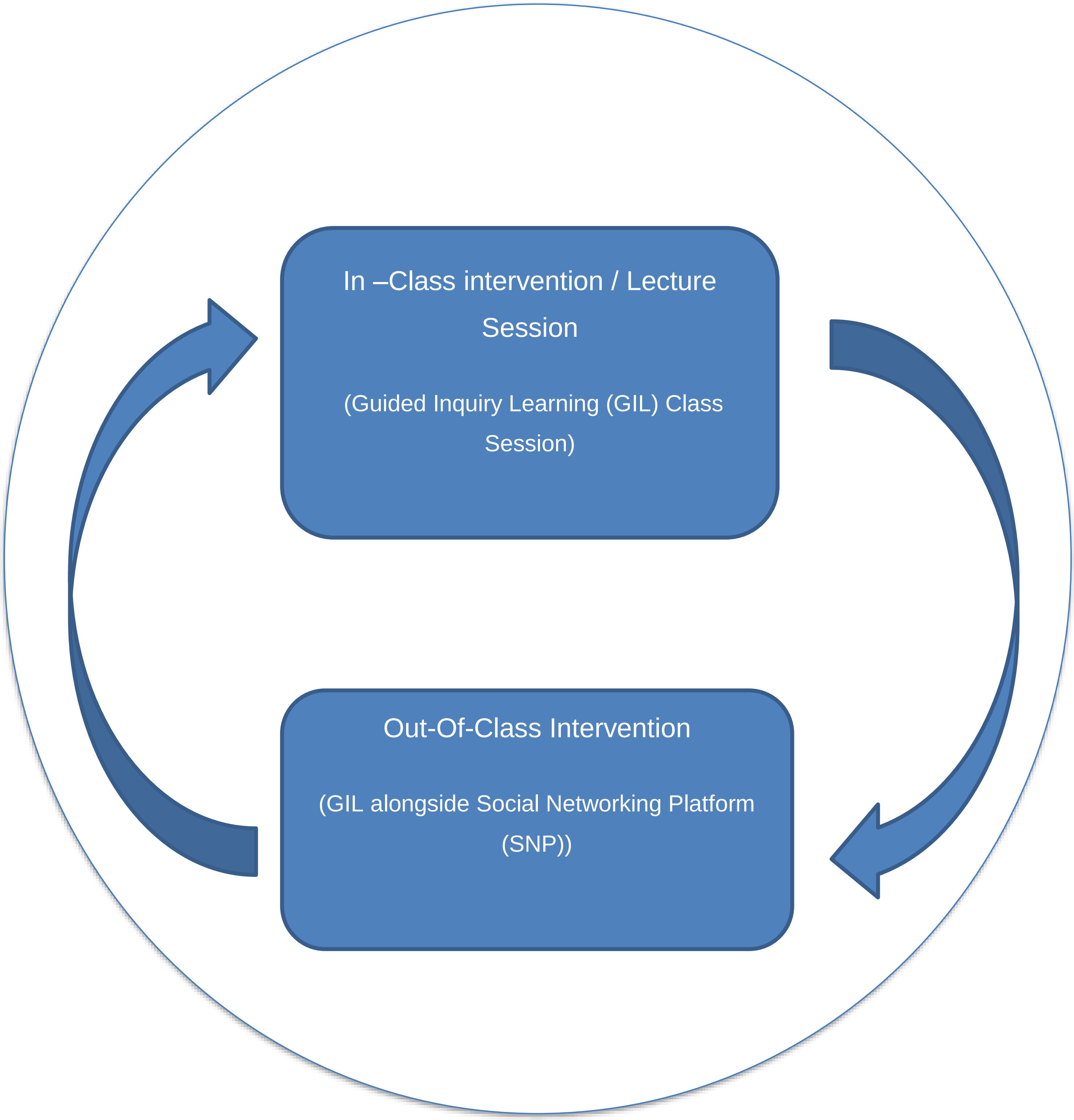

Figure 5.3: Model for Overall Intervention (Guided Inquiry Learning)

Details of this high level model is given in Figures 5.4 and 5.5

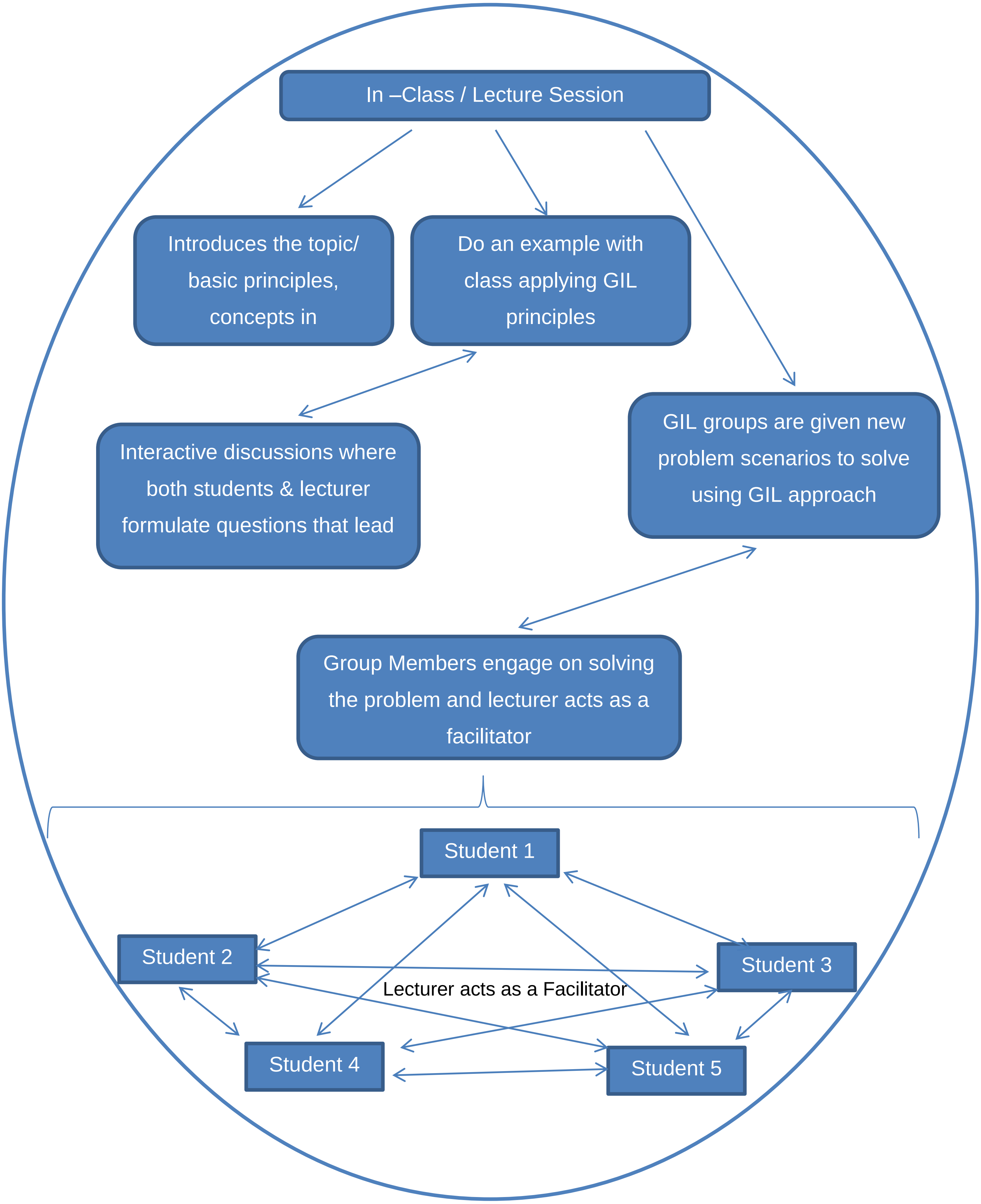

Figure 5.4: In –Class intervention / Lecture Session (Guided Inquiry Learning (GIL) Class Session)

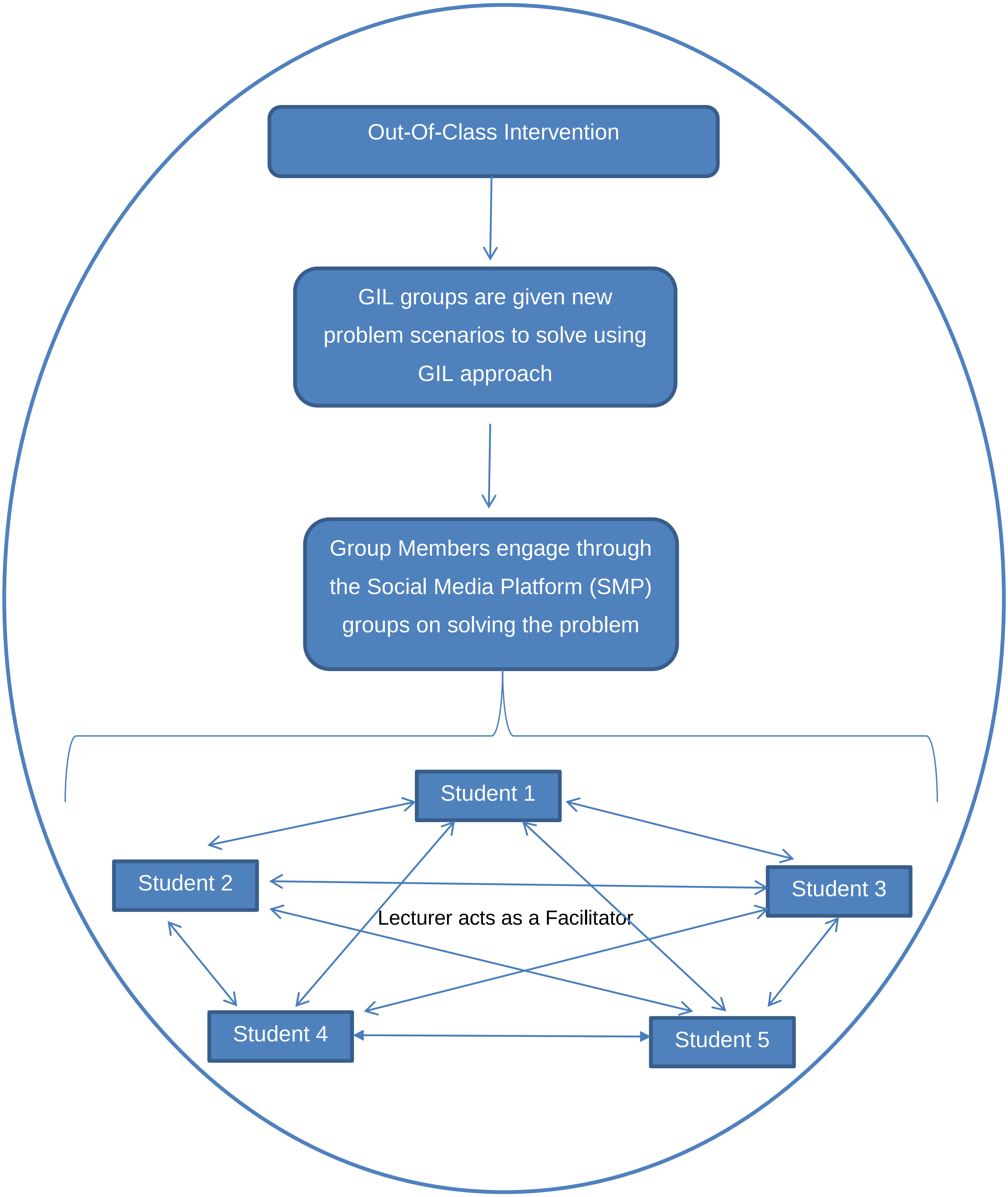

Figure 5.5: Out-Of-Class Intervention (GIL alongside Social Media Platform (SMP))

5.9.3.2 Proposed Conceptual Framework

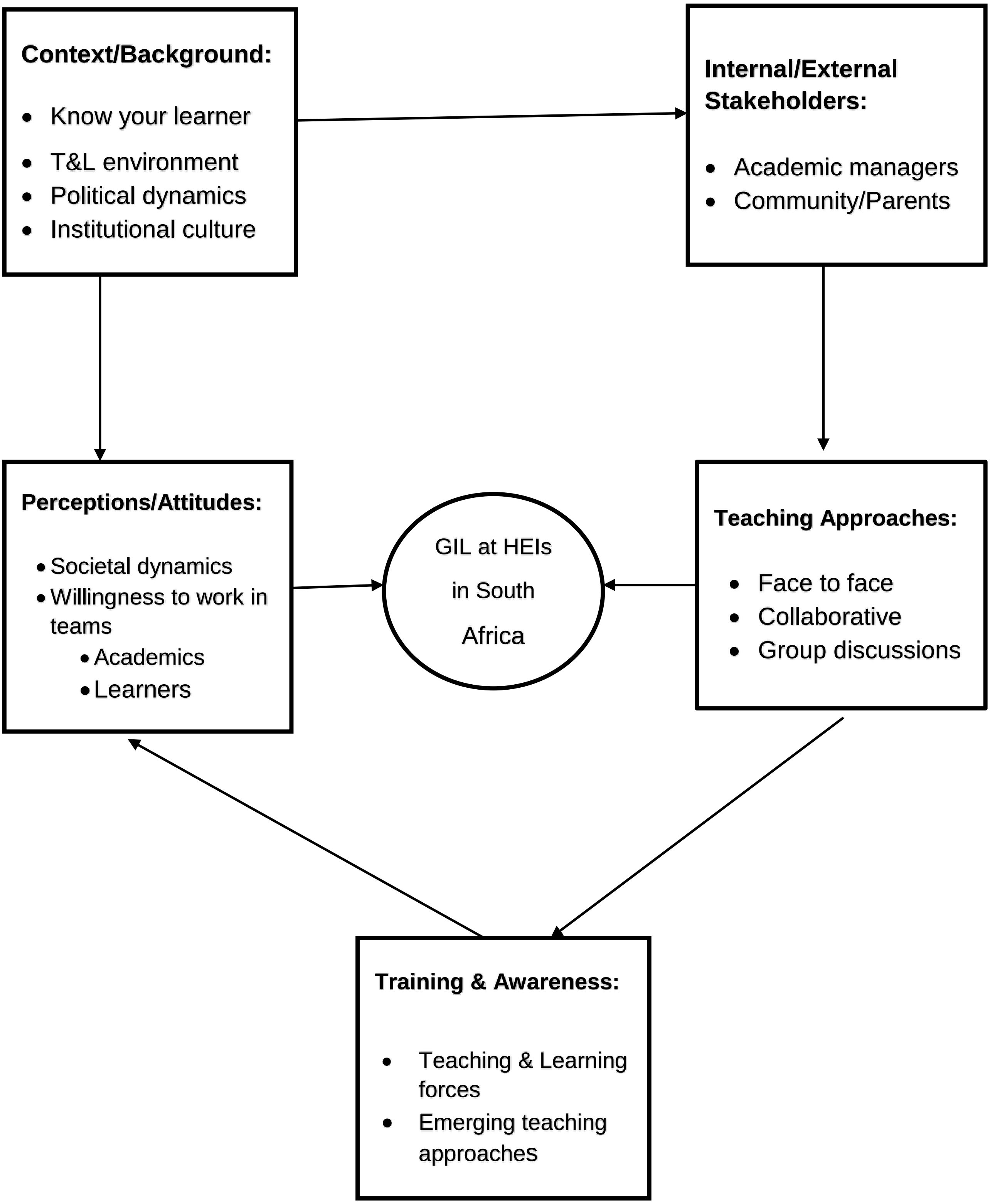

Figure 5.6: Proposed conceptual framework to implement GIL as a learning and teaching strategy in a HEI in South Africa

5.9.3.3 Description of the proposed conceptual framework components

The proposed framework components are based on the theoretical framework discussed in Chapter 2. The proposed conceptual framework is based on the possible factors that influence teaching and learning. The components are also based on different internal and external factors that influence the teaching and learning in a South African context.

The presented conceptual framework is based on social, economic, societal, technological and political factors that provide an environment for applying best teaching practices. These components are summarised as follows:

Internal and External stakeholders

It is important to consider and engage all the stakeholders that are involved in teaching and learning. These stakeholders could be internal such as lecturers, students, teaching and learning divisions and university management. Successful implementation of GIL requires engagement and involvement of stakeholders.

Context or Background

The understanding of the university background and teaching practices is important. The background of students and leaners is also important. This takes time to understand, but there is a need to invest time and effort to understand the students and lecturer's background. The success of GIL is based on the understanding of the context.

Teaching Approaches

There is a need to consider the best teaching approaches because these approaches enable students and lecturers to engage and interact with each other. In the new era of student centeredness, there is a need to clearly understand the best practices that work for both students and lecturers. GIL allows the combination of different teaching approaches and enables lecturers to introduce different teaching techniques and learners to learn differently. There is also the need to consider both the traditional and emerging teaching approaches.

Perceptions and Attitude

There is need to understand that attitude and perceptions are critical in introducing a new teaching pedagogy. Literature shows that one's attitude and perception affect the way teaching and learning could occur. These perceptions and attitude are influenced by social dynamics and one's background. Culture could also be one of the important factors. Additionally, the willingness to learn is essential in introducing GIL as this involves self-motivated team work and engaged students. The staff or lecturers have to be willing to work harder and transform the teaching and learning environment.

Training and Awareness

The final proposed component is training and awareness. There is a need for all academic stakeholders to come together and continuously sensitize the community of the changes and the best teaching practices.

5.10 Contribution to new knowledge

The study examined the effects of GIL in teaching an Introductory programming course in National Diploma studies at a South African university. The finding was that GIL approach in teaching Introductory Programming course had a positive effect on the achievement of the course outcome. The gains were significant and the results of this study contributed to the knowledge base of the best practices associated with teaching Introductory Programming courses. The results further suggest that traditional practices in teaching Introductory Programming courses found in most universities may not be the most effective methods of instruction. It should also be noted that care has to be taken when introducing GIL approach in teaching Introductory Programming courses.

For this study, to apply GIL within a traditionally disadvantaged university where learners face many challenges was also an important contribution. In addition to this, the study provided an innovative GIL framework that could be applied by other lecturers in other courses within the field of CS or IT and in courses from other disciplines.

5.12 Conclusion

The study found the adoption of the GIL approach in teaching Introductory Programming course for entry-level students at the selected site of the university is quite effective. It resulted in positive class atmosphere, engaged classroom, enhanced understanding and academic achievement. Interactive and collaborative learning environments created through GIL approach resulted in improved motivation and confidence among students and assisted them further to improve on their communication skills. It is hoped that these results will encourage other instructors from within and outside the field of ICT to consider introducing GIL in their teaching. It is further hoped that the proposed conceptual framework will assist these instructors in adopting GIL approach in their respective contexts.

5.12 Recommendations for further study

Further studies need to focus on power conflicts amongst the stakeholders and availability of resources and their implications on teaching and learning. Some other key considerations point to the need to fast-track the integration of GIL in other courses include the following:

(a) The adoption of modern teaching models or frameworks by the South African education sector for refinement and alignment of processes, technology and GIL implementation.
(b) Analysis of each teaching strategy, models and documentation of best practices. Analysing the best teaching practices will pave the way to a clear GIL implementation strategy.
(c) Comprehensive research on appropriate teaching philosophies and strategies. This would assist in knowing all the possible best philosophies and directing on how the GIL could be applied in different institutions.
(d) A study that will pilot the GIL framework in several universities with different teaching modes and large classes are recommended. The outcome of the research would enable the best scenarios and environments that could be appropriate for GIL.

There is indeed still a lot to do in the South African context to get the GIL approach applied in other courses. For example, more research on how GIL could be:

- Applied in other IT courses at other levels of study.
- Considered for a large group
- Prototyped and monitored for a couple of consecutive years

5.13 Summary

In summary, the findings of the study were discussed and interpreted to emphasize how the research question and sub questions were answered and research objectives were achieved. Contributions to the knowledge base and specific achievements of the study were presented. The limitations of the study were explained, recommendations for future research and a conceptual framework to introduce GIL within and outside the field of ICT was proposed. Finally, this research emphasised how the GIL was applied in teaching Introduction to Programming at this university. To realize the dream of improving teaching and learning, the results show that GIL is a productive means for both students and lecturers.

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LIST OF APPENDICES

Appendix A: Ethical clearance certificate from UFH

University of Fort Hare
Together in Excellence

ETHICAL CLEARANCE CERTIFICATE
REC-270710-028-RA Level 01

Certificate Reference Number:	MAM011SLUK01
Project title:	**Attempting a pragmatic approach to deal with entry level Higher Education (HE) students' challenges on learning computer programming skills: A South African (SA) case study**
Nature of Project:	Masters
Principal Researcher:	Jose Lukose
Supervisor:	Prof KJ Mammen
Co-supervisor:	Prof ML Mokhele

On behalf of the University of Fort Hare's Research Ethics Committee (UREC) I hereby give ethical approval in respect of the undertakings contained in the above-mentioned project and research instrument(s). Should any other instruments be used, these require separate authorization. The Researcher may therefore commence with the research as from the date of this certificate, using the reference number indicated above.

Please note that the UREC must be informed immediately of

- Any material change in the conditions or undertakings mentioned in the document
- Any material breaches of ethical undertakings or events that impact upon the ethical conduct of the research

The Principal Researcher must report to the UREC in the prescribed format, where applicable, annually, and at the end of the project, in respect of ethical compliance.

Special conditions: Research that includes children as per the official regulations of the act must take the following into account:

Note: The UREC is aware of the provisions of s71 of the National Health Act 61 of 2003 and that matters pertaining to obtaining the Minister's consent are under discussion and remain unresolved. Nonetheless, as was decided at a meeting between the National Health Research Ethics Committee and stakeholders on 6 June 2013, university ethics committees may continue to grant ethical clearance for research involving children without the Minister's consent, provided that the prescripts of the previous rules have been met. This certificate is granted in terms of this agreement.

The UREC retains the right to

- Withdraw or amend this Ethical Clearance Certificate if
  - Any unethical principal or practices are revealed or suspected
  - Relevant information has been withheld or misrepresented
  - Regulatory changes of whatsoever nature so require
  - The conditions contained in the Certificate have not been adhered to

- Request access to any information or data at any time during the course or after completion of the project.

- In addition to the need to comply with the highest level of ethical conduct principle investigators must report back annually as an evaluation and monitoring mechanism on the progress being made by the research. Such a report must be sent to the Dean of Research's office

The Ethics Committee wished you well in your research.

Yours sincerely

Professor Gideon de Wet
Dean of Research

23 June 2014

Appendix B: Concent from the University where the study was conducte

WSU

Walter Sisulu University

DIVISION OF ACADEMIC AFFAIRS AND RESEARCH
DIRECTORATE OF RESEARCH DEVELOPMENT

Nelson Mandela Drive
Mthatha Campus
Private Bag X1
MTHATHA 5117
Tel: +27 47 502 2947/2647
Fax: +27 47 502 2180

Web Fax: 0866 541 093
E-mail: ecishe@wsu.ac.za
bandlac@gmail.com

Buffalo City
Potsdam Campus
EAST LONDON
Tel: +43 708 5444
Fax: +43 708 5458

07 July 2014

Mr. J. Lukose
University of Fort Hare
South Africa

Dear Sir

Re: Request to conduct a Research study among Students at WSU

Permission is hereby granted provided that a copy of your completed study will be submitted to the Directorate of Research Development, WSU.

Regards

Dr. E.N. Cishe
Acting Director: Research Development

Walter Sisulu University

Appendix C: Cover letter and consent form

University of Fort Hare
Together in Excellence

Ethics Research Confidentiality and Consent Form

The University of Fort Hare is conducting research that is ‘attempting a pragmatic approach to deal with entry level Higher Education (HE) students’ challenges on learning computer programming skills: A South African(SA) case study’. We are interested in finding out more about effect and impact this study has in enhancing entry level Higher Education students’ computer programming skills. We are carrying out this research to help explore ways to address the challenges faced by entry level Higher Education (HE) students in learning computer programming.

Please understand that you are not being forced to take part in this study and the choice whether to participate or not are yours alone. However, we would really appreciate it if you do share your thoughts with us. If you choose not take part in answering these questions, you will not be affected in any way. If you agree to participate, you may pull out at at any time and tell us that you don’t want to continue with the study and the associated activities. If you do this there will also be no penalties and you will NOT be prejudiced in ANY way. Confidentiality will be observed professionally.

As part of the study, you will be asked to take part in an interview session. We will not be recording your name anywhere on the interview transcripts and no one will be able to link you to the answers you give. Only the researchers will have access to the unlinked information. The information will remain confidential and there will be no “come-backs” from the answers you give.

The interview will last around 90 minutes. Interviewer will be asking you questions and ask that you are as open and honest as possible in answering these questions. Some questions may be of a personal and/or sensitive nature. Interviewer will be asking some questions that you may not have thought about before, and which also involve thinking about the past or the future. We know that you cannot be absolutely certain about the answers to these questions but we ask that you try to think about these questions. When it comes to answering questions there are no right and wrong answers. When we ask questions about the future we are not interested in what you think the best thing would be to do, but what you think should actually happen.

If possible, we would like to return once we have completed our study to inform you and your community of what the results are and discuss our findings and proposals around the research and what this means for people in this area.

Principal Investigator Name: Jose Lukose

Signature:

Contact Details: 043 748 4388 (H); 084 250 0869 (Cell)

INFORMED CONSENT

I hereby agree to participate in research regarding that is 'attempting a pragmatic approach to deal with entry level Higher Education (HE) students' challenges on learning computer programming skills: A South African(SA) case study'. I understand that I am participating freely and without being forced in any way to do so. I also understand that I can withdraw from this study and or stop this interview at any point should I not want to continue and that this decision will not in any way affect me negatively.

I understand that this is a research project whose purpose is not necessarily to benefit me personally.

I have received the telephone number of a person to contact should I need to speak about any issues which may arise in this interview.

I understand that this consent form will not be linked to the interview transcripts, and that my answers will remain confidential.

I understand that if at all possible, feedback will be given to me on the results of the completed research.

……………………………..
Signature of participant **Date**: …………………..

I hereby agree to the tape recording of my participation in the study

……………………………..
Signature of participant **Date**: …………………..

Appendix D: Certificate of language editing

20 Neale Road
Berea – 5241
East London

R Thomas

22 May 2018

To whom it may concern

<u>CERTIFICATE OF LANGUAGE EDITING</u>

Title of thesis : Towards a framework to enhance entry-level National Diploma students' learning of computer programming – effects of guided inquiry learning

Student : Lukose J

Supervisor : Mammen KJ

Degree : Doctor of Philosophy (Education), Faculty of Education, University of Fort Hare

I confirm that the above thesis was checked for language and the suggestions for improvement have been implemented

R Thomas
(MA - English)

Appendix E: Transcripts of Focus Groups Interviews

Transcript of Focus Group Interview – 1

Good morning students. Welcome to this interview for capturing feedback for the research that we are conducting.

It is just an interview to give some feedback on the impact of prior required learning.

In front of you have a form. Please sign your ethical research confidentiality and give back to me at the end of the interview.

The interview is structured in three sections. The first section will be capturing your experience and your feelings on the interaction you had in class.

The second section will focus on problem solving practices. Before we end the last section that speaks about the perception of the level of writing a computer programme. So, let us start.

Interviewer (I) Question 1	I want to know what is your opinion about these group sessions that we had in class.
P1	Well My opinion - for me it is not something new. I already did this at high school, and it works for me. It's not been something new. But it really works for me because as students we interact and learn ways of solving certain problems in different ways, the ways we will understand. May be we won't understand the way the educator explains the things whereas if it is from your peer make more sense. I think it is a really good idea. It works for me, my opinion.
P2	For me it is the first time and I am gaining a lot sir. It does work for me because if you get from your group mates sir,..it
P3	For me it was the first time. And I think it worked because, now I can understand things easier with my fellow students.

P4	As my fellow classmates has said - it has helped me a lot because we communicate with group members and understand more complex things than may be the teacher just explains and gives homework or class work. We have to try and solve the problem and we come up with different solutions and how to solve the problem yah.
P1	Just to add to that, it also helps because - let's say for instance you don't understand something the lecturer said and you are too shy to ask in front of the class. It will be easier for you to ask someone who's next to you what's happening. And you know the person next to you if they understand he will explain it to you. So it helps in that way.
I	Ok You indicated earlier that you wanted to say something. I didn't capture that. What is your opinion on the group sessions?
P2	What I wanted to say sir, It sounds better sir, when it comes from your group mates. If your lecturer may be it was faster a little bit when it was presented in the class sir, then your group mates will explain it to you in a better way.
I	Thanks for that response.

Question 2	How was the interaction between group members. What happened during the interaction when you were together?
P3	It created a strong friendship. I had people who call sisters because we were so relaxed when we were with each other.
P1	It also built chemistry within us as students because . Now, let's say we have break or recess, and we are just chilling, we are just talking, let's say we are talking about something else whereas when we are going to class. You go to a person, knowing that person , how they live and everything. So, you understand them and you know, you won't expect them to make something funny of you or something like that since you know that, since you socialize with them outside.

	So…chilling and doing group works, also like she said, builds friendships and everything…yeah.
P3	The interaction amongst us was the best because, as they said, we've got the chance to know each other better, to know like, our strong points and weaknesses are when it comes to programming. So we know as a group, when it comes to maybe to floated? maybe he's good on this and she's good on this so when the problem come we know who can explain it better to us…or more complex.
P4	We get to know each other. We understand things easier.
I	How was the mood during the interaction?
P1	It was actually good, Sir because now, Sir, as peers or group members, Sir, we all have different ways to solve these certain problems. So now…maybe my way of solving this certain problem is, and hearing someone else's, we'll start comparing the two and weighing our chances, which one's the better one, which one will I remember for maybe a test or an exam? Which would work for me? So… it helps in that way. It's good, it's exciting and it's also challenging, because obviously everyone is gonna try to be better than someone else. So, people work harder to impress the group basically.

Question 3	How did the group session motivated you to go to the next class or to prepare for the next class?
P1	It motivated me in such a way to wake up every day and be able to come to the class, because we have got so lot in common and we have got so much to do like, we, like…while we are trying to solve a problem….when we are trying to solve the problem, like we discuss first and then see which one is better than other one. So, it was more of like of a competition, but in a good way. So, that motivate us, that motivate me, in particular to be able to come and return.

P2	Listen…the class motivated me for…basically, first thing is because… I am not talkative Sir. I am a shy kind of a person. This too helped me to develop an interest, to educate thyself to work and give me a chance to talk Sir.
I	How did the interaction motivated you not to be shy? (Question to P2)
P2	Where you are given a chance to talk with your friends or group mates and ask questions – they ask like - How did he or she understand the lesson?
P3	To me, it motivated me in a way that working with other people could improve your way of learning, and in that we felt comfortable when we were with each other.
I	How does it motivate that way of learning? (Question to P3)
P3	To me it works, it helped me a lot, the way we were learning because….it motivated me, because…now ….. is one of the subject that I like the most.
P4	Group works for me sir, they motivate me in a way that uhm…obviously I don't want to be like, the one that contributes the least. So, I want to be the one on top like, I want the spotlight on me. So, it will make me wanna work harder than everyone else so…and knowing that maybe this certain person works hard, so it means I have to put in times two the effort and work harder so that I can have the spotlight.. and I'm sure they will have the same mentality to work harder than me. So, it motivates me in that way..that yeah. I want to be better than like, everyone else. Everyone wants to be a winner. No one wants to be a loser.

Question 4	What was the impact on your oral communication skills or any other soft skills during these group sessions?

P1	It helped a lot in terms of oral and presentation, and being able to listen to each other…being able to express what you feel, because each one of us get a chance to speak what she/he thinks about a particular problem. So, it impacted us to be able to communicate with each other, to give each other a chance and be able to communicate well - not having miscommunication or whatsoever.
P2	It helped in terms of discussing sir…. you know how to discuss a problem and come up with a different solution sir and then we can sort out the best one. How to sort the problem and it helped in terms of discussion sir.
P3	It helps in terms of confidence, because in terms of confidence, being confident about what you think about that particular thing that we are doing and in terms of debating hope? I have learned to stand up for something that I have said.
I	How did it impact your confidence? (Question to P3)
P3	Now I am able to stand in front of people and talk, without being scared or something.
P4	For me it helped, because let's say making a new friend – when you are making a new friend it is harder to be open to them, when you talking to someone you already know. So, now with the group works, helped us, because me talking to them, knowing more about them makes me feel more comfortable and if I am more comfortable it makes me more confident to speak in front of everyone. So, for me confidence comes with comfort. So if I am comfortable in front of these people then it's fine, I can think broadly and say what needs to be said and talk, as if yeah. Yeah, so…that's how it helped for me.

Question 5	What was the impact of guided enquiry learning on your level of understanding the problem scenarios of all the tasks you have been given?
P1	Since I have raised Whatsapp, I'll just talk about that sir. For me, it worked because there is no better way to educate a young mind in this generation now, than using social network. Cause, if you put something educative on social network, it will spread, it will be viral. Everyone will learn about it. And, cause, now life now is about technology and everything. So, if it is out there, spreading, more chances are that young adults, as us, will learn about it – enriching our minds and learning everything. So it helps with that for me, cause….yeah it helps like that for me.
P2	To add on what he's already said is that… yes, Whatsapp helped a lot, because wherever you are - you are always with your phone. So, it is easier to solve a problem on Whatsapp. I agree with him.
I	I want to understand Whatsapp better. So did you continue your group sessions on from class on Whatsapp?
P2	Yes
P3	Even the homeworks, when you have homework and you are at home, no one is there to help you. So you talk to your mates…question..how do you do this certain question and people will know how to tell you over the phone..on Whatsapp…you know, that's how it works.
I	The interruption of Whatsapp - how did it impacted on your analysis of the tasks that you have been given?
P1	It helped in a good way, because sometimes you may think that you are doing the right thing while you are do your homework on your own, but I had to find out like maybe you missed something or you misread the question. So, when you're doing it on Whatsapp you will check on your group mates….how did they do it and maybe then they will tell you if you

	have done the problem or you didn't read the question quite well….then, do it again.
P2	Yes, it helped a lot sir…that's because when you're doing homework sir then, if….let's say we are doing a flow chart sir ,then you're trying to do it then you post it on Whatsapp. Then, you let them to see you, what you were…to see the way you're doing it sir then they will comment that if you were wrong to do that then it is done in these ways.
P3	Just to add something else. The social networks also helps sir. Just like everybody else sir we all have personal issues sir so sometimes you can't make it at school. And, if you miss like, one lesson at varsity - you will miss a lot…basically. So, you just need the social network to catch up with your friends and ask them, "what did you guys do today?"…"did anyone get me notes?", and you know all those type of things – so it helps with that too.

Question 6	In your notes in class you learn how to analyse problems. What was the impact of this guided enquiry learning sessions on your programming analytical skills?
P1	It helped us in, in a way that when you are given a certain problem,, to first identify what is needed. Then, how can you try to solve that problem. Which way can you try to solve it - unlike when you are on your own, you are just given a problem and you just pre-assume that maybe it needs this and that and then you just do it the way you think it is and maybe that's not the correct way. But when you are in a group like, we analyse it better and we try to figure it out…. what is the more complex or the more appropriate solution to try to solve the particular problem. Then we came up with different ideas and then we vary them and choose the correct one.
P2	It helps a lot because now, when we are in our groups we analyse problems and try to come up with different ways to solve this problem

	than when you are alone. We will try to find the easiest way to solve the problem. Yeah, it helps that.
P3	We shared our ideas and ways of solving problems.
P4	Well sir, like I said sir and everyone else said sir. We share ideas and ways of solving problems and let's say there is a certain way of solving it, she tells me this way of solving it. I would be like : "No wait a minute. Here is a shorter and sweeter way of solving this problem and in a way that I will remember." And that also helps us as, to, because obviously when we are in a lesson and we are taught how to solve a certain problem, we are only taught one way and…on the contrary, there are a lot of ways of solving problems. So, that one way we learn from the lesson and she coming up with another one, for instance, will help me think, " No… – let me make research"… find other ways of solving these problems. Ways that I will understand, ways that are shorter for me. We all love shortcuts. Ways that will….shorter for me, ways that I will understand it and maybe help someone else…motivate someone else to do the same – make research and learn more about.
I	So make research on new things? (Question to P4)
P4	Learning new things. Yes, making research is very important. Finding ways of solving different problems.
P5	It helps us to come up with the easiest way to solve the problem.

Question 7	You gone through the group section. You were introduced to guided enquiry learning and it has become part of your daily way of thinking. If you look at yourself now - how has this enquiry approach impacted on your problem analytical skills. When you are all alone by yourself at home. You have a problem. How did the guided enquiry learning impacted on your problem solving analytical skills?

P1	As I've said sir. Like…during the group discussions I would like, we will first analyse the problem. What is it that we want to solve and how can we solve it? Then, I list the alternative way on how to solve it and then I choose the most appropriate one. When I am alone – like…firstly, I have to identify the kind of a problem that I want to solve. Look for the solutions then choose the best one…then okay, vary them then choose the best one. It helped me to fully analyse what is it that I want to solve and how can I solve it.
P2	Individually, sir, it has helped me because say for example with Maths - I have this problem in Maths. And I remember from class that this person taught me this way of solving this one. I have my own way. She has her own way. He has his own way. So, I start comparing all four and see if I will get the same answer. And If I do - and they are all working…and It means I am actually learning. So I'll just, from there, choose the best one for me. A shorter one, in my case. Yeah, things that work for me, basically. Because at the end of the day - it has to benefit you as a learner, since you are doing it alone.
P3	To me personally it helped me, because it taught me that in any problem there will be a solution. If only you follow the right steps. Firstly you have to know what is your problem. Then try to find a way to solve your problem. Personally it helped me, because I know in each and every problem there will be a solution at the end.
I	So when you are alone you will always find a solution? How do you go about that? (Question to P3)
P3	I identify what is my problem, firstly. You know, what is my problem. Then, try to find ways to solve this problem.
P4	That is where research comes in, sir. Researching new ways of solving the problem.

P5	If you have a problem sir….When you are alone, I have a problem, sir…. If you follow the right instructions on how to come up with the solutions. Then you will solve the problem, sir.
I	How does the group session impact on how to solve problems when you are alone?
P6	As you are saying - you have heard different ideas on how to solve a problem. Then you combine them, including yours, sir then you compare and choose the best one.

Question 8	How has this method (guided enquired learning) impacted your overall problem solving skills?
P1	To me – it has helped in a way that not to give up easily. I am a person who is short tempered. So it has not to give up easily in a way that, where there is a problem, there is a solution. Yeah…Now I am a cool person. take a steps on how to solve a problem, yeah in a relaxed way. Taking steps is to know what is my problem. What will help me to solve this problem? What is the cause of this problem? And what will help me, to solve this problem? Those are the steps that I have to know first before I give up. Yeah, now, I don't usually give up easily on my problems.
P2	Yeah, me sir. For instance, this year I have learned what we call in Computer Science…Algorithm way of solving a problem, which are certain steps you have to take. There are 5 steps, which is: Identifying the problem; brain storming solutions; choosing the best one; applying it - then check if it worked. So since we have learnt those, to take those certain steps to solve a problem, sir. I have actually learnt a way, a way that works for me to solve a problem.
P3	I have learned to pay more attention when you are trying to solve a problem, because we know that in development software even a

	comma can cause your problem not to work at all. So, I have learned to pay more attention when I am trying to solve a problem. And, as Sive has said, I look for, I use the 5 steps on how to solve the problem and then obviously you come up with the best solution.
P4	I have learned sir, if you keep on sir, practising different programmes, sir that you are taught in class then, you… when you get the , when lets say if you are keep on practising the problem that have been taught in class then you will get familiar with how to solve the problem if you…if you are not ……..then you are required to solve sir then you will solve it just because you are familiar with the certain problem, then you …you…. I have learnt the speed of solving problems, yeah sir..How can I put it?... I have learnt the instructions sir…how to solve a problem.

Question 9	Now that you were part of a group and interacting with your group from the first time you entered the university. You are in the early stage of you university life. How do you see the opportunity to be part of a group and interact with your group at this early stage of university life? Did it help you to manage the pressure?
P1	Sir, what I have learned sir- like chilling with people – and like sitting and… it makes you more, it helps you socially because I will learn something that he has experienced for instance. I will learn like, I will learn plenty of things. Things, maybe I wanted to try, but now you tell me that no, that thing didn't work out for him - then I'll have second thoughts no, let me just not try, let me try something new. So, socializing with people makes you learn more and makes you more comfortable. and Like I said - when you are comfortable, you feel less pressure, more confident. and yeah and when you are In your group obviously its gonna be a competition for everyone. Like if you are in a right group for you and…. because there are certain groups where you are like no this guy is slacking or and, this guy is just lazy he is not contributing to the group so you'll be in a better group, or like in a group

	that people would, where all of you are in the same mindset working harder everything - you will actually learn a lot from them. Socialising with them…and yeah…. it will help you with your pressure basically because if your peers are there you will have less pressure.
P2	To me, as I have said before that we…I created friends, sisters and brothers. In a way that when I am with them, I feel comfortable to share everything with them - school work, personal work, everything…. I share with them and I trust them.
P3	You communicate with your group and it helps that they listen.
P4	The fact that we are interdependent with each other help us when we are in groups. So that you know that you need him as well as he needs you so It helped us like, to communicate well, try and explain to each other our maybe fears and expectations at varsity. Our strains or how far like or how you would like to take our careers in IT and as SIVE has said it helped us to be more comfortable with each other; to know our weaknesses and to know who got our backs.

SECOND SECTION

Question 1	How did you analyse the problems in your sessions when you are given a task?
P1	Let's say sir we are given this problem sir. I will make an example of one of the subjects. Developing Software - we have this section where we do an IPO-chart. We are given a problem there. Our first step is to - what is our output. We have to check what should be the final result of this problem. And When we get to that point where, okay, - in this problem we want this, to be the output so Now, as a group we are going to discuss how do we move from problem to output. So, basically how do you move from input to output? So, we will ask questions where, as in - how do we get there; when do we get there; what do we

	need to get there. You know, All those questions, then all the answers will start coming up – then we will finally make one - like in the IPO-chart - IPO stands for Input Process and Output. So, us sharing, asking all those questions is basically the process where we all come up with these ideas of how to get the output. So, it has helped us in that way.
P2	Yes, when you are given a task - you first read the problem. Then you make sure that everyone understand what is needed. Then you come up with the different ideas on how we are going to get the solution for this problem, sir. As he said - what will be our output? What is needed in order for us to get to that point, to that output sir?
I	Can I you - you mentioned that you make sure that everyone understand what is needed. How do you go about that? (Question to P2)
P2	Sir, we explain sir, explain what is needed. What is actually asked here sir. Then we explain to all of us, then everyone understands then you…so that we can all be able to contribute, sir. Come up with What you are thinking about this.
I	I want to know - how did you go about now that you understand and you are all on the same level of understanding of that problem - how did you analyse the problem?
P3	Like, it will be like hitting the same thing. As Sive has said, like …When we are given a problem. We first identify what is the problem, then what is needed to solve the problem. What we have, to try and solve that particular problem. Fezile has mentioned that we try to check and see if, what each and one of us understands the problem by contributing to the group and telling what does she / she thinks what the solution may be. And fortunately enough, our teacher, Mr Lukose does not spoon feed us. He let us to think on our own and that helped us to analyse the problem better, because we know that we have to come up with a solution.

	Can I just elaborate on the understanding part sir? You have those guys sir, when… you know when you're in a test sir and you're like, you know you studied and you're ready sir, but sir you rush in to the question and you end up missing the key words sir. And you end up not understanding what is needed sir. You think you know but you actually don't know so that's where the group comes in because you have those people you know, they are ready and everything but they just rush into everything .Now they end up not understanding…where you have your peers, the guys that are slow… yeah, maybe they are prepared but they are just slow so they will read and they will understand everything all the key words in the question, all the , everything, the trick parts and the trick questions and everything, so they'll understand. As you being the rushed guy, that guy who is slow will explain …no, I notice this and this and this in the question… so now you, being the guy who rushed into the question will be like,,,oh no, I missed that part… so you know, we end up understanding the question as a whole as a group because of that one guy for instance who read the question slow and…

Question 2	How did you then go about solving a problem in your group?
P1	For me, these questions are kind of interrelated, but I will try to answer it. Obviously so like for instance if you read a question, you will have your own way of answering it. Then when you contribute to your own way to the group of answering that question, maybe you will give the next person an idea of how to solve it and you will add to what you have already. Then the other person will do the same. Then you end up having these bunch of ways of solving the problem. Then we combine them, to ensure, leading the way to the output.
P2	Like maybe just add few things but like as she said like we already analyse the problem then it just runs the way forward on solving it. Just as I've mentioned before, we've all come up with different solution on

	how to solve the problem then we look the most appropriate or the most correct way or the one that will be easier for us to understand and to remember when it comes to exam time, the most appropriate one that will help us to be able to solve even related problems to that one.
P3	Oh I'll just add on a few things, like when we have a problem, what we do we try to give out all the possible points on how to solve the problem and then eliminate those we know that they won't give us the final solution on this problem.
P4	What I've learnt sir is that, with problem solving sir when you have a problem, sir. You don't actually try to solve the problem until you get it right. Like, never do something until you get it right. You actually should do something till you can't get it wrong .So, the more you practice, for me, the more you learn different problems… different ways of solving them. That is where the group comes in, your friends and your mates coming up with different ways. So when you have problems, you know you can solve any problem by now, because you know all these different ways of solving them. So, I think for me, basically the motivation or the motto for young students as us should be never do something until you get it right, do something until you can't get it wrong.

Question 3	Now that you told me about your way of solving the problem. Why did you go about solving the problem that particular way?
P1	As I've said, we choose the most correct or the most appropriate way on solving the problem. The one that will help us understand better and even if we've come across a different or a similar situation – so that we know how to solve it. Like, in development of software there are many ways to solve a problem, but you have to come up with the one that is more correct or is more complex and understandable, much easier and..

P2	She said everything. When you are in a group sir, you come up with different solutions. Then sir, we use the best one that will lead us through to the solution. Then sir,……..there were instructions to follow to come up with a better solution. Then sir, you get to know the instructions to come up with a better solution.
P3	We solve it that way because of, in that way, we tend to have so many points on what is the problem firstly and trying to come with a best solution…….. or what she has said that we list the…We analyse the problem first. Then we list all the possible solutions and choose the best one.

THIRD SECTION

Question 1	Can you write a program that works and explain why?
P1	Well sir, in class we have done a couple of practicals, so I think I can do it. I am actually not hundred percent sure, but I think I can do it - and due to the practicals. And the practicals were successful because we did the programmes and our lecturer was like ,okay this is how we do it, we learnt it, we practise it at home, on my laptop I practise it and I check… okay no I can do programming. I haven't faced any problem that I can't solve at the moment, but I'm not saying I know everything but then again, I haven't faced a problem that I can't solve. And every time I have a problem obviously- I go back to the lecturer and ask him this, I have this problem then he'll tell me about it, this is how you can solve that certain problem or this is where you went wrong
P2	Okay…for me - yes - with the basics and solution and practicals we did in class helped us. And I can, as Sive has said, maybe not 100%, but I can do it. Due to the basics and the practicals we have done in the class.

P3	I think so, I can do it, sir. I am referring to the exercises that we have done in the class…….. I have the confidence.
P3	Based on the classworks, tests and the..everything that we have done in the class, yes, I can do it.

Question 2	How do you see your ability to write a program as to before? How do you assess that?
P1	Well for me sir, I actually went into the department of IT because I thought I knew all about computers, but that was my mistake. I actually learned a lot here and at this point in time I still don't think I don't know enough to be a professional. I think I still have to learn more about computing and everything that has do with…. I have learned the basics - yes – now, like the foundation is there – it's going to be stable. Now I just need to…. the kick basically, learn more and you know finish everything, then I'll be able to answer the question.
P2	I agree with Sive that I still need to learn more……to start a new programme here I still need to learn more.
P3	At this point in time - I can say I still have to practise. Yeah.
P4	Now, I can weigh my ability as a programmer. Maybe, okay…the basics are there and I can tackle to do a programme, but obviously I won't be able to finish it now and with the basics that I got in programming, for sure, I can tackle doing the programme.

General Question	Finally, what is your opinion in adopting this new method in other courses?
P1	It will be perfect if we can adopt it to our other courses as well, because when we are in other classes - we do communicate with each other and

	try to solve the problem. So, like, it makes it easier for us when we are on our own or during the exam time to be able to remember what Sive has told me or what Cindy has told me – the easiest way, if we can do it to other courses as well it can be better and how we understand it.
P2	It we are to do this to other courses, it will be good sir. Just because, as you said earlier sir,……
P3	It will be good in a way that we could be able to do what we did in the …. We are able to discuss the problems, trying to……also I think it will improve our ability in how we learn this subject.
P4	Sir, for me sir - I am the type of person that always look for the bright side of any situation. My advantage of being here and learning ways and applying what we have learned to develop software. What I have noticed is that developing software is not really different compared to system software because it is similar modules and similar chapters. Whereas in high school you get subjects like Life Science then we get Geography and you have to learn both of these subjects and they are actually not the same and you know as a person you get confused because the definitions and everything…. whereas here in development . A computer in development software is a machine, same applies in systems software so those definitions stick with you they get stuck and you end up understanding the definitions and knowing them because you use them on every subject for instance so that's the whole bright side of the situation sir. What I apply in development software automatically you apply with system software and information systems and IT skills. All these courses are interrelated, they all share this mutual thing
I	Thank you so much for coming. This is the end of the interview. I would like to thank you all on behalf of Mr Lukose for your time and your answers. I promise that your information will be kept confidential.

Transcript of Focus Group Interview – 2

Good morning students. Welcome to this interview for capturing feedback for the research that we are conducting.

It is just an interview to give some feedback on the impact of prior required learning.

In front of you have a form. Please sign your ethical research confidentiality and give back to me at the end of the interview.

The interview is structured in three sections. The first section will be capturing your experience and your feelings on the interaction you had in class.

The second section will focus on problem solving practices. Before we end the last section that speaks about the perception of the level of writing a computer programme. So, let us start.

Interviewer (I) Question 1	I want to know what is your opinion about these group sessions that we had in class? What is your opinion about the Group sessions?
P5	Oh well, basically my opinion on the group is that. It was helping a lot. Because I am not a person that enjoys working as a group, but now throughout the year I became quite familiar with the groups and it kind of boosted my ….. a bit. I would put it that was. (2:14)
P3	Yah.. the group thing was helpful. Because what happened is when you make mistake working your own. At some a lecturer doesn't check all your home works, so what usually happens when the lecturer give the home works, you should do them in the groups. You see your mistakes clear. And you get a lot of help from your peers.
P4	Yes it has helped. There was this WhatsApp group was created. When we do the home work, we type it and post. It helped. And lecturer did assist us through whatsApp.

P5	When we put in our possible solution to a problem, group will come up with the best possible answers to that problem.
P1	Yah..it also helped me because, sometimes I can work alone doing works alone, but then when I am with others that confidence help me asking questions something like that.

Question 2	How was the interaction between group members? What happened during the interaction when you were together?
P2	Interaction was good sir. Because we were sharing thoughts and opinions as we know that we have different mind sets. So we come with different opinions, and we come up with one question one answer. Yes I think it worked.
P4	I guess at the beginning of the year we were about to make mistakes and didn't discuss too much. But as the year goes our confidence grew and we discuss a lot and help each other and then
P5	Hm as he has said, it was difficult and slow, but as time went by we got to know each other and became easier for us to interact and share ideas and scenarios. yah
P1	Yes we argue about the answers and our lecturer comes and goes through that direct.
I	So you argue, how do you argue? The interactions, how was it?
P1	Yah it was good. Like some say this could be done this way and we discuss and in a way help each other and we understand.
P3	I think what he is like when we are working as a group, we come up with different solutions and when we come up with different solutions as a group, we have to look a both of the to see which one is correct, student

	obviously will choose what we think is correct, and then when the lecture goes through. Sometimes he will find both is correct.
I	Then the interaction between the lecturer and you, how was it?
P5	It was good basically. It happens many ways, one may not see it at first, but it kind of help us.
I	In which way? You say it was good. It was good in which way?
P3	You see what happened is sir, let me say it help us in this way ne, when we do the group works, the way the lecturer is putting us ne, ok we do them. But we sometimes, there are people who are good in class that are good in this and that, for example trace table or flow chart, we know that Unathi is good in flow chart, so I will call him, how about doing flow chart as group, there are some mistakes I am making as I do, there are some errors. So that's how it helped us.
P4	From my part, for me, I am not good at theory part, I enjoy more practical. So I get that knowledge from my peers.
I	You learn from them? Is it?
P4	yes
P1	Sometimes our lecturer used to change us between the groups. As he has set like this one knows pseudocode, this one knows flow charts so that they can exchange information etc.

Question 3	How did the group sessions motivated you to go prepared to the class? How was the motivation to prepare for the next class?
P5	Well in my part, let's say during the class, in a couple of questions of which one understand it properly and one answers correctly. So seeing the peers get the answers right, kind of motivates the person to prepare

	for the next lecture, so that, you have no fears of left behind in any way, that's how it the kind of motivate, the groups.
I	Do you want elaborate on this or in other ways these sessions motivated the class?
P4	I think it motivated in that everyone in the group debate. In the discussion part. So no one just sit down and listening. So I will prepare for myself, so that I can add, contribute to the discussions. Yah… this is what I can add on.
I	Ok.. is there any motivation for the next class
P2	I think so. It helped a lot because I know I am going to class. I am going to meet other students, that is for them to help me. If I understand the question or the problem. So I have to go them and ask the questions. Then you have to contribute, all of us.
P1	It will be the place where I go back at res or at home, I won't just rest and do nothing. I have to work, so that I come back there I have got some work, my group mates have done this and done this, yes.
P4	When we come up with problems that we can't solve, then ask them (group) through WhatsApp, then they can come up with hints, then lecturer will correct it tomorrow when the next class.

Question 4	What do you think of the group sessions and their impacts on your oral communication skills? What was the impact?
P3	It has helped a lot sir, because you can see that as we are people, we are not the same. So when we sit together, all we are having different attitudes, express they were, then when times goes on you come up and you learn this. You see their weaknesses, their strengths. So there are people who are short tempered, and those who are people, what they have written is what is correct. So in some point you will find out that,

	like I said before, we may come up with two answers, that are different, but they are both correct.
I	So how was the impact coming in the oral or other skills
P5	Well you get different kinds of people, you get people out there, socialising people. Then there are people that are kind of shy. But the way that this group thing had helped us, that everyone became confident in themselves, and they were able to project yourselves, were able to interact when there is a discussion and they were able to how can I put this ham.. but basically what I am saying is, everyone eventually became comfortable themselves and with the group and we were able to interact each other, helped in communications.
P1	It helped a lot sir when it comes to communication skills. Now I am able to go and ask something that I do not know so that I get progress.
P2	Yah it did sir. I prefer reading than talking. these group discussions helped me a lot. Because now, I have gained confidence, I can talk with people and collaborate with them.
P4	From my side, I am a shy person to talk. I get confidence through talking to both group members and then talking to a class. My confidence grew as time goes. Now I can say I am bit confident myself. I can talk in front of many too.

Question 5	How do you see the impacts of guided inquiry learning (GIL) sessions on your level of understanding of the problem scenarios in the various tasks you were given?
P1	I think it impacted me in a way that, when I try to solve a problem, broke it down to smaller parts, instead of trying to solve it as a whole. Take one part at a time, one part at a time, one part at a time, until I have solved it.

I	What can you add? You as a group how did it impacted on the understanding of the problem?
P1	It also helped me. Do not just go through the problem. But by analysing to know what is needed there. You are not just getting a problem and answering. Analyse it best and you know what is it expecting from you.

Question 6	What is the impact of guided inquiry learning (GIL) sessions on your problems' analytical skills?
P4	I can say it helped in that, when I try to answer a problem, I get that thing that what do I do to get the answer? What do I do to solve the problem? So I don't read it thoroughly. I just go through it. So it helped me that, when we are there as a group, someone will be not understand the certain part, then he will ask me to explain to him or her, then I will see that I made a mistake when I explain it to him/her. And we can try and analyse problem thoroughly, and broke it down to smaller pieces, then solve it.
P2	It helped a lot sir, because when we are working with the problem scenario in the group, we first start by asking ourselves questions, what is going to be the answer, or how getting to the answer is.
P5	Getting to elaborate on what he has said, you are able to break down the question into pieces, just so that you could see, what input is needed in the sort of problem we are dealing with, output and processing all of that. So that we cannot just rush into things, because, that's where you get thing wrong. So it kind helps to read the question over and over to be understood it fully, then answer the questions.
P2	It helped sir because, we go through the question, we read it and we ask the questions. For example, if we are doing the pseudocode, we ask questions like, what are the objectives, the inputs and outputs. So we

	don't just go through the question, and write it down without asking questions. So it helped a lot.
P3	To add on to it. What happened is, when we get the questions sir, at the beginning the year, there is ups and downs..but as time goes on, we did manage as group, we did work out things, then we saw mistakes.
I	Right. You saw your mistakes. How did you go about recognising the mistakes. How did you know that this is a mistake? How did you go about it?
P5	As a group we have different opinions. Different scenarios. And not all the time you will be right as an individual. That's why the group is there to correct each other, when you go off the path. So that you can stay true to each other and staying on the same level.
I	How do you make sure is everybody is on the same page?
P5	We interact as a whole among and get to one person's solution that we can work with and we all agree with it. If don't agree we try and look at why we don't agree why one doesn't understand, try and make him understand if other people understand. So that's how we work with each other.
P4	While everyone contribution taking into consideration, try to argue one that we think is correct.

Question 7	With your experience, while working alone how has the inquiry based approach impacted your problem analysis skills? How was the impact of these sessions when you were working alone?
P5	When you work as a group, as time goes by, you acquire certain skills from different individuals, and you are able to use those skills when you on your own. May be let's say, I was analysing, someone somewhere around the line, pick up that skill from them. And I will able to use it when

	I am on my own. And it will be much easier for me to solve problems, may be now than compared to before I was in the group.
P2	I would say, before I approach any question, I am trying to use the skills during discussions. Analysing the problems lists all steps in how to solve the problem and find most effective ways to solve the problem. That's how it helped.
P3	Me as an individual, what I usually do is, when I have to do something on my own, I graph everything down. Do everything graphically down. Then try to use all those attepmts my peers usually use. Ok Unathi will do this, if I was Unathi, he would think it this way, and try all of their attempts, how they do things, and then try my own, so which one would be best actually for this problem?
P1	Yes sir, it has improved my problem solving skills, because now when I am alone, I would spend time to just analysing the problem before I get through it.
I	When you are on your own, what was the impact of the approach Inquiry based approach on your analytical skills?
P4	Before, when I am trying to code, when I was writing programs, I just write write write and get lost. But now, first I write download all objectives, all the inputs, write things that are row, come up with..what do I say trying to come up solutions.

Question 8	Now let us talk about your problem solving skills. How has this method affected your problem solving skills?
P5	Well, I am an patient person. A person who is really working through a problem, you kind of miss some of steps that are required you to follow. But ever since I was in a group, I was able to calm myself down, and

	take my time in everything I do, step by step until I can basically solve what is needed in solving a certain problem.
I	Do you want to add something? How does this affected your problem solving skills? The fact that you were in those sessions. What was the impact on your problem solving skills? Was there any impact?
P1	As he says sir, it has improved my problem solving skills. And if look back, before we were made as groups sir, and look at my problem solving skills, it has been poor sir. Now with the knowledge that we have with these groups sir, it has helped me a lot. It has improved my problem solving skills.
I	So how, how does it improved? How has it improved? Just elaborate on the improvement.
P3	For an example sir, as we work as a group, what we usually do. Ok let me go to the pseudoceds, Let us we are given a question there. Even if we are not supposed to draw a IPO chart, what we do is we start with the IPO chart..
P5	Because once we have the IPO chart, its going to become simple to go to pseudoce. So before we solve the problem, may be look at another way you can solve it, may it will be solution to the problem that you have.
P4	To me, it helped me in that, now if I look at the question, if I try to solve it as a whole, it will look too big and I will panic and pressure will build up. But now, I look a the question, and break it down, trying to understand the objectives, and trying to understand what is required from me to solve the problem, solve it case by case.
P2	At first I used to say, I don't know the question without reading it. Now my peers will help me say, just go through the question, and then try to understand. But now, I can read a question, be patient and read it and understand it.

Question 9	Now, let us go back to the interaction you had between yourselves in a group. How do you see the opportunity to be part of groups and the group interactions in the early stage of your University life in managing the pressures of the new University environment?
P4	I think for me it helped me because, it look good in this (33:25), and my peers will help me, explain it slowly to me when what the lecturer was saying about the class, try get to understand what he was saying. I think it helped me, for some of the things that I know and understand now I wouldn't have understand it.
I	Was there any pressure of the University environment
P2	Can you repeat the question?
I	The question says, the fact that you are coming here and your were put into groups in this class, would that helped you in any ways, to target the pressure within then University environment?
P5	Hm I for one, when you come from my school straight into the University, you kind of feel that you don't belong either. And that may lead to one's attendance up to scratch. But having a group to interact with in the class, that kind of made the person feel that if they don't go to school they will miss out on a lot, but when you are here, you just enjoy yourself, because you are having a good company. And it is said that there are many activities which happen in the University, but having a group to help you to through certain things you don't really succumb to the peer pressure of the things that happen in and outside of the University.
P4	It helped me also too because, when I came here the first day, I didn't know anyone. I would just sit here alone, and when the group started, I start chatting to the guys, and get being friends, and now I am confident, and get undippressed easy (35:43).
I	How do you think the groups has impacted in managing the pressure as a new student in the University?

P3	You see what usually happens before we were groups, after classes what we usually do, go home, do nothing then come back next day to school. So what these groups have done to us is that we know that by the time the classes end, we are supposed to meet us a group, and go through what we have been lectured. See which one has a problem there, try to make each other understand, challenges and everything. So they have helped a lot. Even now, the WhatsApp groups, even now I can go, you can still do your work. Then you capture by a camera, then you send it, those guys see a problem there or see any errors, then we will react.
P2	It helped also. Because high school is different from the university. In high school there are teachers always watching you. whereas in the university, there is no one who is watching you. So get to … like. So the WhattsApp groups helped us lot, because, when I am at home, I have something to do. And if we do nothing, Mr Lukose will ask you, why didn't you do the home work.
I	So which kind of pressure of the university you were managing just by this group?
P5	workload
I	Can you elaborate on that, workload?
P5	If we work as a group, you are able to divide the work into different segments, work them out piece by piece. Working in that way, makes it easier to go through the work. Whereas if you just given the whole load, it will take some time probably you may make some errors.
P1	As he has said, it helped a lot sir. At the beginning you would come to the class and go back home without checking with anyone asking any questions. But after these groups started, after the class, then we go outside and ask questions about something you learned there at the class sir. We are able now even to socialise. Just cool there.

SECOND SECTION

Question 1	How did you analyse the problems in your sessions when you are given a task?
P4	We read it may be three or four times and ask ourselves some questions. What is required, what are the inputs for this, what are the processing needs to be done to get to the required answer?
P1	What is important is in one understand the question. Just analyse it and say what is expected from us?
I	Just from that point, how do you make sure that everybody understands the problem? How did you go about to know that so and so now doesn't understand?
P3	The thing is sir, as a group what we usually do is everyone would be writing down something. Then we put them together. By that we see who understands and who doesn't.
P5	May be another person understands certain part of the problem. Another person understands certain other part of the problem. Put those people /ideas together. Let the one explain to the others the part they don't understand. So that they can also understand and then
P3	As time goes by you what happens is when you making mistakes in the groups, you are corrected by your peer. And when you face similar problems, you will know that Unathi assisted me in similar questions.
P1	What we used to do that we understand the question us ourselves as a group. Questions, so to see that this one understand this, what does he thinks the answer is and we sit there if we got same answers or
I	What kind of questions

P1	Questions like sir, what are the objectives or this question, then we sit there when someone comes with different answers, and we try again explain the questions, and come up with one answer.
P4	And we use scenarios to explain if one does not understand.

Question 2	How did you then go about solving a problem in your group? You have now analysed the problem. Now how do you go about solving the problem?
P4	Solving the problem… by asking question ourselves, write the objectives, the processing that need to be done to get to the objectives, and the inputs that need to be used in the processing, and get the calculations and go and try to solve the problem.
P2	First analyse the problem. What the problem and then find the most effective ways on how to solve the problem, then list all the steps in how we are going to solve the problem, then we find the algorithms to solve the problem.

Question 3	Now that you told me about your way of solving the problem. Why did you go about solving the problem that particular way? In terms of as a group, why did you use this particular way you mentioned now?
P5	Easy to understand, basically
P4	We didn’t try to solve the problem as a whole, start breaking it down. You see when you try to solve the problem as a whole, you don’t understand that. Were you get to the answer, there are some other things you need to do. And you used to calculate the answer. So we did that to see that we cover everything that needs to be done in the question.

I	Why did you go about doing it the way you do it? Meaning that, the way you did it, why you were convinced that was efficient?
P4	Every time when we solve the problem the way we solve it, the goal is to come out with the answer. You don't just get stuck; you don't know what to do. When we break it down and solve it by asking questions, piece by piece, we come up with final answer, which is always the case.
P1	It is like that. It is the best to answer. To attack the problem to come up with answer.

THIRD SECTION

Question 1	Can you write a program that works and explain why? Can you now say that you can write a program that works? And explain to me, why?
P1	I can say sir, I can write the program that works. Because, with the skills that I have now with those group sessions, yes, I can
P4	When I go to evaluate the programs, I tell you now now, that I can do a program, all that works, and if it does not work, I will go and check my errors. Yes..
I	I want your view on this particular question. Can you tell me?
P5	Yes. Reason being is, throughout the year, we have been writing programs and been correcting our mistakes. And now we have VB to check. We have been doing it the whole year and we get the kind of confidence that we can.
P2	I tell you because Mr Lukose taught me, and I gained skills from groups peers. So the skills that I have I can apply them. So I can write programs
P3	I agree. Because sir, we did write programs even in VB and we see.

Question 2	Now, how do you assess your ability to write computer programs?
P4	One thing I ca say is that I rate myself at about 6.5.
P5	6 may be. Because, repetition of something can help you grow, and if you keep on doing same thing over and over a particular field of work, you kind of better and better it. And seeing we been repeating over and over, we are kind of getting better in that. So as time goes by we would improve into something that is better than this,
P4	They say that practice make you expert.
P2	Yes sir. Because we had the best lecturer, he was not just a teacher.
P4	When we do the program through WhattsApp, he will avail and guide us when we are having a problem, he use his own free time.
I	Ok, let us come back to your own assessment on your own ability to write computer programs, except from the fact that you had the best lecturer.
P5	I am not perfect, but we are heading towards where we are supposed to be. Because we are first year students and still have a lot to learn. So far we are on the right path where we need to be as programmers.
P1	I agree because firstly we can start creating a program then along the way we might have some problem. But what I am trying to say that we can start write the programs sir.
I	I can see you are shaking your head, your opinion?
P4	I agree sir. I can say at this stage of study, I have sound background.

General Question	Ok the last question for you. What is your opinion in adopting this new method in other courses?

P4	I think it would be grate thing. Because in some other courses, we do have problems. Some problems some problems we are doing in the class that we have a problem in class. And when are trying to do a homework or trying to practice for yourself, you get this problem and there is no one to help you. If you extend it to other courses, it would be good.
P1	It will help a lot sir. Because it helped me with programs sir. And it will help a lot in other courses.
I	What would be your reasons?
P1	It has helped me a lot in Development Software.
P5	I think it would be very helpful. Because, in development software, there a kind of bond amongst the students and the lecturer whereas in other courses, there isn't that bond whereby one can really feel free to ask questions and interact with the lecturer and other students. If were to adopt it to other courses, it would be easier for us to ask questions if we don't understand certain aspects of the work. It would definitely improve our marks as a whole.
P2	I agree with them, yes
P3	I also agree with these guys sir.
I	So adopting it in other courses
P2/P3	yes
I	Thank you so much for coming. This is the end of the interview. I would like to thank you all on behalf of Mr Lukose for your time and your answers. I promise that your information will be kept confidential.

Transcript of Focus Group Interview – 3

Good morning students. Welcome to this interview for capturing feedback for the research that we are conducting.

It is just an interview to give some feedback on the impact of prior required learning.

In front of you have a form. Please sign your ethical research confidentiality and give back to me at the end of the interview.

The interview is structured in three sections. The first section will be capturing your experience and your feelings on the interaction you had in class.

The second section will focus on problem solving practices. Before we end the last section that speaks about the perception of the level of writing a computer programme. So, let me start.

Question 1	I want to know what is your opinion about these group sessions that you had in class.
P2	I think it's a great good idea because your class mates can help them out, not only hear from your lecturer says, your class mates says as well. It helps a lot, I think it's a very good idea.
I	I think you mentioned class mates. Is there anyone else who wants to add regarding that interaction between the class mates?
P3	Interactions within the class mates..its really helped because sometimes that person understand the question more, like an advocate that member can explain to others like when we are done with the lecture. Then like it will help us understand more.
P4	I think it was a great idea because it taught us to work as a group and to work with other people and it taught us to compromise with your own thing, since programming is a subject that let you do your own things ..it helped us to improve our understanding skills

P5	And it helped us to improve our communication skills meaning when we discuss in groups we then we argue with people and yah
Question 2	Ok let us talk about interactions among the groups. How was the interaction between group members? What happened during the interaction when you were together?
P1	It was very instructed in a way, first find out what we need to be found from the question, then what needed as the outputs and what we needed in the inputs instructed by the program.
I	Look, I am talking about interactions among the group members in terms of who speaks and who doesn't.
P2	Basically it is not about who does or doesn't speak but about everyone given their opinion.
I	Brainstorming
P2	Exactly.. Everyone tend to talk like if we are stuck with something. Everyone is gonna give their opinion and discuss it, come to an answer and then we do it.
P1	When we disagree, we question each other
P2	Yah we disagree as well…then we discuss it further
P1	Argue each other…
P2	Exactly..
I	So you are kind of interact either there is a position or two views or something…
P1	Yes we are open to all opinions in a group. So if one has to give their own inputs, then one of us disagrees or agrees and we take it from there.

I	From the opening up of everybody's views, what else were your interactions? Was there time when you feel that you don't belong to the group or something like that?
P5	If you…you don't know the answer or you answered wrong, its cool because then we have someone telling the correct one.
I	You were saying
P3	I was saying that if some people like for example if you come up with an answer, then I remember the group which disagree with it but at the end of the day, you come like with the right conclusion like everyone will try to help like although it was not the right way to go..there is an easiest way to go. So at the end of the day, you go with the easiest way, although your way might be correct but you take the easiest way because you may complicate things..

Question 3	Ok..lets move on to the next question. On your motivation. Now that you worked as a groups, after your group everybody goes home. How did the group session motivated you to go to the next class or to prepare for the next class?
P1	Sometimes you get
P4	And when we working as a group, you have your fault and your group members tell you your fauls and when we arrive at home then you can attend to those faults preparing for the next class. So that when you come for your next class, you will be familiar for and both understanding.
I	Try to add on that, do you want to add to that. What was your motivation of that group session you had in class and what is the impact at home when you now on your own.

P1	Motivation is getting it right, I would say.
P3	And that is true getting the answer right and getting back to a position that could persuade, so that you belong to them with your understanding so when you come to the group like for example you explain to them. That is the motivation for you to tell what you understand to your group, if they are understanding
P2	Yah at home for instance if you struggling like the stuff and all, before you go to the class like you whatsapp your questions to your group members and class mates can all help you to give you the answer.
Question 4	Ok. What do you think these group sessions really had an impact on your oral communications or any other soft skills?
P3	Yes it is more to the communication skills. Because some of us English is not our first language it is our second language. As we engage in our group it improved our communication skills. Some of us are shy, we are not able to speak out. But now we can speak out fluently and could put our idea across so that everyone present could hear you
P1	Also to get others to speak. Get to the idea first, allow others to speak, and now on the idea if is correct we use it and you can explain why you use it
P4	Also then to be confident, because you said that the answer is like this, they would ask qustions how did you go about it to find certain answer, so you have to be confident explaining your views to them so that you get the feedback so that you can interact and explain how you get to the result.
P3	It also improves your listening skills, like when someone discusses, you have to pay attention to them and give them the chance to put their idea across, and this will like at the end of the day if those same people to listen to you have to listen as well.

P1	I wouldn't say it helped too much because you are only discuss among yourselves, and may be then if everyone to explain to the lecturer, how you got it.
I	Ok..so you feel it did not improve the oral skills, because it was only one person reporting to the class.
P1	yes
I	Anyone to add on to this?
P2	I wouldn't say necessarily one person answers from the group. Anyone can explain or assist from the group
P4	And also when he (lecturer) approach the group, he would ask each one of you, like would chose whoever he wants to choose, so how did you get to this answer, and if there is something wrong, he ask the second one so that he makes sure that there was interaction between the group.

Question 5	What was the impact of guided enquiry learning on your level of understanding the problem scenarios of all the tasks you have been given?
P1	It has a positive impact because helped on our analyse of the question, on what is needed in order to what the output needs to be required by the problem because that's the user wants.
P4	I would also say that it had a positive impact, it taught us the approach to the problem, because before there was Inquiry learning, we didn't approach the problem, I myself I didn't approach the problem, I just look at the question and attack it. But after this learning, I learned the approach of approaching a problem.

P5	And it assists you in get to know different ways of approaching a problem. Now you know that different ways from others.
I	Yes the problem scenario. You know when you are given a programming problem. The scenario itself, how did this learning impact? What was the impact of GIL on the level of understanding the problem
P3	It taught us how to approach the problem in different ways, and …………….. what else(18:07). And when you are solving a problem, you don't have to .. first you have to read and understand the question before you try to do anything, make sure you understand the question, if you don't read and understand the question problem isthat you have 90 percent of the chance of answering something else.
I	So when you approaching the program how do you make sure that you are right in the scenario or maintain that you are right in the scenario?
P1	Critical analysis. Analyse what the problem wants and those steps to reach the end result.
I	Ok. You mentioned a lot about steps, how do you know that you are on the right steps while interacting with each other when you are analysing the scenario?
P1	For every program there has to be an output. You need to know what the program or what it expect and what the input there must be for us to carry out to get there.
P2	And last thing is that, once you come up with the answer, students will sit back and check if it answers the problem, check it ourselves and what I would do I get my book to my group mate and I get his book and I check his and he checks mine, and compare the words and see if we agree or not.
Question 6	Still on the GIL sessions in your class, what was its impact on your analytical skills? How did you came about analyse the problem now?

P1	So you understand the question. Now what needed from you as a programmer in order to make the program work.
P3	I think it improved our skills to analyse. If somebody give us a question, we will first get the question and try to understand the question, from there you can get what is needed from you, like if I had a question, identify the things which you needed to put into your program and identify what the solution, for example how you are going to put across your outputs to the user or if you are asking the user, how you are going to ask the user to input the things,
P4	And when were doing the problem, they would seem to be big. Then he taught us a way of breaking them into pieces, so that we can understand them, for example if question is asking for commission or whatever, he would first ask us some questions regarding the input then what we need to accept then output and in that manner we would analyse the problem more easily and then get to the solution more easily.
P2	I agree with them.
P5	I agree with them

Question 7	With your experience, while working alone how has the inquiry based approach impacted your problem analysis skills?
P1	Now you know which questions to ask yourselves to analyse.
I	So there could be some questions that help you to analyse?
P1	Yes.
P2	I think, it has a positive impact because programming is not always done in a single way. Like for example, I just see how the class members found the problem in different ways, for example you got a question and

	you argue in the first way, but he gets it in the other way, but you still get the same answer. So you get to see how there are different ways.
I	Anything to add on them?
P4	When you are working alone, now you are able to ask yourself some questions, and from experience of the group, now that you are alone, you will think you ask yourself some questions. It will help me to have the conversations with myself, because you are trying to understand the problem in a different way, and then probably you want to come up with two things because you are being used to working as a group. Now you are a single person, you want to find out if there can be more ways, because programming is not that something that is done in one way.
Question 8	On your problem solving skills, How has this method affected your problem solving skills?
P3	This taught us that problems are not solved only in one way. That there are different ways.. So at the end of the day you need to understand that if you do it this way, some other person can do it the other way, and they are not fault, so you need to think of the optimal ay of doing it to get the great answer.
P4	To me it improved my logical thinking. Because having to work alone now, I believe that when I am alone I am going to come up with these solutions, so I must have a logical power to work out another thing. So it really improved my logical thinking.
I	How did it affected your problem solving skills compared to what you think you had before this way of doing things?
P1	It is in the way you look at the question now. You also look at it in part. So this part of the question, it might affect the next. So now when you decode something, you do it thoroughly
P2	I think it is when you are working in there, like alone, you are actually quite used working in groups with multi-way of doing things. So we are

	actually like, one terms of working alone and one terms of working in groups. So you think different ways.
I	So if you are used to it in groups, what was the impact on your individual problem solving skills.
P5	For me, it gets hugged me to the problem because I am doing it with people. But when I am alone now, it is difficult.
I	For you it is difficult when you are alone, and is more understanding when you are in a group. Can you elaborate on that?
P5	When I am in the group, if I don't understand this section, some people will explain it to me then I will get the answers. But when I am alone, I just become hard. Because I am used in doing it as a group. Getting different options, etc
Question 9	Let us talk about the pressure. How do you see the opportunity to be part of groups and the group interactions in the early stage of your University life in managing the pressures of the new (University) environment?
P4	For me it happened to me as a surprise. Because when I came here I expected to feel that loneliness for quite some time, because I don't know people, and I don't know who will approach me first, I don't know who to approach. So working as a group, now we didn't have an option, but to interact. Interacting as a group really helped, because now interacting and then we created some relationships in between the groups so that we can talk and interact with our own idea. So for me it really helped.
P2	Yah. I think it's good. This kind of weirdness kind of thing. And when we work in the groups, kind of open up, you voice yourself and
P3	It helped like when you coming new in the University, you don't know anyone, you have class with lecturer speaking. You are afraid to voice your opinion. But now you when you are in a group now, you are free to

	interact, now you get more confidence to speak out, if you have any question, you speak out through the group. If the group doesn't know, you ask the lecturer. So, as for me, it helped me to be of more confidence about myself.
I	Which kind of pressures you experienced when you come early at the university and how these groups actually affected that
P5	I think it helped in communication because now you know how to tell people, different people.
P1	Yah..when you arrived, you are bit nervous. To communicate to people. But in the groups, everybody is speaking same as you is. So there isn't too much pressure. Because after a while, you feel like talking to one of your own people.

Second Section

Question 1	When you are given a problem, How did you analyse the problem?
P4	We broke them down into pieces of information. Try to take out the input, process and output. So that if we know the input and what need to be accepted, we will know what formulas you need to get the outputs.
P2	What we do that we ask ourselves first questions, when we find answers to that questions, then we will find answers to subsequent questions we ask ourselves. We ask ourselves questions and try to answer and find other questions to get what needs to be found, accepted, how many times this program has to be run and stuff like that
P1	When to stop running,
P2	What formula to be used,

I	So in addition to those questions, what else do you do
P1	Declaring variables, what are they and how to declare them,
I	Just to follow up, after those questions, is there any activity or methods to interpret the problems.
P5	Which are the things you are supposed to find out from the question?
I	How did you follow this interpretation?
P3	Some time we go and draft an IPO chart to give us a clear view of how our interpretations
I	After that how do you proceed
P4	We try to write the program in the way that we think it should be after the reviewing our own different opinions, and then we check if it is correct or not.
Question 2	Ok. After this, how did you go about solving the problem?
P4	Then each one of us write. Then each one of us has to explain how they went about planning to that conclusion of theirs. So we would explain to each other and most of the time views would be different, so then we discuss and discuss and discuss talking in the programming language. Steps to follow and what need to be done. So we debate and debate and come up with the answer we think is correct following the depth that we know of programming.
I	Anything else to add on that? So when there are disagreements, how do you solve the disagreements?
P1	We debate each other. We kind of receive the proposed idea. And if I think, I don't agree with that, then I will show my idea, I will show with a

	sample, it might be correct, then we find a way to agree on that, but then we both disagree then go back to her program and see if it works.
I	How do you know that this is the solution that works?
P3	We chat to each person's idea and see if it is correct, and now if we are not too sure we call the lecturer to come and guide.
Question 3	Why did you go about solving the problem the way you did? You did solve problem. You said that how did you solve the problem. Then why did you use that way to solve the problem?
P2	I think it is the best possible way of solving the problem. Because, you can't just solve the problem and say that it is right in one person's perspective. Everyone should see what the question and give the opinion as much you want and ultimately discuss it with the lecturer and lecturer discusses it and show if it's the right or wrong answer and if necessary tell you what you need to do and stuff like that.
P3	This is the right way. Everyone in the group is involved. So like, if I am not too sure, like some people are not sure of like themselves, but it is like time now everyone will be doing will be confident even to showing the answers to the friends like of this the way I am doing it. If your way correct or my way correct, so you interact like, you opened it.
I	Anything else?... so why did you use that? That is the question.
P4	It helped us to figure out the answer
P1/p2	We just liked it

THIRD SECTION

Question	Now we are into section C. Can you write a program that works? How do you know?
P1	yes
P4	yah
P3	yes
P2	yes
I	How do you know?
P1	Because we are doing it. We do it in different ways. Students know, do it in different groups, do selections, plus the results will tell
All	laugh
P4	And I know I can do it. And now we know that we have a lecturer who communicates with us. He would let you write the program initially and he would go step by step showing our own mistakes, so after he has showed us, now we are confident enough to say. Because we know that he didn't do it for us, but we did it ourselves, and just helped and guided here and there. So that's why we can say that, we actually have no problem.
I	Can you write a good program?
P2	Yes we can
I	How do you know?
P2	If everything is perfect at the end and it works.
P1	Yes we can.

P2	As we say, when you write program, sometimes, when you first write, it is not like perfect. You always catch-up. You always like catch-up on those small errors, to make it perfect. You write it, then you run it. You see those minor mistakes, you correct them.
I	So you are saying that you can write good programs. Will you attribute this to the intervention?
P1	Yes
P2	yes
P4	yes
I	How?
P1	Because now when you generating this program, and when the lecturer ask you a question about your sequence, you end up asking yourselves question like are you doing the right thing.
P3	Also like, in a group, you get different ways. So when you are alone doing programming, now you remember, oh.. say Ayabonga did it that way a similar one, and it guide you that way which is the quicker solution to do it, make the program good and you tell yourself, let me do it this way.
Question 2	How do you see your current ability to program?
P1	Mine I would say it is not that great, because I haven't got too familiar with the software used, Visual Basic.
P2	I would say, first year is the beginning. Teaching up the basics, and I think what the most important thing is to know the basics, and you can make anything from there. I think we got the basic side strong. Strong basics we have, therefore we can learn anything else, that would make programming easier once you know the basics.

P4	I think my programming ability is fair, because programming has been introduced to me this year, and we only learned the few things as the basics. So I think from now, its good on my level. Now as I go forward, it is going to be perfect.
P5	I think not much, its just knowing the basics.
P3	I would say I have learned but I agree what he is saying that we do have room to actually learn more and things like that, but as for now, we have got some background of programming. So for like for example if I have to learn C++ next year, I will understand better from what I learned through the group work and my lecturer this year.
General Question	So overall, what is your opinion in adopting the guided Inquiry Learning method in other courses that you are doing?
P4	I don't think it would do great for me in other subjects because Development Software is programming and it not theory. Some other subjects are theory, whereby you have to read and understand what you are reading and then. You just know the answers, there is one way of answering. So we won't have something to interact with others.
P2	DS is one subject that we discuss and so that you…but other subjects are theory based. In other subjects for example in the beginning of the year we did practical on System Software. For that it is good. Other than that I don't see much.
P4	But I do think one can use this eventually what we learned from problem solving approach. For example, now the way that we use in learning this subject, we are not only use in Development software, but also using that approach to other subjects. So in that way we can.
I	So you are using it in other subjects as well, even though it was not taught in other subjects?
P4	yes

P2	Definitely improves your problem solving ability.
P1	It helps us understanding questions sir. Not just in development software. Analysis of question.
P3	As for me I disagree with guys who are saying we mustn't adopt in other subjects. For example when you do binary calculations, you need someone like a third party to help you. You might do it, then you think you are correct, but without someone else to tell you this is wrong, you will lose. You still need that someone else mend you in the correct way. So if you are in a group you discuss, he or she will come up with their own opinion and I will come up with my own opinion, then we compare these opinions. And as for the more theory based subjects, I do like, when you are alone when you are reading most of the time, you won't focus that much. But now when you are discussing in a group, you may ask what is this, and this one explains, then you will understand now. Of course when you are alone just reading the theory, then you after like you forget. But now you keep on discussing that in the group, your memory will be refreshed most of the time.
P5	I agree with him. When you are discussing with your class mates, it gets and even to memorise, you can't forget. You get different ideas about whatever. So I think it is the best.
I	Ok. Thank you so much for your time.

Transcript of Focus Group Interview – 4

Good morning students. Welcome to this interview for capturing feedback for the research that we are conducting.

It is just an interview to give some feedback on the impact of prior required learning.

In front of you have a form. Please sign your ethical research confidentiality and give back to me at the end of the interview.

The interview is structured in three sections. The first section will be capturing your experience and your feelings on the interaction you had in class.

The second section will focus on problem solving practices. Before we end the last section that speaks about the perception of the level of writing a computer programme. So, let me start.

Question 1	I want to know what is your opinion about these group sessions that we had in class? What is your opinion about the Group sessions?
P1	I think the group sessions are more efficient and more interactive to students. And I think it is more productive in that manner that, we share ideas in a group and then we combine them and table the best solution that can be to cut to the problem that we are having in the current class or whatever situation.
P2	And helped us to communicate with each other. Yah it improved our communication skills and do programs. While we are all together someone will come up with another question that you didn't think of and then we just, she said that and this and we come up with the best solution and then yah
P3	I think it helps like, hm.. helping each other, let's say someone following one answer, but because it is interacting, we help each other to solve the problems

P1	Yah it helps. There will be many ideas with different people though..yah

Question 2	Ok let us move to the second question. Still about your group sessions. How was the interaction between group members? What happened during the interaction when you were together?
P2	Some were good, some were bad. We learned to. Learned from our differences, we didn't come to the class knowing each and every one of us. We didn't know each other, but when we were in groups, sat down and got to experience how Amos is like, got to see how Apiwe is like, how interactive he is and how he deals with us, and what not and then and we also got people that wouldn't participate in certain groups. We avoid different groups as much. We were only like task and
I	Let me ask a follow up question here. The bad interaction. What was its nature? Tell us more about it. Anybody else? Who agrees with what she just mentioned? Can you elaborate on bad interactions. What do you mean by that?
P3	I think it is the fact that some people do not want to participate as much as others. Some people are too shy to speak out,
P1	Then also some people are by nature not talkative as other people. So in that sense, they wont participate when we were talking and discussing something. So we need to like, go to that person and persist and tell, that you need to participate, you need to talk to us. So its.. I think it is bad in that way, but then we learned through the year to understand each other, as she has said, and then now some of the people that were preserved at the beginning of the year are now interacting with us, and we are in a group and each and every one of us knows the other person in our class.
I	So you know each other

P4	yes

Question 3	How did the group sessions motivated you to go prepared to the class? How was the motivation to prepare for the next class?
P1	I think it gave us more confidence, in a sense that when you are acting with people rather when you are acting alone, when you are acting individually, meaning that anything that you do, you are not even sure that if you are correct about what you do, but when with the other people, you can go an confirm, if whatever you are doing is in correct form or is correct. And then now, this motivates us because, if you know that everything that I did is as same as Amose's or Vuyo's. making sure that my work is correct, or what ever or as in the same line as they are and we are in the same group. I think in that sense, it motivates us
P2	Yah I agree Yes.
I	Anything to add?
P2	Ok… it comes to bit of competition between us as groups. Yah. You know if you are in a group wit Apiwe, you know, ok Apiwe is good that I will improve myself so that I can be also in his standard. I am in a competition with him, yah its good.
P4	Yah I agree.
P3	There is not much to add. Yah it does motivates in the sense that the whole group thing with each other, so it helps in that sense.

Question 4	What do you think of the group sessions and their impacts on your oral communication skills? What was the impact of these group sessions? Can you just elaborate on that.

P4	Yah it helped us to improve our communication skills. Some people, we did not have good communication skills, but when we were in groups, we managed to get some benefits. We are not scared (now).
P1	I think, it is going to help obviously, we need to talk. Some of us come here from rural areas or whatever schools. So we come over here not confident of our English. When we are in class, we need to speak English. Like when we communicate, we need to speak in English most. So we are more fluent now. Speaking with our friends, when we are in a group, when I say some wrong words, obviously they are going to laugh me for a while, then after a while they are going to correct me, no dude, this is not the way you suppose to say, this is supposed to say in this way. In that sense, in influenced my vocabulary, improved my oral sense, and made me more fluent with my English and whoever we are communicating with.
P3	I think it also makes you more comfortable, knowing that you are speaking to your peers and people who see me and so in future, you can speak in front of many people. So confidence
P2	Yah it is those confidence that improves
I	So, it is the confidence that improved. You were all confident with those group sessions.
P1/p3	obviously
I	So, how do you know that you are confident
P2	Ok you can tell easily. I saw him in the beginning of the year, you know he was not like present, he was reserved, he was shy in the way, but now, it’s a different story.
All	Laugh
P2	He participates even more than when I was here. You get to improve you know.

P3	I think, I was also very quiet at the beginning of the year. I didn't like rising my hands and answering questions. Through the interactions, I became more open.

Question 5	How do you see the impacts of guided inquiry learning (GIL) sessions on your level of understanding of the problem scenarios in the various tasks you were given? What was he impact of these interactions with your peers in understanding the problem scenario?
P1	As we said before, there is like different minds over here. So the way she understands the problem, is different from the way I understand the problem. So with me in a group, with other students, we gonna come back as a group and try and break it down. Obviously in her understanding she is gonna tell me something I didn't understand in my understanding. And in that way we gonna find a solution for us to tackle the problem.
P3	I think it had a positive impact. Certain students might misunderstand the question, or let us say we didn't understand it at all. But when we are in a group, we get to explain to each other in different ways and ask questions and come up with a solution that we all going to understand and so that a person can see, this is how we got to the solution. And it is better that way, because we did it all together. Yah, so it makes it more easier to understand when people are explaining it to you

Question 6	What is the impact of guided inquiry learning (GIL) sessions on your problems' analytical skills? The way you analyse the problem.
P2	Ok, at first me personally, when I see a problem, I analyse it ok this is how I can do it. But when we sat with the group, then we discuss it and we explain it, and understand it and analyse it in a different way than I did it before. Rather than quickly judging the problem, and say I can't do

	it, its hard, I sit down and understand it in different sections, so that I can understand. Yah it helped.
P1	Just to press on that, I used look at a problem as a whole, but in groups we put it into sections and make it more easier an we combine the work as a whole. That way you solve the problem easier.
I	Which other aspects of this sessions impacted on your problem analytical skills?
P3	I think it is also positive in the sense that when you analyse a problem by yourself, when you reading through it, sometimes you skim read. You don't really make into it. So then with others, you get to see what you missed out on. Something you really didn't catch on. So with the help of others, you can read through the questions and we get to understand the problem,
P4	And also underpinning the key points that are important

Question 7	With your experience, while working alone how has the inquiry based approach impacted your problem analysis skills? How was the impact of these sessions when you were working alone?
P3	I think it had both positive and negative impact. Positive is that you are motivated by your group. So then, you got confidence in the fact that, ok I can do it on my own. I understand from previous examples. And it is also negative in the fact that, when you are alone, you tend to underestimate yourself and you find it harder to work alone.
P2	You get lazy. You get bored when you are alone. You used to be in the group. You used add on to your knowledge, you add it to them. And when you are at home alone doing it, you just get lazy like if Amos was here, I will probably doing this, and you just settle, ok I will probably do it in the class.

P3	Sometimes when you answered your questions, then you are like hei, may be I would be better, if I were in a group. You are not sure, if this was the right path,
I	When you were uncertain, is there something that you could do?
P1	I was going to that point. We had some WhatApp groups. We do communicate with others like when we have those lazy moments of hours at home, hei I am not sure about this question like, then we go to WhatsApp and discuss like don't you know this and that. In that way she is going to help me on continuing or making sure that my answer is in the right track.

Question 8	Now let us talk about your problem solving skills. How has this method affected your problem solving skills?
P2	It was positive. Because when you are given this problem and you are asked to solve it, you know that you have to work things on the sides to help you in solving these problems. When you are in that group, you have to first write those/the questions down first and then you analyse. yes
P1	After analysing, in the question obviously you are gonna see what you are given and what is required of you and in this manner like, when you have this method, in this manner you are gonna see what is needed of you and what problem that you need to solve. You gonna find with help of the group members the best solution that you need to take in order for you to solve the problem. Because, may be like you know who you are and you are going to come up with that solution. Amos is going to come with another solution. We gonna try to find the best out of the all. Then in that way we gonna best way to solve the problem.
I	Wo can elaborate on the best way. How do you chose the best way?

P4	One which is the most easier to understand for everyone. Just simple and short, especially
P3	Going about with the easiest way for everyone to understand. Because we know that we don't have the same mind to understand. Our thinking are not the same. So the simplest way is the best way.
P2	Everyone come to understand the shortest way. With the level of thinking, we all in one standard. Basically when we are in class. Then some has broader thinking, broader knowledge, then he can come down and explain to us how did he go about doing that. Then we begin to ask how is the best way incorporating the whole set of ideas and put it together.
P3	In such a way that everyone going to understand.

Question 9	Now, let us about the early days in the University. How do you see the opportunity to be part of groups and the group interactions in the early stage of your University life in managing the pressures of the new University environment? What was the impact of the GUI sessions in facing the challenges of the University life?
P3	I think it had a good impact with the fact that, when we came in to the University, we had a perception that you are on your own. It is going to be hard, so you just deal with, it is you, yourself. Then when we were in a group, like ok, there things like more something, more understandable. yah
P4	Yah, I think it has helped me, in improving my English. Because when I came here, I was not having good English. But now I see there is some, there is a progress in terms of communication and so on.
P3	Can just add on. I think in terms of pressure, it has lowered the level of pressure you had, because you were like, ok I am on my own.. you just

	always constantly thinking about it. It worries you in the fact that you lose focus when you are by yourself. Then in the group, there is less pressure on you. You are more relaxed to work and interact with others.
P2	Ok, there are some people who find it hard to first react in a group. You first have that challenge of ok, I don't know that person. May be he or she may judge me for not knowing how to do this and that pressure of judgement … I think I am not gonna speak, I am not gonna participate, yah in these group discussions. Because I don't have that confidence in myself. But as we were continuing, we resolved that. Ok these people are here for the same thing. They are here to help, they are here to get this degree and you also. Yah, so what is different between him and me. There is no difference because we are here for the same thing. So why must I shy in getting my Degree. He is not going to be pushing me to talk or what not. I must just be myself and talk with people and help them and help me understand. Yah.
P1	Yah when we think of varsity life, like you are thinking you can do whatever you like, there is no lecturer is going to come here your back and tell you, why not in class, why your home work is not done and everything. Its all about independent and some sort of thing. But then with this Guided Inquiry Learning, I think its more of a High School kind of vibe than a Varsity kind of vibe. I think it is the hybrid of the two. Because like, hm when the groups like we understand each other and what so ever and teachers like, when you are not coming to school, you just know that the next day when you are in the school, you are going to bust it, why you are not coming to school whatever. In that sense, its more like more acceptable or more easier to adjust in the University life and then that mentality of thinking that you are in varsity is long gonna be gone and that changes you attitude at all like you are in the varsity like place or whatever. Yah.

SECOND SECTION

Question 1	How did you analyse the problems in your sessions when you are given a task? How did you go about analysing the problem in your GIL sessions?
P3	Ok first we have to read through the question thoroughly and make sure that we all understand what the question requires of us, what solution we must come up with, what do we need to input into that problem that we are given to come up with the right answer. So we need to understand clearly what is needed of us and what are we asked from the question.
P2	Ok, someone will read the question for each and everyone, then each and everyone will give the out, input and the processes to solve the problem. yah
P1	I think as just they said, it is all about knowing what is given in the question and what is required of you and what solution is best for you to solve the problem.
P4	I think it is also good for us to ask if you don’t understand the question,
P2	I think if we are all confused about certain problem, we will call the lecturer so that he can guide us in the right way and that’s where we kind of ok..ok
P1	Actually he hasn’t really given us the answer. He guides.
P2	Yes he guides us. yah

Question 2	Now that you analysed the problem. How did you then go about solving a problem in your group? You have now analysed the problem. Now how do you go about solving the problem?
P2	Yah we basically chose the best way to solving the problem.

P3	We analysed, then we plan. Planning with your group. Ok he came up with this, he came up with this. Ok, basically what he says and what she says are the same thing. So we take that the best ways proposed.
P2	We ask each other, how do we go about solving the questions, how do we go about answering. Like if we have to have a do while loop or If statement etc.
P4	We also ask questions to make sure that the steps that we are taking are in the correct order in the algorithm. Are they going in order or in the right sequence?
P3	I think also when we after analysed the problem, we break it down simply like, we don't just answer everything at once, we have to do it bit by bit, so that we all understand it and come up with solution that make sense, that is good and that we all can agree on.

Question 3	Now that you told me about your way of solving the problem. Why did you go about solving the problem that particular way? why did you use this particular way you mentioned now?
P2	Ok in problem scenario, you have to look at each of the sections on its own. You mustn't just leave it all together. That why we have to break it down and I think, we break it down for understanding, we can understand more clearly what is going on.
P1	It is all about algorithms and following the steps that we needed to follow in a logical manner. Obviously we know that we are given a problem. Breaking it down into sections, for example, let me give a rough example may to find total money with tax one without tax. May be some us will jump to give total money with tax. In that way if we break it down, we go to see accurately like, we need to look at the amount without a tax and we like find 14 percent of the money and add it and then to get total with tax or whatever. So braking it down, it is

	going to be more efficient and more easier. Because when you are solving a problem it is more accurate. In that manner, if we gonna find a solution, then we have to find the perfect way of solving the problem. So for us braking it bit by bit, making it more accurate and more leading to a better solution needed.
P4	I agree.

SECTION C

Question 1	Can you write a program that works and explain why? Can you now say that you can write a program that works? And explain to me, why? At this point, can you be given a program and how sure are you that you can write and is going to work?
P1	Yes. Obviously. I mean in a sense that I am confident that I could write a program that runs on VB. Because, we were given algorithms, steps to follow in order to get the right solution. So us being given a problem we are going to go through the pseudocode, to understand the problem more, do the flowcharts do the IPO tables, and try to find the best solutions. And we are going to run the program. And if it doesn't work, we are going to go back and try to understand were we went wrong.
P3	Yes I think I can write.
P4	Yah it is possible. Because, if you have completed the program you need to prove it, check it to see if it is correct or not. Trying to solve a problem by using it yah the trace table.
P2	I am confident that I can write programs. It is easier to write pseudo code first and then move to actual VB programm. If your pseudocode is right, obviously your VB is going to be right.
I	So , you can write a program. Which is good.

Question 2	Now, how do you assess your ability to write computer programs? Your overall assessment as an individual.
P3	with me I would say, assessing myself, I wouldn't say I make some very stupid mistakes as well.
P2	But judging from the time when we started, ok we didn't have much time. But in that small amount of time, we understand, we are confident enough to write a program. So I would say, we are in the right track. Probably by second year we would be the best programmers.
P4	Since I have been managing the problems that were given, I think I can manage to. If I rate myself, i think I would be at seven out of ten.
I	Why do you think, you rate yourself at that level, seven?
P4	Well I can never be always right. So the three I minus.
I	And about you?
P1	Yah I think sir, it is more about confidence at the same time of knowing what you are writing or doing. In my way sir, I think I am confident and I could write programs. Again I cannot say that I reached my limit or reached my potential yet. Obviously there is still room for improvement, to learn more about it. So if we get more time, we could be the bests.
I	So all of you what rate would you give yourself? You gave seven.
P2	I would give probably a six. Because you get to a point you need help. I do understand how to work it out, yah but a six
P3	I think I will give myself a strong five. Yah 5.5
P1	7.5.towards eight.

General Question	Ok the last question for you. What is your opinion in adopting this new method in other courses?
P4	Yah. I think it can help in IT Skills, because it has a lot of calculations. Calculations need to be solved in groups most of the time, so that you understand it better. You need to practice in groups. It would be difficult to practice it on your own.
P2	Another negative, it could be good, it could be bad because, individuals have different personalities. And you find it such, there is a person in your group who is not willing to participate because there is you involved. Probably they have, whatever feelings they have. Probably there is something against you, it it
P1	We are teenagers. Like we have our personal vendettas and whatever.
P2	yes
P1	Yah that is the bad waves. But mostly in groups, there having going good waves. but obviously we are teenagers, we have our reckless vendettas and whatever. But then coming to school we have to communicate with each other, we have to work with each other. So when we are out of the class room, some of us didn't want to help each other, call each other. In that sense it could be wrong. Then it could good as well. Because right now in Development Software, we are very good at, because of this kind of learning and we are there smiling with each other, very friendly with each other and very cool with each other because of it. So maybe even though we have personal vendettas, may be that person, if we were in a group, he would be like knowing me and he is gonna know me like we will be cool with each other, maybe we will be friends too.
P3	I think, it could help but I don't think for every other subjects. Subjects like for system software for example. It is just basically questions, and you just have to study and read. The more you read the more you

	understanding. So I don't think it would be of much help there, in that sense.
P2	Yah some people prefer being studying alone, like for system software. But in IT skills, where there is like calculations. We are not very good at Maths.
P3	I think like for IT Skills, we have all not done pure Maths. In that way we will help each other. So

Appendix F: Guided Inquiry Learning (GIL) guide for assisting students' learning

Guided Inquiry Learning (GIL) guide for assisting students' learning

(A guide to learn and understand)

Background

The purpose of this guide is to help programming students to learn solving problems using Guided Inquiry Learning (GIL) approach. Before one can attempt to solve a problem, it is extremely important that the student understand the problem completely. Questions are to be asked to guide the student through an information gathering process relevant to process to follow to understand the problem scenario under discussion. Active involvement of students in gathering information is required to find answers to these questions. Reference materials listed in the study guide, text books, websites, papers and/or journals may be used to gather relevant information. The questions asked must be structured to take you closer to the solution with every answer. Students are reminded that for every problem, there is a solution and in many cases more than one. Students might find this process very time consuming initially, but with consistent practice and more knowledge gained in the field, the skill to ask goal-oriented questions will be developed among them.
The type of examples given is aimed at entry level (first year) students assuming that they have had not much prior experience in computer programming. There is one example given per chapter with a guide to understand how to go through the process of asking questions in order for the student to understand the problem scenario better and gain more information about the problem so that a solution can be developed. There are more questions given pertaining to the topics under discussion for students' practice. The content of this guide should be regarded as merely a support document for students to learn the introductory programming subject Development Software 1.

<u>Develop an Inquiry mind – Solve problems by inquiring (asking questions)</u>

Once you are faced with a problem, ask questions pertaining to the problem. Act on each of the questions you ask – read, investigate and search to find answers to the questions. This will guide you through the process of gathering information and learning. By going through this process, you will learn more about the scenario under question, understand it better and eventually find a way to solve it. This requires active involvement of the learner. You may find this process time consuming initially. But once you developed the skills through consistent practice to ask critical questions that lead you to understand the question, define the problem and eventually find the solution/s, this process will become much simpler and enjoyable.

Extract from the GIL Guide

MODULE: Introduction to Pseudocode

Outcomes

On completion of this chapter all learners should be able to

- Explain what pseudocode is and why it is used by programmers
- Explain the 6 basic operations a computer can perform
- Use the correct data type and syntax to declare variables and constants in pseudocode
- Use the correct syntax for pseudocode instructions to:
  receive data from a keyboard, assign or store values, perform basic arithmetic operations, display messages or values on a screen
- Use the sequence control structure within a pseudocode algorithm

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In this course, you are learning how to create algorithmic solutions for problems that will be carried out on a digital computer. As you have already learnt, you cannot solve a problem properly before analysing it and then designing the solution - BEFORE writing the instructions in a programming language. Flowcharts are an important tool used for solution design. They provide an easy to follow, graphical, representation of a solution. Another important design tool widely used in industry is pseudocode.
Pseudocode is an English-like representation of all the logical steps, in the correct sequence, needed to solve a problem. The prefix pseudo means false or fake and ***pseudocode means 'false code'***. In other words, the English-like code used does not represent any particular programming language (but it can very easily be translated into a programming language later). The advantage of writing a solution in pseudocode first is that you can test your pseudocode thoroughly in order to check your logic, before you need to worry about the syntax and other rules, etc. imposed by a particular programming language. There are many styles or formats used for writing pseudocode – each format chosen has its own syntax and operational rules (just like a programming language).
We will define our own rules to be used in this course.

Generally all pseudocode keywords, instructions and symbols relate directly to the ***six basic operations which can be carried out by a computer***. These basic operations and the keywords, instructions and symbols that will be used in this course to represent them in pseudocode are:

1. A computer can receive data (from a keyboard, disk file, etc.)
   Accept (usually from a keyboard)
   Read (only from a disk file)

2. A computer can output information or data (to a screen, printer, disk file, another computer, etc.)
   Display (only to a screen)
   Print (only to a printer)
   Write (only to a disk file)

3. A computer can assign and store values (in memory - using variables and constants)

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4. A computer can perform arithmetic (addition, subtraction, multiplication, division, etc.)

+	i.e. addition	^	i.e. exponentiation
-	i.e. subtraction	\	i.e. integer division
*	i.e. multilication	MOD	i.e. modulo division
/	i.e. division		

For more information on these, refer to the text book notes on Arithmetic Operators.

(We will do these in depth in Module 5).

5. A computer can compare values and select one of two alternate actions.

```
If    …        then
        …
Else
        …
EndIf
```

For more information on these, refer to the text book notes on Control Structures.

(We will do these in depth in Module 6).

6. A computer can repeat a group of steps a given number of times (known as iteration).

```
Do While …           or     For …
…
 …
Loop                        Next
```

For more information on these, refer to the text book notes on Control Structures.

(We will do these in depth in Module 6).

USING VARIABLES AND CONSTANTS

As discussed in the section on Data Representation in a Computer, all data and instructions to be processed by a computer are temporarily stored at addresses in main memory. In computer programs, the memory locations for data are assigned names, which are known as identifiers or variable or constant names. We also saw previously that variable names are used in algorithms for the processing and storing of data, ***so that the same instructions can be used on different sets of data.***

We know from English and algebra that the term variable means that a value can change. Constants on the other hand are values that cannot change. In computer programs, constant values can also be assigned names and stored at addresses in memory.

Names used for variables and constants must be unique so that each one is stored at a different location.

Each programming language has its own naming rules.

When designing solution algorithms using tools like flowcharts and pseudocode, variable and constant names must be used correctly - just as they will be in the final programming language.

<u>RULES FOR NAMING VARIABLES AND CONSTANTS</u> (in pseudocode & flowcharts):

1. Names must start with an alphabetic character.
   e.g. legal name: sum2 illegal name: 2sum

2. Names may not contain any spaces.
   e.g. legal name: averagemark illegal name: average mark

*** Be careful when writing – make sure it is obvious that there is no space in the name*

3. Names may only contain the characters of the alphabet, the digits 0 to 9, or the underscore character _
   e.g. legal name: final_total
   illegal names: final-total final,total final/total final.total

4. Upper and lowercase will be treated as different characters
   e.g. The following will be treated as *different* variable names:
   averageMark and averagemark
   FinalSum and finalSum
   SUM2 and sum2

5. Names should not be longer than 20 characters.
   e.g. illegal name: name_of_highest_paid_hollywood_actor

<u>OTHER NAMING TIPS:</u>

- Names used should be meaningful, so that when reading the instructions one has an idea of what the variable or constant is being used for.
- Names should not be too long because the longer they are, the more chance there is of making a spelling mistake when using the name. Remember that spelling mistakes will create different names and therefore different variables and constants!
- A change in case is often used to differentiate multiple words in a name to make it easier to read, e.g. averageMark studentRegistration

<u>DATA TYPES FOR VARIABLES AND CONSTANTS</u>

We know that the two main types of data stored in a computer are numbers and characters and that these two types of data are stored differently in memory. Arithmetic operations can only be performed on numeric data.
In all programming languages, it is good practise to declare what variables and constants are going to be used in the instructions that follow and what data type they will be. In some languages you are actually forced to do this, and we will follow this rule from now on in our design (e.g. in flowcharts and pseudocode). In other words, ***if you want to use a variable or constant name in your instructions, it must be declared correctly first.***

DATA TYPES TO USE:

Numeric:	integer	(numbers with no decimals)
	real	(numbers with decimals)

Character: character or string may be used (regardless of the 'length' of the item)

VALUES IN VARIABLES CAN ONLY BE CHANGED BY INSTRUCTIONS

<u>BASIC PSEUDOCODE INSTRUCTIONS: SYNTAX AND RULES</u>

1. ***Syntax rules must be <u>strictly</u> obeyed*** (you cannot make up your own rules!)
If an error occurs in a pseudocode instruction because of incorrect syntax or incorrect use of pseudocode rules, the algorithm will end on the line that has the error and the instructions that follow will not be executed. We will say that your pseudocode has 'crashed'.
A pseudocode instruction is not an English sentence
- do not include a fullstop at the end, do not automatically start a 'line' with a 'capital letter'

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2. - The start of a block of pseudocode is indicated by the keyword Begin
The end of a block of pseudocode is indicated by the keyword End
- Each instruction should be written on a separate line.
(Instructions/keywords can be written in upper or lower case).
- Each instruction should start with one of the keywords or a variable name.

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3. - When working with currency values (rands) or kilograms, etc., only the numeric value must be used, i.e. the R sign or unit (kg, etc.) must not be included in the instructions.
- Decimals must be written as decimal points and not as decimal commas, e.g. 15.2 and not 15,2

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4. <u>DECLARATIONS</u>:

- All declarations for variables and constants must be placed at the beginning of the code, immediately after the keyword BEGIN

4a. <u>SYNTAX FOR DECLARING VARIABLES</u>

DECLARE name1 AS data type
or DECLARE name1, name2, … AS data type
where name1, name2, etc. are valid variable names
(The second version is acceptable only if each item listed is of the same data type)

e.g. DECLARE examMark AS real
DECLARE studentFirstName, studentLastName AS string
DECLARE cellNumber AS character
(a cell number is numeric, but it is unlikely that you will want to do arithmetic with it)

4b. <u>SYNTAX FOR DECLARING CONSTANTS</u>

CONSTANT name1 AS data type = value
where name1 is a valid variable name

e.g. CONSTANT courseCode AS string = "DEV1120"
CONSTANT vatrate AS real = 0.14
** see 7. for discussion on literal values

4c. <u>OTHER RULES</u>

- If you write an instruction that uses a variable or constant name that has not been declared properly, the pseudocode will crash on that instruction.
  Remember that if you spell it differently it will be treated as a different variable!
- When a variable is declared as numeric (integer or real), it is automatically assigned an initial (or starting) value of 0 (i.e. zero)
- When a variable is declared as a character (or string) data type, it is automatically assigned an initial value of null.

<u>** NB ** PLEASE NOTE:</u> *null is not the same as spaces*.
The ASCII code for null is 0000 0000 and the ASCII code for a space is 0100 0000
A null means 'nothing' or 'empty', whereas a space means a 'blank character'.

- When you declare a constant you must assign the initial value in the declaration. That value can never be changed in an instruction (because the data item is a constant).

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5. <u>RECEIVING DATA FROM A KEYBOARD</u>

5a. <u>SYNTAX</u>

ACCEPT name1
where name1 is the name of a variable which has been declared.

- The data input by the user is automatically assigned to the variable which follows the ACCEPT keyword, e.g.

Instruction: ACCEPT mark1
The user inputs: 54
After the instruction has been executed, the variable called mark1 contains the value 54

or ACCEPT name1, name2, …
where name1, name2, etc. are the names of variables which have been declared.
- If more than one variable is used in an ACCEPT instruction, the input from the user will be assigned to the variables in sequence, e.g.
Instruction: ACCEPT mark1, mark2
The user inputs: 54 65
After the instruction has been executed, the variable mark1 contains 54 and the variable called mark2 contains 65

5b. RULES

- When an accept instruction is executed, the program waits for the user to input data and press enter (i.e. no other instruction will be executed until the user has pressed enter).
- If the variable used in the instruction is a numeric data type and the user inputs character data, the instruction will crash.
- When data is accepted into a variable, the previous value in the variable is overwritten (i.e. it is permanently erased).

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6. DISPLAYING INFORMATION OR DATA ON A SCREEN

6a. SYNTAX FOR DISPLAYING VALUES STORED IN VARIABLES OR CONSTANTS

DISPLAY name1
or DISPLAY name1, name2, …
where name1, name2, etc. are the names of variables/constants which have been declared.
e.g.
Instruction: DISPLAY total
Displayed on the screen: 57
(if total contains the value 57)

Instruction: DISPLAY firstName, lastName
Displayed on the screen: Thabo Ngwenya
(if firstName contains the value Thabo and lastName contains the value Ngwenya))

6b. SYNTAX FOR DISPLAYING TEXT OR MESSAGES

DISPLAY “text”
where text is the message to be displayed on the screen
Text ***must be enclosed in double quotes***. The double quotes are not displayed or printed.
e.g.

Instruction: DISPLAY "Please input your name"
Displayed on the screen: Please input your name

6c. SYNTAX FOR DISPLAYING MESSAGES AND VALUES TOGETHER

DISPLAY "text", name1
or DISPLAY "text" name1
Separate the text from the variable name with a comma or a space.
e.g.
Instruction: DISPLAY "The total price to be paid is" total
or DISPLAY "The total price to be paid is", total
Displayed on the screen: The total price to be paid is 57
(if total contains the value 57)
- The comma is not actually displayed. It is used to separate the message (text) and the variable name in the instruction.
- If you want the comma to be displayed, it should be placed inside the double quotes
e.g.
Instruction: DISPLAY "The total price to be paid is, " total
Displayed on the screen: The total price to be paid is, 57
(if total contains the value 57)

6d. RULES
- Each DISPLAY instruction will move the cursor to a new line on the screen
- Text (enclosed in double quotes) will be displayed EXACTLY as typed in the instruction (e.g. case will not be changed)

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7. ASSIGNING AND STORING VALUES (excluding receiving data and calculations)

7a. SYNTAX FOR ASSIGNING A LITERAL VALUE TO A NUMERIC DATA ITEM
(see RULES for definition of a literal value)

name1 = value
where name1 is a numeric data item that has been declared
and value is a number
e.g. mark1 = 55.3
the value 55.3 is stored in the variable called mark1

7b. SYNTAX FOR ASSIGNING A LITERAL VALUE TO A CHARACTER DATA ITEM

name1 = "value"
where name1 is a character data item that has been declared
and value can be anything - ***it must be enclosed in double quotes***
If you do not enclose the value in quotes, the value will be treated as a variable name!
e.g. month = "March"
the value March is stored in the variable called month

month = March

will cause the system software to try to assign the current value held in a variable called March to the variable called month
You will not have declared a variable called March and your pseudocode will crash!

7c. <u>SYNTAX FOR ASSIGNING A VALUE FROM ANOTHER VARIABLE/CONSTANT TO A DATA ITEM</u>

name1 = name2
where name1 and name2 are data items of the same data type that have been declared
e.g. highestMark = mark1
topStudent = studentName

7d. <u>RULES</u>

- *Assignment instructions <u>always</u> work from right to left*, i.e. what is on the right of the equal sign is always assigned to what is on the left of the equal sign.
- Values can be assigned to numeric or character variables in one of two ways:
  a. as a literal value
  A literal value is an actual or specific value which can be used in an instruction.
  (Literal values are not stored in memory locations like variables).
  b. from another variable/constant
- Values can be assigned to constants as literal values only (in the declaration).
- If a character value is assigned to a numeric data item, the instruction will crash.
- When a value is assigned to a variable, the previous value in the variable is overwritten (i.e. it is permanently erased).

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8. <u>BASIC CALCULATIONS</u> (arithmetic operations: add, subtract, multiply, divide)

8a.<u>SYNTAX FOR ASSIGNING A RESULT FROM A BASIC CALCULATION TO A VARIABLE</u>

(Any valid arithmetic operator can be used: + - * /)

name1 = name2 + name3
where name1, name2, name3 are numeric variables which have been declared
e.g. total = mark1 + mark2
- In this case the value currently stored in the variable mark1 will be added to the value currently stored in the variable mark2 and the result will be stored in the variable total
The values in mark1 and mark2 are not changed by this calculation.

or name1 = name2 / value
where name1, name2 are numeric variables which have been declared and value is a number
e.g. average = total / 2

- In this case the value currently stored in the variable total will be divided by 2 and the result will be stored in the variable average. The value stored in total is not changed by this instruction.

or name1 = name1 + name2
where name1, name2 are numeric variables which have been declared
e.g. total = total + mark1

- In this case the existing value in total is added to the existing value in mark1 and the result is stored again in total (so the 'old' value in total is lost). This is known as accumulating a total.

or name1 = name1 + value
where name1 is a numeric variables which has been declared and value is a number
e.g. total = total + 1

- In this case the value 1 is added to the existing value in total and the result is stored again in total (so the 'old' value in total is lost). This is known as 'counting'.

8b. RULES

- If a character variable is used anywhere in a calculation instruction, the instruction will crash.
- The calculations are written on the right of the equal sign and the resulting value is always assigned to what is on the left of the equal sign.
- The name of a declared constant can be used anywhere to the right of the equal sign.
- When the result of a calculation is assigned to a variable, the previous value in the variable is overwritten (i.e. it is permanently erased).

Arithmetic operators and order of precedence (from Zak, 2007:157).

Operator	Operation	Precedence number
^	Exponentiation (raises a number to a power)	1
-	Negation	2
* , /	Multiplication and division	3 (left to right)
\	Integer division (gives integer result from a division)	4
Mod	Modulus (gives remainder from a division)	5
+ , -	Addition and subtraction	6 (left to right)
Note that operations within brackets are performed first.		

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9. SELECTION STRUCTURES

9.1a. SYNTAX FOR SIMPLE IF

IF condition THEN
Intructions to be executed if condition is true
END IF

9.1b. RULES

- condition consists of one or more relational expressions joined by logical operators
- If the condition is false, execution 'jumps' to the first instruction after END IF
- If the condition is true, execution continues with the first instruction after THEN and executes all instructions up to END IF. Execution then continues with first instruction after END IF

9.2a. <u>SYNTAX FOR IF THEN ELSE</u>

IF condition THEN
Intructions to be executed if condition is true
ELSE
Intructions to be executed if condition is false
END IF

9.2b. RULES

- condition consists of one or more relational expressions joined by logical operators
- If the condition is false, execution 'jumps' to the first instruction after ELSE and executes all instructions up to END IF. Execution then continues with first instruction after END IF
- If the condition is true, execution continues with the first instruction after THEN and executes all instructions up to ELSE. Execution then 'jumps' to the first instruction after END IF.

9.3a. <u>SYNTAX FOR NESTED IF</u>

IF condition1 THEN
IF condition2 THEN
Intructions to be executed if condition2 is true
ELSE
Intructions to be executed if condition2 is false
END IF
.
ELSE
IF condition3 THEN
Intructions to be executed if condition3 is true
END IF
.
END IF

only executed if condition1 is true

only executed if condition1 is

9.3b. RULES

- same as for 9.1 and 9.2

9.4a. <u>SYNTAX FOR SELECT CASE</u> * Other variations are possible but not shown here

Select Case *name1*
    Case *value1*
        Instructions to be executed if value in name1= value1
    Case *value2*
        Instructions to be executed if value in name1= value2
    Case Else
        Instructions to be executed if value in name1<> value1 and <> value2
End Select
    Where:
        - name1 is a variable that has been declared
        - IF data type of variable is character, then values must be enclosed in double quotes.

9.4b RULES

- If the first condition is false (i.e. name1<>value1), execution 'jumps' to the next Case instruction and the next condition is tested. This sequence is repeated until the condition is true or until the Case Else instruction is reached or until END SELECT – see below.
- If the condition is true, execution continues with the first instruction after the condition and all instructions are executed up to the next Case instruction. Execution then 'jumps' to the first instruction after END SELECT.
- If the Case Else instruction is reached, all of the instructions after the Case Else are executed (up to END SELECT) and then execution continues with first instruction after END SELECT.
- If END SELECT is reached, execution continues with first instruction after END SELECT

<u>Relational Operators</u>

Operator	Operation
=	equal to
>	greater than
<	less than
>=	greater than or equal to
<=	less than or equal to
<>	not equal to

* All have equal order of precedence and are evaluated from left to right.

<u>Logical Operators</u> (most commonly used)

Operator	Operation	Precedence Order
NOT	reverses the result	1
AND	All conditions must be true for the compound condition to be true	2
OR	Only 1 of the conditions has to be true for the compound condition to be true	3

Pseudocode Writing

Example 1

Vusi graduated with his Bachelor's Degree recently. He is planning to organise a graduation party at his home. He wants to calculate the cost for that party. The following list shows the cost of catering and hiring the equipment.

Item	***Cost***
Tent	R 1550.00 to accommodate upto 50 guests. If there are more guests, R1000 for an additional tent.
PA System	R 600
Chairs	R 20 for each chair
Catering	R 150 per person if number of guests are 20 or less. If the number of guests is more than 20, the charge is R 130 per person.

In addition to the above, he needs to pay for the services of a DJ at R 200 per hour. The program must then calculate and display the following with meaningful messages.

- The total cost of catering
- The total cost of hiring the tent and chairs.
- Total cost of hiring the PA system together with services for the DJ
- The final amount he need to pay

Write the complete program in pseudocode.

Questions to ask in order for me to understand the problem and to come up with a solution:

1. What is expected from this problem?
   a. What are supposed to be found out?
   b. What are the outputs?
2. What are the available data (what is given by the question)?
3. What needs to be displayed/output?
4. How can I get to these outputs?
   a. What are the conditions?
   b. Which types of control structures/statements to be used to find each of these output?
   c. What arithmetic formulas to be applied to get the solutions/outputs?
   d. Do I need anything more to get this output?
5. Does the question provide all data that are required to get to the solution?
   a. If not, what data are still need to be asked from the user as input to get to the solution/output?
6. Have I answered all what is expected by the question?

Exercises

Solve the following problems following GIL approach

1. Andile own a Spaza shop. He sells the following items to his customers: Rice, Oil, Maize flour and beans. He gives generous discounts to his customers based the quantity they purchase. The price of each item and the discount given are as follows:

Item	Price
Rice	R11 per Kg. Give 10% discount for purchase more than 8kg
Oil	R15 per litter. Give 5% discount for purchase more than 6lits
Maize flour	R3 per Kg. Give 20% discount for purchase more than 15kg
Beans	R20 per Kg but no discount

Andile wants to prepare the invoice for each customer who purchases from his shop. The invoice should show the items purchased, price per item and total for each item and the discount given (if any) and the grand total at the end with total discount given to the customer. Write the pseudocode with appropriate messages.

2. The student Bursary office gives bursary to second year IT students doing undergraduate programmes based on their year one performance. IT students do four courses in their year 1 of studies. If they score more than 80% overall, then they are given R10000 as bursary. Below 80% upto 60% gets R7500. Below 60% upto 55% gets R2000. They want to find out the bursary based on the overall percentage mark scored in year 1 study when a student approaches the bursary office with his/her academic record. Write the pseudocode that displays appropriate messages.