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DEVELOPMENT OF AN ASSESSMENT DESIGN MODEL FOR INQUIRY BASED LEARNING PEDAGOGY IN CONSTRUCTION EDUCATION IN SOUTH AFRICA

By

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A thesis submitted to the College of Agriculture, Engineering and Science, School of Engineering, University of KwaZulu-Natal, South Africa in fulfilment of the degree of Doctor of Philosophy in Construction Management

Supervisor: Dr. Nishani Harinarain

Co-supervisor: Professor Theodore Conrad Haupt

DECEMBER 2020

DECLARATION OF ORIGINALITY

As the candidate’s Supervisor I agree to the submission of this thesis.

Signed:

Supervisor: Doctor Nishani Harinarain Date: 27 December 2020

I, Adesoji Tunbosun Jaiyeola, hereby state that this thesis represents the original work of myself the author, and is submitted for the Degree of Philosophy in Construction Management at the University of KwaZulu-Natal, South Africa. Where the works of other authors have been used, they have been duly acknowledged and referenced. This research has not been submitted before for any degree or examination to any other university.

Signed: [redacted]

Candidate: Adesoji Tunbosun Jaiyeola Date: 27 December 2020

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I, Adesoji Tunbosun Jaiyeola, declare that

1. The research reported in this thesis, except where otherwise indicated, is my original research.
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DECLARATION 2 - PUBLICATIONS

Details of contribution to publications that form part and/or include research presented in this thesis (include accepted abstracts, publications in preparation, submitted, in press and published and give details of the contributions of each author to the experimental work and writing of each publication)

Publication 1 – Developing 21st century conceptual assessment design model for inquiry based learning pedagogy. Accepted at 4th International Conference on Engineering for a Sustainable World, August 10-14, 2020, Ota, Nigeria

Contribution: Adesoji T Jaiyeola - Experimental work and writing; Nishani Harinarain and Theo C. Haupt – Co-authors

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Contribution: Adesoji T Jaiyeola - Experimental work and writing; Nishani Harinarain and Theo C. Haupt – Co-authors.

DEDICATION

This dissertation is dedicated to my ever supporting wife – Abosede Oluwabukola Jaiyeola; my children – Favour, Precious, Blessing and Gideon; my late father – Joseph Ayoola Jaiyeola; my mother – Victoria Jaiyeola; and the King of kings and Lord of lords, who has sustained me by His grace through this journey of my life.

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"Trust in the Lord with all your heart, and do not lean on your own understanding. In all your ways acknowledge him, and he will make straight your paths". Proverbs 3:5-6

All glory belongs to the almighty God for His faithfulness, mercy, grace and for given me knowledge and wisdom to start and finish this study successfully. The journey would not have been possible without HIS PRESENCE.

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ABSTRACT IN ENGLISH

Construction education in South Africa is in the main undertaken using positivist methodologies which are at the core of university education. Current construction curriculums present subjects and content in silos that have no connection to each other. Students therefore experience individual classes, sessions and content perceived to have no connection or relationship with each other. Also, in this positivist approach assessment tools generally take the form of tests, examinations, assignment and projects. Success in tests and examinations indicates to the lecturer that a student has learnt something. Conversely, failure in tests and examinations suggests that no learning has taken place at all. The student experience is therefore typically one of being a receptacle in which information is deposited.

Construction programmes have responded to these criticisms by experimenting with various pedagogy approaches like inquiry based learning (IBL), to improve the quality and employability of their graduates while trying to narrow the gap between what academia produces and what industry needs. Consequently, engineering and science disciplines began shifting from the lecture-based classroom and assessment format to emphasise active, research-based, and problem-based student learning. It is within this context that several researchers have called for changes in the curriculum and assessment design.

This study researched the problem that the current mode of assessments in construction education at undergraduate level does not adequately measure learning so does not prepare students for construction professional practice and therefore requires an alternative assessment design model which incorporates different contemporary theories of learning synergistically in an IBL pedagogical framework.

The research followed a subjective ontological philosophy, a deductive research approach, a survey research strategy, a cross sectional time horizon and a data collection technique and procedure of a questionnaire using the non-probability sampling technique of convenient sampling. The research procedure included an extensive literature review of articles that fully discussed the use of inquiry for learning in an educational context. The search resulted in 49 articles. These articles were further reviewed to identify the common facets of Inquiry based learning pedagogy. Thirty-two facets were identified as the common and importance facets. The facets were reduced to 28 base on the frequency of appearance in the IBL articles. Delphi survey with 14 construction education experts was used to identify 18 facets as the most important and having the greatest impact on assessment design in Inquiry based learning pedagogy. These facets were used to develop a conceptual model. The developed conceptual model was refined and tested using student survey assessment questionnaire administered online to 563 undergraduate students studying construction programmes at six universities in South Africa. The data from the student survey were screened using the anomaly detection node in IBM SPSS Modeller v 27, excel and statistics before subjecting them to exploratory factor analysis (EFA) using IBM SPSS v27. Subsequently, structural equation modelling (SEM) using IBM SPSS AMOS v27 was used to assess and validate the structural relationship among the research constructs.

The results show that the 18 facets of IBL pedagogy directly and positively influence the development of effective assessment tools to measure learning and achieve effective learning in construction programmes in South Africa and the eight hypotheses between assessment design, facets of IBL and learning were also supported. Subsequently, an IBL assessment design framework for construction programmes was developed which integrate and relate theories of learning and IBL pedagogy to construction practice and learning. The assessment model provides a foundation for policy makers, lecturers, curriculum developers and other stake holders in the improvement of the quality of education in construction education by developing effective assessment tools.

Keywords: Assessment; Assessment design; Delphi approach; Inquiry Based Learning, Learning; Learning theories; Structural equation model.

ABSTRACT IN ISIZULU

Imfundo yezokwakha eNingizimu Afrika yiyona esemqoka eyenziwayo kusetshenziswa izindlela zokwenza okuhle okuyizinto ezisemqoka emfundweni ephakeme. Izifundo zamanje zokwakha ziveza izifundo nokuqukethwe kuma-silos angaxhumani. Ngakho-ke izitshudeni zithola amakilasi ngamanye, amaseshini nokuqukethwe okubonakala kungenakho ukuxhumana noma ubudlelwane komunye nomunye. Futhi, kulokhu amathuluzi wokuhlola indlela yokwenza okuhle ngokuvamile athatha uhlobo lwezivivinyo, izivivinyo, ukwabiwa kanye namaphrojekthi. Ukuphumelela ekuhlolweni nasezivivinyweni kukhombisa umfundisi ukuthi umfundi ufunde okuthile. Ngakolunye uhlangothi, ukwehluleka ekuhlolweni nasezivivinyweni kusikisela ukuthi akukho kufunda okwenzekile nhlobo. Okuhlangenwe nakho kwabafundi ngakho-ke ngokuvamile kungokwamukelwa lapho kufakwa khona imininingwane.

Izinhlelo zokwakha ziphendulile kulokhu kugxeka ngokuzama izindlela ezahlukahlukene zokufundisa ezinjengokubuza okusekelwe ekufundeni (i-IBL), ukwenza ngcono izinga nokuqashwa kwabafundi babo ngenkathi bezama ukunciphisa igebe phakathi kwalokhu okwenziwa yizifundiswa nalokho okudingwa yimboni. Ngenxa yalokho, imikhakha yezobunjiniyela nesayensi yaqala ukusuka kufomethi esekwe ekilasini nasekuhloleni ukugcizelela ukufunda okusebenzayo, okususelwa ocwaningweni, nasekufundeni okususelwa ezinkingeni. Kungalesi simo lapho abacwaningi abaningana becele khona ushintsho kwikharikhulamu nakwindlela yokuhlola.

Lo mqondo ucwaninge inkinga yokuthi indlela yamanje yokuhlola emfundweni yezokwakha ezingeni le-undergraduate ayilinganisi ngokwanele ukufunda ngakho-ke ayilungiseli abafundi ukwenza umsebenzi wobungcweti wokwakha ngakho-ke idinga enye indlela yokwakhiwa kokuhlola okubandakanya imicabango ehlukahlukene yesimanje yokufunda ngokuvumelana ku-IBL uhlaka lokufundisa.
Ucwaningo lulandele ubuhlakani ye-epistemological positivist kanye nefilosofi ye-ontological, indlela yokucwaninga ehlukanisayo, isu lokucwaninga ngenhlolovo, ubude besikhathi sokuhlukaniswa kanye nenqubo yokuqoqa imininingwane nenqubo yohlu lwemibuzo kusetshenziswa inqubo engeyona engenzeka yesampula elula. Inqubo yocwaningo ibandakanya ukubuyekezwa okubanzi kwezindatshana ezikhuluma ngokugcwele ngokusetshenziswa kophenyo lokufunda kumongo wezemfundo. Ukusesha kuholele kuma-athikili angama-shumi amane

nesishagplolunye. Lezi zihloko ziphinde zabuyekezwa ukuze kutholakale izici ezivamile zemfundo yokufunda esekwe kuphenyo. Izici ezingamashumi amathathu nambili zikhonjwe njengezici ezijwayelekile nokubaluleka. Ama-facets ancishisiwe abanga mashumi amabili nesishagalombili base kumvamisa wokuvela kuma-athikili e-IBL. Ucwaningo lweDelphi olunezazi eziyi-shumi nane zezemfundo yezokwakha lusetshenziselwe ukukhomba izici eziyi-shumi nesishagalombili njengezibaluleke kakhulu futhi ezinomthelela omkhulu ekwakhiweni kokuhlolwa ku-pedagogy yokufunda ngokusekelwe kuphenyo. Lezi zici zisetshenziselwe ukuthuthukisa imodeli yomqondo. Imodeli yomqondo esunguliwe yathuthukiswa futhi yahlolwa kusetshenziswa uhlu lwemibuzo lokuhlolwa kwabafundi olwenziwa nge-zobuchwepheshe kubafundi abangama-563 abafundela phansi abafunda izinhlelo zokwakha emanyuvesi ayisithupha eNingizimu Afrika. Imininingwane evela ocwaningweni lwabafundi ihlolwe kusetshenziswa i-anomaly detection node ku-IBM SPSS Modeller v 27, excel kanye nezibalo ngaphambi kokuzinikela ekuhlaziyweni kwezinto (EFA) kusetshenziswa i-IBM SPSS v27. Ngemuva kwalokho, imodeli yokulinganisa kwesakhiwo (i-SEM) isebenzisa i-IBM SPSS AMOS v27 isetshenziselwe ukuhlola nokuqinisekisa ubudlelwano besakhiwo phakathi kokwakhiwa kocwaningo.

Imiphumela ikhombisa ukuthi izici eziyi-shumi nesishagalombili ze-IBL pedagogy ngqo futhi zinomthelela omuhle ekwakhiweni kwamathuluzi wokuhlola asebenzayo ukukala ukufunda nokufeza ukufunda okusebenzayo ezinhlelweni zokwakha eNingizimu Afrika kanye nemibono eyisishiyagalombili phakathi kokuklanywa kokuhlola, izici ze-IBL nokufunda nakho kwasekelwa. Ngemuva kwalokho, kwasungulwa uhlaka lokwakhiwa kokuhlolwa kwe-IBL lwezinhlelo zokwakha ezihlanganisa futhi zihlobanise imicabango yokufunda kanye ne-IBL pedagogy kumkhuba wokwakha nowokufunda. Imodeli yokuhlola inikeza isisekelo kubenzi benqubomgomo, abafundisi, abathuthukisi bekharikhulamu kanye nabanye ababambiqhaza ekuthuthukiseni izinga lemfundo kwezemfundo ngokwakha amathuluzi okuhlola asebenzayo.

Amagama abalulekile: Ukuhlola; Umklamo wokuhlola; Indlela yeDelphi; Uphenyo Olusekelwe Ekufundeni, Ukufunda; Imibono yokufunda; Imodeli yokulinganisa kwesakhiwo.

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CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION

This chapter introduces the research topic of assessment design in inquiry based learning pedagogy and discusses the importance of shifting from a lecture-based and classroom format of teaching and learning to an active, research-based, problem-solving and student-focused format. It states the research questions, the study aim, objectives and the hypotheses to be tested. The research methodology is outlined followed by limitations of the study. Significance of the research in the area of designing effective assessment to measure learning and improve the quality of construction graduates are discussed. The assumptions and ethical issues of the study are presented. The outline of the structure of the dissertation is also presented.

1.2 BACKGROUND TO THE STUDY

Engineering and science-based programmes are designed to empower students with necessary skills, attitudes, and knowledge to become competent graduates in the 21^{st}-century workplace (Crawley *et al.*, 2011, Rugarcia *et al.*, 2000). These programmes are expected to exhibit three major characteristics namely, alignment with professional practices, use of models or representations, and emphasis on design (Johri and Olds, 2011). According to De Graaff and Christensen (2004), engineering graduates should be able to design and find solutions to real-life problems because engineering education and active learning are a natural pair. Engineering education should also endorse inquiry-based activities, teamwork, and engagement with the industry among other requirements (Dori *et al.*, 2018). Therefore, engineering programmes must produce graduates that are capable of planning, designing, implementing, and controlling complex and dynamic engineering and science processes, products, and systems relevant in the 21^{st}-century workplace *(ibid*). This expectation necessitates the need for improved educational frameworks that will produce the next generation of graduates who are equipped with relevant skills and competencies (Crawley *et al.*, 2008).

Hands-on and active learning plays an important role in 21^{st} century engineering and science education. It exposes students to real-life work and professional experiences. To acquire such experiences, it has been recommended that the curriculum of classic engineering and science-related programmes like construction management must be anchored on the principles of inquiry-based learning (IBL) (Dynn *et al.*, 2006). Assessment procedures must also be made relevant to IBL activities (Olds *et al.*, 2005).

Researchers have observed a perturbing trend in engineering and science education. The trend relates to the use of outdated, teacher-centred models for student-education (Fogleman *et al.*, 2011). A fundamental change within the system has been deemed necessary. In South Africa, higher education institutions are expected to produce graduates who will contribute to national social, cultural, and economic development, and also participate actively in fostering the global economy (Pandor, 2007). It is a national imperative that educational programmes and practices are conducive to, inter alia, critical discourse, and creative thinking.

In recent years, there has been considerable debate on the development of the construction education sector. Researchers have reported concerns relating to knowledge transmission or delivery modes being adopted, identifying a disconnect between the academy and professional practice (Afolabi *et al.*, 2017, Huang-Saad *et al.*, 2020, Latif Rauf *et al.*, 2019, Waller *et al.*, 2021). The argument is that current delivery modes have achieved limited success, and have failed in providing graduates with adequate preparation for lifelong, autonomous learning (Haupt, 2009). Schon (2010) summarises these concerns by stating that 'what aspiring construction professional practitioners need most to learn, professional schools seem least to teach'. Professional educators are concerned about the gap between the prevailing conception of professional knowledge held by schools and the actual competencies required of industry practitioners (*ibid*). Regrettably, the traditional didactic instruction approaches that characterise many professional university degree programmes have been reported to be not well suited to improve the situation (Raidal and Volet, 2009). Besides these concerns, construction education institutions are increasingly being subjected to pressure to facilitate the development of 21^{st} century competencies and skills that include communicative, social, creative meta-competencies, and cognitive skills. This pressure is exacerbated by increasing complexities, globalisation, rapidly changing technological advances, ever-shortening project cycles, tightening economic competition, and innovative capacities. Arguably, these competencies and skills need to be taught through learning processes characterised by structured, self-regulated, real-life contexts and collaboration (Scheer *et al.*, 2012).

Construction education in South Africa is mainly implemented using positivist methodologies that are at the core of university education. Many authors have criticised positivism due to its instructor-centred characteristic which typically positions students as passive by-players, giving them limited opportunity to contribute and facilitate their learning process (Armbruster *et al.*, 2009, Healey, 2005a, Healey, 2005b, Kahn and O'Rourke, 2005, Laxman, 2013). According to Armbruster *et al.* (2009), the capacity of students to think critically and synthetically are not being properly developed by existing curriculums or methods of instruction. The authors observe that engineering and science instruction, in particular, suffers from an obsolete, teacher-centred model and recommended a complete overhaul of teaching and learning approaches (Armbruster *et al.*, 2009, Boyer, 1998). Existing learning systems are therefore characterised by students typically receiving information in a receptive manner without much debate on the validity of the information.

Assessments, in the positivist approach, generally take the form of tests and examinations. Success in tests and examinations indicates to the instructor that students have undergone effective learning. Conversely, failure in tests and examinations suggests that zero or minimal learning has taken place (Armbruster *et al.*, 2009, Healey, 2005a, Healey, 2005b, Kahn and O'Rourke, 2005, Laxman, 2013). Students are therefore likened to a receptacle wherein information can only be deposited. Therefore it is necessary to align assessment design with an integrated curriculum that is student centred (Drake and Reid, 2018).

Current construction management curriculums have been found to present subjects/modules and contents to students in silos without any connection to each other (Zulu and Haupt, 2019). Students, therefore, experience classes, sessions, and contents that are perceived to be isolated and have no connection or relationship with each other. Consequently, students do not integrate modules into an interlinked coherent whole or professional skillset needed for a successful career in the construction industry or professional practice. Instructors have decried this negative learning experience (Jungst *et al.*, 2003). Investigative researches on workplace performance have shown that graduates from construction-based programmes who were taught using positivist approaches have a high tendency to encounter challenges in their careers, often requiring further training from their employers to undertake basic and intermediate professional roles in the industry (Yuan *et al.*, 2020).

Managers of construction-based programmes have responded to these criticisms by experimenting various approaches like inquiry based learning, collaborative teaching, collaborating learning and project based learning to improve the quality and employability of graduates and thereby narrow the gap between the products from the academia and industry needs (Chu *et al.,* 2017). To this end, disciplines began shifting from a lecture-based and classroom format to an active, research-based, problem-solving and student-focused format. This shift has resulted in some changes in curriculum design, for example, the initiation of simulated projects which entails the use of simulated scenarios and environments for both task achievement and learning (Forcael *et al.*, 2018). This approach enables students learn most effectively when working on projects and tasks related to real-time problems (Hussein *et al.*, 2020). Therefore learning is better achieved through constructivism that is learning through construction of knowledge from experience (Jumaat *et al.*, 2017).

Constructivism as opposed to positivism constitutes a practical and theoretical perspective in current education research (Boudourides, 2003). Although there are many forms of constructivism, the regular form views learning as an active process of knowledge wherein students are engaged in its construction and definition of learning (Nie and Lau, 2010). It is premised on the notion that people construct their knowledge actively through their personal experiences (Boudourides, 2003). This implies that students are given the opportunity to determine whether learning has taken place. There is a consensus that constructivist instructional practices should emphasis on a deep understanding of knowledge, substantive and elaborated communication, and connections with real-world situations (Nie and Lau, 2010). According to Singer and Moscovici (2008), the constructivist approach in contrast to the positivist approach promotes the following roles:

a. Students as independent thinkers and explorers who share their opinion, ask questions for understanding, build arguments, exchange ideas, and cooperate with others in problem-solving rather than being passive recipients of information who reproduce instructors' ideas (taught or written) and works in isolation;
b. Instructors as facilitators of learning, namely coaches as well as partners, who help students to understand via explanations, as opposed to being knowledgeable authorities who give lectures and impose standard points of view;
c. Classroom learning is aimed at developing competences and based on collaboration, rather than on developing factual knowledge – focused on only validated examples and based on competition to establish hierarchies among students (Singer and Moscovici, 2008); and

d. Effective learning is anchored on preparation of both instructors and students, with students solving complex problems in an engaging and interactive environment. The challenge in construction education is to develop strategies towards making these roles more realistic and exciting, thereby growing partnerships between instructors and students in the knowledge creation process.

The use of inquiry-based pedagogy in construction programmes is typically likely to comprise of several core components such as:

a. Project-based work on complex and open-ended problems;
b. Rapid iteration of solutions;
c. Frequent formal and informal critiques;
d. Consideration of heterogeneous issues;
e. Use of precedent and holistic thinking;
f. Creative use of constraints; and
g. Use of various media (Mathews, 2010).

Students participate in the learning process by leading their inquiry and engaging in a 'proposal-critique (or reflect) and iterate again' procedure, and thereafter offering adequate solutions to the design problems encountered (Brandt *et al.,* 2013). While it is important that undergraduate programmes produce students with demonstrable skills of critical and synthetic thinking, nowhere is it considered more important than in the construction-related disciplines which deals with capital intensive projects that affect human lives. The rationale for this study is based on (a) the limited institutionalisation and implementation of IBL instruction in construction education; (b) the need for additional research considering this challenge; and (c) the need for a standardised and universally accepted constructivist instruction-based model (d) the need for assessments that measure and improve learning.

Assessment is a vital aspect part of curriculum implementation and can be executed at different levels, either nationally or institutionally (Mugisha, 2010b). Assessment plays a major role in the education system, ensuring accountability and quality in higher education while also assessing and improving the learning abilities of students (Ewell, 2009b). According to Gibbs and Simpson (2005), assessment impacts on how students manage their study time. Assessment also affects the quality and depth of the knowledge of students, as well as their learning strategies. Assessment could also serve as a motivation or discouragement to learning (Harlen and Deakin Crick, 2003). It has also been reported to be the most influencing factor to be considered in a learning environment (Anderson, 2004, Hannafin *et al.*, 2003). Considering the characteristics of assessment, its role in curriculum design and development of learning environments cannot be overemphasised.

This study, therefore, seeks to evaluate the theories of learning and facets of IBL pedagogy as well as its influence on assessment design. This is with the aim of developing an assessment model for creation of non-generic assessment tools for measuring learning. It is envisaged that the model will improve the communication, interpersonal and critical skills of students as required by the construction industry in the 21st century. Educational institutes could adopt the proposed model to improve their learning processes and in meeting their mandates.

1.3 STATEMENT OF THE PROBLEM AND RESEARCH QUESTIONS

An effective assessment strategy should entail a combination of assessment tools, corresponding to different learning outcomes including individual and interpersonal skills, disciplinary/ industry-based skills, product development skills, among others. These assessment tools may include, oral and written tests, student reflections, self- and peer- assessments, rating scales, portfolios, and journals.

In construction education setting, assessment plays a vital role in diagnosing the skills and knowledge of students in construction courses so construction education needs an alternative assessment strategy different from the traditional assessment strategy (Rompelman, 2012) that focus on reproducing memorised information (Suskie, 2018). An effective assessment influences learning by motivating students to partake in the learning process, create knowledge and acquire skills and knowledge needed in the industry (Subheesh and Sethy, 2018).

Current assessment methods used in construction programmes have been found to be inadequate in producing graduates with essential skills required by the industry (Duval-Couetil *et al.*, 2011). Ongoing 21st century advancements as increased the need for individuals with both technical and soft skills. This expectation has placed additional demands on educational institutions in terms of the quality of graduates they produce. Assessment designs therefore require an urgent transformation, with effective strategies put in place to improve learning outcomes. Assessment design modelling could offer a viable pathway towards the realisation of this objective.

1.3.1 Research aim and objectives

This study aims to develop an assessment design model in inquiry-based learning pedagogy in construction education, indicating the relationships between the leading influences of the facets of IBL pedagogy.

The key research question to be addressed in this study can be stated as:

What are the key design facets that will significantly affect the development of a model for the design of effective assessment in inquiry-based learning pedagogy in construction education in South Africa?

The key research question is extensive and is further simplified into three specific research questions as follows:

a. What are the key facets of IBL pedagogy that influence assessment design in construction education in South Africa?
b. What are the relationships between the identified IBL facets?
c. How could the identified facets be used for assessment design in construction education in South Africa?

To address the specific research questions, three specific research objectives were developed, namely:

a. To identify the key constructs for assessment design in IBL pedagogy.
b. To determine the relationships between the identified constructs in the development of an IBL-based assessment design model.
c. To establish how the identified constructs can be used for assessment design in construction education.

1.4 RESEARCH METHODOLOGY

For these objectives to be achieved, this study will implement a convergent parallel, mix of qualitative and quantitative research methods (mixed method). This approach is aimed at strengthening the study and its outcomes while also generating an in-depth understanding of the current teaching and assessment practices in construction education programmes in South Africa, and globally. This study will comprise of a comprehensive review of relevant literature of theories of learning, IBL pedagogy, and assessment practices in higher education. Information obtained therein will be used in determining and establishing the relationship between learning, IBL pedagogy, and assessment design.

With regards to sampling and sampling methods, the target population for the study will include construction/engineering education experts and undergraduate students of construction education.

This study involves the use of Delphi technique for data collection. A heterogeneous sample of experts for this study will be identified via purposive sampling for diverse opinions. The sampling approach therefore will comprise of an evaluation of scholarly papers and identification of universities to ensure the selection of qualified and experienced professionals. The experts in this study are to fulfil the under listed criteria:

a. Knowledge of and experience in construction education or engineering education or IBL pedagogy;
b. Knowledge and experience within the construction or engineering sector;
c. Five years of construction education or engineering education experience;
d. An academic in construction management or related program;
e. Minimum of a master's degree in construction management or related program;
f. Authored scholarly articles in the field of construction education, IBL, or related construction programmes; or
g. Presented conference papers in the field of construction education, construction-related programmes, or IBL pedagogy.

The experts will be individually notified about the study and a request for participation will be sent via email. The experts will also be assured of confidentiality and anonymity. Upon acceptance of the invitation, requests will be sent to the participants to provide copies of their curriculum vitae to verify their eligibility for the task.

Students who are pursuing undergraduate construction-related studies at South African public universities are part of the target population for this study. These participants are chosen because of the limitation of the study to undergraduate construction education in South Africa. According to Gill and Johnson (2010), for a population size of 5,000 participants with variance P of 50%, confidence level of 99% and margin of error of 5, a sample of 583 participants is recommended. Consequently, a sample of at least 560 participants is required to fulfill the requirements of performing structural equation modelling (SEM). The universities to be sampled will be purposively selected from a total of 26 universities. Non-probability sampling will be used due to (a) the difficulty in establishing a comprehensive list of all eligible students from the 26 universities in South Africa; (b) the resulting cost and time of accessing them in person; and (c) the low response rates that often typifies email- or internet-based questionnaires, especially when administered to students. For these reasons, convenience sampling will be used to select universities near the research base- University of KwaZulu-Natal. From the convenience sample, eligible students present on the day of sampling who consent to participate in the study will be provided with the questionnaire for completion.

With regards to data collection methods, paper copies of the self-administered questionnaire of Likert scale questions will be emailed to the Delphi experts for an iterative online survey until a predetermined level of consensus is reached. Based on the responses of the Delphi expert panel and under strict adherence with all COVID-19 health protocols including social distancing, a modified questionnaire will be circulated to students who are then asked to complete the questionnaire preferably at either the start or the end of a lecture. Paper copies of questionnaires will be preferred over email or internet surveys due to the low response rates that characterise the adoption of these formats among students.

Information obtained from the literature review and Delphi survey will be used to develop a conceptual model for an IBL appropriate assessment design. The developed conceptual model will be thereafter refined and validated using student survey of current practices. The final model will be developed using SEM. The model will thereafter be used to develop assessment tools for measuring students' learning in construction education. The model will not only be used to develop generic assessment tools but will be specifically designed to develop assessment tools to measure students' learning using IBL teaching and learning strategies. Unique tools comprising a hybrid of existing and/or new tools, different from those currently in use under the positivist paradigm, but suitable for IBL pedagogy will be explored.

1.5 LIMITATIONS OF THE RESEARCH

This study is subject to the following limitations:

a. Student samples will be taken from full-time undergraduate students in selected construction-related programmes in South Africa;

b. Construction education programmes in South African universities apply different levels of the IBL approach. This research takes no account of any inconsistency in the different learning approaches adopted by the universities;
c. A sample of universities that offer construction-related programmes in South Africa will be used in implementing this study; and
d. The source of data that will be collected for validation will be limited to experienced construction education lecturers and students.

1.6 ASSUMPTIONS

The following assumptions were made in executing this study:

a. All the data and information obtained during the course of this study would be accurate and are based on the experience of the participants;
b. Participants of the Delphi study should understand the concept of the IBL approach;
c. Participants of the Delphi study should be familiar with the foundational and advanced methods for measuring learning in an IBL environment;
d. Experienced lecturers in constructed-related programmes should understand the principles of IBL and its application in assessing students.

1.7 ETHICAL ISSUES

To comply with international standards for ethical purposes, the methods of data collection to be used in this survey will not contain the names of participants. No monetary compensation will be given to participants. Participation is, therefore, voluntary. Besides, all necessary permission will be obtained from designated authorities before the implementation of the survey. During the implementation of the survey, reliability, validity, and ethical issues such as invasion of privacy, informed consent of the respondents, and confidentiality requirements will be taken into consideration. Also, an ethical clearance certificate that will authorise and approve the data gathering methods will be obtained from the Humanities and Social Sciences Research Ethical Committee at the University of KwaZulu-Natal.

1.8 STRUCTURE OF DISSERTATION

The layout of this dissertation is as follows:

Chapter 1: Introduction

This chapter gives a general synopsis of the study. This includes the background to the study, statement of problem, objectives, research methodology, limitations to the study, assumptions, and ethical issues.

Chapter 2: Theories and Concepts in Education

This chapter will explore relevant literature on approaches to learning, learning theories and concepts in education. The implications of learning theories for assessment will also be discussed.

Chapter 3: Inquiry-Based Learning

This chapter will comprehensively review relevant literature and study of previous research on Inquiry-Based Learning. It will look at the various levels of inquiry based learning and its forms of assessment.

Chapter 4: Assessment in Higher Education

This chapter will comprehensively review relevant literature and study of previous research on assessment in the field of construction education. The theoretical framework of assessment will also be discussed.

Chapter 5: Inquiry-Based Learning in Construction Education

This chapter will present the theoretical framework of assessment in IBL and it will also present the various forms of assessment in IBL.

Chapter 6: Theoretical Framework in Current Assessment Practices

This chapter will present the theoretical framework in current assessment practices in higher education.

Chapter 7: Development of Conceptual Model

A conceptual assessment design model for measuring student learning in IBL pedagogy in construction education from literature will be developed in this chapter.

Chapter 8: Methodology

This chapter will discuss in detail the methodology that will be used in this study to achieve the study objectives and to develop the tool which will be used for collecting data and for testing the proposed structural model.

Chapter 9: Application of Delphi Approach/Technique

The conceptual model will be tested using an iterative Delphi approach/technique with a panel of local and international construction/engineering education experts.

Chapter 10: Results of the Delphi Survey

The results of the iterative Delphi survey will be analysed and discussed.

Chapter 11: Effective Assessment Design Conceptual Model

This chapter will discuss the design influences for considerations in the development of an assessment design conceptual model for IBL pedagogy in construction education. The conceptual model will be discussed and the relationships between the design constructs will be hypothesised and outlined.

Chapter 12: Results of Students Survey and Model Validation using SEM

This chapter will give an account of the student questionnaire survey that will be carried out in this study, including the methods that will be used for data collection and data analysis.

Chapter 13: Discussion of SEM results

This chapter will discuss the findings of the survey that will be administered to student. The descriptive data analysis and the tested hypotheses of the model will also discussed.

Chapter 14: Summary, Conclusion and Recommendations

In this chapter, all the results from this study will be discussed and key findings will be summarised. Relevant conclusions and recommendations for future studies will also be stated.

1.9 SUMMARY

It is necessary to shift from a lecture-based and classroom pedagogy to an active, research-based, problem-solving and student-focused pedagogy. It more important to design assessments that measure learning in such pedagogy. This chapter discusses the rationale and background to this study. It also states the research questions, the study aim, objectives and the hypotheses to be tested. The research methodology and limitations of the study were outlined. The significance of the research in the area of designing effective assessment to measure learning and improve the quality of construction graduates are discussed. The assumptions and ethical issues of the study were presented. The outline of the structure of the dissertation was also presented. Chapter 2 will discuss the various theories of learning and their implication on assessment.

CHAPTER 2 THEORIES OF LEARNING AND ASSESSMENT

2.1 INTRODUCTION

As a result of societal changes occasioned by advancements in the 21st century, there has been an urgent demand for new skills and knowledge. Continuous learning is now a necessity for survival, thereby heightening the importance and role of education institutions (Urh and Jereb, 2014). One of the most crucial steps to take in meeting the demands of life is developing relevant and adequate life and career skills (Greenhill, 2009). According to Luke and Hogarth (2011), feedback from employers suggests that graduates in the 21st century should be self-directed and be able to learn independently. Being able to select and consistently apply learning theories and styles often results in a more efficient and effective mastery of new knowledge. This ability will enable students to learn better and easier while also improving their adaptation to changes (Urh and Jereb, 2014).

Over the past 30 years, many understandings and theories of learning have evolved (Abas, 2015). These theories were developed based on different content, epistemological platforms, and perspectives. New standards and new knowledge have overtaken some of the theories. However, there are still many perspectives and theoretical learning approaches that are competitive, relevant, and compatible in the 21st century (Illeris, 2018). One of the purposes of assessment is to measure the extent of learning within the confines of an educational institution and an academic program or offering. It is therefore necessary to examine the various approaches to learning as it relates to assessment. This examination will help in developing a framework or an overall understanding of the relationship between assessment and learning.

2.2 TEACHING AND LEARNING IN HIGHER EDUCATION

According to Biggs (2011), students in higher education need to be taught effectively for them to acquire a higher level of thinking through learning. Learning entails students identifying different learning styles and understanding how to maximise them. Learning and teaching theories are based on the constructivist and phenomenographic theories (*ibid*). In terms of the constructivism theory, knowledge is created by the student while in terms of the phenomenographic theory, the student determines what is learned and what is taught by the teacher. Therefore, the learning and teaching approach adopted will affect how students see learning. Biggs (2011) further identified the relationship between learning and teaching by stating that the quality of learning defines teaching.

Teaching in higher education does not only involve transmitting knowledge but also initiating, training, supporting, and encouraging the thought processes relevant to the education of students (Vermunt, 1996). The teaching process help students to engage in a search process towards understanding and improving their learning (Biggs, 2011). It is also expected that facilitators in higher education institutions educate students to independently reflect, make decisions, and persist with their learning (Van Rensburg, 2002). As reported by Machemer and Crawford (2007) and Maree (2015), two learning theorists, namely Piaget and Vygotsky derived seven principles that play an important role in learning and teaching. The seven principles relate to

(a) careful development of the process of learning and contents;

(b) incorporation of active learning;

(c) connecting prior knowledge to new knowledge;

(d) guided discovery;

(e) scaffolding;

(f) integrating group work and cooperative learning to encourage learning; and

(g) language interaction.

These principles came into effect as a result of the concern of lecturers regarding the decline in the performance, lower standard of teaching, and the apathy of students (Hutchins, 2003). The principles were initially designed to define and evaluate effective teaching in a positivist learning environment (Batts *et al.*, 2006). However, research has also shown its relevance in the constructivist learning environment (McCabe and Meuter, 2011). The principles allow for an improvement and assessment of online courses where students are actively involved in learning (Arbaugh and Hornik, 2006, Batts *et al.*, 2006, Graham *et al.*, 2001, Hutchins, 2003).

2.3 APPROACHES TO LEARNING IN HIGHER EDUCATION

Newly employed lecturers in the 21st century who seek to adopt a student-focused approach to improve teaching are often asked to complete different questionnaires meant to deliver useful information about their students (Case and Marshall, 2009). The information obtained focuses on the ways students handle learning tasks and the qualitative ways they engage in studying and learning (Entwistle, 2009, Lonka *et al.*, 2004). Some of these "student' approaches to learning" (SAL) tools relate to "learning patterns", "learning styles", "approaches to learning", and "study orchestrations". According to Baeten *et al.* (2010), these approaches to learning will help students to develop a deep approach to learning in higher education. This deep approach to learning is necessary considering the need to produce graduates with skills necessary for a productive career. This approach is unlike approaches that only focus on teaching students disciplinary insights using domain-specific frameworks (Asikainen and Gijbels, 2017). Students therefore have to adopt a deep approach to learning which leads to critical learning and not deposition or repetition of knowledge (Asikainen, 2014).

To emphasise different aspects of learning, different types of conceptual models can be developed from the SAL tools. These tools use different methods to measure empirical concepts (Vanthournout *et al.*, 2014). It is believed that these SAL tools can also provide answers to other complex challenges that are currently been experienced in higher education learning. In a study carried out by Coffield *et al.* (2004), the potential of SAL tools in representing different learning theories was investigated. 'Approaches and Study Skills Inventory for Students' (ASSIST) – a tool for measuring "approaches to learning" (Entwistle, 1997), was identified by Brown *et al.* (2015) as the most appropriate because it measures the characteristic study approaches of students, which imply the achievement of learning outcomes and not the preferred mode(s) of presentation of the content by students. The tool can also be used by teachers who do not have an in-depth understanding of the principles underlying "ASSIST". Such as: (a) the relationship between characteristic orientation of a student and different learning outcomes; and (b) the relationship between learning styles and approaches to study.

In a study carried out by Asikainen and Gijbels (2017), three main approaches to learning in higher education were identified, namely:

a. a surface approach which is based upon the student memorising the course materials for the sole purpose of assessment;
b. a deep approach which is based on the student understanding the meaning of course materials; and

c. a strategic approach to learning where the student only aims to obtain the highest grades by studying according to the assessments in the module.

Students have been found to give priority to assessment and monitoring, resulting in a fragmented understanding and poor integration of learning (Leite *et al.*, 2010). This approach to learning differs from the deep and surface approaches as it describes how students organise their learning, while the other approaches describe the measures students adopt in learning (Vanthournout *et al.*, 2014). A student can adopt any of these approaches to study, depending on the context, the content, the quality of the teaching, the nature of the assessment, and the demands of a given task (Richardson, 2000). This adaptation implies that the design of appropriate course content, use of the appropriate teaching methods, or administration of the appropriate assessment forms can positively affect how students learn. This outcome was confirmed in a study wherein traditional, subject-based curricula were compared to problem-based learning (Sadlo and Richardson, 2003). It was found that most students in the problem-based learning environment prefer to adopt the deep learning approach over the traditional learning approach. Research has also shown a close relationship between the approach to learning adopted by students and their perception of the quality of the course (Richardson, 2005).

Newman (2004) reports that students who have been exposed to a subject-based curriculum and hold a reproductive conception of learning may find it hard to adjust to a more student-centred curriculum. Duarte (2007) investigated the meaning of learning to students and discovered six different conceptions of learning. Some students view learning as:

a. An abstraction of meaning;
b. Acquiring of facts and procedures;
c. Memorisation;
d. An interpretative process to understand reality;
e. An increase in knowledge; or
f. An understanding and application of knowledge.

These perceptions of learning have been found to be related to learning approaches often adopted by students (Dart *et al.*, 2000, Lee *et al.*, 2008). The understanding of these perceptions/concepts is therefore important in determining how students perceive learning and how to apply them in different contexts to aid teaching (Bowles and Hattie, 2016). It will assist in identifying factors relating to personal experiences and different contexts for effective communicate with students (Lin *et al.*, 2012, Vermunt and Vermetten, 2004). Identification of these concepts will also assist teachers to understand the various learning theories and approaches for both informal and formal classroom setups (Vermunt and Vermetten, 2004). Entwistle and McCune (2013) investigated how the integration of various factors impacted on learning. Factors considered in the study included approaches to learning, metacognitive factors, concepts of learning, and motivational factors. The study discovered that a significant number of students view learning as an understanding and application of material presented in the classroom. Only a few adopted a deep approach to learning using a monitoring or organised effort.

Generally, learning can be defined as any process that leads to a permanent capacity change in any living organism, and may not be due to aging or maturation (Illeris, 2009). The concept of learning includes a very complicated and extensive set of processes, and a comprehensive understanding does not only depend on the nature of the learning process but also on all the factors that are influenced by, or which influence the learning process. Figure 2-1 shows the principal aspects of learning and how they are mutually connected (Illeris, 2018).

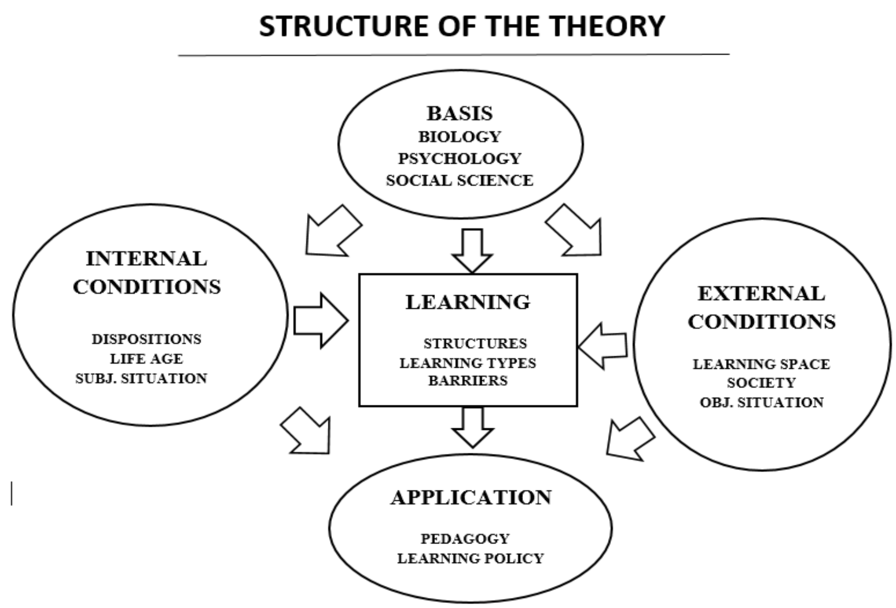

Figure 2-1: The understanding of learning

(Illeris, 2009:8)

At the top of the cycle in Figure 2-1 is the basic application of learning theory which comprises areas of understanding and knowledge. These include social, psychological, and biological conditions associated with learning. These conditions underpin the development of coherent and comprehensive theories. At the centre is learning, comprising its dimensions and processes, barriers, and types which are the central to the concept of learning. Some external and internal conditions also influence learning. These conditions include dispositions, age, learning space, and environment, among others. The application of learning including pedagogy and policy also affect the understanding of learning (Illeris, 2009, Illeris, 2018).

2.4 LEARNING THEORIES

Many perspectives and approaches have been adopted in analysing learning, the most common being:

a. critical (critique of the society by the student);
b. human (focus is on the uniqueness and individuality of each person);
c. constructive (students' construct their knowledge);
d. cognitive (cognitive constructs and mental processes); and
e. behavioural (stimulus-response behaviour) (Weibell, 2011).

Theories relating to instruction, learning, teaching methods, and instructional design have all originated from these perspectives (Weibell, 2011). These theories are the abstract principles that underpin empirical relationships while providing a rationale for them (Hawthorne and Stanley, 2008). According to Young (2008:43), theories of learning "*provide systematic, well-delineated ways of describing and explaining the teaching/learning process, often with the support of a distinct vocabulary representative of underlying epistemological and ontological perspective"*. In addition to furnishing an organised and structured way of looking at teaching and learning, many theories and taxonomies of learning also provide characteristic vocabularies, often metaphorical, that reflect their underlying epistemologies (Young, 2008). In an early study, Hill (1977) observed that learning theories have two primary values. One relates to providing a vocabulary and conceptual framework for interpreting the examples of learning being observed. The other suggests where to look for solutions to practical problems. These theories do not produce solutions but provide direction to variables that are crucial in finding solutions.

To have a better understanding of how students learn in a higher education context, it is vital to exploit relevant learning theories that focus on the student, and more importantly what makes them learn (Mwamwenda, 2004). Before these theories can be applied in practice, it is important to understand them, not just as a way of thinking but as tested principles for making practical judgments. Some of the theories are discussed in subsequent sections. Theories are modified over time based on the insights and research of practitioners. They describe various interrelated parts of a complex learning process which later form a more connected whole (Hammond *et al.*, 2001). This view was confirmed by Hammond *et al.* (2001:18) by stating *"what teachers need to do is to dip into a deep basket of intersecting theories, research, and personal as well as professional knowledge and decide how they come together in their work"*.

There are several types of learning theories but to understand students in the teaching and learning context and to explore the implication of these theories on assessment, six common learning theories will be examined in this study. These include behaviourist; cognitive; social; humanistic; experiential; experiential; constructivist; and critical learning. The next section presents a brief description of these learning theories.

2.4.1 Behaviourist learning theory

Behaviourist learning theory originated from the works of Pavlov (2010) and Skinner (1953). It is one of the foremost learning theories (Silva, 2018), and focuses on obtaining behavioural outcomes from students using a set of measurable and observable learning objectives (Leonard, 2002). Behaviourist learning theory is based on a stimulus-response model that ignores mental activities while emphasising observable behaviour. The stimuli are found in the external environment, and learning is regarded as a behavioural change of the student. Two factors underpin behaviourism namely:

(a) negative and positive reinforcements which play an important role in the learning process; and

(b) stimuli that affect behaviour are not in the mind but the external environment (Kolomitro, 2013).

Skinner (1953:35) states that *"the objection to inner states is not that they do not exist, but that they are not relevant in a functional analysis"*. The principles that underpin behaviourism in terms of learning can be stated as:

a. Objectives need to be clearly stated before learning can take place. This is because behavioural objectives determine the learning activities;

b. Reinforcement is the driving force. Punishments and failures are replaced with rewards and successes; and
c. Generalisation, repetition, and discrimination are necessary. Vital skills can be developed only through regular and diverse practice (Hartley, 2008).

In schools that practice these theories, teachers transfer knowledge to students while students are passive participants. The knowledge transferred is factual, objective, and absolute (Harzem, 2004). Behaviourist schools are usually constructed in single buildings with several floors. Classrooms are located in such a way that new students are located at one end of the floor while older grades are arranged along the floor. Sitting arrangements in the classrooms are in rows and columns with the teacher's desk located at a centre of attraction as illustrated in Figure 2-2 (Guney and AI, 2012:2335). This arrangement is suitable for a teacher-centred education.

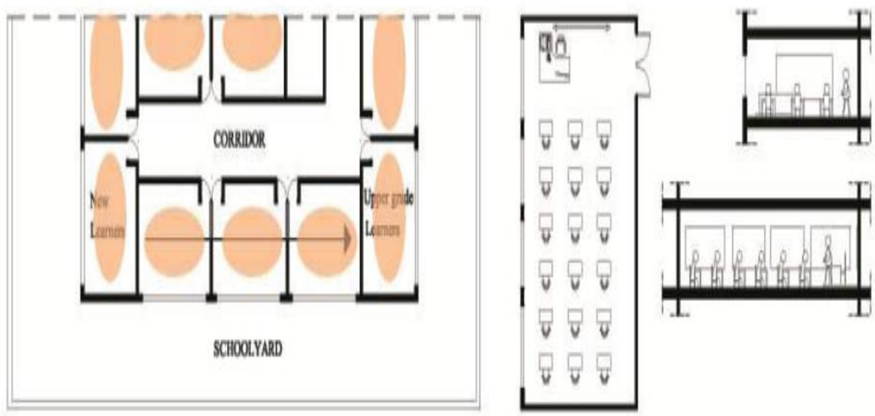

Figure 2-2: Typical learning environment for the behaviourist learning theory
(Guney and Al, 2012:2335)

2.4.2 Cognitive learning theory

Cognitive theory focuses on how students process information through mental consciousness that they are processors of information (Mwamwenda, 2004). It claims that *"students can control their learning activities and have inherent capacity to learn"* (Mwamwenda, 2004:192). This theory is based on the same working principle as a computer. It stipulates that the human mind takes in learning as inputs, processes it, and produces outputs (Leonard, 2002). As information emanates from the external environment, it is changed, integrated, and stored into symbolic mental processes. Focus is on the transmission of knowledge from the lecturer to the student. When the student has the same mental concepts as those of the lecturer, then learning has taken place

(Leonard, 2002). Wilson and Myers (2000:63) also demonstrate that students have their knowledge built by someone else, stating that *"instructional designers could now think of learning in terms of taking experts' cognitive structures and mapping of knowledge into the heads of students"*. The degree of similarity in cognitive structure between expert and novice was a good measure of whether learning objectives were being met". In summary, learning has taken place when there is a modification in the student's schemata and the student is actively involved in the process.

Based on this theory, students are supposed to manipulate, explore, question, experiment, and search for answers. Therefore, the learning environment motivates curiosity and allows for exploration. Schools that use this theory are built like campuses with one or two-storey buildings connected with walkways. This is necessary for the students to interact with the external environment and for explorative purposes (Akinsanmi, 2008). The students need space for group and individual study and also for social interaction as illustrated in Figure 2-3.

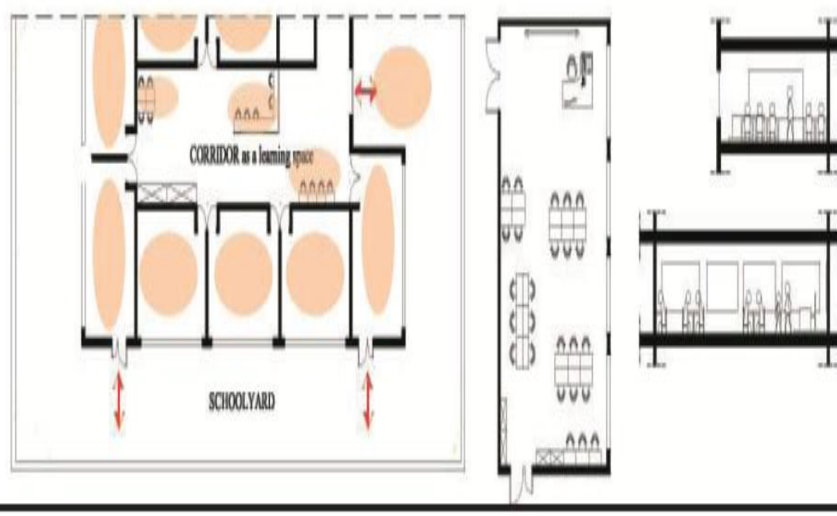

Figure 2-3: Typical learning environment for the cognitive learning theory

(Guney and Al, 2012:2335)

2.4.3 Social learning theory

This theory is also known as imitation or observational learning, and it was developed by Bandura and Walters (1977). According to Mwamwenda (2004:185), the theory *is "based on what a child learns in his/her environment as he/she interacts and observes others".* This theory guides individual behaviour, bringing it into line with societal beliefs, norms and values, thereby improving the integration of the individual in the society. In this theory, learning takes place in three dimensions, namely observational learning, direct experience, and self-regulation (Mwamwenda, 2004). Observational learning is when learning occurs through the observation of others. Direct experience sees the students interpreting, thinking, and making sense of the information they receive. Self-regulation refers to the ability of students to control their learning processes by changing approaches that are not working for them and rewarding themselves after achieving their goals. Mwamwenda (2004) identifies the factors that impact social learning to be, attention, memory, motor skills, reinforcement, identification, status of a model, and nurturant model. In the social learning theory, social contexts play an important role in learning (Osman and Castle, 2006). Students are involved in learning activities through a process of engagement in a community of practice (Lave and Wenger, 1991). According to Osman and Castle (2006:517), students must *"build social relationships, share knowledge, tools and resources for the benefit of all"*. Higher education should therefore support shared knowledge and social relationships for effective learning to take place. The basis of the social learning theory is based on Vygotsky (1978) socio-cultural theory which states that social interaction impacts cognitive development. The theory also states that learning occurs at the Zone of Proximal Development (ZPD) (Mattar, 2018). ZPD is the distance between what is known and what can be known. It is the space where students cannot solve problems on their own and needs the help of the lecturer through scaffolding or collaboration with capable peers (Maree, 2015).

2.4.4 Humanistic learning theory

Humanistic learning theory was established by Carl Rogers in 1942 and built upon further by Abraham Maslow in 1954. The theory sees the student as a holistic individual that wants to fulfil his/her full potential and is concerned with the emotional and affective aspects of learning. It focuses on the need to understand the needs of the students (Nafukho *et al.*, 2005). Every student has the potential to succeed in higher education, making every student to be valued and acknowledged (Van Rensburg, 2009). This theory values the relationship between the students and the lecturer, and teaching and learning (Fasokun *et al.*, 2005). The relationships should include motivation, openness, transparency, respect, and caring for the students, and in summary, *free will and drive*. This attitude will assist students in developing their full potential (*ibid*).

This theory is underpinned by seven principles, namely:

a. There is freedom of choice in learning.

b. There are no threats in learning
c. Experiences are at the centre of self-actualisation and learning
d. Participation is essential in learning
e. Self-evaluation is necessary
f. Motivational forces are self-actualisation and growth
g. Self-esteem and self-concept are taken into consideration when designing learning programmes (*ibid*)

2.4.5 Experiential learning theory

This theory is mainly based on the works of Jung, Dewey, Rogers, Lewin, and Kolb (Hansman, 2001). It is a student-centred learning approach (Kolb and Kolb, 2005), based on the belief that the teaching of students should be anchored on the experiences of students which are considered as valuable resources (Kolb, 2014). It deals with how experience is converted into ideas for new ideas can be integrated (Kolb and Kolb, 2005). According to Hansman (2001), this theory is built on six propositions, namely:

a. Learning is a process and not an outcome;
b. Relearning is vital;
c. There is a need to resolve conflicts between contrasting modes of adaptation (to the world) before learning can take place;
d. Learning is a holistic process;
e. The interaction between a person and an environment results in learning; and
f. The process of creating knowledge is learning.

2.4.6 Constructivist learning theory

Constructivist learning theory can be traced back to philosophers, and specifically Socrates who argued that knowledge is created by the student and not transmitted from the lecturer to the student. This theory was supported by John Dewey (1859-1952) who stated that prior beliefs and ideas of students are vital and should not be dismissed when developing learning activities. The role of students in education was also recognised by Jean Piaget (1896-1980), who stated that accommodation and assimilation are significant in explaining learning circumstances. Lev Vygotsky (1896-1934) is another supporter of constructivism, and believed that learning is a social activity and that understandings and meanings can only be derived from collaboration. Hoover (1996) presented four main principles of constructivism on teaching and learning. These include:

a. Learning is an active process and not a passive process;
b. Lecturers act as guides;
c. It is a process that needs sufficient time; and
d. Learning is both a social and an individual process.

2.4.7 Critical learning theory

Critical learning theory is different from the other theories previously mentioned in the sense that it provides a critique of contemporary society. According to Horkheimer (1982), a theory is critical if it seeks human emancipation, *"to liberate human beings from the circumstances that enslave them"* (Finlayson, 2005:244). This purpose is with the ultimate aim of empowering individuals, "*not just to determine what was wrong with contemporary society at present, but, by identifying progressive aspects and tendencies within it. This will help to transform society for the better"* (Finlayson, 2005:4). The central theme in this theory is the examination of beliefs and values so that they can be changed or rejected. According to Brookfield (2005:43), this theory views *"thinking critically as being able to identify, and then to challenge and change, the process by which a grossly iniquitous society uses dominant ideology to convince people that this is a normal state of affairs"* and further that *"a critical society needs to focus on challenging ideology, contesting hegemony, unmasking power, overcoming alienation, pursuing liberation, reclaiming reason, and practicing democracy"*.

2.5 CHARACTERISTICS OF SOME MAJOR LEARNING THEORIES

These learning theories are grouped based on their shared principles. However, an overlap of principles exists due to similar characteristics. What can be termed as the "best" learning theory will depend on factors like learning context, types of learning required, and the type of students. This view is supported by Hammond *et al.* (2001:2), who states that *"to a substantial extent, the most effective strategies for learning depend on the kind of learning that is desired and toward what ends"*. The key features of these learning theories are summarised in Table 2-1.

Table 2-1: Characteristics of some major learning theories

(Modified from Kolomitro 2013:45)

Paradigm	Behaviourism	Cognitivism	Constructivism	Humanism	Critical Theory	Social learning
Learning theorist	Thorndike, Pavlov, Watson, Guthrie, Hull, Tolman, Skinner	Bloom, Ausubel, Gagne, Gardner	Dewey, paiget, Vygotsky, Vico	Maslow, Rogers	Horkheimer, Adorno, Marcuse, pollock, Habermas	Bandura, Rotter, Engestrom, Eraut, Lave and Wenger, Salomon, (Vygotsky) (Piaget) (Boud)
View of the learning process	Stimulus – response mechanism	The focus is not on an outward exhibition of learning on internal mental process and connections that take place during learning	Individuals actively build knowledge and skills	Develop the student as a whole	To seek human emancipation and freedom in circumstances of domination and oppression	Interaction with, and observation of others in a social context, situated learning, communities of practice, distributed cognition
Locus of learning	Stimuli in external environment	Mind as a computer: information comes in, is been processed and leads to certain outcomes	Internal construction of reality by the individual	Affective and cognitive need	The critique of the social reality	Interaction of persons, behaviour and environment
Purpose in education	Produce behavioural outcomes predicted by a defined set of learning objectives	Leads to change in a student's mental schemes	Construct knowledge	Become self - actualised, autonomous	Education should be a transformative process	Construct knowledge
Educator's role	Set up a controlled environment to elicit a particular outcome	Finding better method of transmitting their mental construct to the students	Facilitates and negotiates meaning with students	Facilitates development of the whole person	Progressive educator	

Manifestation in adult learning	Behavioural change; competency – based education; skill development and training	Cognitive development	Experiential learning; self -directed learning; perspective transformation; Reflective practice	Self-directed learning	Active learning	

The theorists presented in Table 2-1 were selected based on their perceived relevance to the learning theories and psychologies. The theorists are representative of the various theorists within each domain. The current importance and role of the theorists in teaching and learning was also considered in their selection.

2.6 IMPLICATIONS OF LEARNING THEORIES FOR ASSESSMENT

2.6.1 Implications of behaviourist views of learning for assessment

This perspective of learning was developed from the concern that experiment and observation can be used to develop a proper science of human behaviour. This approach to learning believes that, since the mental processes of information are not observable, physical processes of information can be used to express consciousness (Gardner and Gardner, 2012, James, 2008). Therefore, learning is viewed as a response to external stimuli. This theory of learning, though now considered as unfashionable and out of favour, is the platform upon which the first generation assessment practice is structured (James and Lewis, 2012). The beliefs and assumptions of the behaviourist theory of learning are the underpinning factors used in the development of the most suitable kinds of assessment for this theory. According to Gardner and Gardner (2012), James (2008) and James and Lewis (2012), first generation assessment practices have the following characteristics:

a. Only the learning of the students is assessed. External influence is considered as cheating;
b. The emphasis is on performance under test conditions;
c. The ability of the student to recall information and facts or demonstrate skills is considered as learning;
d. Tasks and test are used as assessments, administered at the end of the module;
e. Students prepare for the assessment (test) through the practice of past question papers;
f. The duration of the tests is time-restricted;

g. Only materials needed for the test are allowed because the skill or knowledge is expected to be established or memorised;
h. The questions or tasks are arranged in the order of difficulty, starting with less difficulty;
i. The answers or performances assessed, and the student is allocated a score either by comparing the student with other students (norm-referenced) or against a standard (criterion-referenced) or previous performance (ipsative referenced) or a combination of the above; and
j. Students get feedback when their scripts are returned. However, very interactive and structured computer-based assessments can direct the student back to an easier level of an assessment, if the student fails a level given to him/her initially.

These assessment characteristics may seem very familiar and it may be assumed that all assessment practices or tests have these characteristics, implying that the assumptions underpinning behavioural views of learning are still dominant in assessment strategies. However, there are other possible views of learning for assessment which are better aligned with factors underpinning other theories of learning. These views of learning for assessment are discussed in the following sections.

2.6.2 Implications of cognitive constructivist views of learning for assessment

The denial of the need for mental processing in learning by behaviourists brought about criticism from cognitive scientists, neuroscientists, computer scientists, linguists, and psychologists, who insisted that learning must involve thinking. These professionals all argued that learning is highly influenced by what goes on in the mind and making sense of the world, and of new information – not just absorbing information, but processing it (Gardner and Gardner, 2012, James, 2008).

The assessment practices based on cognitive constructivist views of learning are referred to as second-generation assessment practices and are similar to first-generation assessment practices but with significant differences in emphasis and approach (James, 2008). The features of second-generation assessment practices according to James (2006), James (2008), and James and Lewis (2012) include the following:

a. The assessment of an individual's learning occurs;
b. The focus is on understanding and problem-solving;

c. The ability to demonstrate and apply conceptual frameworks using cognitive skills to provide solutions to problems determines performance;
d. Examinations and tests are used for assessment during the course or after;
e. Assessment may be extended to show depth and breadth of understanding and an ability to solve complex problems. Therefore, concept maps, essays, open-ended assignments, think-aloud protocols, theses, projects, and coursework are suitable assessment practices;
f. Assessments are often time-limited with the belief that the speed of completion shows the acquisition of conceptual models, indicating problem solving and understanding;
g. Limited access to materials may be allowed because the assessment is more a test of understanding than of memory;
h. Specific criteria are used to assess tasks or problems. Trained assessors use these criteria to make judgements since there are usually more than one answer. They are often given marking schemes or model answers and the moderation process is included to share and discuss judgements. This helps to develop appropriate standards progressively;
i. Some norm-referenced assumptions are used to develop the notion of a progression like levels, scores, or grades;
j. It is also assumed that the effort to close the gap between experts and novices leads to an improvement. It may not be in the form of a linear progression, but it can be considered as a horizon of possibilities; and
k. Failures to find solutions to problems or a misunderstanding show areas that need improvement. This also shows poor frameworks or flawed conceptual understanding that needs to be unpacked, revisited, or reconstructed in the formative processes or by developing new cognitive skills.

Practices of these forms are regarded as the second generation of assessment. Similar to the first generation, it focuses on the acquirement and processing of knowledge by individuals (Gardner and Gardner, 2012). As a result, some examinations or tests combine elements of both constructivist and behaviourist approaches such as, for example, starting with factual recall short answers questions and progressing to more complex problem-solving questions. This approach is similar to bloom taxonomy where assessment design moves from the lowest level of cognition of recalling knowledge to the highest level of cognition which is an evaluation with four levels of cognition - comprehension, application, analysis, and a synthesis between the lowest and highest levels (Morton and Colbert-Getz, 2017).

2.6.3 Implications of socio-cultural view of learning for assessment

This is the third generation of assessment practice. Assessment practices in this generation places more emphasis on involvement in social practices than understanding or acquiring knowledge (Gardner and Gardner, 2012, James, 2008). The socio-cultural theories offer powerful explanations and descriptions of learning but their implications for assessment are still been developed because key theorists focus on learning and not on assessment (Gardner and Gardner, 2012). However, assessment should be better aligned with learning using the most powerful ideas in contemporary learning theory. According to Gardner and Gardner (2012), the pointers for third generation assessment practices that can be extrapolated from the socio-cultural theory include:

a. Assessments should be carried out alongside learning, and not after learning since learning cannot be separated from the process of learning;
b. Therefore, assessment should involve the community and not just the external assessor, consequently, peer-, self-, and teacher-assessments are encouraged;
c. Group assessment is as important as individual learning;
d. Assessment involving complex problem-solving tasks are most appropriate because learning takes place during participation in solving authentic or real-life problems;
e. The focus is on the use of the available tools or resources (human, intellectual, material) to articulate problems, work efficiently, and evaluate their efforts. This justifies the use of course-work assignments and encourages access to source materials;
f. Learning outcomes can be expressed and stated through various forms of audio- and visual media;
g. The use of portfolios is encouraged, but according to Serafini (2000), care should be taken when using ‘scoring rubrics’ to grade it as it may be out of line with the socio-cultural perspective because the use of ‘assessment as measurement’ or ‘assessment as procedure’ is reduced; and
h. Judgement needs to be qualitative and holistic, not quantified and atomised as in measurement approaches.

These features of third generation assessment practices show assessments that support teaching and learning in workplaces and schools (Bennett, 2015, James, 2008). James (2017) supports group work on projects which develop the skills needed by students in the workplace and students can therefore work as a group to provide creative solutions to complex problems.

2.7 EMERGING LEARNING THEORIES AND NEW TECHNOLOGIES

The advancement in technology and research have led to the discovery of other learning theories which are either an outcome or a mixture of the well-known learning theories, or a completely new theory (Pange *et al.,* 2010). The Dual Coding Theory (Paivio, 2014:149) *"…proposes that memory consists of two separate but interrelated codes for processing information – one verbal and the other visual".* The verbal and visual systems can be activated independently, but there are interconnections between the two systems that allow dual coding of information. The interconnectedness of the two systems permits cueing from one system to the other, which in turn facilitates the interpretation of our environment…" The area of distance and electronic education which is not offered by many universities has also experienced the rise of a more attractive learning system which has changed the ways of passive learning (Pange *et al.*, 2010). For instance, in the Engagement Theory developed by Kearsley and Shneiderman (1999), engagement is the amount of psychological and physical energy that a student commits to learning. An active student could therefore commit substantial energy to his or her studies and will be active in the classroom and outside the learning environment (Akbari *et al.*, 2016). The key factor underpinning this theory is the engagement of students in learning activities involving the other students, the lecturer, meaningful tasks, and the environment. This approach may not involve the use of technology which could enable engagement and learning in situations that do not encourage engagement (Ituma, 2011). Engagement theory aims to create successful collaborative students that can work on projects that are beneficial to the society. The theory can be divided into three components, namely Relate-Create-Donate, implying that learning activities:

a. occur in a group context in the form of collaborative teams;
b. are project-based; and
c. have an outside or authentic focus (Ituma, 2011).

Laird *et al.* (2003) identified four inputs necessary to produce a product or service in every system:

a. People: workers that constitutes a group and are linked by a common activity.

b. Material: raw products that go into the system.
c. Technology: techniques for achieving a practical purpose or goal.
d. Time: measured period during which an action or process begins and ends…”

Furthermore, Laird *et al.* (2003:66) states *that “…although a new behaviour may be learned in a variety of methods, it can always be traced back to three major activities:*

a. Cognitive (knowledge) – mental skills that requires the use of the brain to perform intellectual tasks;
b. Affective (attitude) – best described as coming from the heart, – the knowledge of a concept/phenomenon does not mean it will be acted upon; and
c. *Psychomotor (skills) – physical skills where the body must coordinate muscular activities (some are minor, such as turning a dial with the fingers)”*.

2.8 IMPROVING ASSESSMENT PRACTICES AND LEARNING

Students in higher education in South Africa are faced with low pass rates, high dropout rates, and poor academic performance. Higher education institutions are, therefore, faced with the challenge of improving teaching and learning. To this end, lecturers must have a basic understanding of the theories of learning for effective teaching and learning to take place. In addition, it is imperative to evaluate assessment using different learning theories to gain better understanding on how students learn.

The previous discussion has shown some consistency between the various theories of learning and assessment. The backwash effect from the current assessment practices may not produce effective teaching and learning outcomes. There is, therefore, a need to align teaching, assessment, and learning. Three generations of assessment practices based on different learning theories have been highlighted in this study. Assessors and lecturers are expected to adopt one of these assessment practices and learning theories or a combination of two or more in future assessments. An underlying factor to be considered in selecting a generation of assessment practice for use is ‘fitness for purpose’. For instance, when developing habitual behaviours or basic skills, behaviourist approaches are often the most appropriate. However, if the intention is to develop a deep understanding of conceptual structures, the appropriate choice could be the cognitivist approach. The nature of the program could also influence the choice of an assessment practice. For instance, engineering and science-based programmes may be based on constructivist approaches while the expressive arts are more aligned to the socio-cultural approaches.

In summary, advancements in research and technology have resulted in the emergence of new learning theories. Constructivists have identified the relevance of social dimensions in learning, and have introduced the term ‘social constructivism’ (Edwards, 2005). The development of a comprehensive theory via hybridisation and blending of key features in existing theories could be a worthwhile goal to pursue as it could extend the impacts of assessment practices and teaching.

2.9 SUMMARY

In this chapter, an urgent need for new skills and knowledge resulting from societal advancements or changes has been highlighted. Continuous learning is a necessity for survival considering the dynamic nature of the society, elucidating the importance and role of education in societal development. Students in higher education need to be taught effectively to unleash their creative abilities via the process of learning. Learning must also drive students to identify their learning styles and how best to use them.

Implementation of the learning techniques discussed in this chapter could assist students in developing a deep approach to learning. The deep approach to learning is key in overcoming current challenges, especially, the inability of graduates to exhibit relevant skills for the 21st century. The adoption of a deep learning approach goal enables students eliminates memorisation and fosters critical learning. Using different methods that measure empirical concepts and “students’ approaches to learning” (SAL) tools, a variety of conceptual models that emphasise different aspects of learning can be developed. SAL tools could also provide answers to other complex challenges (in the context of learning) that are being experienced in the higher education sector.

Several perspectives and approaches have been identified to study learning, the most common being the critical, human, constructive, cognitive, and behavioural approaches. Theories relating to instruction, learning, teaching methods, and instructional design are products of the above perspectives and theories. These theories have also been identified as the foundational principles that underpin empirical relationships. The significance and impact of each of the learning theories on assessment as well as the emergence of new learning theories such as the dual coding and engagement theories have also been highlighted.

CHAPTER 3

INQUIRY-BASED LEARNING IN HIGHER EDUCATION

3.1 INTRODUCTION

The IBL approach is a student-centred learning approach that contextualises learning based on real-life situations (Savin-Baden and Major, 2004). The use of IBL is favoured across the world by many lecturers due to the significant role it plays in achieving many important learning outcomes like self-regulation, collaboration skills, student engagement, and critical thinking (Hmelo-Silver *et al.,* 2007, Strobel and Van Barneveld, 2009). IBL also fosters the achievement of content learning outcomes. However, research on the effect of IBL environments and belief that IBL environments are more effective than traditional lecturing environments are being challenged in some spheres (Loyens *et al.,* 2010). There is therefore a need for more research on the dynamics of learning in an IBL context (Bergstrom *et al.,* 2016).

The notion that the implementation of IBL "does not work" has not been widely supported in the literature. Instead, many research questions that need to be investigated include: Under what circumstances does IBL work best? What types of learning outcomes are IBL suitable for? What types of practices does IBL promote? What kinds of scaffolding and support will be required for different learning outcomes and students? Consequently, it is suggested that there should be further theorising, conceptualisation, and data collection for further development and implementation of IBL in higher education through exploratory research. The saying "Tell me and I will forget; show me and I may remember; involve me and I will understand." also supports IBL *(*Hmelo-Silver *et al.,* 2007). Many studies have highlighted the effectiveness of IBL. Some of these studies were carried out by Alfieri *et al.* (2011), de Jong *et al.* (2014) and Furtak *et al.* (2012). These studies show that the construction and mechanics of IBL pedagogy as well as identification of its merits when compared to more traditional methods of education are imperative (Levinson and Consortium, 2017). A better and in-depth understanding of the characteristics and benefits of IBL is therefore required to eliminate misunderstandings and misconceptions (Bell *et al.,* 2010).

The first part of this chapter is a succinct exposition of the definition, basic principles, and history of IBL, wherein the framework of the pedagogy will be set forth. The chapter will establish a firm foundation for a subsequent critical analysis of the advantages, disadvantages, and possible future development of IBL. The different theories of IBL will be analysed in detail. The types of IBL, its implementation methods and tools of assessment will thereafter be analysed critically.

The chapter concludes with an academic assessment of the current state of research on IBL, including the prospects of its future development.

3.2 WHAT IS IBL?

The word inquiry etymologically is from Latin. According to the Latin dictionary, the word inquiry (inqu¯ır¯o) means looking or searching for something, while in English, it means "close examination of a matter" (TheFreeDictionary, 2016). According to John (1910), the concept of inquiry is based on deduction, abduction, induction, verifying and defining hypotheses, transfer of knowledge, and an analogy of experience of new situations. Therefore, it can be concluded that inquiry is more than just problem-solving but also includes the desire for cognition, dispersing and investigating of doubts, as well as a search for the truth.

There are other acronyms of inquiry-based learning (IBL) in the literature. These include acronyms like IBSE (inquiry-based science education) used by (Bolte *et al.*, 2012), IBT (inquiry-based teaching) (Magee and Flessner, 2012), IBE (inquiry-based education), (inquiry-based instruction), and EBI (enquiry-based instruction) (Fook *et al.,* 2016). It is important to also note there is no difference between the term "inquiry-based learning" and enquiry-based learning. The difference is in the historical development of English.

Published literature suggests that IBL can be viewed in two streams. In the first stream, IBL is viewed as a teaching method based on problem-solving. Papáček (2010) states that IBL is one of the best teaching methods for problem-based education, following the constructivist approach to learning. The teacher does not transfer knowledge to the students in form of a class presentation but through a system of question-asking and problem-solving. Furthermore, the basic principle of IBL includes students asking inquiry-related questions, their search for evidence, the forming of knowledge based on evidence discovered, their evaluation of knowledge with a possibility of using alternatives, and seeking of clarifications via cross-checks and communication. VOT'APKOV'A (2013), in a manual designed for teachers, states that IBL can be only be presented as a problem-solving method in the process of learning.

In the second stream, IBL is viewed as a broader concept – bigger than just using a problem-solving method to learn. It is an education concept that goes beyond analysing a problem, searching for the necessary information to form hypotheses, and checking and confirming the hypotheses.

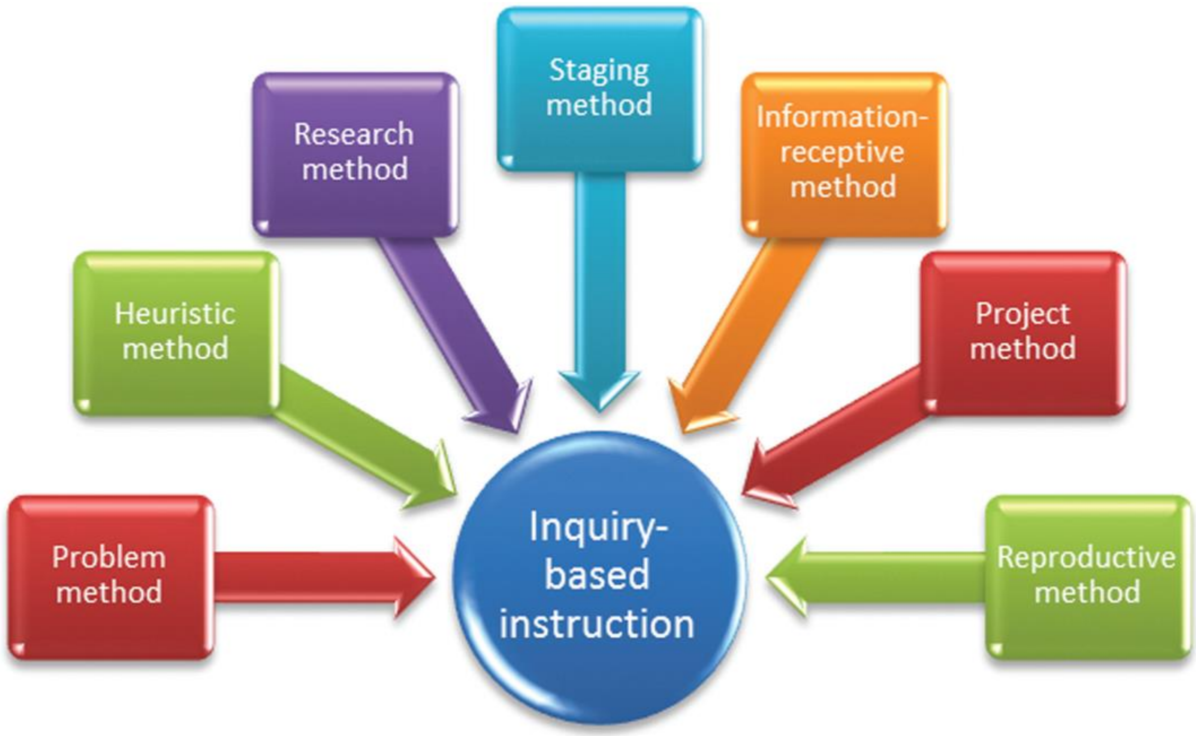

Figure 3-1: Diversity of methods within IBL

(Dostál and Gregar, 2015:43)

IBL involves various methods of discovering knowledge as indicated in Figure 3-1. For instance, Artigue and Blomhøj (2013:12) define inquiry-based instruction as *"a way of instruction where the students are stimulated to work in a usual scientific way"*. This definition was also confirmed by Keselman (2003).

Various definitions of IBL have been put forward. Levy *et al.* (2010:6) defined IBL as *"a cluster of strongly student-centred approaches to learning and teaching, and that they are driven by inquiry or research"*. In the context of 'inductive teaching', Prince and Felder (2007:9) defined IBL as teaching that begins by *"presenting students with a specific challenge, such as experimental data to interpret, a case study to analyse, or a complex real-world problem to solve"*. IBL has also been defined as a process of learning where the students discover new knowledge through the formulation and testing of hypotheses through experiments and/or making observations (Pedaste *et al.,* 2012). IBL can therefore be regarded as a teaching and learning approach that involves the use of several problem-solving skills (Pedaste and Sarapuu, 2006). It involves active participation of students and ensures that they are responsible for knowledge discovery (De Jong and Van Joolingen, 1998). In IBL, students *"often carry out a self-directed, partly inductive and partly deductive learning process by doing experiments to investigate the relations for at least one set of dependent and independent variables"* (Wilhelm and Beishuizen, 2003:387). This approach to teaching and learning also expects students to generate questions, "play around" with materials physically, and ideas to develop working explanations that will help them understand global systems better (Bencze *et al.,* 2006).

Many educational learning objectives are associated with IBL, including social-development, collaboration and communication skills (Justice *et al.,* 2007). Communication skill is considered as the hallmark of a clearly thought-process as well as mastery of language (Commission, 2008). IBL also produces an epistemic outcome, meaning it can promote the ability of students *"to think critically and reflectively about the production of knowledge"* (Justice *et al.,* 2007:4). A metacognitive learning outcome could also be produced via IBL, whereby students develop metacognitive knowledge (Spronken-Smith and Walker, 2010). Other learning outcomes achievable through IBL include procedural, conceptual, and affective skills – 'love of learning' and "appreciation of concepts and theories" (Justice *et al.,* 2009, Prince and Felder, 2007). Goals relating to these learning outcomes are often stated with cognitive skills like problem-solving and critical thinking skills.

3.3 PRINCIPLES AND HISTORY OF IBL

It is noteworthy of the relatively late development of the concept of IBL, when due consideration is given to the earliest concepts of philosophical inquiry, dating back to the times of Socrates, Epicurus, and the Stoic philosophers, as early as 300 BC (Laertius, 1853). Even at this early time in history, there appeared on the philosophical horizon, a discontent with the notion that a simple regurgitation of facts should represent the concept of 'education'. Later proponents of this school of thought as it developed into the 20th century School of Constructivist Learning, under the founding efforts of Jean Piaget also arose. (Dewey, 1997, Freire, 2000, Vygotskiĭ *et al.,* 2012). The basic point of departure of the theory of Constructivist Learning is that the most beneficial results are achieved when students are exposed to an interaction between their experience and the facts they have been taught or introduced to. This school of thought was also the first to recognise the importance of the background and culture of the student, as they influenced personal perception of concepts such as ‘truth’ and ‘fact’.

One of the greatest motivating factors behind the push for IBL has been its inspiration of certain confidence in students about their ability to learn new things (Kuhn *et al.*, 2000). This confidence stems from a personal inquiry onto the truth of propositions set forth by factual instruction. For example, the approach adopted by science students in performing their experiments to confirm, in practice, the qualities and characteristics of the elements contained on the Periodical Table. The role of the facilitator is crucial in the practical application and prospects of success of IBL. There are various ways in which a facilitator may initiate and/or assist the process of personal experimentation, as will be assessed later in this chapter. However, without meaningful intervention by a qualified facilitator, IBL runs the risk of deteriorating into random and meaningless experimentation (Drexler, 2010).

IBL is a strongly developing and well-respected concept in the circles of educational thought and philosophy, especially in the 21st century. In 2009, the Ontario City kindergarten program, in the United States of America, officially implemented the IBL system (Pascal, 2009). In further defining and formalising the concept of IBL, the next section will discuss the division of the process of Constructivist Education into four distinct levels and inquiry types (Banchi and Bell, 2008, Schwab, 1960).

3.4 LEVELS OF IBL

Modern theories of IBL are closely related to various inquiry levels as discussed in the following sections (Banchi and Bell, 2008, Dostál and Gregar, 2015):

3.4.1 Inquiry by way of confirmation

Inquiry by way of confirmation is the most basic and lowest level of inquiry application in Constructivist Learning. There is no ‘element’ of surprise and no real sense of discovery by the student as this method is limited to the practical experimental testing of previously explained facts and results. In other words, students merely embark upon the process of scientifically testing certain concepts which were previously explained to him or her by the facilitator (Chu, 2009). An example is testing the resilience of Kevlar by striking at it with a sharp object such as a screwdriver after the facilitator had explained that the screwdriver will be stopped by this very strong and resilient material. Inquiry by the way of confirmation is the 'safest' IBL level, as the possibility of misconceptions is greatly eliminated because of the well-controlled inquiry environment (*ibid*).

3.4.2 Structured inquiry

Structured inquiry is one level deeper than inquiry by the way of confirmation as the outcome is known by the facilitator, but not disclosed to the student upfront. This leaves the student with a greater sense of discovery and achievement, where the facilitator merely provides the student with the question and the outlined procedure which may be followed to find out the answer to the question (Artayasa *et al.,* 2018). Using the same example on the qualities of Kevlar, the facilitator could thereafter ask the following question, 'How strong and resilient is Kevlar?' and then propose that a screwdriver may be struck against a Kevlar vest to test the results; leaving the student to discover the resilient qualities of the material. The possibility of misconception is greater at this level, as the student does not have a precognition of the kind of result he or she would obtain.

3.4.3 Guided inquiry

Guided inquiry is the third level of inquiry where the facilitator only provides students with a question (Edelson *et al.,* 1999, Mulyana *et al.,* 2018). For example, 'How resilient is Kevlar?' Students are then left to adopt their own exploration strategies and develop a means to test the strength and resilience of Kevlar. A student could adopt the test of striking a sharp object against a Kevlar vest, or possibly some other experiments with even more vivid results. At this level, there exists a great possibility for students to misconceive the nature, scope, and motivation for the enquiry. For example, a student may only test Kevlar for resilience against a dull blow using a fist; not appreciating the level of strength of the material. Therefore there is need for scaffolding.

3.4.4 Open-ended inquiry

Open ended inquiry is the fourth level which is also known as 'true inquiry' as it leaves both the formulation of the propositional question, as well as the method of finding an answer thereto, to the imagination of the student (Council, 1996). In the chosen example, the facilitator would merely give to the student an instruction to formulate an interesting question and then invent a way of answering it. The student would then formulate the question and test, for example, the resilience of Kevlar; or embark on any other inquiry which the student may conceive. At this level, the danger of cognitive overload exists. This is in addition to the possibility of misconceptions, as there is such a limitless universe of possibilities to explore that it is impossible to ascertain the comprehension of basic concepts in the specific field of study by students (Kirschner *et al.*, 2006). For example, the student may set up an impressive experiment to display the resilience of Kevlar, and yet have limited or deficient knowledge of general scientific principles.

Various theories on inquiry-based education are based on different ways of applying the four levels of inquiry. Some theories, such as the theory put forth by Banchi and Bell (2008), suggest that these levels should co-exist. The authors propose that the facilitator should only move on to levels three and four (guided and open-ended inquiry) after the student is comfortable with the earlier levels (confirmation and structured inquiry) (Yoon *et al.*, 2012). This approach is in contrast to the theory that views IBL as truly effective only at its purest level that is, level four – where open inquiry or open learning is the effective method of education (Bruner, 2009). The open-ended inquiry theory stresses that open inquiry is the only true way to stimulate the learning and development of the mind to its fullest potential (Berg *et al.*, 2003).

3.5 FORMS OF ASSESSMENT IN IBL

IBL in its purest form creates unique challenges of assessment. For instance, each student may select different inquiry types, as well as different unique methods for implementing their inquiries. This approach makes the scope for assessment to be limited as results obtained may vary vastly given the different inquiry types and methods adopted in answering their proposed questions (Mayer, 2004). Three basic ways are adopted in assessing IBL. These assessment methods are discussed in the following subsections.

3.5.1 Assessment for learning in IBL

Assessment for learning in IBL is maintained by the facilitator throughout the learning process, enabling the facilitator to adjust and 'fine-tune' his or her approach to ensure that the student achieves the best possible results. The emphasis, here, is on a preliminary assessment before initiation of the learning process. This assessment provides the best motivation to students, as there are no penalties for misconceptions or 'wrong answers' but merely an adjustment to eliminate such misconceptions or errors (Kauffman, 2002).

3.5.2 Assessment as learning in IBL

Assessment as learning in IBL is closely related to assessment for learning, with the emphasis falling on the results achieved as the learning process is in full swing. This ongoing kind of assessment that requires a very focus driven involvement by the facilitator and the level of skill required is high in the sense that the more skilled facilitator will produce more inventive ways of amending and adjusting the learning method to correct misconceptions that may arise along the way (Hattie, 2003).

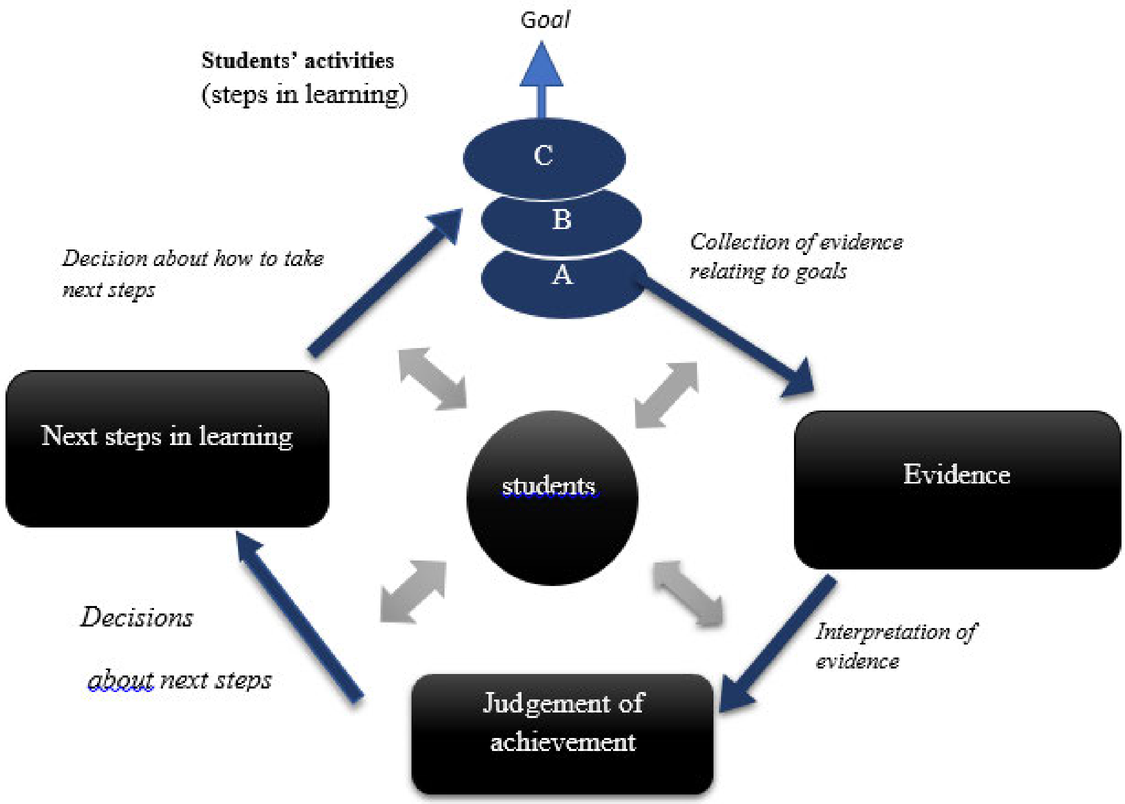

Figure 3-2: Assessment for learning

(Harlen, 2007a:8)

As indicated in Figure 3-2, the students are the focus of the learning process as they receive feedback from the teacher and also provide information (Harlen, 2013).

3.5.3 Assessment of learning in IBL

This assessment is commonly known and encountered in the form of exams and tests, and serves the purpose of evaluating empirical knowledge of students at the end of the learning procedure.

The evidence derived from the special tasks, tests, or regular activities is collected from different sources like artefacts, written answers, portfolios, presentations, discussion of work or, observation of actions.

The assessment carries a negative connotation as it assigns the student a certain final value for their level of comprehension, thereby impeding any further inquiry (Williams, 2014). As indicated in Figure 3-3, students do not have a role in this form of assessment. The assessment criteria are only shared with the students and users of the report (Harlen, 2013)

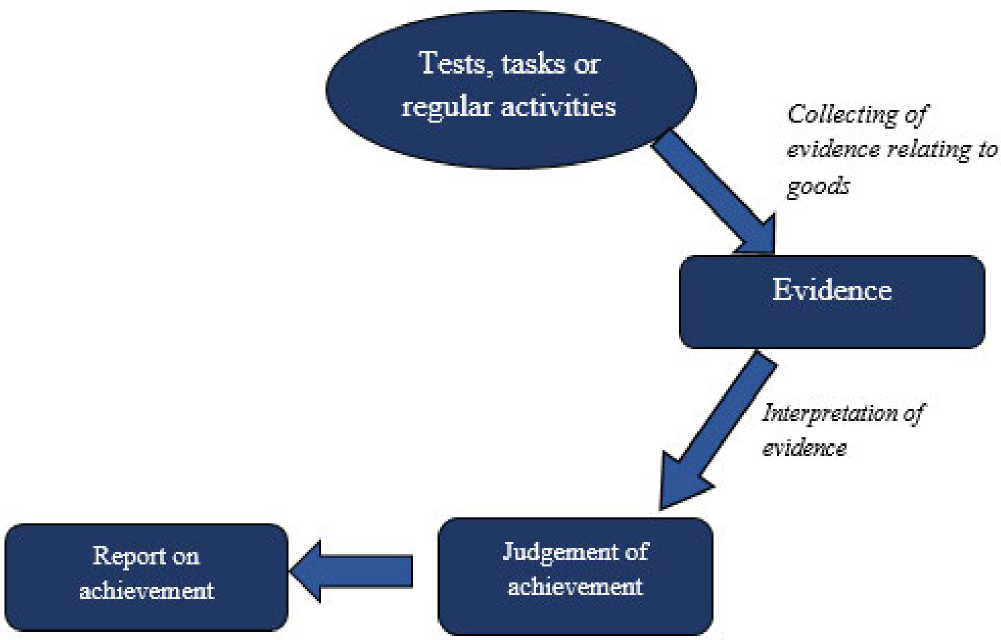

Figure 3-3: Assessment of learning

(Harlen, 2007a:10)

The most effective way to assess IBL is a combination of 'assessment for learning' and 'assessment as learning', as it facilitates continuity which typifies an inquiry and learning process (Education, 2010).

3.5.4 Triangulation of evidence as a method of assessment

The most effective methods of assessment involve pre-defined criteria, careful planning, and ongoing assessment via the "triangulation of evidence" (Bruner, 1961) involving the constant interaction including:

a. Conversation between facilitator and student

These may include live conversations in a class context, or via a journal where the student keeps a record of his or her experiments, and the facilitator provides helpful comments and suggestions. Conversations between students may also facilitate the learning process as well as assessments (Goldie, 2016, Kuhn *et al.*, 2000).

b. Observation

Observation represents the kind of results achieved by the student during his inquiry, and the conversation mentioned above will include a reference to these observations (ROTH and Jornet, 2014). Such observations will include direct results from the inquiry. For example, the formulation of an answer to the propositional question upon which the inquiry is based, as well as other observations such as those contained in a study journal.

c. The product of inquiry

The product of inquiry is closely related to the concept of observation, except emphasis is on the end product of the inquiry. This may be in the form of a final equation or a scientific model, representing the answer or answers to the propositional question asked at the outset of the inquiry.

It is important to maintain a smooth interaction between the above-listed aspects of triangulation, to facilitate an assessment of high quality (Learning *et al.*, 2004).

3.6 PLANNING FOR ASSESSMENT IN IBL

The most important aspect of assessment in the IBL process is the planning. Although, most modern theories support the notion of assessment being an ongoing process rather than a final judgment via a final mark or symbol being awarded to the student. This notion however, does not diminish the need for careful planning and structuring (Learning *et al.*, 2004). There is a need for a recognisable and repeatable standard of assessment that also allows for flexibility and improvisation. In practice, certain methods and suggestions have crystallised to being the most beneficial guidelines in this regard (Bruner, 1961). These methods are discussed in the following subsections.

3.6.1 Planning before the inquiry commences

This can be done by laying out certain procedures that will be maintained throughout the learning process. These include class discussions, interviews between facilitator and student, and the keeping of a study journal. Planning should not necessarily be a unilateral exercise by the facilitator, but may also include some input from the student, as is discussed more fully hereunder. Successful planning will include the determination of predefined assessment criteria, the communication of such criteria to the student as well as an undertaking to adjust and amend the set of predetermined criteria, should the need arise (Dostál and Gregar, 2015).

3.6.2 A pre-defined curriculum

This suggestion does not necessarily stand in contrast to the idea of open learning as a curriculum does not have to be restrictive, that is, prescribing the kinds of inquiries the student may embark upon. Rather, it may set out the desired fields of inquiry that should be covered during the study term (Wilhelm and Wilhelm, 2010). For example, ‘comprehension of the characteristics of various elements on the Periodic table’. In certain instances, the requirement of a defined curriculum may be indispensable as it may represent the fulfilment of a statutory or similar peremptory requirement (Henson, 2015).

3.6.3. Assessing the tangible results of the inquiry

Assessment can be effective if a room is allowed for adjustment after the assessment. This implies that students can be allowed to adjust or amend his/her method after a scientific experiment has been assessed. This opportunity could enable the students to obtain a clearer result as opposed to scoring the student based on his/her initial attempt and preventing him/her any further inquiry (Zion and Sadeh, 2007). It is, however, important to note that there could be time constraints as the opportunity to adjust an experiment may be a once-off event, rather than an open-ended offer (DiBiase and McDonald, 2015).

3.6.4 Student input in assessment criteria

Student input in assessment criteria is a helpful initiative that allows the student to provide his or her input in the construction of assessment indicators and measurement. This opportunity helps the student to understand the scope of the opportunity provided to them. Such students are more likely to feel positive about the outcome of the assessment process. The facilitator should make sure that the correct guidance is provided to the students. For example, reference can be made to the kind of input that previous groups of students have given and an invitation may be extended for suggestions to improve on such previous methods (ROTH and Jornet, 2014).

3.6.5 Improvised assessment

IBL allows for a great degree of scope adjustment and improvisation by both student and facilitator. This freedom should also be extended to the assessment of the student's progress (Darden, 1998). Although it is essential to decide beforehand on a set of tools and methods to achieve an accurate assessment, there should also be scope for improvisation. A helpful suggestion is that such adjusted or improvised assessment should not represent the largest component of the assessment model, but rather a small part which is reserved to ensure manoeuvrability (Lombard, 2010). Assessment should not only be used to measure learning but to also motivate students to be become more active in the learning process. Product and process assessments can therefore be used in various proportions (Airasian, 2000, Stiggins *et al.*, 2004).

3.6.6 Peer review

Peer review is one of the most effective ways of approaching assessment, as fellow students tend to be fair in their assessment, especially when they know that they, in turn, will also be assessed by fellow students (Zion and Sadeh, 2007). Another great advantage of peer review is that a student being assessed is far more likely to accept criticism in a positive light when it emanates from his fellow students, rather than from an authoritative facilitating figure. The nature, scope, and process of peer review should be decided before the process is initiated. The input of the student may, again, help in designing the most effective ways to implement the concept of peer review (Reinholz, 2016).

3.6.7 Various other means

The keyword for successful assessment is "variety" (Wanner and Palmer, 2015). An evaluation by a facilitator should be a combination of live interaction as well as the keeping of a written journal to monitor progress. Peer review allows for this to be achieved by a combination of one on one reviews and the use of small groups. One of the innovative ways to test a student's comprehension on a subject matter is to require a drawing as part of the products of the inquiry (Koester, 2014). For example, a student may be asked to produce a drawing of an effective building that guarantees fire safety. The drawing will provide helpful indications of the student's level of comprehension on the subject matter (Adelson, 2004). More research therefore needs to be conducted on IBL assessment and learning. This is one of the areas where greater research and academic inquiry is needed to investigate even more effective ways of assessing students' progress and ability to maintain/ repeat the successful outcome obtained from a learning process (Wilhelm *et al.*, 2009).

One of the criticisms directed at the concept of IBL is that it is difficult to monitor progress and comprehension of students as there is the danger of misconceptions arising or not being detected. Critics of the IBL concept argue that the institution of test and final exams, as negative an experience as it may be for the student, at least provides a final indication of the level of comprehension the student has achieved on the subject matter as prescribed by the curriculum (Marcham *et al.*, 2018). Although this argument may carry some weight, it does not imply that IBL cannot achieve the same empirical indication of final comprehension by means other than written tests and exams. Although the outcomes from traditional-based education has empirical identification as its strength and measure of comprehension level, it serve as an inspiration to, and not an indictment of, IBL (Education, 2010).

3.7 CHALLENGES IN IMPLEMENTING IBL

The implementation of IBL for science learning, in the context of higher education, is a welcoming concept, however, there are some challenges that could inhibit its successful implementation. Previous research from the literature has shown that it is difficult for students to conduct systematic scientific inquiries (Krajcik *et al.*, 1998, Rönnebeck *et al.*, 2016, Shah and Martinez, 2016, Schauble *et al.*, 1995). The need for content-area knowledge has made data gathering, analysis, interpretation, and communication more challenging. According to Edelson *et al.* (1999), the challenges and issues hindering the successful implementation of IBL appear in many different forms and could be addressed effectively by a well-structured curriculum design and effective technological strategies. It is important that each of these challenges should be effectively dealt with to prevent them from undermining learning and to ensure that the students successfully engage in meaningful investigations.

Five of the most significant challenges are presented in the following subsections (Castro and Morales, 2017, Edelson *et al.*, 1999):

3.7.1 Motivation

Motivation is one of the greatest challenges that might hinder student-centred learning, especially IBL (Soloway *et al.*, 1994). Students need to be sufficiently motivated to contribute and participate positively in any IBL. This is necessary because students must develop an interest in the inquiry, the results, and implications, for effective learning to take place. A lack of interest by students often results to non-participation in the inquiry activities or participation in a way that does not support learning.

3.7.2 Accessibility of inquiry techniques

Of great importance is the need for students to understand how assigned inquiry activities are to be executed. A clear understanding of the targeted goal and the interpretation of the result is mandated. For instance, inquiry-based students are required to master to a higher level of precision, the act of data collection and analyses, which are not typical of their everyday experience. Such learning tools are needed to conduct an inquiry that produces meaningful results (Pewnim *et al.*, 2011, Soloway *et al.*, 1994).

3.7.3 Background knowledge

The science-content aspects of students' knowledge from formulating research questions to the interpretation of data also influence learning in IBL. IBL provides an opportunity for students to develop and apply their science-based knowledge. A lack of science-based knowledge in students often leads to inability to complete meaningful inquiries.

3.7.4 Management of extended activities

Students need to manage and organise extended complex activities for effective learning in IBL. This is necessary as IBL learning activities involve proper planning, coordination, and resources and product management before learning can take place. Students should therefore be able to organise their work such that they can manage any extended activity that may arise.

3.7.5 Learning and environment needs

The activities and technologies used in any IBL should be suitable for the environment and learning context as inability to work within the available technology or fixed schedules may lead to failure of a design inquiry. Therefore, both learning and environment including infrastructure needs should be considered carefully during IBL design.

Besides taking into cognisance the challenges mentioned above and the implementation of new curricula in IBL, some additional challenges require continuous reworking to achieve an effective IBL pedagogy implimentation. Using the Mississippi State University and California Polytechnic State University at San Luis Obispo as case studies, Monson and Hauck (2012) investigated their

IBL-based construction management programmes and identified six common challenges. The challenges identified include accreditation of programmes, an understanding of the inquiry process, curriculum development, identification of suitable lecturers, theorising of skillsets and construction content, and assessment of learning in IBL.

The study aims to address the challenge relating to assessment of learning in IBL and to answer the unique research questions associated with it.

3.8 SUMMARY

The literature on cognitive science research has shown that students do construct their knowledge by building on knowledge gained previously. Researchers have opined that students learn best from each other, especially when they work in a group. Literature also shows that students are better when they are asked to solve a compelling problem through experience. The foregoing, coupled with the fact that students learn at different levels and in different ways, has necessitated a shift from teacher-centred to student-centred learning. It has been argued that this shift could be achieved via the development of new "powerful pedagogies" underlining learning. This study has shown that the implementation of IBL in undergraduate programmes comes with many benefits to teaching and learning. IBL enhances student performance and learning, and also equips students with relevant skills for the 21st century.

Different views have been shared by key players in teaching and learning (including lecturers, students, and institution authorities) on the introduction of new pedagogies and need to shift from a positivist to a constructivist form of learning. Generally, empirical evidence shows that IBL approach encourages student-centred and deep approach to learning.

The next chapter examines the adoption of IBL in construction education and its assessment strategies in higher education.

CHAPTER 4

ASSESSMENT IN SOUTH AFRICA HIGHER EDUCATION

4.1 INTRODUCTION

Research suggests that more emphasis be placed on discovering the existing knowledge of students on a subject matter and that teachers must build upon that knowledge (Al Hakim *et al.*, 2018). This view stems from the notion that a student's prior knowledge of a concept or system would influence learning positively. Although such an approach appears simple, students however do not showcase an accurate understanding of what they have been taught. Even in situations where a teaching approach is well-planned and effectively executed, the learning outcomes achieved may have minimal representation of the desired intention. It is challenging to predict students' understanding of a particular sequence of instructional activities, even if the sequence of activities were initiated to students concurrently (Wiliam, 2011). Within minutes of starting the sequence, students already start to showcase different levels of understanding (Xu and Brown, 2016). Assessment can therefore be used to determine if a particular sequence of instructional activities has achieved its intended learning outcomes (Heitink *et al.*, 2016).

Assessment can be regarded as the most influencing factor in a learning environment (Anderson, 2004, Hannafin *et al.*, 2003), and an essential component of a curriculum (Van den Akker, 2004). It can be applied at different levels, either nationally or institutionally to measure the learning abilities of students in a module (Mugisha, 2010a). Assessment ensures accountability and quality in higher education and seeks to improve student learning (Ewell, 2009a). According to Series (2004), assessment also affects the way students manage their study time as students seem to focus more time on the content of previous assessments to understand the development of questions by lecturers. Assessment also impact on the quality and depth of what students learn and their choice of learning strategies, and could also motivate or discourage students (Harlen and Deakin Crick, 2003).

4.2 THEORETICAL FRAMEWORK OF ASSESSMENT

4.2.1 Assessment in higher education in South Africa

The South African higher education landscape has undergone massive changes, leaving a permanent imprint on the system, practices, and its constituent institutions (Bentley, 2006). The post-apartheid period commenced with an introduction of a symbolic policy aimed to declare the change from the past and also signal the start of a movement into a new direction (Kanjee and Sayed, 2013). However, the new policy has enabled limited improvement in the profile of higher education institutions as little emphasis is placed on producing graduates with requisite 21st century skills (Chui and bin Ahmad, 2016, Cloete, 2006,). The effective use of assessment in higher education institutions has been recognised in various parts of the world as one way of improving the quality of education (Castells, 2001, Zeng et al., 2018). The improvements recorded in the efficiency and quality of higher education systems worldwide has therefore led to an increase in the adoption and implementation of various assessment methods (Ashburn, 2006).

In the South African higher education system, the focus has been on teaching and evaluation of the understanding of students, rather than the challenges and opportunities associated with establishing and utilising assessment to foster effective learning (Archer and Brown, 2013, Delanty, 2001). In such a system, the role of assessment in enhancing learning processes may be undermined.

An analysis of the changing views of assessment in learning institutions was conducted by Beets (2007). The study reveals that three stages have been developed during specific periods in history. The first stage is a conventional assessment which usually follows teaching. The main purpose of this stage is the discovery of how much has been learned by students. The second stage relates to education measurement which builds on the underlying premise of conventional assessment but also focuses on making the assessment process more technically defensible, efficient, and rational. The third stage is ‘competency and authentic assessment’. This assessment seeks to ensure a genuine correlation between what is being assessed and the actual competence of students. It brings a close correspondence between higher education learning and professional practice.

An analysis of the higher education system in South Africa using data from academic programmes in various universities reveals that assessment models which focus on one of the three mentioned stages or only the first two stages are being adopted (Barak, 2010). This revelation supports the assertion of Beets (2007) that academic institutions experience problems by clinging to traditional practices such as the use of obsolete assessment tools in the first two stages. Despite being viewed as one of the methods for reforming the higher education system in South Africa, change in assessment methods remains largely stifled by common practice and tradition which both ignore the relationship between learning and teaching (Brookfield, 2017).

Assessment should not only be targeted at measuring students' and lecturers' performance but also at creating a substantial reciprocal interaction between learning and teaching processes, thereby unfolding possibilities and opportunities that guarantees the most appropriate learning and teaching outcomes (Walvoord, 2010). According to Alade (2006) and Buzzetto-More, assessment is a continuous cycle that involves many tasks, with the primary aim of improving students' learning. The tasks and associated order of operation are illustrated in Figure 4-1.

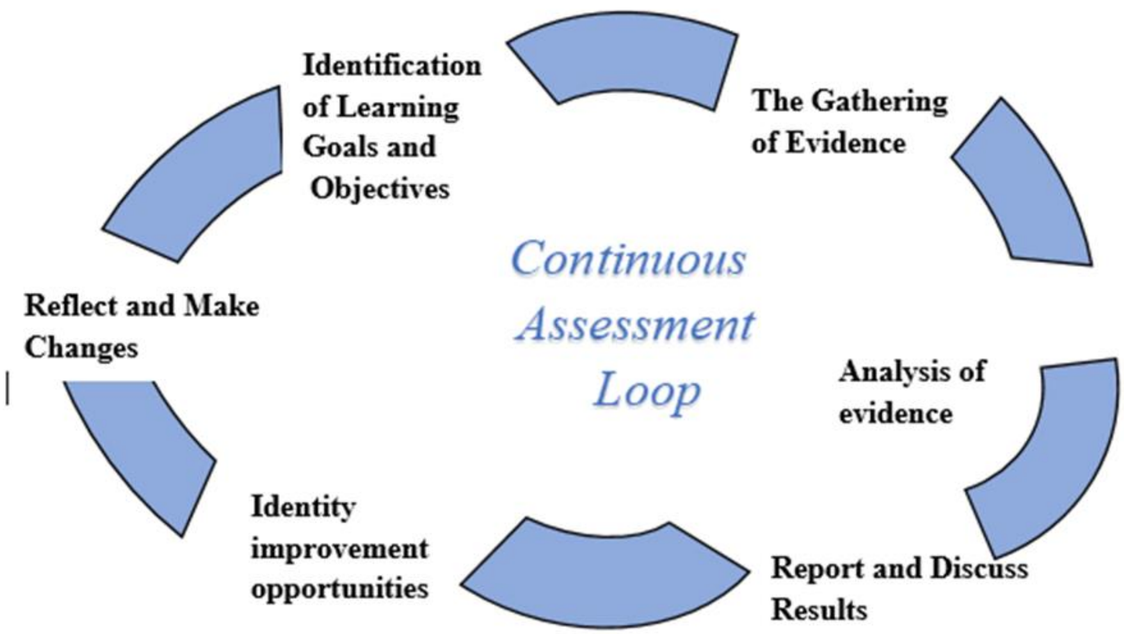

Figure 4-1: Illustration of the assessment continuous cycle

(Buzzetto-More and Alade, 2006:256)

The assessment process in the South African higher education system is deemed to be insufficient in equipping students to learn without the dominant presence of teachers, and the use of examinations (Rhodes University, 2015). An effective learning process is required to counter-discourse in a manner that underpins a formative purpose, thereby transforming assessment practices. There is therefore a need to put in place an assessment system that can provide feedback to both lecturers students, regarding the correctness and appropriateness of their teaching and learning, respectively, to foster effective learning in higher education institutions (Rust, 2002).

South Africa is currently facing some challenges that could negatively influence assessment practices. Some of these challenges include the threat of plagiarism, poor implementation of new or emerging assessment technologies, incessant changes in the composition of student bodies including frequent disruption of learning processes, inordinate focus on the development of generic skills, and inability of staff to identify assessment methods that are cost-effective and less time consuming (Murray, 2013).

Plagiarism is not accepted in academia as it is an ethical issue. It is a part of academic dishonesty which opposes academic integrity (Vehviläinen *et al.*, 2018). Plagiarism has been on the increase in higher education since the advent of information and communication technology, and the development of the internet (Comas-Forgas and Sureda-Negre, 2010). A student may have an understanding of the consequences of plagiarism, but may not clearly understand the act of paraphrasing and proper referencing (Gullifer and Tyson, 2010). Students therefore need to develop academic writing skills and not engage in cheating when completing assignments or exams (Vehviläinen *et al.*, 2018). To avoid plagiarism, students need to have a clear understanding of assessment expectations (Sterngold, 2004). Assessment criteria and grading rubrics therefore need to be made available to students before an assessment (Thomson, 2013). Although the adoption of computer-based assessments to aid learning has provided many opportunities, it however come with its own risks (Webb and Gibson, 2015). For instance, the use of an automated essay scoring (AES) (Davis, 2000), has become popular because human assessment takes time and is also expensive (Barron, 2003). Human assessment is also considered as highly controversial due to its validity issues (Clark *et al.*, 2007). AES is characterised by the following drawbacks:

(a) violation of the social nature of writing and communication;

(b) the scoring bias is unidentifiable; and

(c) creates an impression in students that they are writing for a machine (Anderson *et al.*, 2009).

According to Fullan and Scott (2009), societal development depends largely on the quality of graduates produced in colleges and universities. Higher-education institutions need to produce graduates that possess, not only generic skills, but also soft and technical skills relevant for societal development (Orr, 2004). This assertion is supported by Wals (2010), who opines that learnings in universities often lack a robust thought-based, research, and teaching profile needed for accelerated sustainability. Regrettably, the capacity of higher institutions in producing graduates with skills relevant for the 21st century, and requisite pedagogical innovation to drive this, have developed at a slow rate (Armstrong, 2011, Ferreira and Tilbury, 2012). Consequently, teaching and learning systems in higher education require an urgent re-evaluation. In particular, revisioning, rethinking and aligning of academic curricula and assessment practices are necessary to produce graduates with requisite 21st century skills to achieve sustainability at municipal, provincial and national scales.

The promotion of sustainable and effective learning processes through efficient assessment practices have been regarded as not straightforward or problematic in South African higher institutions (Heystek and Minnaar, 2015). A shift is required in the conceptual understanding of assessment – from the utilisation of assessment results to support administrative functions, towards the development and utilisation of assessment in collaboration with students (Beets, 2007). This shift will lead to an improvement in learning processes as well as establishment of self-regulated learning institutions for the future. A self-regulated learning institution is an environment where metacognitive, cognitive, motivational behavioural, and emotional aspects of learning are taken into consideration. The environment also takes into cognisance variables, volition, self-efficacy, and cognitive strategies that affect learning in a holistic and comprehensive approach (Panadero, 2017). However, such an initiative will require the establishment of a ‘scholarship of assessment’ which can be described as a systematic inquiry on assessment. The integration of these concepts in the South African higher education system will serve as a viable platform for the development of a new assessment culture that aligns instruction and learning more with assessment.

4.2.2 Assessment in higher education

Assessment refers to the collection of information on a subject matter for utilisation in a specific way (Crisp, 2012). Assessment is also a conglomerate of measurement which applies a set of rules and procedures to key attributes to obtain quantitative data about it (Dixson and Worrell, 2016). Assessment can be inclusive of measurement. For instance, when a lecturer uses a multiple-choice test to measure the achievement of knowledge and skills achieved, the outcome is a score, which is used in ranking the students (Brookhart, 2004). The score is meant to represent the knowledge acquired by the student.

Assessment can also be defined in terms of the collection of qualitative data such as, for instance, in tests that require descriptions. Both qualitative and quantitative data in assessment are vital (Miller *et al.,* 2006). The objective of an assessment is dependent on the type or choice of data, either qualitative or quantitative. According to Harlen (2007a), there are two main types of assessment - formative and summative assessment. 'Formative assessment means that the assessment is carried out with the aim of learning' and 'when the concept has been learned'. Formative assessment is an integral part of teaching and learning as the information emanating from it is continuously used to improve learning. As indicated in Figure 3-2, formative assessment involves the collection of data from the assessment which is related to the learning outcomes with the information being analysed to improve the learning process. The student is at the centre of this process. Also, there is active participation and interaction between the lecturer and the students.

From Figure 3-3, it can be observed that the process of collecting data and judgement-making are common to both formative and summative assessment. However, the difference is that summative assessment is not student-centred (Harlen, 2007a). The summative assessment could also be used cautiously for formative purposes at the earliest stage of planning the teaching.

4.2.3 Seven pillars of assessment

Seven questions are to be answered in any assessment as they constitute a platform upon which higher education rests (Falchikov, 2013). The seven questions are:

a. Why do we assess?

This question relates to those who require and use assessment results as well as the purpose of the assessment. According to Rowntree (2015), a large percentage of the literature on assessment have centred on the use of assessment for ranking and grading purposes. Only a few have considered assessment as a tool for enhancing student learning. Assessment, however, can be used for the following purposes, namely selection, quality control, motivation, provision of feedback to students, provision of feedback to lecturers, and preparation of students for life after school. The four primary users of assessment results include administrators, policymakers, students (or parents), and lecturers (Dietel *et al.,* 1991). Figure 4-2 illustrates the purposes of assessment and the areas of overlap among stakeholders.

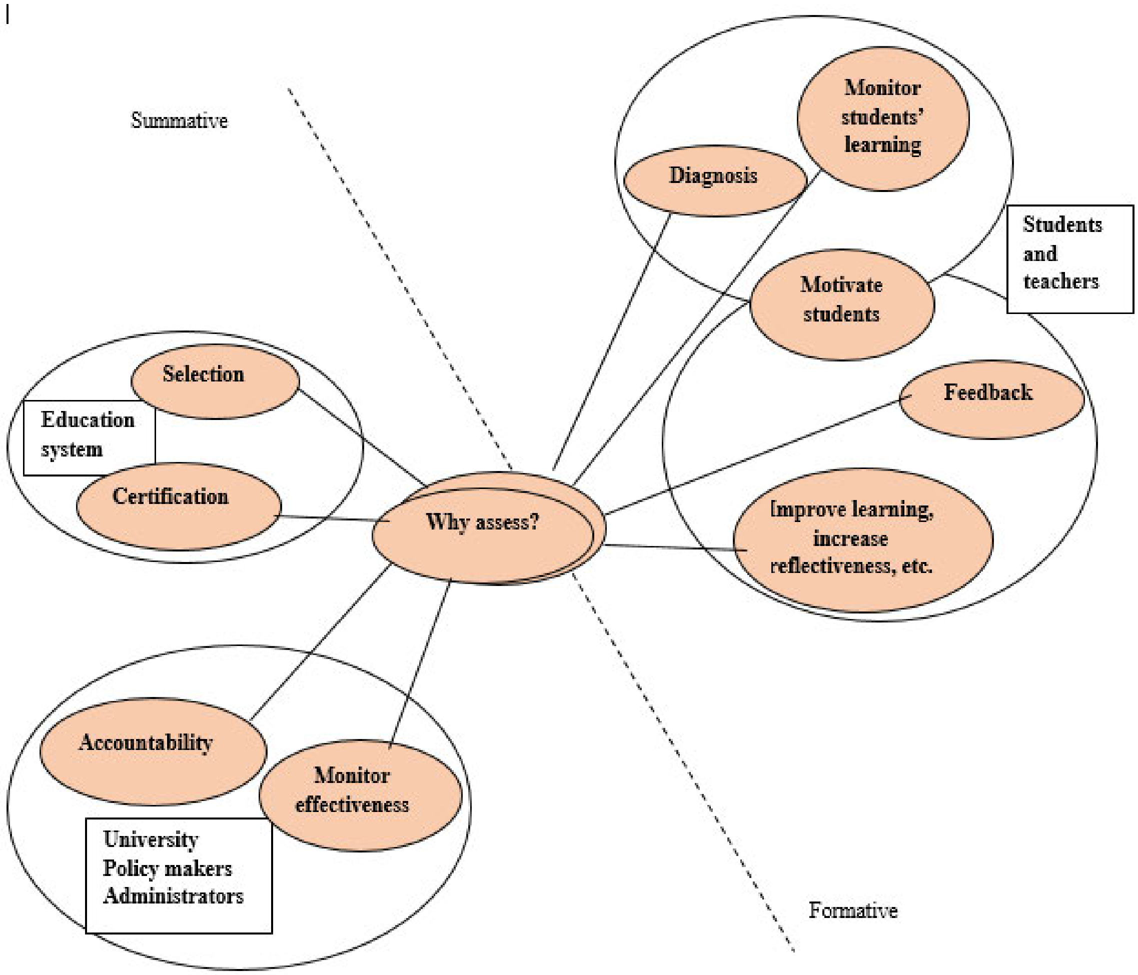

Figure 4-2: Primary purposes of assessment and areas of overlap

(Falchikov, 2013:3)

b. How is an assessment carried out?

An assessment could either be formal or informal. It could also be carried out qualitatively or quantitatively. The focus of assessment could be a product or a process of learning which may occur during the teaching of a course or at the end of the course. It may also be spread throughout the course of the academic year. This is assessment achieved by the administration of assessment tools. (Dixson and Worrell, 2016, Falchikov, 2013, Kuh *et al*., 2015).

c. What do we assess?

An assessment could range from examinations, laboratory report, case studies, 'devolved assessment', exhibitions, interviews, journals/reflective logs/diaries, learning contracts, negotiated reporting procedures, observations, oral presentations, portfolios, and profiles, to products and processes of newer assessment methods these assessment tools are used to measure knowledge, skills and understanding. (Schuurman *et al.*, 2007, Serafini, 2000, Falchikov, 2013).

d. When is an assessment carried out?

Summative assessment takes place regularly or at the end of the course, year, and program, while formative assessment takes place regularly during the course (Buchholtz *et al.*, 2018).

e. Who does the assessment?

Assessment can be carried out by the students, peers, lecturers, and the quality control department (Kuh *et al.*, 2015).

f. How well do we carry out the assessment?

Assessment is aimed at promoting teaching and learning. Assessment is therefore used for learning and for assessing learning. Better assessment tools that measure learning need to be developed to enhance teaching and learning.

g. What next?

An improvement in assessment modes is suggested, especially in the field of engineering and construction studies. This is necessary for graduates from these programmes to possess the required skills required in the 21st century such as communicative, social, creative meta-competencies, and cognitive skills. (Harty and Leiringer, 2017). Therefore more research is needed to measure student learning through effective assessment design.

4.3 INFLUENCE OF ASSESSMENTS ON LEARNING

Contrary to the belief of many that assessment is used to systematically collect and analyse data about a student (Bennett, 2011), assessments have a greater influence on student-learning than teaching. Assessments have a large influence on how students respond to what they learn in class. Assessments serves as a pointer to what their instructors regard as either important or just contemporary. Assessments also provide an incentive for students to study and ensure that they develop study strategies to cover as much ground as necessary (Barak, 2010).

Baeten *et al.* (2010) presents four reasons why students learn and study. These include:

a. Meaning: students with this orientation have interests in the learning content and are motivated by their intention to understand. They, therefore, adopt learning strategies like comprehension learning, relating ideas, and use of evidence;
b. Reproduction: Students exhibit fear of failure, and they are motivated by external rewards like grades, praise, money, and fame so they study the curriculum narrowly;
c. Achievement: The students in the group are motivated by the need for achievement. These students know what is expected of them to pass their modules, so they organise their studying accordingly; and
d. Apathy: The last group is not academically motivated and their approach to studying is known as an apathetic approach. Their level of motivation is low, adopting a disorganised and negative attitude to studying.

According to Bound (1995), students may escape the effects of poor teaching by learning independently, but it is inexplicably hard for them to escape the effects of poor assessments as they have to undergo the assessment. This relationship demonstrates the influence that assessments have on the lives of students, and the need to prioritise it.

For many students, assessments act as a lever, which determines the extent to which they will learn, how, and what they will learn. This approach is often because only lecturers plan for a course, develop learning activities, and then, set the assessment. As a result, assessment usually takes into account what the lecturers consider to be vital for developmental learning (Brown and Knight, 2012). When students take on a new course, the first aspect they often evaluate is the assessment framework for the course. They thereafter formulate their learning activities to meet the requirements of the assessment (Knight, 2012). As a result, the students end up missing important data that could have been of high importance to the course. Individuals involved in the design of assessments should, therefore, ensure coherence across all aspects of learning to assure that the desired learning outcome is achieved through the assessment.

In recent years, the assessment domain has evolved considerably (Bamford *et al.,* 2012). New assessment methods have been developed and implemented in higher education. For instance, the benefits of adopting projects, portfolios, simulations, collaborative assessment, and alternative assessment have been considerably reported and embraced for developing responsible, reflective, and autonomous students (Almond, 2009). Also, student-centred assessments like oral presentations by groups or individuals, as well as service-learning assignments encourage collaborations and feedbacks among students, while also increasing student-lecturer contact (Webber, 2012). Assessments therefore constitute a defining feature of student teaching (Barnett, 2007).

When students are requisitioned about their approaches to learning, there are mainly three approaches that they often specify. These include, a surface approach to learning, deep approach to learning, and strategic approach to learning (Brookhart, 2004). Surface approach to learning encompass undertaking a task and coursework, without necessarily engaging the work on a personal basis. Student who adopt this approach view learning as an unwelcome imposition on their being, reducing their autonomy to engage in better and productive self-chosen practices. These students often memorise materials and use procedural problem-solving skills, with a limited conceptual understanding of the topics (Biggs and Tang, 1997). The deep approach to learning motivates students to understand the course work, conduct an active conceptual analysis which is consequent to a deep level of understanding on the subject matter (Brookhart, 2004). The strategic approach to learning constitutes a better and more refined path to learning where the student has an objective, vision, and mission on learning. The students aim at the highest possible results from the assessment and as such, students tend to be engaged in well-organised and conscientious study methods. The students also must be good time managers. The strategic approach ensures that students are well versed in the content of the materials (Ramsden, 1987). *"The way in which anyone goes about learning is a relation between the person and the material being learned"* (Ramsden, 2003:103).

An assessment in higher education is a fundamental link between learning and progression. It provides an avenue and an opportunity for administrators and instructors to assure and express academic standards and has an important influence on the behaviour of students. In many higher education institutions, however, the practices have not kept up with the pace with which the education structure has evolved (Barnett, 2007). For instance, modularisation which is the delineation of a curriculum into small non-sequential and independent units has limited the ability of students to acquire constructive knowledge; leading to fragmented and incoherent learning (French, 2015). This process has led to significant growth in the use of summative assessments (Redmond *et al.,* 2018). The adoption of some assessment modes contributes to existing challenges being faced by students and institutions. The student-lecturer ratio has been gradually eroded, with students remaining confused about what is expected of them. As a result, students taught using the summative assessment approach often developed personal strategies to ensure their excellence without necessarily benefitting from what should have been a constructive build up to their knowledge.

4.4 TYPES AND FORMS OF ASSESSMENT IN HIGHER EDUCATION

4.4.1 Formative and diagnostic assessment

Formative assessment gives information and data on an assessment for enhancing continued learning for the student. It is a form of assessment that provides a change in classroom learning and other additional aspects (Brookhart, 2004). Assessments are used to guide the teaching and learning process which, in turn, fosters the acquisition of information. It therefore enables the observation of student skills and abilities as gained from the learning process. Formative assessment is a way of enticing hard-pressed instructors to source for better and more refined resources and education materials, while also ensuring quality (Rushton, 2005). Formative assessments act as a stepping stone for students to gain a higher level of attainment, and not only acknowledging and measuring learning (Bentley, 2006).

A diagnostic assessment has been introduced into the curriculum as a means to tell whether a new student can cope with the demands of a course (Benseman, 2008, Berger and Dreher, 2011). Traditionally, diagnostic assessment is used to identify deficiencies in specific knowledge areas like the ability to interpret sentences, recall factual information, and solve mathematical problems (Crisp, 2012). This form of assessment could be used proactively to allow students understand that identifying their existing capabilities is important towards developing self-regulation abilities, making them capable of controlling their learning environment (Crisp, 2012).

Informal formative assessments take place during events, and are not necessarily stipulated in the in the curriculum (Värlander, 2008). These types of assessments include instantaneous feedback as the students take part in a certain activity that is causative of continued learning (McLean, 2018). Informal formative assessments are primarily characterised as being continuous, although this requirement has never been a necessity (Brookhart, 2004). Although, informal formative assessments can be occasional, yet it provides students with the requisite support for continued learning. Under the informal formative assessments, students can gauge their abilities during peer assessments. Students therefore have the autonomy to acquire knowledge and receive contribution from outside parties (such as parents and guardians) who are not formally part of the learning process (Furtak *et al.,* 2017). Formal formative assessments are, however, primarily administered by the academic staff or supervisors (Barnett, 2007).

4.4.2 Summative assessment

Summative assessments provide requisite information for making final decisions, for instance, when an instructor assigns end of term grades for progression to the next grade (Brookhart, 2004). These are high-stakes assessments that are also used to gauge the extent to which the student has grasped the content of the course (Gardner *et al.*, 2010). Summative assessments are typically graded and less frequent in nature, occurring at the end of segmented teaching. These include final exams, term papers, state tests, and entrance exams (Dixson and Worrell, 2016). Summative assessments are used to (a) determine students that qualify for a special program, (b) determine whether a student should advance to the next grade, (c) assist students with career guidance, and (d) determine eligibility for academic awards (Harlen and Gardner, 2010). Many individuals think of assessments in a summative sense, associating them with final decisions (Borba, 2012). This ideology continues to subsist even when these assessments are attached to formative, integrative, and other forms of assessments.

Considering that summative assessments are definitive, their validity and reliability are of high importance (Knight, 2002). In recent decades, researchers have attempted to link both summative and formative assessments since both models are based on the same evaluative analysis (Isaac, 2016). The summative assessment normally occurs at the end of a year or semester or towards the end of a unit or course. Therefore, the result may not help to improve the learning for students but could assist in improving the teaching technique for lecturers. Summative assessment therefore become formative for the lecturer and other students (Dolin *et al.,* 2018). This view implies that any assessment can be use formatively in accordance with a general principle that the ultimate purpose of assessment is to improve learning.

In most cases, summative assessments are designed to tell the extent to which the student has grasped the objectives that were outlined in the curriculum. This view is quite different from formative assessments which evaluates the ability of the student to conceptualise the course work and apply it in real-world cases. Some assessments are purely designed to be simultaneously formative and summative (Värlander, 2008). They may be formative in the sense that the student is expected to gain from the feedback that has been given to them, and summative in that the grade or the result that has been formally awarded will be adopted in delivering a final decision (Värlander, 2008). Summative assessments can only be formative if the student learns from them. The results from summative assessments are either norm-referenced or criterion-referenced. In norm-referenced, the assessment outcome of a student (indicating the level of achievement) is judged against the performance of a fellow student. In some institutions, a norm-distribution curve is used for this purpose (Mugisha, 2010a). This form of grading encourages competition and discourages cooperation among students (Lok *et al.,* 2016). It could also lead to many students being passed by the lecturer. In criterion-referenced assessment, the aim is to discover how well each student has achieved the intended learning outcomes (Mugisha, 2010a). According to Davis (2009), criterion-referenced assessment is used to reflect individual mastery of the learning outcome relative to the performance of other members in the same class.

A disadvantage with summative assessments is that feedback occasionally comes too late for the student to extract any concrete knowledge from them, thereby eradicating the formative characteristic of summative assessments (Ashburn, 2006).

4.4.3 Integrative assessment

In this form of assessment, a traditional approach to research is adopted as an intrinsic part of learning. Johnson (1977) proposed an evaluation schema for a continuous and integrated assessment model that was to be engraved in the learning process. Adherents such as Paul Zachos implemented a model of evaluative processes in developing a curriculum (Crisp, 2012). Under an integrative approach, the student derives the learning experience through a demonstration of case studies where the various issues under study are emphasised. As such, an integrative assessment is mostly carried out at a classroom level.

4.4.4 Teacher assessments

Teacher assessment is administered by teachers as part of the learning process by the student. The instructor, therefore, makes an assessment of the ability of students to handle difficult situations and utilise the information learned as a focal point for their efforts (Gardner *et al.,* 2010). These forms of assessments tend to develop a student profile for every pupil based on their strengths and weaknesses over a range of subjects (Borba, 2012). This theory is however applied to longitudinal approaches in the measurement of student performance, and acts as an explanation of how well theory relates to practice.

4.4.5 Convergent and divergent assessments

Convergent assessments refer to assessments that test whether students can fulfil objectives that had been outlined before the commencement of the course. Divergent assessments look to evaluate whether the students can succeed in a more open-ended scenario (Crisp, 2012). Since the objective of higher education is to ensure that students have the autonomy to learn and apply the knowledge, the module and form of assessments that are applied in the schools must encompass both convergent and divergent approaches to learning (McLean, 2018). This approach is imperative as students are expected to acquire skills and also think in a structured way (Hettiarachchi *et al.*, 2013).

4.4.6 Computer-assisted assessments

Computer-assisted assessments seek to utilise the capabilities and developments in the field of information communication technology (Crisp, 2012). Institutions have been developing assessments where they rethink or relearn aspects of their assessment modes. Many researchers have emphasised the need for instructors and administrators to rely on and align their strategies with innovation, through assessments (Crisp, 2012). The assessment components are put together, through collaboration by all involved parties to ensure that the assessment is both acceptable, reliable, and valid. This approach brings about the development of a data bank that will ensure that the process of administration is smooth and free of any hitches (Isaac, 2016). Computerised assessment is very helpful to lecturers and administrators in terms of cost and time reduction, security of questions, automatic recording, speed of result, and distance learning (Parshall *et al.*, 2002, Smith and Caputi, 2007) Studies have also shown that students prefer computerised assessment to written assessment as they view computerised assessments as more objective, credible, promising, fun, fast, and less stressful (Croft *et al.*, 2001, Terzis and Economides, 2011).

4.4.7 Work-based assessments

These kinds of assessments often take place in a workplace setting, with their preference being in technical subjects. Workplace assessments aim at integrating both academic and vocational education for developmental enhancement of the assessment experience (Wangenge-Ouma, 2012). They are often continuous assessments and are based on competence and the ability of the student to perform related tasks and functions to a predefined acceptable standard. This view is based on the current belief that good assessments should go beyond competencies to advising the student, through practical knowledge on the next step in their career (Hettiarachchi *et al.*, 2013).

Assessments are not an end, but the beginning of educational improvement. In higher education, the term "assessment" has various meanings (Anderson, 1986). It can be a process of grading the assignments of students or a testing method imposed on the education institute for external accountability. Moreover, it can be designed to gather information about a successful program, course, or project assignment. Assessments in education institutions are tools designed to improve how students learn by collecting and analysing information systematically (Ashburn, 2006).

The next section describes the various methods and tools of assessment, elucidating their advantages and disadvantages with the South African education system in perspective.

4.5 METHODS OF ASSESSMENT

The South African higher education system is characterised by various methods of assessments. Educational institutes are often responsible for developing and implementing methods of assessment as deem relevant to their requirement. These assessments are formative and are based on classroom assessment and teaching techniques (McLean, 2018). The formative assessment technique is used to monitor learning of students and to provide feedback. The collected feedback is used to determine the part where a student is struggling to learn so that the lecturer can modify their teaching method and students can improve their learning (Braun, 2006). These assessments often have low values or scores, and usually occur during the semester.

4.5.1 Informal assessment techniques

Informal assessments are written reflections and are also referred to as minute papers or muddiest points. This assessment technique is implemented by asking the students to answer one or two simple questions at the end of a learning session or immediately after outdoor class activities. The questions should be simple like "What was the important topic you learned today?", "What was the topic you don't understand?" Answers to these questions show what students have learned and which part they need more explanations (Burke, 2013). It saves time and immediate feedback can improve learning quickly. Student opinions, behaviours, or attitudes in learning can be collected either during a learning session or outside the class, utilising polls or surveys. This method of assessment often requires a periodical check of the understanding of students, whereby a lecturer pauses at intervals (for instance, every 15 minutes) during a learning session to ask questions, thereby assessing the level of concentration and understanding of students. Reflective questions which are also known as wrappers are asked in a wrapping activity which assists students in improving their skills and monitors their learning (Delanty, 2001).

4.5.2 Formal assessment techniques

To ensure a strong peer to peer learning method, In-class activities are recommended. Students are asked to work in pairs or groups to have meaningful discussions in the class and to solve problems with the help of their group members. The lecturer walks around the classroom and assists students' who find difficulties in their works. Quizzes are another effective method of assessment that do not have to be included in the student grades. It is often used to assess prior knowledge of students and to create a friendly competition inside the class (McLean, 2018). A quiz session before starting a lecture can be helpful to identify what the students have already known about the topic, what are they going to learn more about the topic. It can cover a wide variety of topics in a short time. In-class activities involving group activities and teamwork helps to improve skills (Borba, 2012).

4.5.3 Summative techniques

These techniques of assessment have a high point of values/scores. Summative assessment happens at the end of a course or a semester to determine the extent to which students have accomplished the expected outcome of learning (Isaías *et al.*, 2015). This technique entails subjecting students' to mid-term and final examinations (Braun, 2006). Examination or question papers are set by the lecturer, and these could be in form of multiple-choice questions, true or false, short answers, and essay questions that enable students to write on all they have learned during the semester. Assignments, oral presentations, and projects are used to assess the skills of students in applying knowledge creatively. These methods of assessment are critically important as their outcomes provide the lecturer with feedback that he/she can use to improve his/ her teaching (Burke, 2013). These types of assessments also provide an opportunity for students to showcase their multiple talents and creativity. They are regarded as the most valid method for assessing skill development (Darling-Hammond, 2017).

Both students and lecturers must evaluate the progress achieved for each semester. An effective approach for this evaluation is the development and submission of a portfolio at the end of the course (Lam, 2016). There are various forms of portfolios which include learning portfolio, job portfolio, personal portfolio, development portfolio, performance portfolio, and assessment portfolio (Doina *et al.,* 2012). Portfolios can include student learning reflection and their performance during the semester. Process assessment is used to identify the milestones of a project to be reached, activities to be undertaken to reach the milestone and products to be delivered in the course to attain the final goal of learning (Barak, 2010).

4.6 TOOLS OF ASSESSMENT

The understanding of learning should reflect in multidimensional and integrated ways. It should show an increase in performance over time and make an assessment effective. The purpose of any program should be clearly and implicitly stated to reflect the assessment in the best way. Assessment should focus on identifying the result, but it is also necessary to identify the various experiences of students to achieve that result. To achieve an effective result, assessment should be carried out periodically but not just at the end of a semester (Borba, 2012). Examination and program assessment are the two main tools of assessment in higher education and are discussed below. Students' learning and their experience have to be assessed to find out whether students have obtained the knowledge, skills, and talents related to their course of study.

Assessment tools are created by education institutions to achieve three major objectives (Burke, 2013), – to improve, to prove, and to inform. Based on the result of an assessment, education institutions can determine the expected outcome has been achieved or not, and thereafter determine an approach for improving the learning process to achieve the expected result.

4.6.1 Program assessment

Program assessment is aimed at improving the program to improve student learning. Program assessment involves investigating how programmes impact students' learning and whether program goals are achieved. To achieve this, lecturers are required to show that students benefit from the program and make them ready for the world of work (Gardiner *et al.,* 2009, Martell and Calderon, 2005).

A program assessment should be designed in a way to meet certain criteria to determine the student learning and the outcome results effectively. It should be more systematic in an open and orderly way of obtaining information about student performance over time. The program assessment should be built within an integral part of the program or department. It should have multi-face to use many methods and multiple sources for gathering information in multi-dimensions *(Doina et al.,* 2012). The purpose of assessment is not to gather the information for a record but to improve the education system by improving teaching and learning. Program assessment takes effort to build evidence to improve the program or course assignment. By making the program assessment more effective, education institutions can set an objective by determining what they are trying to achieve, how well they are performing to achieve their objective, and how can they improve their process to obtain the expected result. There are some steps to achieve an effective program assessment (Paulson, 2015). The steps begin with agreeing on the process, creating objectives for learning outcomes, finding out the activities for each objective, brainstorming and evaluating significant measures, determining methods to assess, collecting information, using the information to plan for improvement, implementing the plan, and ends with announcing the results. Many colleges and academies use the program assessment tool to accomplish their goals (Ramlo, 2015).

The goal of the program is to produce students that have achieved detailed learning outcomes and the objective of the program is the skill the students possess which reflects the goal. Program assessment involves the following activities:

a. Open discussion with the lecturer about the topics describing a student, including what skills the students have? What does the student know? What can be done to improve the knowledge of students?
b. Collect and verify the materials of a student including the student's syllabus, course outlines, course assignments, classroom tests, handbooks.
c. Gather information about the student from other departments and react to the goals and objectives of that department.
d. Determine what goals should be reduced and what goals should be improved based on the student information gathered before.
e. Once the program goal is determined, develop a program objective to transfer goals into student performance and knowledge (Stassen *et al.,* 2004).

The different aspects of student learning are determined by three types of learning objectives: cognitive, affective, and behavioural objective. They define what a student should know, what he/she should care about, and what he/she should be able to do. The assessment design involves writing the program objectives in simple language describing the possible outcomes. Members of the department should accept and support the objectives (McLean, 2018). The assessment design can be made as a formal document to circulate outside the department or an informal one to keep within the department. The document should contain learning goals and objectives, process of learning, methods and process of assessment, outcome and results, decisions and recommendations to improve learning. Assessment plan that describes curriculum and uses available source is most effective (Isaac, 2016).

4.6.2 Examination assessment

Competency exams, grades, capstone courses are all the various methods of assessing the learning of students. Department members and instructors are already using these methods to assess student learning. Assessment matrix can be broadly classified into two, namely: direct and indirect measure. The direct method wants the student to show his skills and knowledge through tests, presentations, seminars, classroom assignments, essays and projects. The indirect method asks the student to reflect on his learning through interviews and surveys but not asking him to display his learning and skills. To identify an effective assessment method, identify what should be assessed (Pascu, 2010). In general, student learning, attitudes, perceptions, and services of the department should be assessed. Assessment includes what a student knows, what can he be able to do, and what his attitude towards curriculum, mentoring, learning, preparation for exams, scheduling for a course, and co-curricular activities. It also includes assessing departmental services like advising and counselling the distressed students, providing library and computer assistance, tutoring slow students, financial and medical aiding, conducting orientation programmes for new students (Doina *et al.,* 2012).

The overall performance and proficiency of students are evaluated globally and given a grade. Grades are important for student achievements. However, grades do not depict overall student performance and assist in identifying specific skills in students. Grading also does not provide detailed information necessary to determine a student's performance on the program. It provides only a little information about the overall success of a program to help students. To make program assessment a most effective assessment tool, it is important to link the preferred method, outcomes and the expected results of assessment. The final step is to produce the assessment report. The content of the report should include the assessment process, purpose of assessment, findings, improvement plans and evaluations. Assessment report need not be a formal document as it is going to be presented only to the department (Katz, 2012).

4.7 BENEFITS OF ASSESSMENT

Assessment and its related feedback are important to student learning, especially in higher education. It has a significant effect on communicating to students about what they can succeed and what they cannot succeed in doing (Berger and Dreher, 2011). Students and lecturers can work on improving their ability to achieve success in everything. It builds the level of confidence of students. Assessment gives information about the skills and knowledge of students when they undertake a course (Assiter, 2017). Lecturers can create objectives to focus on the skills and knowledge the students should gain upon completing the course. It will become easy for the lecturer to identify the thinking and responding level of the students (Doina *et al.,* 2012). This approach will result in lecturers depending less on the comments displayed on the evaluation of students as a reference to the success of teaching. Assessment gives notable information about student learning and appropriate information from the evaluation of students (Pascu, 2010). Also, it provides available information about the curriculum effects and richer data about the method of teaching. Lecturers can be involved in more useful discussions about the level of achievements of each student, which becomes helpful to make better decisions about how the department can improve its student level of achievements. With the help of assessment, useful data are generated which in turn assist lecturers in developing innovative and experimental projects for instruction purposes, and therefore improving success rates. Lecturers can have a high degree of satisfaction in their teaching methodology as the assessment process gives proof or evidence that lecturers can bring an improvement in student learning. Also, assessment is useful to provide larger information about the needs of students and their accomplishments. It will therefore be easy for faculty members to create directions for instructional development in the future. Faculty members can take important decisions regarding analysing the goals, identifying an assessment process, determining the method to achieve their goals, and indicating directions for future student learning (Doina *et al.,* 2012).

Learning-based assessment is used to focus on the wide opportunities available for the students to develop their ability to assess themselves by self-evaluation or peer to peer review technique (Roberts *et al.,* 2017). It also helps students to make aware of their skills and knowledge experience and to improve their performance. By using formative assessment and summative assessment it gives wide chances for students to improve their skills and knowledge and it uses authentic assessment methods for the effective outcome (Pascu, 2010).

A well designed and innovative assessment can bring enthusiasm for active learning among students. Assessment through technology like online discussion blogs or online examinations can introduce new skills to students (Bryan and Clegg, 2019). Through assessment, the special skills of students are identified, and special training given to improve his skill. Standardised examination is used to test a large number of students in a short time via an external evaluation process. Local exams are used for a pre-test assessment to obtain results more quickly and to improve student knowledge before their exam.

Assessments through essay writing, oral exams, presentation, exhibition, research papers, and practical exams encourage students to be more active in learning outside the academic (Barak, 2010). They also promote creativity in students and connect lecturers with students through the feedback loop. Assessment through surveys and questionnaires can be used to collect information from the students. Portfolio assessments can increase the participation of students in the assessment process.

Overall, assessment is used to highlight the strength of students, identify the weakness of students and provide a method of improvement of their skills, knowledge and learning experience (Seminar and Brown, 2016).

4.8 DRAWBACKS OF ASSESSMENT

In the course-based assessment and direct assessment methods, differences among departmental authorities and instructors may affect the results. Lecturers may be reluctant in sharing the obtained results with the entire department (James, 2015). Assessment through hand-written tests, pre-tests, and post-tests, as well as entry and exit tests therefore becomes complex. It takes a long time and comparative skill to create appropriate questions that are related to student learning and course. It is difficult to create question papers for pre- and post-tests as their conduct varies with time (Felix, 2016).

The ability of students and their overall learning are not effectively assessed by graded homework (Andersen *et al.*, 2019). Rubric dimension to reflect the outcomes of student learning is difficult and it has a long time of implementation and requires a high level of skill (Chowdhury, 2019). Capstone course project makes labour-intensive for both students and lecturers (Kim, 2019). A high stake course and project can induce anxiety on the student resulting in lesser marks in assessment than the actual performance (Dillette and Sipe, 2018).

Assessment through mapping of concept or knowledge makes it difficult to compare across students and also difficult to get an objective judgment on student abilities (Schiuma and Carlucci, 2015). For art, entertainment, sport, and healthcare, expert judgment is needed to assess the performance of students in the relevant field which is usually time intensive. Students with language difficulties find it difficult to do oral presentations. Also, it is difficult for lecturers to design questions considering the diversity of students in the class (Ali Alghail and Ali Mahfoodh, 2016). Difficult to assess through essay writing, presentation, exhibition, and seminar as content varies widely among several students based on their creative skills (Clark, 2016).

Alternatively, it may be judged based on presentation rather than content. Examples given by students may not match with the examples given by lecturer. So, it is difficult to judge creative writing papers (Flaherty, 2015). Surveys and questionnaire assessments may only able to assess the communication skills of students but not for general learning (Moore *et al.,* 2018). Through outside evaluations, without partiality, an expert can assess the overall performance of students but at the expense of time and labour costs associated with a panel of internal and external judges (Moore *et al.,* 2018).

Assessments also make students feel pressured, affecting performance (Venne and Coleman, 2010). In some education institutes, reassessment is conducted for students who do not meet a threshold score in the original assessment (Ahmadi and Barabadi, 2014). Health issues and stress may also influence the performance of students. Finally, the cost of computers and other technology-based devices needed for online assessments may be regarded as high, especially for institutions domiciled in developing economies.

4.9 ACHIEVEMENTS AND AREAS OF IMPROVEMENT FOR SOUTH AFRICAN HIGHER EDUCATION SECTOR

Since the end of Apartheid in 1994, the higher education sector can boast to have achieved quite a milestone (Dickhaus, 2010, Wilson-Strydom, 2015). The very first outstanding achievement is the increase in the number of black South Africans who have been enrolled in institutions of higher learning (Mayet, 2016). The population of native South Africans has grown by up to 80% (Le Roux *et al.*, 2016). This increase is a step in the right direction towards achieving equality. The output of research papers and projects has also been on the rise in the last two decades (Zhao *et al.*, 2018). The government has put considerable effort in learning and teaching in these institutions of higher learning. The government has also made available and increased Financial Aid to the needy students (Le Roux *et al.*, 2016, Matukane and Bronkhorst, 2017). There has also been national coordination in addressing gaps that continually are identified in the sector.

Despite the above achievements in the higher education sector, there is still a lot that needs to be done to make higher education relevant and useful to the Native South Africans. To start with, the sector has become more volatile even beyond the levels witnessed during the Apartheid era. The common citizen has not realised economic equity and social transformation (Ntshoe and Selesho, 2016). The sector is still underfunded especially in terms of availability of Financial Aid to the needy and bright South Africans (Ntshoe and Selesho, 2016). Student enrolment has increased beyond expectations especially from the government. This expansion has increased the student-to-teacher ratio, which negatively affects the quality of education. Students being the free agents of change in society (Monchinski, 2010), they have the right to education, knowledge, and access to government aid. The government, therefore, needs to work closely with the students to develop ways in which these students can be used to drive change to achieve an equitable and just society.

4.10 SUMMARY

Assessments in higher education play an important role in the development of student learning and teaching method. With the various theories and methods of assessment, the education institutes should ensure the adoption of effective methods in assessing students’ performance and lecturers’ teaching ability. Also, it is important to develop strategies for improvement based on outcomes from assessments, otherwise, the essence of assessments is defeated. Benefits derivable from conducting assessments during the course, and not just at the end of the course, have also been enumerated. Education institutes must also develop and implement strategies for improving the learning, thereby meeting their responsibilities to students and the public. Effective assessments in higher education systems will ensure that South Africa achieves notable development in the education sector, thereby producing highly skilled and knowledgeable graduates all year round.

CHAPTER 5

INQUIRY-BASED LEARNING IN CONSTRUCTION EDUCATION

5.1 INTRODUCTION

The implementation of IBL in construction management programmes in universities is a welcome initiate. This view is as a result of the disconnection between professional and academy and the demand by employers to produce graduates that are adequately prepared for autonomous and lifelong learning (Haupt, 2009). Therefore scholars in the Construction industry have seen the need to develop and implement new curricula to develop problem-solving, integrative, and thinking skills in Construction education students (Burroughs *et al.*, 2009, Othman, 2013). These skills are quite difficult to develop in a traditional construction education lecture course system unlike in the IBL operated system which brings students closer to professional practise by engaging in authentic and relevant learning in groups in a classroom setting (Burroughs *et al.*, 2009, Raidal and Volet, 2009). New pedagogic methods are also needed to react to contemporary changes in construction practice. Courses are taught in "studios or labs" where students are shown how to use strategies of proposition and reflection to develop solutions to multivariate construction problems (Foote, 2016). This type of pedagogy develops active students through a master-apprentice relationships between the students and their lecturers (Monson, 2011). The students are repeatedly exposed to demanding and difficult tasks which helps them to improve their knowledge, skills and critical thinking. Therefore, the introduction of IBL in construction education holds tremendous advantages in educating the 21st century construction education students.

5.2 IBL IMPLEMENTATION AND CHALLENGES

The IBL approach was implemented in two higher institutions of learning in the United State of America – Mississippi State University and California Polytechnic State University, San Luis Obispo. The construction management programmes at both institutions have been developed and implemented over the past 10 years using IBL (Monson and Hauck, 2012). The comparison of both programmes identified some challenges that needed to be addressed for more effective implementation of IBL in construction education. The common challenges identified included program accreditation, staff development, curricula development, content construction, skillset development, pedagogical approach to development, and outcomes evaluation (Monson and

Hauck, 2012). In their attempt to overcome these challenges, the authors compared the traditional lecture approach model (Figure 5-1) with the IBL model of education (Figure 5-2).

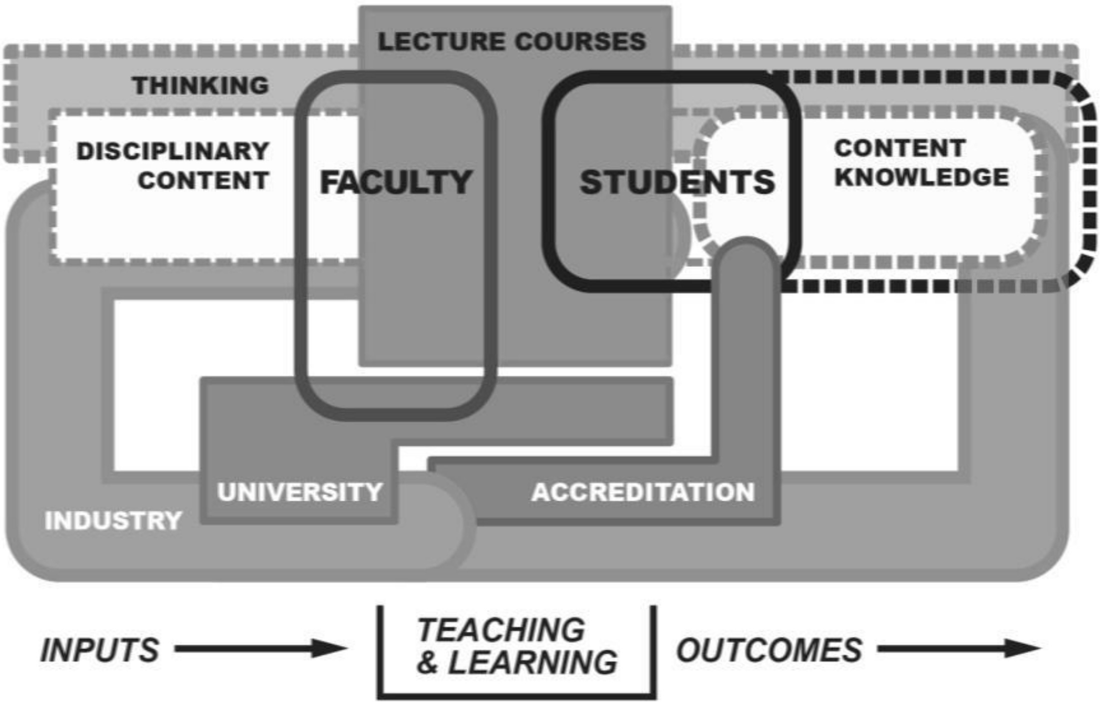

Figure 5-1: Traditional lecture approach model

(Monson and Hauck, 2012:2)

In both institutions, it was discovered that the traditional approach is inadequate in preparing construction education students with the required skills relevant for a professional career in the 21st century. These inadequacies were mainly due to the relationships and structures of the various components of university education. However, through the implementation of the IBL model, both institutions were able to produce high-quality construction graduates, with evident outcomes in skills and knowledge transfer, critical thinking, and curricula content (Monson and Hauck, 2012). In a computer science program, based on studio-based instruction, Hundhausen *et al.* (2010) compared, the IBL approach with the traditional learning approach. Emphasis was laid on programming and individual problem-solving skills. The traditional approach is inadequate for their students to get good jobs in the industry considering the expectation that students must have collaboration, communication, and critical thinking skills relevant in the construction industry. The authors added that the use of studio-based instruction adapted from fine arts and architectural education will equip students with relevant but missing skills (Hundhausen *et al.*, 2008).

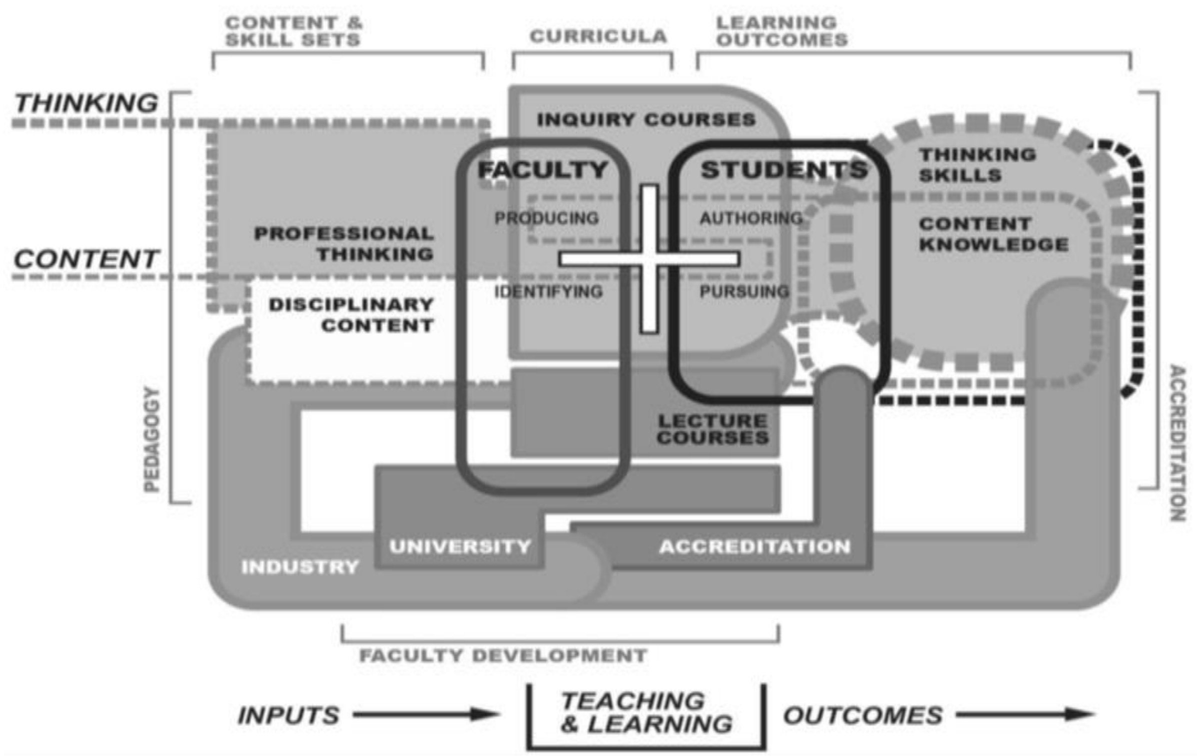

Figure 5-2: IBL model of education

(Monson and Hauck, 2012:3)

5.3 STUDIO-BASED LEARNING (SBL)

The use of studio-based learning can be used to tackle the challenge that will be encounter in transiting from the traditional lecture approach to the IBL approach. This approach comprises various major component such as *" Project-based work on complex and open-ended problems; Rapid iteration of solutions; frequent formal and informal critiques; consideration of heterogeneous issues; use of precedent and thinking about the whole; creative use of constraints; and use of various media"* according to Mathews (2010:88). The approach can be summarised into four major steps according to Hundhausen *et al*. (2010). With the lecturer moderating these steps, it includes:

a. Giving students meaningful and complex real-life problems to solve and come up with solutions;
b. The solutions from students with its justification are presented to the class for feedback and discussion;
c. The class critiques the solutions and offer their comments; and

d. Students respond to the class comment and make necessary modifications in their solution.

These approaches have been successfully applied in mathematics and science-related subjects at both high school (Rensselaer Polytechnic Institute, USA) and undergraduate levels (Faro and Swan, 2006, Lister, 2001). The approach was also implemented in the Construction Studies Department at the University of KwaZulu-Natal in 2015 wherein a decision was made to change the approach to learning from a traditional lecture approach to an active learning pedagogy in the form of studio-based learning (Harinarain and Haupt, 2016). Second-year students were taught using the approach for a semester, and an evaluation was conducted thereafter. The main features of SBL as indicated in the literature were demonstrated despite the absence of physical instructional space. Results from the study also showed an increase of 10% in the understanding of module contents as an improved average final grade of 66.5% was attained by students. However, students perceived the SBL approach to be too risky as they were not used to this approach of learning, and therefore not confident enough to take the responsibility for their learning (Harinarain and Haupt, 2016).

5.4 THEORETICAL FRAMEWORK OF ASSESSMENT IN IBL FOR CONSTRUCTION EDUCATION

It has been reported that the involvement of students in solving real-life problems via IBL could improve the standard of student learning in construction education. To solve real-life problems, the students must ask and refine questions, design and conduct investigations, analyse gathered information, interpret the information, seek its explanation, conclude and report its finding (Linn *et al.,* 2003, Songer *et al.,* 2003). This approach to learning in construction education presents challenges to students and teachers because it is new. Teachers are expected to restructure their modes of teaching to include new subject contents, new pedagogical methods, new approaches to classroom management and assessment (Anderson, 2002, Blumenfeld *et al.*, 1994).

5.4.1 IBL assessments in construction education

The IBL-based formative and summative assessment techniques have found application in construction education (Bernard *et al.,* 2019). Table 5-1 shows how these techniques can be implemented in construction education.

Table 5-1: Implementation of IBL assessment

[Adapted from (Harlen, 2013:83)]

Assessment for learning	Assessment as learning	Assessment of learning
- Conducted before instruction is given a product to proceeding to the next stage of the inquiry process in order to determine what skills student already know and can do. - Helps educators plan for anticipated challenges - Formative – frequent and ongoing assessment as students are learning inquiry process skills - Information is used by educators to monitor students' progress towards achieving critical, creative, self-awareness, and adaptive skills during inquiry - Helps educators provide timely and specific descriptive feedback to students	- Ongoing during instruction and throughout the inquiry process - Educators models and supports students in learning to assess themselves and peers - Used to by students to: 1. Provide feedback to other students (peer assessment) 2. Monitor their own progress towards achieving their learning goals for inquiry 3. To make adjustments in the learning approaches 4. To reflect on their learning, and 5. To set individual goals for learning	- Occurs at or near the end of a period of learning (any stage of inquiry process or end of entire inquiry; i.e., both process and product) - Used by the educator to summarise student learning at any given point in time - Used to make judgements about the quality of student learning on the basis of established success criteria

According to Ruiz-Primo and Furtak (2007), an "**E**licit **S**tudent **R**ecognise **U**se-cycle" comprising four cyclic steps is useful in conducting assessments during teacher-student class interactions. ESRU was coined from the expression – "**E**licits information from the student by formulating a question, the **S**tudent responds, teacher **R**ecognises the student's response, and then **U**ses the information collected to student learning". This approach is an informal form of formative assessment that is aimed at obtaining evidence of student learning (Cagasan *et al.*, 2020). Torrance and Pryor (2001) also states that IBL formative assessment could also be used in conjunction with divergent and convergent formative assessment in construction education. The authors state that divergent assessment allows for open-ended questions to students, encouraging discussions that will unveil their understanding of the contents as well as their abilities. Convergent assessment, on the other hand, allows for close-ended and pseudo-open-ended questions to students, and enables the discovery of their ability to assimilate and perform tasks (*ibid*).

Students who are participating actively during practical sessions are developing problem-solving skills needed in construction education (Correia *et al.*, 2015, Correia *et al.*, 2016). This formative method of assessment, including practicals in science classrooms, is encouraged in England through a “Get Practical Project” (Abrahams *et al.*, 2011). The project brought practical works to schools which, in turn, triggered an improvement in the learning of science-related subjects. Another form of formative assessment in construction education is project execution. Projects help students to develop lifelong skills needed by allowing for creative thinking and logical reasoning in solving real-life problems. Assessment of projects therefore goes beyond an evaluation of students’ understanding of scientific principles but also comprises other important learning outcomes that encourage the development of openness, social competencies, and interest and prepare students for lifelong learning (Correia *et al.*, 2015).

5.4.2 Self and peer assessment in construction education

It is important to develop construction students in such a way that they become independent and can create knowledge such that they become directional. This type of skill can be developed through self and peer assessment (Hodgson and Pyle, 2010). According to Harlen (2007b:30), self and peer assessment play an important role in improving learning in an inquiry classroom. The author argues that this form of assessment is useful in *“helping children to take responsibility for their learning, an essential outcome of education”*. She further states that self and peer assessment will help the students to take charge and direct their learning to current and future situations in society. Harlen (2011) identified four features of self-assessment, including monitoring and checking self-progress, learning needs recognition and diagnosis, stimulating noble learning practices, and learning practices linkage. She also argues that self-assessment is a part of learning assessments as it directs the actions of students towards their learning objectives. According to Lingard *et al.* (2008), the social interactions involved in peer assessment is a form of constructivist activity and serves as a built-on on learning assessments. There are different forms of peer and self-assessment which include self-assessment journals; paired marking; self-marking; and plenary self-evaluation. These forms of assessment are beneficial to construction education because they put students in control of the learning process (Lindsay and Clarke, 2001).

The use of peer and self-assessment in construction education encourages reflectiveness in learning as students become reflective of tasks before them, enabling them to adopt a deeper approach to learning. This form of assessment is the cornerstone of good practice, especially for science-based modules in like construction education. It prevents misconceptions and encourages students to be actively involved in scientific procedures and the overall learning process (Hodgson and Pyle, 2010).

5.4.3 Bottlenecks and challenges of assessing construction professional competence in IBL

It is evident from literature that assessments in construction-related IBL are centred on interactive activities such as discussion, observation, products, and questioning. According to Keogh and Naylor (2007), the use of these forms of assessment in IBL are based on collecting evidence of learning from students but according to McNamara (2013), this approach has limited use when assessing construction professional competence because the evidence is not necessarily verified by an objective source. It is possible to assess specific discipline skills and knowledge but how to measure professional competence is not clear (Shiu, 2008). Reducing construction professional competences to observable, pre-specified actions, works or behaviours is educationally not sound (Hodges and Ayling, 2007). Learning, critical reflection and career skills can be assessed in IBL based on the evidence from students, these forms of assessment does not measure professional competence because the evidence provided does not necessarily assess professional competence but the ability to express the competence (Brodie and Irving, 2007). As a result, assessment of construction professional competence should look beyond the evidence provided by students because the effectiveness of assessment tools in construction-related IBL is majorly a function of the classroom climate, the teaching pedagogy, and the assessment type (Hodgson and Pyle, 2010).

5.4.4 Feedback

The giving of feedback to construction students after an assessment in IBL is as important as the assessment itself. Constructive alignment of the feedback, the learning objectives, and the assignment criteria is critical to effective learning as it increases the awareness of students towards what is expected of them. According to Black and Harrison (2004:5), there are two types of feedback: feedback from the teacher to students; and feedback from students to the teacher. Effective feedback rises from *"learning experiences that provide rich evidence so that judgements about the next step in learning can be made"*. This view is supported by Harlen (2006) who states that students should give feedback to their teacher so he/she can assess their level of understanding and know the next steps to be taken.

Black and Harrison (2004) summarised the features of effective feedback as follows. Effective feedback must:

a. *"Make the student discuss his or her thoughts with the teacher or a peer"* (Black and Harrison, 2004:12);
b. Make the student take immediate action from the feedback;
c. *"Relate to the success criteria*" (Black and Harrison, 2004:13);
d. Allow for comparison of students' understanding to that of his/her peers or teacher; and
e. Direct students to *"where to go for help and what they can do to improve' their learning"* (Black and Harrison, 2004:13).

In a study conducted by Chin (2006), the inter-relationship between assessment and feedback was examined and four approaches to improve learning via feedbacks were identified. These include:

a. Accepting the response of students but reinforcing it and suggesting further reading;
b. *"Accepting the student's response but asking further questions to 'probe or extend conceptual thinking"* (Chin, 2006:1326);
c. For incorrect responses, the correct answer must be well-explained, and teaching is reinforced;
d. A neutral comment is given and *a "reformulation of the question or formulate a challenge via a new question"* (Chin, 2006:1326). This approach *"forces the student to reflect on and reconsider her answer"* (Chin, 2006:1334).

5.5 SUMMARY

Research has shown that the introduction of IBL approach to construction education could yield significant improvement to learning. However, the effective implementation of IBL in construction education programmes in South Africa may likely encounter some challenges. These may include accreditation difficulties, need to update curricla, additonal/new skill sets requirements, additional staff training, developing IBL pedagogy, and effective measuring of student learning outcomes. Further study is needed in these areas to foster IBL implementation. This study aims to eliminate one of these challenges by developing a suitable assessment design model for measuring learning in IBL.

The use of both formative and summative assessments has been found to be suitable for IBL. However, the application of formative assessment is more popular as it enables teachers to assess the students, concurrently, during the learning process. The information obtained can then be used to determine the next approach in the inquiry. The use of formative assessment also increases creativity and triggers innovative ideas in students during the learning process.

It is important to develop suitable models for assessing learning outcomes. Feedback also plays an important role in assessments as it aids learning and gives students an indication of their learning progress. Ultimately, this review submits that a strong link exists between assessment and feedback in construction education, and that they both influence students' learning and thinking to a great extent.

CHAPTER 6

CURRENT ASSESSMENT PRACTICES IN SOUTH AFRICA

6.1 INTRODUCTION

The first democratically elected government in South Africa in 1994 was faced with the challenge of creating a democratic dispensation that ensures equal rights for all citizens. This regime brought about certain changes within the educational sector, including the forming of a national department. The national department was made up of regional education departments that were saddled with the responsibility of creating equal and standard admission requirements (Kanjee and Sayed, 2013). After 19 years, the educational system is still faced with the challenges of implementing a new curriculum and ensuring a profile of competent teachers. Moreover, due to the harmonisation of study models and educational structures as well as globalisation, skills necessary for quality education are required (Brennan *et al.*, 2009, Lucena *et al.*, 2008). These have led to profound programmatic and structural changes in higher education (Kanjee and Sayed, 2013) such as changes in the shape and size, meaning of accountability and autonomy, character of governance, management and student distribution, models of delivery and roles of student politics (Mouton *et al.*, 2013).

In recent years, the modelling and assessment of academic learning outcomes have always been a source of concern internationally (Coates, 2014). Consequently, there has been a need to develop valid and fair assessment guidelines for assessing students' learning outcomes and competences (Zlatkin-Troitschanskaia *et al.*, 2015). Considering that competency drives performance, it is regarded as a combination of social, cognitive, volitional, and affective motivational dispositions (Shavelson, 2013). A paradigm shift in assessment focusing on the learning of students in higher education is therefore required. This paradigm shift needs to transcend the changing of traditional structures and methods of learning and extend to educational practice and philosophy (Tam, 2014). The traditional teacher-centred approach and curriculum design have focused on how well the students assimilate knowledge as imparted by teachers. However, the shift towards the student-centred approach places more emphasis on the use of assessments to confirm, monitor, and improve student learning (*ibid*). The proposed paradigm shift resonates with the theory of constructive alignment which links learning pedagogy and subject content with students to improve learning (Biggs, 2011, Biggs, 2003). Therefore, when designing a learning experience, attention should be given to learning outcomes and the following questions should be taken into consideration: (a) what activities are necessary for students to learn effectively? (b) what level of understanding are students expected to demonstrate after undergoing a learning process? and (c) how can lecturers determine if learning as taken place? To answer these questions, there is a need to develop and integrate the following: learning and teaching activities; learning outcomes; and assessments, to ensure consistency and compatibility in the curriculum (Tam, 2014).

Assessment plays a vital role in any educational and instructional setting. It is used mainly for two purposes in higher education. Firstly, it is used to enforce accountability and quality within the institution, and secondly, it is used to improve the quality of learning that takes place (Ewell, 2009a). The type of assessment used by university lecturers influences different aspects of student learning including the management of their study time, the choice of learning strategies, and the motivation to learn (Harlen and Deakin Crick, 2003, Series, 2004). Therefore, the importance of assessment in student learning cannot be overemphasis as no factor influences learning like assessment (Anderson, 2004, Hannafin *et al.,* 2003).

The various definitions of assessment are grouped by theorists into (a) assessment of learning (AOL); and (b) assessment for learning (AfL). AOL is used for certification to demonstrate the amount of knowledge a student has acquired over time. This information is used for high-stakes, cumulative purposes, such as for promotion, certification and grades. It is administered at the end of the marking period or school year while AfL is used to stimulate students to learn more. The information from these assessments is used to support learning and teaching. The assessment is merged into the curriculum and its results are used as the basis to adjust teaching pedagogy in order to improve learning. It is administered more frequently (Houston and Thompson, 2017). Although both assessment types are regarded as important, AfL has been reported as the preferred approach as it offers a platform for greater achievements to students (Stiggins, 2002).

Many studies has shown that the learning approach adopted by instructors has a huge influence on the quality of classroom-based learning (Aşcı *et al.,* 2016, Bruno and Dell'Aversana, 2018, Ho *et al.,* 2001, Jaques *et al.,* 2019, Knoll *et al.,* 2019, Ramsden, 2003, Shah *et al.,* 2016). Huertas-Barros and Vine (2019) and Wanner and Palmer (2015) have also linked students' perceptions of assessment with learning approaches (Crossman, 2004, Gibbs, 1999a).

6.2 ASSESSMENT AND MEASUREMENT IN HIGHER EDUCATION

The existing theoretical insights on learning, teaching, and assessments coupled with technological changes have led to the shift in education from teacher-centred to competence-based and student-centred approaches (Boud and Falchikov, 2007, Gibbs, 2006). This approach has emphasised the need for students to be prepared as competent professionals, become self-adaptive, and life-long students. To achieve this, Baartman et al. (2007:144) identified two areas in education that needed change: *(a) "changing its focus from one that transmits isolated knowledge and skills to one that acquires complex competences," and (b) "guiding students in developing skills for learning and getting information from the diverse range of sources available in modern society"*.

Two policy initiatives were created in South Africa to make this transition possible – to challenge the traditional roles of lecturers who concentrate on knowledge transmission instead of developing critical skills and competencies. The initiatives include (a) the enactment of outcomes-based education and training (Tam, 2014), and (b) the endorsement of the South African Qualifications Act, 1995 (Act 58 of 1995). In a study on current educational and assessment practices conducted by Friedrich-Nel *et al.*, (2005), the authors found that most 20th century teachings are based on exposing students to information that they could not manage. The results from the study agreed with the studies by Beets (2009) and Rickards (2017), who found out that written examinations, which are associated with content-based education and training, are the main form of assessment tool used in higher education in South Africa. The introduction and implementation of alternative assessment strategies in higher education in South Africa have therefore achieved limited success, despite having the following advantages (Maclellan, 2004):

a. Students are involved in the setting of criteria and goals for assessment;
b. Involves doing a task, including the production of products/ artefacts;
c. Allows for application of problem-solving skills and/or higher-level thinking;
d. Measuring collaborative, metacognitive, and intrapersonal skills as well as scholar products;
e. Allows for measurement of meaningful instructional activities;
f. Enables the conceptualisation of real-world applications; and
g. Its specified criteria enable the development of standards for good performance.

6.3 CURRENT RESEARCH IN ASSESSMENT

The various forms of assessment in higher education including practical exams, coursework projects, written exams, and oral interviews have been researched, analysed, and scrutinised for more than 30 years. However, much emphasis has been on subjects that require an evidence of writing in their forms of assessment (Wilson *et al.*, 2019). This view has been criticised by Ehmann (2005), who stated that design education has been neglected due to the lack of standard methods and procedures. Also traditional or existing forms of assessment lack the development of conceptual understanding in students (Georgiou and Nielsen, 2019). The research of assessment methods for design education has been highly neglected when compared to other areas of research (Goncher *et al.*, 2017). Research on design-based assessments has been scantily reported in the literature, unlike module-based assessments which received extensive attention, resulting in a high number of publications (Hartell *et al.,* 2015)

6.4 ROLE PLAYERS IN ASSESSMENT

Assessment in higher education requires the involvement of several role players, including students, towards the attainment of a student-centred approach. This view has not been the case in many institutions as students are not involved in designing, choosing, structuring, and assessment evaluation processes (Giloi and du Toit, 2013).

In South Africa, the roles players include the government and different education departments such as the Department of Higher Education and Training (DHET) and the Council for Higher Education (CHE). All recognised institutions of higher education in South Africa work within the Higher Education Qualifications Framework (HEQF*). "The HEQF is an outcome-based education and training framework for education and training standards and qualifications. As such, the assessment practices and procedures for the HEQF have to be aligned to those of an outcome-based education and training system"* (Authority, 2000:6). HEQF is also responsible for providing Higher Education with Critical Cross-field Outcomes (CCFOs) that determines the outcomes to be accomplished in various qualifications. These outcomes include qualities such as critical and creative thinking, problem-solving, time management, and working effectively in groups (ditto). According to the Improving Teaching and Learning (ITL) Resource No. 5 (CHE, 2003:18 *"the South African Qualifications Authority (SAQA) has assigned to the Higher Education Quality Committee (HEQC) as the Education and Training Quality Assurer (ETQA) for higher education and training (HET) formal functions regarding the quality assurance (QA) of assessment in the*

Higher Education system". In terms of the ETQA Regulations (ETQA, 1998:32), *"the HEQC is responsible for ensuring the integrity, validity, and reliability of assessment in the HET system"*.

The industry also plays a huge role in the assessment and education of students. However, the relationship between higher education institutions and the industry is not always satisfactory. According to the South African Bureau of Standards (SABS) Design Institute, in 2008 during the IDA World Design Survey Pilot Project South, only 17 per cent of industry respondents strongly agreed that *"design students studying at accredited governmental institutions in South Africa (Universities and Universities of Technology) get the relevant training and practical experience required for the job market"* (SABS, 2008:61).

Throughput and pass rate statistics are used to determine success within institutions and can be useful in performance-based funding for bonuses, budgets, and subsidies. The examination of assessment results and the use of the results becomes of great importance to potential students and their parents, the institution, the government, management, faculties, campuses, and individual lecturers (Giloi and du Toit, 2013).

The role players can, therefore, be influenced by using the statistics gleaned from assessment for secondary purposes which can lead to confusion if there is a lack of consensus among the players. According to Remer (2010:82), *"there is still little agreement on whether or how aspects relating to arts require an assessment, and who the facilitators of the assessments should be as well as, whose standards the assessments should adhere"*.

6.5 CURRENT MODELS AND APPROACHES TO ASSESSMENT

6.5.1 Outcomes-based

Outcomes-based education (OBE) is usually used at both school and higher institution level in South Africa. The Higher Education Quality Committee (HEQC) indicates that *outcomes "should be derived from the knowledge base of the curriculum and the demands of the discipline as well as the needs of the profession or career"* (CHE, 2004:24). In this approach, emphasis is laid on what that student should know and be able to do and thereafter developing ways to assess them. The principle of OBE is to have an end (outcome) in mind. The curriculum development process should start with the desired skills, abilities, attitudes, knowledge, that students must exhibit and then ensure that assessments are centred on what the student has achieved (Ndebele and Maphosa, 2013). This approach demonstrates the shift from “content” to “outcomes” and it is in line with the term constructive alignment which will be discussed later (Gibbs, 1999b). Assessment in OBE is criterion-based, implying that students are assessed based on pre-defined criteria. The marks obtained by the student shows the extent to which the outcome has been achieved (Ndebele and Maphosa, 2013). This approach is different from the norm-referenced assessment that does not compare the achievement of students directly to learning outcomes but compares one student to another (Knight, 2001). *“Norm-referencing is comparative as it provides information on how a students’ performance is better than another, similar to a third and not as good as a fourth”* (Knight, 2001, 17). According to Carlson *et al.* (2000), the advantages of criterion referenced assessment (CRA) includes the following:

a. Provides clear goals which the students must attain are clearly stated;
b. Aligns both student and lecturer to the pre-defined criteria; and
c. Ensures that students have a detailed understanding and knowledge of the scope of the assessment

6.5.2 Analytical approach

In this approach, each learning outcome is allocated a mark. Therefore it is defined as an *“analytical approach to assessment”* by Davies (2000:4). In the analytical approach, lecturers identify the learning outcomes that are crucial for the development of students. Each assessment criterion and learning outcome is clearly defined making learning easier and faster. The administrative nature of this approach makes it easy to attend to queries. This approach is most appropriate for the assessment of technical skills expected from students (Giloi and du Toit, 2013). However, it could lead to students producing the same or similar work or product. This view was observed in a practical examination conducted by Walker and Parker (2006) in England wherein the authors expressed concern on the outcome-driven examination model. The authors stated that the examination model could lead to formulaic practice that inhibits the creative potential of students and restricts the nature of their experiences. They added that the approach may neglect unintended learning outcomes and may concentrate on the pre-defined technical outcomes, resulting in lecturers teaching and assessing only those outcomes that can easily be measured (Davies, 2000). Some lecturers opine that *“assessment objectives [learning outcomes] need to be* *read as open expansive statements evidenced in wide variety ways and forms, rather than as narrowly specified prescriptions”* (Walker and Parker, 2006:300).

6.5.3 Expert/Connoisseur

There has been a long tradition of using connoisseurs or experts to appraise the design or work of students. Hickman (2007, 81) defines a connoisseur as being someone with experience, a high degree of perception, and ‘sensitivity to otherwise subliminal characteristics. The lecturer is an expert that passes judgement and feedback on the learning process, and consequently, grade and judge the final product. For instance, it is a common practice in South Africa that internal and external examiners (who may be an industry or academic expert), are involved in the assessment of final year modules. This approach may produce an impartial assessment of the work of students because the external examiner might be familiar with the learning outcomes but not with the students (Giloi and du Toit, 2013). Connoisseurs and experts are expected to make reliable judgement due to their knowledge of the standards of the discipline and their level of education (Ecclestone, 2001).

According to Knight (2006), the assessment of learning in technical disciplines can only take place effectively within the context of a department, module, or subject discipline. Inefficiencies may occur due to discrepancies in the manner with which the assessment criteria is adopted for in grade allocation. This inefficiency may be attributed to the use of locally-developed standards in judgement making (Norton *et al.*, 2004, Price, 2005). Also, differences in experience types and levels, values, and professional knowledge may cause a huge disparity in the way lecturers evaluate the work of students (Read *et al.*, 2005, Smith and Coombe, 2006). However, Elwood and Klenowski (2002) believed that common standards will eventually be established amongst lecturers over time.

The use of external examiner was established to convey a level of external accountability to assessment decisions. This approach will ensure that standards are comparable with similar qualifications in other institutions and ensure that assessment procedures and academic regulations are fairly and effectively applied (Academy, 2004).

6.5.4 Assessment of final product

Considering a shift from a teacher-centred approach to a student-centred approach, assessments have been extended beyond the evaluation of the final work of students or product ability to include an assessment of the students' person and progress (Giloi and du Toit, 2013). It is important that the not too visible aspect of learning, for instance, evidence of problem-solving, thought processes, and creativity, are equally important as the mastery of technical skills. This view was supported by Davies (2000:2), who claims that *"the difficulties in assessment in art and design entail being able to differentiate between the quality of a student's product and the quality of learning, as an outcome of the making of that product"*. Lindström (2007) developed based on the notion that the assessment of a final product requires the adoption of product-based criteria while that of a process requires process-based criteria. He tested his approach with Swedish school students by developing a rubric and thereafter assessed the portfolio of students. The rubric included a section for assessing the final product, taking into consideration aspects such as communication, adoption of relevant principles, intention, visual elements, and craftsmanship. The rubric also included a section for assessing the process taking into consideration aspects like inventiveness, investigative work, capacity for self-assessment, and the ability to use models. His study disproves the view that process criteria are intrinsically difficult or impossible to assess (Lindström, 2007).

6.5.5 Authentic assessment

Boud and Falchikov (2005) suggest that lecturers should move from a summative assessment that focuses on standards, specifics and immediate outcomes to a more sustainable assessment that will make students more active, not only in their learning but also in their ability to impact lives beyond the end of the course. So the use of authentic assessments will provide multiple paths in assessing the learning ability of students based on their ability to demonstrate skills, competencies, and knowledge as opposed to traditional assessments such as multiple-choice questions that lack variability (Council, 2001). An authentic assessment therefore emphasises practical application of tasks in real-world settings (Fook and Sidhu, 2010), and encourages students to assess their skills relating to thought, communication, and action against industry expectations (Kern, 2006). The authentic assessment approach, therefore, enables students to learn and understand how important skills are to employers. It increases the awareness of students to the idea that their employability is a function of their performance in employer-based learning outcomes.

6.5.6 Holistic assessment

De La Harpe et al. (2009) suggest three parts to assessment which include the process, the person and the product or art/design artefact which is position above the others. The authors also suggested that assessment structures should change to integrate studio assessment as well as assessments of the final product, especially in design modules/courses. The use of studio assessment gives the lecturer an opportunity to assess both the process and the involvement of students in self and peer-assessment. Ehmann, (2005) adopted this approach in his study where he allocated equal weighting to both process and product while involving the students in self and peer assessment during a design process. Assessing the process *"can encourage a deeper approach to learning where risk-taking and discovery are emphasised, rather than a surface approach"* (Ehmann, 2005:109). Also, in a study conducted by Ellmers *et al.,* (2008), a hybrid assessment approach that combines holistic assessment and authentic assessment was adopted. Assessment was carried out at different stages of a design process. The assessment criteria were divided between 'design doing' and 'design thinking'. The students could develop their concepts and use the feedback they get to present their design for assessment at the different stages of the process and on completion. The expected final product was also expected to meet the criteria required from a student using a deep learning approach (Ellmers *et al.*, 2008). Hickman (2007:85) also supported the approach in stating that the broad aims of education in the South African context includes *"social utility, visual literacy, and personal growth"*.

For a student to become employable after graduation, Knight and Yorke (2003) recommend that list of attributes from employers (in new graduate hires) must comprise items that have strong emotional overtones. Orr, (2007) also suggests that more attention should be given to Ipsative assessment, which considers the personal growth and experiential transformation of the students during the learning process and allows for students to be marked in part; according to their effort and on an individual learning journey.

6.6 CURRENT STATUS OF ASSESSMENT IN ENGINEERING CONSTRUCTION EDUCATION

Research on assessment of engineering-based programmes has been in the spotlight for over 10 years (Besterfield-Sacre *et al.,* 2003, Duval-Couetil *et al.,* 2010, Shartrand *et al.,* 2008). These studies agree that there is a lack of high-quality assessment instruments, especially regarding skills that are required for the workplace after graduation. According to Duval-Couetil *et al.* (2010), there is a lack of consistency in the structure of engineering programmes and therefore, it will be difficult to develop and apply a generalised assessment tool to multiple contexts. The authors also observed that most of the current assessment tools used in assessing engineering programmes originated from the management field, and therefore lack concepts that are peculiar to engineering education. The study conducted by Shartrand *et al.,* (2008) also revealed that many assessment instruments used in engineering-based programmes lack reliability and validity. Shartrand *et al.,* (2008) investigated the assessment modes of 126 instructors and discovered that only 40% of the instructors provided evidence of validity in their assessments and that only 18% of the assessments (i.e., those with an evidence of validity) were based on industry outcomes. This result implies that current assessment practices in engineering-based programmes suffer majorly from validity and reliability issues (Shartrand *et al.* (2008).

The development of an alternative assessment tool for engineering-based programmes is an iterative and on-going process but the development rate is considered to be very slow (Douglas and Purzer, 2015). There is, therefore, a need for more assessment-oriented researches including assessment models given the critical role assessment plays in academic and societal development, offering huge benefits when developed and deployed appropriately (Songer and Ruiz-Primo, 2012).

6.7 SUMMARY

This chapter has reviewed the assessment practices used in South African. Key players in the assessment domain were identified and their roles examined. Existing assessment models and approaches were also discussed. It was established that the current educational system in South Africa still faces huge challenges; 27 years after apartheid. Although, modelling and assessment of academic learning outcomes have received some attention in recent years, this study has shown that traditional assessments (based on a psychometric model of examination) remain popular despite inherent biases. A review of evolving assessment approaches shows that engineering- and design-based programmes have received little attention in assessment-oriented research. This view suggests that despite the well-documented changes in educational theory – behaviourist to constructivist; teacher-centred to student-centred approaches; and the shifts in assessment practices and policies in the country, the introduction, and implementation of alternative assessment methodologies in the higher-education sector seem to remain inadequate and have been employed with fear. Although, policies (structures) that emphasise the integration of competence and principles underpinning outcomes-based assessment are in place, the transitioning of these policies into practice at higher-education institutions has been slow, with no significant difference from the traditional assessment practice observed.

The chapter has also highlighted that, besides the current traditional assessment approaches adopted in South African, most of the national documents address assessment processes and guidelines from a broad perspective. There is therefore a need for a holistic approach to assessment in which key players in the educational sector will engage effectively with lecturers to bring about the paradigm shift that has been envisioned – a shift from the current traditional assessment practices to more innovative methods of assessment.

CHAPTER 7

CONCEPTUAL FRAMEWORK OF ASSESSMENT DESIGN IN IBL PEDAGOGY

7.1 INTRODUCTION

This chapter describes the theoretical basis for the development of the conceptual framework in this study. It explains the basic definitions and discusses the key concepts of inquiry-based learning (IBL), with emphasis on identifying key design considerations for assessment design and evaluation of learning. The elements for assessment design considerations in IBL are described briefly and a theoretical framework is presented with the list of key factors and indicators for assessment design considerations for undergraduate construction management programmes.

7.2 ASSESSMENT DESIGN FOR EFFECTIVE ASSESSMENT TOOLS

Identifying the reasoning patterns of students and measuring their knowledge through assessment is a significant part of researches that focuses on the science of teaching (Opfer *et al.*, 2012). Most assessment tools are expected to provide reliable and valid inferences on student progress through guidance and instructional efficacy (Council, 2001). But assessment tools used in "field-oriented" based programmes like construction management often lack validity – the ability to independently predict outcomes based on real-world assessments (Opfer *et al.*, 2012). These tools produce false or contradictory inferences about student reasoning processes, knowledge, or misconceptions (Nehm and Schonfeld, 2008). It is therefore necessary to re-evaluate assessment design in construction management taking into consideration the pedagogical approach of IBL.

Assessment design may be cumbersome but remains one of the primary keys used in promoting student learning (Carless, 2015). In a phenomenographic study conducted by Postareff *et al.*, (2012), assessment practices in higher education were found to be largely conventional and most academics could not even identify the purpose of assessment. Price *et al.*, (2011) states that the level of academics' 'assessment literacy' is low and has a great impact on assessment practice. Bearman *et al.*, (2017) opine that, even if deficiencies in academics were addressed, academics are still expected to develop assessment tasks taking into consideration their environment and pedagogical beliefs and approaches. It is therefore important that programmes based on IBL pedagogy adopt assessment design strategies and systematically integrate them into teaching and learning (Bearman *et al.,* 2017).

7.3 MEASUREMENT OF LEARNING IN IBL PEDAGOGY

The use of an inquiry-based pedagogy in professional programmes like construction management has proven to improve teaching and learning (McKendree, 2019). This is because the acquisition of scientific understanding by students is its primary focus; not the memorisation of content and facts (Liu *et al.,* 2010). The IBL curricula and instructional strategies also enhance the ability of students to explore scientific concepts (Aidoo *et al.,* 2016). However, a major challenge in the use of an IBL pedagogy is the development of assessment tools to measure the amount of learning that has taken place in reality (Grob *et al.,* 2017). Goldman and Pellegrino (2015) stated that the measurement of learning in a particular program should be aligned with the content covered and the instructional practice adopted in the program. According to Slavin (2008), curriculum, instructional practice, and assessment should be well integrated and aligned to achieve positive learning. Therefore, in a science-oriented program like construction management where the IBL pedagogical approach is practiced, assessment design and students' learning will be influenced by the features of that particular pedagogy. Also, there will be improved learning through well-designed assessment tools that are strongly correlated to instructional practice and curriculums (Liu *et al.*, 2010).

7.4 KEY CONSIDERATIONS IN ASSESSMENT DESIGN

The literature was reviewed systematically to identify the key elements of inquiry-based learning pedagogy. The Google Scholar database was used to search for articles using the following search words "inquiry-based learning", enquiry-based learning, inquiry learning processes, inquiry stages, inquiry phases, inquiry cycle, inquiry stages, and inquiry models. The Google Scholar search engine comprises peer-reviewed academic articles, conference papers, books, dissertations, thesis, technical reports, abstracts, and other academic literature like patents and court opinions. Google Scholar has a database of about 389 million documents making it the world's largest academic search engine (Gusenbauer, 2019).

The search was carried out in January 2020 and the following matches were obtained: "inquiry stages" 564 results; "inquiry cycle" 5,850 results; "inquiry phases" 801 results; "inquiry learning processes" 476 results; "inquiry models" 2,810 results and "inquiry-based learning" 52,100 results.

To retrieve publications that are relevant academically, the following search criteria were further applied, (i) a search within the entire publication itself and not just in the abstract; (ii) words that are related were also considered; (iii) the full article had to be available; (iv) the article must be published in an academic journal; (v) one article per author/s was considered; and (vi) the article had to only focus on educational issues. These criteria narrowed the results to 49 articles that fully discussed the use of inquiry for learning in an educational context.

The review of the 49 articles resulted in a list of terms/features/ descriptors/ concepts associated with inquiry-based learning pedagogy. Terms that are similar or have the same meaning were combined. Furthermore, the number of terms/ features/ descriptors/ concepts associated with inquiry-based learning pedagogy mentioned in each article was identified and analysed. As such, all the terms/features/ descriptors/ concepts associated with inquiry-based learning pedagogy mentioned by at least 7 of the 49 articles were chosen as key elements of inquiry-based learning pedagogy. These key elements are to be taken into consideration during assessment design (

Table **7-1** and

Table ***7-2***).

Table 7-1: Identification of key elements/factors of IBL pedagogy for assessment design

Sources / **Elements**	Friesen 2013	Buckner and Kim 2013	Lazonder and Harmsen, 2016	Pedaste *et al*., 2015	Meijerman *et al*., 2013	Kahn and O'Rourke, 2004	Spronken-Smith and Kingham,	Margus Pedaste *et al.* 2015	Harinarain and Haupt 2016	Dai *et al*.,, 2011	Spronken-Smith, 2005	Spronken-Smith *et al*., 2008	Lim, 2012	Jones & Brader-Araje, 2002	Haupt and Harinarain 2015	Levy *et al*., 2013	Ernst *et al*.,2017	Chu *et al*., 2011	Kogan and Laursen 2014	Aparicio-Ting *et al*., 2019	Demaria *et al*.,2019	Prayogi *et al*., 2018	Yuliati *et al*., 2018	Hsiao *et al*., 2017	Laksana 2017	Frequency
A	X	X	X	X			X	X	X	X			X	X	X		X	X	X	X	X	X	X		X	**19**
B			X	X				X		X					X	X				X		X		X		**9**
C	X	X			X			X		X				X	X		X	X	X	X	X		X	X		**14**
D				X		X	X			X			X			X				X						**7**
E			X	X			X	X												X						**5**
F					X				X																	**2**
G			X		X					X				X							X	X		X	X	**8**
H									X		X	X			X	X	X	X	X			X		X		**10**
I	X	X					X		X	X			X		X	X	X	X	X	X	X	X		X	X	**16**

J			**X**		**X**					**X**		**X**	**X**	**X**		**X**	**X**					**X**		**X**		**10**
K	**X**						**X**	**X**	**X**				**X**		**X**			**X**	**X**	**X**	**X**		**X**		**X**	**12**
L					**X**		**X**		**X**	**X**	**X**	**X**				**X**				**X**	**X**			**X**		**10**
M																**X**										**1**
N									**X**						**X**		**X**	**X**	**X**				**X**			**6**
O																	**X**	**X**							**X**	**3**
P														**X**												**1**
Q		**X**					**X**	**X**		**X**				**X**		**X**				**X**	**X**	**X**			**X**	**10**
R	**X**		**X**	**X**			**X**	**X**	**X**												**X**		**X**			**8**
S	**X**			**X**			**X**	**X**	**X**	**X**			**X**				**X**	**X**		**X**		**X**	**X**	**X**		**13**
T				**X**					**X**															**X**	**X**	**4**
U	**X**							**X**		**X**							**X**		**X**	**X**		**X**		**X**		**8**
V	**X**	**X**		**X**			**X**	**X**	**X**	**X**					**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**18**
W		**X**		**X**			**X**	**X**								**X**	**X**	**X**		**X**	**X**			**X**	**X**	**11**
X		**X**	**X**					**X**	**X**					**X**	**X**	**X**	**X**		**X**	**X**		**X**		**X**		**12**
Y	**X**		**X**				**X**	**X**	**X**	**X**					**X**	**X**		**X**		**X**	**X**		**X**			**12**
Z	**X**								**X**						**X**											**3**
A A					**X**									**X**					**X**	**X**						**4**
B B				**X**	**X**			**X**		**X**		**X**						**X**				**X**		**X**		**8**
C C														**X**		**X**				**X**				**X**		**4**
D D	**X**		**X**				**X**	**X**		**X**				**X**		**X**		**X**				**X**		**X**		**10**
E E			**X**		**X**				**X**					**X**				**X**			**X**	**X**				**7**
F F														**X**			**X**			**X**	**X**			**X**		**5**

Table 7-2: Identification of key elements/factors of IBL pedagogy for assessment design

Sources / **Elements**	Constantinou and Tsivitanidou 2018	Spronken-Smith *et al.*, 2012	Asay and Orgill 2009	Lentinen and vilri 2017	Maab and Artigue 2013	Abdi 2014	Aditomo *et al.* 2013	Seung et al. 2014	Schmidt *el al.* 2011	Cennamo*et al.* 2011	Hendrix *et al.* 2010	Megahed 2018	Brandt *et al.* 2011	West *et al.* 2013	Hwang *et al.* 2014	Levy and Petrulis 2012	Duran 2016	Monsonand Novak 2012	Suraz *et al.*, 2018	Monson and Hauck 2012	Monson 2011	Zulu *et al.*, 2018	Correla and Harrison 2019	Ozgur and Yilmaz 2017	**Frequency**
A	**X**		**X**	**X**							**X**	**X**				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**14**
B	**X**		**X**	**X**	**X**	**X**	**X**	**X**					**X**		**X**	**X**	**X**	**X**	**X**	**X**			**X**		**15**
C			**X**		**X**		**X**		**X**			**X**		**X**			**X**	**X**			**X**	**X**	**X**	**X**	**12**

D	X		X									X						X							4
E				X		X																		X	3
F																									0
G				X	X			X	X	X					X	X									7
H		X			X				X	X	X	X		X		X		X	X	X	X	X	X		14
I	X	X	X	X	X		X	X	X	X			X	X	X		X		X		X		X		16
J	X		X	X	X			X	X	X	X	X		X					X						11
K	X	X	X			X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	21
L	X		X		X	X			X	X						X	X	X		X	X				11
M																									0
N	X					X				X		X	X		X						X			X	8
O	X		X										X												2
P																									0
Q	X								X			X				X		X	X		X	X		X	8
R	X						X	X						X					X	X	X		X		8
S	X	X			X				X	X			X		X				X	X		X			10
T	X						X														X				3
V	X		X		X	X		X			X				X								X		8
U	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	23
W	X		X	X	X		X			X			X	X			X					X	X	X	12
X			X		X	X			X						X	X	X			X	X				9
Y	X		X		X	X	X	X	X	X			X	X	X	X		X	X	X	X	X	X		18
Z												X	X	X				X		X	X				6
AA				X				X			X							X							4
BB	X				X		X																		3

CC		**X**			**X**												**X**		**X**						**4**
DD		**X**		**X**				**X**			**X**			**X**		**X**									**6**
EE																					**X**				**1**
FF			**X**																				**X**		**2**

The identified constructs were categorised into four factors, namely, thinking-related factors; teaching-related factors (Bearman *et al.*, 2017); student-related factors (Brazeal and Couch, 2017); and operational-related factors (Figure 7-1). This classification was done by identifying the key components in the core ingredients of IBL and better assessment design practice.

Table 7-3: Legend for identifying elements/factors of IBL for assessment design considerations

	LEADING FACTORS	Total Frequency
FF	Technology	7
EE	Self-efficacy	8
DD	Classroom climate	16
CC	Lecturer care	8
BB	Lecturer challenge	11
AA	Mastery goal structure	8
Z	Schemata construction	10
Y	Modelling practice	30
X	Prior knowledge	21
W	Formulating hypotheses	23
V	Construction of knowledge	41
U	Evidence - based practice	16
T	Inductive approach to teaching	7
S	Self-directed learning	23
R	Inquiry skill - critical thinking, problem solving	16
Q	Social constructivism approach	10
P	Zone of proximal development	1
O	Epistemological understanding	6
N	Surface structures/constructivist environment	14
M	Self- and peer- assessment	1
L	IBL/integrated curriculum	21
K	Questions/problem driven	33
J	Scaffolding/active guidance	21
I	Instructor’s role	32
H	Group dynamics/ collaborative discussion	24
G	Cognitive loading/ engagement	15
F	Student Experiences	2

E	Inquiry cycle- propose, critique, reflect, iterate	8
D	Experiential learning/processes	11
C	Student- centred pedagogy	26
B	Inquiry activities- explore, validate, categories	24
A	Active and participatory learning	33

After the review of 49 IBL related articles to identify the core components/facets of IBL pedagogy, 32 facets were identified as the important facets. Further review identified 28 components/facets as the most important facets because the facets were mentioned by at least seven of the 49 reviewed articles. The four components/facets of IBL pedagogy considered as less important include: zone of proximal development mentioned by one article; epistemological understanding mentioned by six articles; self- and peer- assessment mentioned by one article and student experience mentioned by two articles. The facets were further classified into four for more analysis based on the core statements of IBL pedagogy and best assessment design practices.

Many researchers (De Jong *et al.*, 2010, Justice *et al.*, 2007, Kahn and O'Rourke, 2004, Maeots *et al.*, 2011) agreed that the following are the core statements of IBL pedagogy:

a. Inquiry stimulates learning using problems, and questions. This process could be termed as an operational related factor;
b. The process of creating new understanding and constructing knowledge is learning. This process could be termed as a thinking related factor;
c. Students learn by doing and are therefore are active and participatory. This process could be termed as either an operational related factor or thinking related factor;
d. It is a student-centred pedagogy where lecturers only act as facilitators. This process could be termed as a teaching-related factor; and
e. Student takes more responsibility for their learning through self-directed learning approach. This process could be termed as a student-related factor.

Also, the best assessment design should incorporate the following practices:

a. Lecturers should provide feedback to students. This process could be termed as either student or teaching related factor;
b. Assessment should be conceptualised as part of the work of students. This process could be termed as either thinking or operational related factor;

c. There should be flexibility in the assessment process. This process could be termed operational related factor;
d. Assessment should inform instruction so that lecturers can improve their teaching aiding learning. This process could be termed as either an operational or a teaching-related factor; and
e. Students should be assessed using more than one measuring stick. This process could be termed as an operational-related factor.

When seeking to categorise the constructs of inquiry-based learning pedagogy, the risk of oversimplifying the constructs, and the complex relationship between them is acknowledged. The elements of IBL were categorised in this form not to reduce their complex relationship but to provide a platform where the practices, beliefs, tools, and concepts, used by students and lecturers in IBL pedagogy could be examined and used for assessment design.

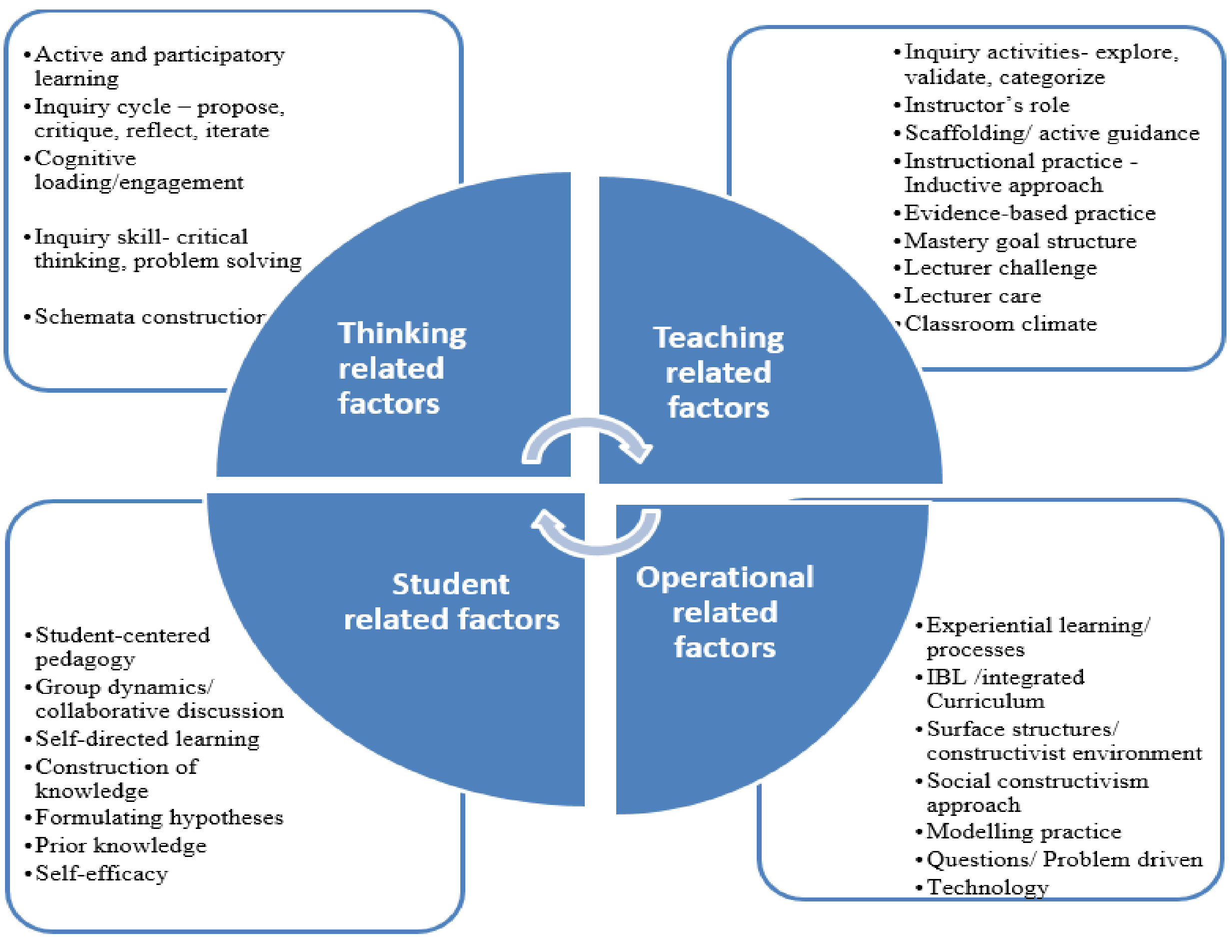

Figure 7-1: Classification of elements of IBL for assessment design considerations

7.5 ELEMENTS OF IBL FOR ASSESSMENT DESIGN CONSIDERATIONS

7.5.1 Thinking-related factors

a. Active and participatory learning

In IBL, students experience active learning by asking questions on a problem and suggesting hypotheses about the problem. They also collect, investigate and analyse the available information to solve the problem, thereby discovering and constructing knowledge previously not known to them (Lazonder and Harmsen, 2016, Maeeots and Pedaste, 2014, Scanlon *et al.*, 2011, Spronken-Smith *et al.*, 2008). This pedagogical approach promotes the development of higher-order thinking skills (HOTS) which plays an important role in construction management (Madhuri *et al.*, 2012). Research has shown that engineering-related students learn more when they are given activities that make them participate, act, and reflect (Hernández-de-Menéndez *et al.*, 2019, Olinger and Hermanson, 2002). Active learning is student-centred as it encourages cooperation, and establish the ability of the students to acquire lifelong skills and learning (Savage *et al.*, 2008).

b. Inquiry cycle – propose, critique, reflect, iterate

IBL pedagogy engages students in an authentic, science-based, and discovery learning process. This learning process can be divided into smaller units that are connected logically which leads students to important features of science-based thinking. The units are called inquiry phases and their connections form the inquiry cycle (Pedaste *et al.*, 2015). There are various forms of inquiry phases and inquiry cycles: propose; critique; reflect; iterate (Harinarain and Haupt, 2016), and the 5E learning cycle model: engagement; exploration; explanation; elaboration; and evaluation (Bybee *et al.*, 2006). The inquiry cycle activities could be embedded in class activities, module(s), or in the philosophy for a program (Spronken-Smith *et al.*, 2008).

c. Cognitive loading/engagement

The cognitive load theory (CLT) states that working memory does not have unlimited capacity and can be overloaded with activities that do not support learning (Sepp *et al.*, 2019). When the working memory is full, metacognitive activities will not transpire and the cognitive load will be high (Pollock *et al.*, 2002). This theory suggests that it is necessary to reduce cognitive loading for working memory so that metacognitive activities can take place (Bannert, 2002). It is therefore not advisable to administer assessments or questions that need complex reasoning to students who do not have sufficient prior knowledge (Hadie and Yusoff, 2016, Shehab and Nussbaum, 2015). The absent of prior knowledge in terms of schemata will need a high cognitive effort and load to solve authentic problems or complex questions (Hadie and Yusoff, 2016, Shehab and Nussbaum, 2015, Zulu and Haupt, 2019)

d. Inquiry skills: critical thinking and problem solving

According to Flores *et al.* (2012), the role of educational institutions is to produce students that are critical thinkers who are not only able to reproduce contents and facts. Therefore, 21st century students should be able to ask questions, develop hypotheses, carry out investigations and arrive at logical conclusions built on evidence because this leads to the acquisition of thinking, communication, and problem solving skills (Minner *et al.,* 2010). This ability can be achieved in an IBL environment that encourages students to take initiatives and responsibilities for their learning (Friedman *et al.,* 2010).

e. Schemata construction

Learning takes place when complex and large procedures and interactions are stored in long-term memory (LTM) (Sweller, 2016). The information acquired and stored as a single entity in the LTM is known as schemata. Learning takes place when new information connects to existing schemata and changes the existing schemata (Yu and Zhu, 2019). The schemata stored in the LTM can easily be manipulated to easily interpret new information and link it with itself (Ma *et al.,* 2018). It is, therefore, necessary to combine schemata of lower levels to become high-level schemata in building skilled performance (England, 2018). Therefore, the levels of schemas and their availability in LTM are an indication of a student's experience and knowledge on a particular domain of study and should be viewed as the main purpose of assessment (Kalyuga, 2006).

7.5.2 Teaching-related factors

a. Inquiry activities: explore, validate, categorise

The framework for IBL could include a process that conceptualises scientific inquiry as activities conducted by students, and the underpinning competencies required by these activities (Bell *et al.*, 2010, Pedaste *et al.*, 2015). These activities in IBL make students proactive towards learning, leading to a higher-level of thinking and better social interaction skills which, in turn, aids the process of teaching (Bob Price, 2001). According to Lim (2004), the process of conducting inquiry activities make students more responsible and confident to work with other students, and also to be in charge of their learning.

Further, the process of implementing inquiry activities can be viewed as potential assessments which serve as evidence of students' learning in different forms (Eisenkraft, 2004). This could be in form of the following: oral evidence; written evidence; graphic evidence; practical evidence and non-verbal (Ruiz-Primo, 2011).

b. Instructor's role

The role of the instructor in IBL pedagogy could be streamlined to the following goals: to help students to build and extend their ideas; to make students share their ideas; to assist students to deepen their reasoning, and; to help students to collaborate with other students (Marrongelle and Rasmussen, 2008, Rasmussen and Kwon, 2007, Rasmussen *et al.*, 2017, Wawro *et al.*, 2017). Additionally, the use of the appropriate form of assessment by the lecturers can help to trigger learning in students. It could also assist both students and lecturers to achieve proximal development (Black and Wiliam, 2009, Heritage, 2010).

c. Scaffolding/ active guidance

Scaffolding is a temporary support given by the lecturer to students to accomplish a learning task (Lim, 2004, Spronken-Smith *et al.*, 2008). Students also engage in scaffolding when they engage in group learning by supporting each other in difficult aspects of the task (Zulu and Haupt, 2019). The role of feedback could be highlighted by the use of scaffolds. Using scaffolding strategies like encouragement, questioning, and guidance in problem-solving, assist to critically and actively engage students in the learning process (Nyamupangedengu and Lelliott, 2012, Sousa, 2014).

d. Instructional practice: Inductive approach

Inductive approach is an effective teaching approach whereby the lecturer introduces a topic by using practical issues or specific observations which students need to solve or interpret after which the lecturer presents the concepts and foundational principles (Narjaikaew *et al.*, 2010). This approach encourages students to learn deeply and also motivate them to seek knowledge (Bennett, 2006) while promoting the retention of long-term concepts (Gavriel, 2015). It is, therefore, necessary for lecturers to adopt this constructive approach of teaching and also attain new assessment skills while implementing inquiry-based learning pedagogy (Constantinou *et al.*, 2018).

e. Evidence-based practice (EPB)

Evidence-based practice is more than reviewing empirical evidence/concepts and identifying effective interventions for students, but also an instructional practice that prioritises the selection of the 'best' evidence/concept, and its application in other problems (Nevo and Slonim-Nevo, 2011). Therefore, EBP is a process that requires both students and lecturers to identify, apply, and evaluate evidence relating to a particular problem to subsequent problems (Jenson, 2007). Students give priority to evidence that enables them to evaluate and develop reasoning that address scientifically-oriented problems and questions (Grandy and Duschl, 2007). Therefore, students support the use of this approach in problem-solving (Conole *et al.*, 2008).

f. Mastery goal structure

The adaption of IBL as a pedagogical approach has shown a positive influence on students' interest in learning and the achievement of their goals (Renninger *et al.*, 2014). Mastery goal orientation in IBL improves the students' perception to participate in a task either for curiosity, challenge, or mastery (Vansteenkiste *et al.*, 2006). Mastery goal orientation is directly proportional to interest (Tapola *et al.*, 2013), therefore, the interest of students in a task shows the adoption of mastery goals which further increases students' focus on a given task (Harackiewicz *et al.*, 2008).

g. Lecturer challenge

The measurement of inquiry competencies in IBL pedagogy is influenced by the challenges lecturers encounter while facilitating learning (Correia and Harrison, 2019). Among others, lecturers have the perception that they can collect richer evidence of students' learning during the inquiry cycle than through report writing (Harrison, 2014). They also find it difficult to carry out a real-time formative assessment for every student during the inquiry process. They believe students working in groups may affect individual performance, and this would affect the reliability of the assessment tool used (Correia and Harrison, 2019). As lecturers change their perception of how to collect evidence for learning, they would be able to challenge both the process they use and their philosophies about teaching and learning (Harrison, 2014).

h. Lecturer care

According to Capps and Crawford (2013), lecturers do not implement an inquiry-based approach in their teaching as expected. Their level of experience in IBL pedagogy is a hindrance (Kuzhabekova, 2015). Also, their teaching beliefs are based on traditional teaching approaches and not IBL teaching approaches (Isiksal-Bostan *et al.,* 2015). No significant relationship was found between lecturers' readiness to implement IBL and teaching experience. However, there may be a need to train lecturers based on their level of experience (Xie and Sharif, 2014). Lack of knowledge and understanding of IBL approaches could be a reason why it is not being implemented (Capps and Crawford, 2013). Therefore lecturers must have learning strategies suitable for IBL, sound knowledge of IBL, suitable assessment techniques in IBL, appropriate teaching materials, and students' perception of IBL (Davis and Krajcik, 2005). The pedagogical content knowledge of IBL is therefore considered as essential for lecturers (Silm *et al.,* 2017).

i. Classroom climate

Classroom climate in IBL pedagogy is channelled towards student-centred orientation where the teaching disposition is more focused on students, their needs, and the learning process (Peters, 2013). Classroom climate plays a major role in students' learning by promoting performance skills and reducing achievement gaps (Salinas and Garr, 2009). It also has a positive influence on students' motivation irrespective of the learning style (Tuan *et al.,* 2005). According to Fast *et al*. (2010), classroom climate in IBL gives students a sense of mastery and an ability to challenge and care about their learning with a higher level of self-efficacy.

7.5.3 Student-related factors

a. Student-centred pedagogy

Student-centred pedagogy is a developmental approach to learning, where the activities of students play a major part in the process of learning and the development of a learning product with high quality (Zohrabi *et al.,* 2012). This pedagogy is connected to self-directed learning, experiential learning, and flexible learning (Acat and Dönmez, 2009). In this approach, the needs of students at both individual and group levels are considered, and they are encouraged to participate in the learning process (Emaliana, 2017). The administration of regular formative assessments during the inquiry process produces timely feedback for students and is considered as a critical element of student-centred pedagogy (Connell *et al.,* 2016).

b. Group dynamics/ collaborative discussion

Group dynamics is an innovative educational approach in IBL to teaching and learning that improves the quality of learning (Colleges and Council, 2007). In this practice, students are given educational activities in groups so that they can participate in the inquiry process and in the knowledge creation concerning the specific task or problem instead of receiving transmitted knowledge from the lecturer (Gilardi and Lozza, 2009).

Collaborative discussion leads to productive learning activities and interactions, such as questioning, justifying and explaining opinions, argumentation, articulation, and elaboration (Prieto *et al.*, 2011). Collaborative learning occurs during the processes of shared meaning-making when there is a dynamic relationship between individual interpretations and shared meanings (Häkkinen *et al.*, 2017). Through this process, students negotiate and verify their individual views to attain group cognition or shared understanding (Stahl, 2005).

c. Self-directed learning

IBL pedagogy requires students to carry out research, integrate practice and theory, and also use skills and knowledge in the development of solutions to real-life problems (Savery, 2015). Students are expected to integrate, apply, and seek knowledge from different subject matters or disciplines related to the problem for a solution. They are also expected to find additional information and knowledge to provide solutions to a given task (Harinarain and Haupt, 2016). Peers and group collaborations are valuable resources and essential tools for a successful experience of IBL pedagogy (Cennamo *et al.*, 2011).

d. Construction of knowledge

According to Day et al. (2004), the constructivist theory states that learning occurs best by actively constructing knowledge in a meaningful way. Therefore, it is necessary for students' learning and thinking to go through an iterative process in IBL. This iterative process is based on the building of knowledge and engaged learning, as students go through each step in the process (Friedman *et al.*, 2010).

Group discussions during a task can lead to a higher level of thinking and cognition but the lack of appropriate mechanisms or strategies to facilitate discussions can severely limit and affect the construction of knowledge by the students (Hwang *et al.*, 2012).

e. Formulating hypotheses

Both the contents and methods of science are important in science-based education like construction education (Oh, 2010), as students can construct knowledge using scientific methods by generating and testing ideas (Lawson, 2000). The generated ideas which are tested during an inquiry include hypothesis, possible solutions, and tentative answers to a problem or question (Ooms *et al.*, 2019). Though hypothesis formulation needs to be validated, it is an important facet of IBL pedagogy because it fosters the development of new theories and resolution of anomalies. It also enables students to make valuable representations of objects in real-world contexts (Giere *et al.*, 2006).

f. Prior knowledge

Active learning pedagogies like IBL that encourage higher-order thinking skills (HOTS) play critical part in the engineering and construction education sectors (Rooney, 2012). Students undertaking programmes like construction management typically have diversified prior knowledge and cultural backgrounds. This creates a challenge when transmitting practical transferable skills as individual students adopt different behavioural strategies when completing a task (Madhuri *et al.*, 2012).

g. Self-efficacy

Self-efficacy is an important part of the Bandura Social Learning Theory (Chen *et al.,* 2015). This theory outlines the impact of social factors on the learning process of students (Chen *et al.,* 2015). The theory also focuses on predicting, understanding, changing or reshaping behaviours (Bandura, 2018). Self-efficacy is the personal views and beliefs of students on what they can do and how much effort they can put in to solve possible problems (Bikmaz, 2002). These are individual beliefs and goals set by each student which affects (a) the amount of effort required in achieving their personal goals, (b) the time required in managing and dealing with the problems and failures encountered respectively (Bilgin *et al.,* 2015). Lecturers who can identify the relationships between self-regulated students and self-efficacy can improve their students' learning by manipulating student perceptions, environmental factors, and learning behaviours (Wang and Wu, 2008).

7.5.4 Operational-related factors

a. Experiential learning/ processes

Experiential learning is a direct encounter with what has been learned rather than its imagination thereof. The term 'experiential learning' is used when learning occurs from direct experience. According to Davis (2004), formal and clear knowledge can arise from informal experiences (Brailas *et al.,* 2017). Therefore, experiential learning can be described as acquiring knowledge from doing. Exposing students to early practice allows them to learn from their mistakes because knowledge construction can only occur when students are actively involved in the process of learning (Sanford *et al.,* 2015).

b. IBL /integrated curriculum

IBL curriculum is underpinned with the idea that students actively construct their knowledge through question-asking, exploration, investigation, and self-directed experimentation (Alfieri *et al.,* 2011, Edson, 2013). As such, IBL assessment and curriculum must be authentic, student-centred, relevant, interdisciplinary, and constructive, to develop creativity, innovations and 21st century skills (Boahin, 2018). To this end, student learning should be compatible with the IBL curriculum (Kumral, 2016). This view implies that the curriculum must emphasise on reflection and repetition towards professional practice (Chien-Sing and Kolodner, 2011). Student should be led to the end of the Blooms' Taxonomy for higher-order learning where they can evaluate and create knowledge without experiencing cognitive overload (Sweller and Paas, 2017, Watagodakumbura, 2017).

c. Surface structures/ constructivist environment

Surface structures are the temporal, physical, and material conditions of the IBL learning environment which exceed the layout of the learning environment but include surfaces, furniture, tools, and objects that make up the learning environment (Shaffer, 2007). This environment allows certain types of pedagogical interactions which leads to the creation of a shared social space. This social space may influence the physical space leading to students coming close to share ideas on the creation of personal space (Brandt *et al.,* 2013).

d. Social constructivism approach

Social constructivism approach is influenced by Vygotsky's work that emphasises the idea that knowledge is mutually constructed. It also emphasises the social perspectives of learning (Bodrova and Leong, 2018, Yıldırım, 2008). Students interact with their peers so that they can share their opinions and views, and in the process, develop a shared understanding related to the concept (Kalpana, 2014). This is a conceptual shift from individual learning to collaborative learning, sociocultural activity, and social interaction (Gredler, 2008)

e. Modelling practice

Engineering programmes like construction management offers a platform to navigate the world towards sustainability using advances in technology, thereby creating positive ecological impacts (Fitzpatrick, 2017), and social benefits (Baillie *et al.*, 2012). It is, therefore, necessary for construction management programmes to adopt pedagogical approaches like IBL pedagogy – to enable students to acquire the broader values and capabilities needed in workplaces (Beanland and Hadgraft, 2013). This approach will ensure that students are successful in their professional careers (Kolmos and de Graaff, 2014).

f. Problem-driven questions

IBL has been defined in various ways. Oliver (2008) defined IBL as a teaching approach that uses a task or problem as a catalyst to engage students, thereby enhancing their participation. This is consequent on the notion that learning occurs when students process the information while seeking solutions to a given task or problem. Justice *et al.* (2007) defined IBL as any instructional practice that uses instructor-guided and student-driven investigations to promote student learning through student-centred questions. These two definitions as based on the 'problem- or question-driven' characteristics of IBL pedagogy. This view implies that students must perform investigations to solve problems or address questions in IBL (Aditomo *et al.*, 2013).

g. Technology

Communication and information technologies including social networking technologies are effective tools in IBL that can be used to enhance critical thinking skills while also improving instructional approaches in an online environment (Thaiposri and Wannapiroon, 2015). Technology can be used to motivate students to construct knowledge actively in IBL pedagogy (Slotta and Linn, 2009). It can be used: to share and gather evidence by the students (Reiser, 2006); and as a tool for data collection, visualisation, and argumentation (Linn *et al.*, 2003).

7.6 THE PROPOSED MODEL

A model is generally used to characterise reality for scientific interpretation (Fellows and Liu, 2015). As such, a conceptual model should not be too detailed or complex but should be simple and clear enough to unveil the relationships between a given set of variables (Hair *et al.*, 2010). Researchers in construction management present models in either mathematical expressions or graphical forms (Fellows and Liu, 2015). In this study, the conceptual model is presented in a visually comprehensible and graphic form using a path-modelling approach. The proposed conceptual model is shown in Figure 7-. It comprises of lines, shapes, two-way curved arrows, ellipses, and single-headed straight arrows.

Four leading variables/factors and the interrelationships between them are represented in the model. Ellipses are used to represent the four factors or latent variables. Curved two-way arrow lines show the co-variation between the variables, while single-headed straight arrows indicate direct influence between two factors

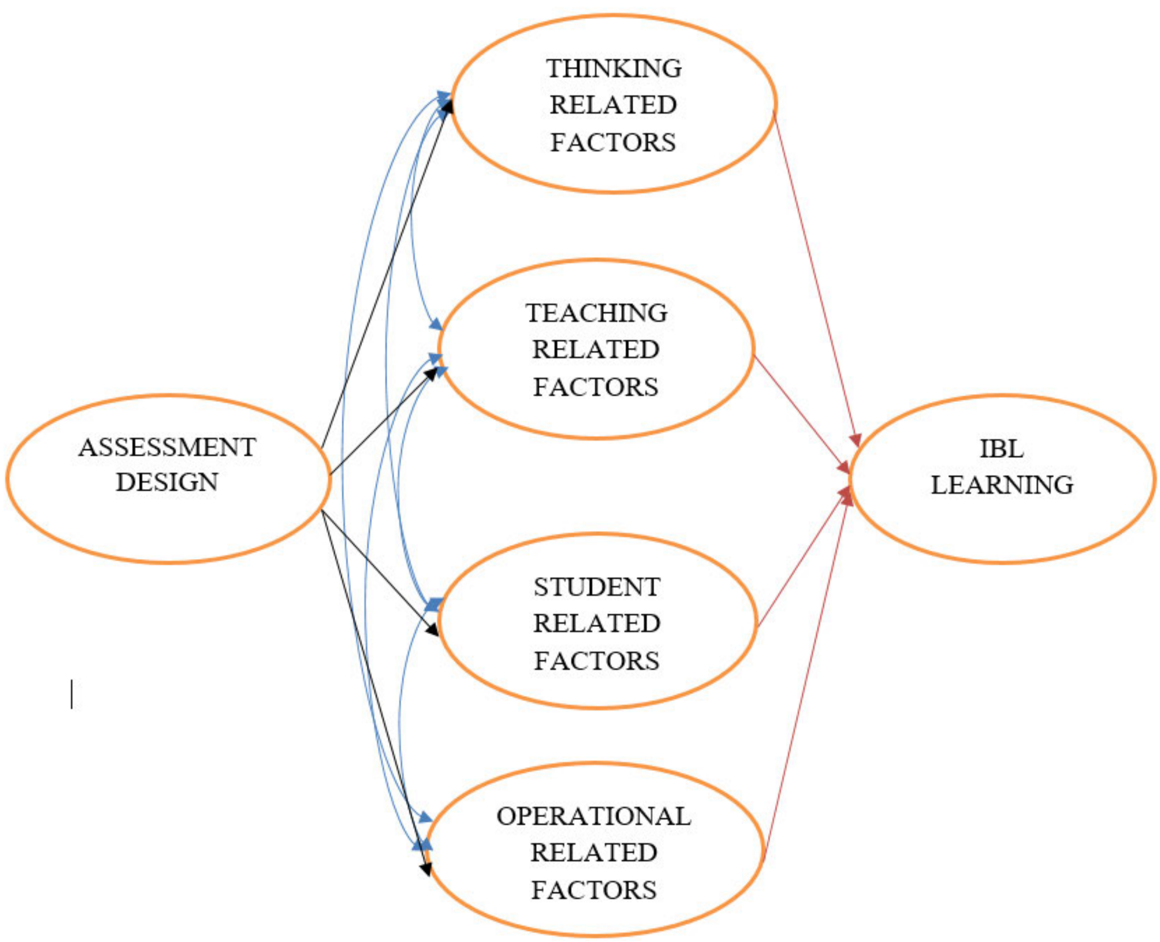

Figure 7-2: Proposed IBL assessment design considerations conceptual model

7.7 SUMMARY

The conceptual model of this study based on the review of the literature was presented in this chapter. The main features and concepts of IBL pedagogy were identified from the literature as key assessment design considerations in IBL. These key design considerations for effective assessment design has been discussed in this chapter. The next chapter described in detail the research methodology adopted in this study.

CHAPTER 8

RESEARCH METHODOLOGY

8.1 INTRODUCTION

This chapter describes the methodological approaches used for this research. It highlights the justification for the choice of the most suitable strategies, approaches, procedures, and techniques used in this research. A mixed research method was implemented to balance the deficit of quantitative and qualitative research methods. A justification for the methods and their illustrations are also presented.

Specifically, this chapter demonstrates how the research objectives were achieved using the following research procedure. Firstly, elements that are perceived to have a remarkable impact on the design of assessments in inquiry-based learning pedagogy were identified from the literature. This process was followed by an iterative Delphi technique using national and international construction education experts to refine the leading factors and elements identified in the literature review. Findings from the Delphi study was used to develop a conceptual model. Finally, questionnaires were used to collect quantitative data from students from a sample of universities offering construction management or building-related programmes in South Africa. Using the SEM, information obtained via the questionnaire was thereafter used to validate the conceptual model (Estiri *et al.*, 2020).

8.2 RESEARCH METHODOLOGY

According to Dawson (2007) and Walliman (2017), research is the act of exploring or deliberately searching for knowledge and information to answer questions. Research is also an inquiry done systematically to discover valid evidence concerning an area of study (Polit and Beck, 2012b). It can also be defined as the search and discovery of knowledge and hidden facts using different sources like journals, human beings, nature, books among other sources (Rajasekar and Philominathan, 2013). While research methodology is the overall approach or the philosophy of research that outlines the overall principle that guides the research (Dawson, 2007). Research encompasses the philosophical assumptions and rationale that underpin a particular study (Knight and Ruddock, 2009). Research methodology shows a researcher's approach, understanding, and strategy adopted to address the research questions (Martelli and Greener, 2015). Therefore, research methods can be defined as systematic ways of solving a problem and the science of studying how the problem will be solved, and the steps involved in obtaining the most appropriate method in addressing the research problem (Rajasekar and Philominathan, 2013).

8.3 RESEARCH PROCES

Knowledge improvement through systematic Inquiry involves probing researchable questions by discovering appropriate methods to answer these questions (Fellows and Liu, 2015). As a result, it is important to design a strategy involving steps to be followed from the beginning. The steps should be followed systematically to answer the framed research questions.

The research process adopted in this study follows the research 'onion' framework which organises the research process – research philosophy, research approach regarding data collection and data analysis (Thornhill *et al.*, 2009). This approach is represented in Figure 8-1. Issues like ethical considerations are discussed in this chapter.

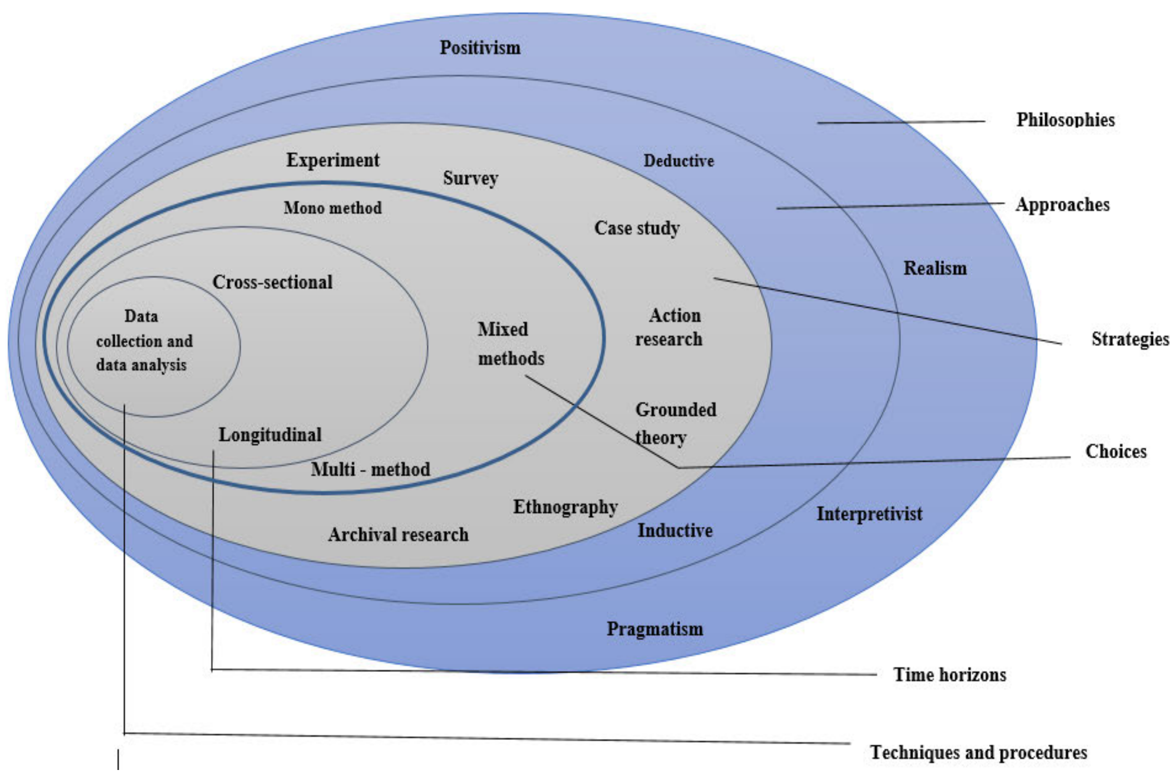

Figure 8-1: Illustration of a typical research process

(Thornhill *et al.*, 2009:108)

8.4 RESEARCH PHILOSOPHIES

Research philosophy is the set of philosophical assumptions underpinning the research design and research process (Thornhill *et al.*, 2009). This research philosophy is not a set of fixed assumptions but it is determined based on the goals and intentions of the study (Grix, 2018). Research philosophies can be broadly classified into epistemological philosophies and ontological philosophies (Zulu and Haupt, 2019). Epistemological philosophies define the approaches to discovery and questioning in a study (Thornhill *et al.*, 2009) while ontological philosophies define the assumptions and the nature of reality made about how the world operates (*ibid*). Furthermore, epistemological philosophies can be divided into interpretive, realism, phenomenology, and positivism while ontological philosophies into subjectivism and objectivism (Zulu and Haupt, 2019).

According to Bell *et al.* (2018), positivism suggests that natural sciences and social sciences are similar. Therefore, arguably social sciences research can follow the rigor and logic of natural sciences in research. Knowledge generation is either by gathering facts deductively or inductively (Bell *et al.*, 2018, Thornhill *et al.*, 2009). Positivists believe that knowledge is quantifiable and objective so it is the best mean to understand human behaviour through reasoning and observation (Yu, 2016). Positivism regards humans as passive, controlled and determined by the external environment. Positivism has evolved and has given rise to post-positivism which propagate that interpretations should be derived directly from collected and observed data. The limitation of post-positivism is that it assumes the researcher is able to observe and document reality objectively. This is a challenging task as the research process is influenced by the researcher's own past experiences or cognitive predilections (*ibid*).

Realism is pro-positivist (Thornhill *et al.*, 2009) because it suggests that, even though there are differences between the natural and social sciences, similarities exist to enable similar research approaches to be adopted in both areas (Bell *et al.*, 2018). Phenomenology philosophy, on the other hand, is anti-positivist because it capitalises on the differences between natural and social sciences, therefore, the same research approaches cannot be adopted in both fields (Bell *et al.*, 2018). The interpretive philosophy is also anti-positivist (Bell *et al.*, 2018), suggesting that both fields are different because the social science fields are far too complex to be theorised by definite natural 'laws' (Thornhill *et al.*, 2009). Therefore, it requires a different logic of research approaches which recognises the uniqueness of humans as opposed to natural law (Bell *et al.*, 2018).

Both subjectivism and objectivism are ontological positions. Objectivism suggests social entities and social actors are meaningful entities that are independent of each other (Thornhill *et al.*, 2009) while subjectivism suggests that social entities are formed from the actions and perceptions of social actors (*ibid*).

The choice of research philosophy to be adopted in a study depends on the research question, data source, scope of the study, the constraints, the hypotheses, and the research objectives (Yin, 2009). It is worth mentioning that no philosophy is superior to the other but each philosophy is best suited for different types of research questions though more than one research philosophy can be used to answer a research question (Thornhill *et al.*, 2009).

Under the epistemological philosophy, the structural relationships in the leading factors can be tested empirically. The preferred ontological philosophy was objectivism because students who are the main social actors in this study play a major role in assessment design.

8.5 RESEARCH APPROACH

The next step after identifying the most appropriate research philosophy is the determination of the most appropriate research approach to be adopted. Research approach denotes the relationship between observation and theory in a research study (Thornhill *et al.*, 2009). There is a connection between what is observed in a study (observation) and generalised statements about processes relationships or structures (theory) (*ibid*). The research approach expresses these connections. The choice of approach to be adopted in a study depends on the objectives of the study and its research questions (Maylor *et al.*, 2016, Yin, 2009).

There are two main research approaches namely, (a) inductive approach; and (b) deductive approach (Thornhill *et al.*, 2009). There are also secondary approaches like the abductive and retroductive approaches (Blaikie and Priest, 2019).

8.5.1 Inductive approach

Inductive approach is based on the use of observations in a study to develop a theory or hypothesis (Thornhill *et al.*, 2009). According to Locke (2007), the inductive approach involves determining the general from the particular, for instance, making empirical observations in a study and developing theories and concepts from it. It is believed that the behaviour of people is also influenced by social interaction and not just a function of their mechanistic response to situations

(Thornhill *et al.*, 2009). The efficiency of this approach is often debatable. This is because it cannot be used to test hypotheses considering that it has been used in developing the hypotheses. Sekaran and Bougie (2016) supports this by stating that 'no new evidence can prove that no contrary evidence exists'. It is therefore necessary to complement the inductive approach with the deductive approach (Woiceshyn and Daellenbach, 2018).

8.5.2 Deductive approach

The deductive approach involves developing theories or information from a specific deduction that can be used to test a hypothesis (Thornhill *et al.*, 2009). This approach implies, using a theory to derive hypotheses and testing the developed hypotheses while reviewing the theory (Bell *et al.*, 2018, Locke, 2007, Nola and Sankey, 2014). In this way, a phenomenon can be explained using the deduction derived from universal theory or law (Thornhill *et al.*, 2009).

A deductive approach mostly includes:

a. Developing hypotheses on different concepts to derive a theory;
b. Deducing hypotheses for testing from the literature;
c. Comparing the logic of the hypotheses with current theories to determine if the hypotheses are comprehensive;
d. Collecting data to test the developed hypotheses; and
e. Accepting or rejecting the results of the test if consistent or inconsistent with the theory and repeating the process if necessary (*ibid*).

8.5.3 Abductive approach

According to Blaikie and Priest (2019), this is a process where the accounts of social actors are used to develop social scientific accounts. In this approach, theories and technical concepts are developed from common interpretations and concepts of social life (Ong, 2012). Therefore, this approach is aimed at constructing theories that are based on daily activities, in the meanings and language of social actors (*ibid*). It is the collection of data to either identify theories or patterns or to amend theories that will be tested through more collection of data (Thornhill *et al.*, 2009). It is a back-and-forth process between theory and data, involving both the inductive and deductive research approaches (*ibid*).

8.5.4 Retroductive approach

The retroductive approach is related to the critical realist philosophical approach (Bhaskar, 2013). It is the process of developing explanatory hypotheses about the generative context of an observable study and testing the hypotheses for validity (Wuisman, 2005). It is the only research approach that uses a new idea to develop new knowledge (Fischer, 2001). In research, it is used to complement the limits of deduction and induction research approaches (Papachristos and Adamides, 2016).

This study adopts the deductive survey approach to tests the developed hypotheses on the antecedents to effective assessment design in IBL pedagogy in construction education.

8.6 RESEARCH DESIGN

There are three types of designs to research – qualitative, quantitative, and the combination of both types -mixed methods. According to Creswell and Creswell (2017), research designs within these three methods are made of different types of inquiry known as "strategies of inquiry" (Denzin and Lincoln, 2008). The strategies of inquiry include grounded theory, narrative research, case study, and ethnography (Priya, 2016). The advancement in technology has resulted in multiple opportunities for advanced procedures and innovative research designs in social sciences researches (Creswell and Creswell, 2017). Both qualitative and quantitative research designs have advantages and disadvantages. Consequently, the adoption of a hybrid approach will ensure that both approaches complement each other, thereby enhancing the validity and reliability of the research (Fellows and Liu, 2015). Therefore, a mixed research design was adopted in this study. The subsequent subsections will explain in detail the implementation of the research design methods.

8.6.1 Qualitative research

Qualitative research understands and explores the interpretation subjects give to their experiences (Creswell and Poth, 2016). It attempts to throw more light on interpretations that are less noticeable and also to investigate the complexities in the social world (Hennink *et al.*, 2020). Qualitative researchers are inductive towards exploring 'what' 'how' and 'why' questions as opposed to 'how many' and 'how much' questions in quantitative studies (Tuffour, 2017). Qualitative research is used to study peoples' life experiences and is preoccupied with exploring, describing, interpreting, and understanding a phenomenon (Finlay, 2011).

All the qualitative research approaches have diverse and multiple epistemological roots but when viewed in the context of how meaning takes place, they seem to converge (Madill *et al.*, 2000, Willig, 2013). Researchers carry out studies in their natural settings and interpret or give meaning to the explanations given by the subjects based on everyday experiences (Hennink *et al.*, 2020). The research approach is unique due to its experiential understanding of the intricate interrelationships between its direct analysis of events and phenomena (Braun and Clarke, 2013). The emphasis is therefore on exploring the patterns of expected and unanticipated relationships in phenomena or cases (Kang *et al.*, 2017, Stake, 1995). This can be achieved by exercising subjective judgement while making visible how knowledge is constructed using preconceptions. These preconceptions are produced through personal reflexivity in the form of self-evaluation and self-analysis during the study (Braun and Clarke, 2013, Willig, 2013).

8.6.2 Quantitative research

Quantitative research is mostly used in the positivist research philosophy. It can also be used with the pragmatist or realist research philosophy (Thornhill *et al.*, 2009). Quantitative research is also considered a deductive approach but may also incorporate the inductive approach in a study when quantitative data are used to develop a theory (Rovai *et al.*, 2013, Thornhill *et al.*, 2009). It is used to determine the relationships between variables using principles and statistical analyses and strategies like structured observation, questionnaires, or structured interviews (Thornhill *et al.*, 2009). According to Rovai *et al.* (2013), the world is subdivided into smaller reality pieces that are manageable in a study for easy understanding. Within these smaller realities, observations can be made, and hypotheses can be reproduced and tested in relationships with the study variables. This is illustrated by proposing a theory from a specific hypothesis and testing the hypothesis to draw up conclusions through data analysis and observations (Rovai *et al.*, 2013). In quantitative research, the collection of numeric data and determination of the relationships among variables are used to develop the hypothesis. The hypothesis describes the expected outcome, relationship, or result from the question being investigated (Polit and Beck, 2012a).

8.6.3 Mixed methods research

Mixed methods research is the use of both qualitative and quantitative methodologies in a study. According to Tashakkori and Creswell (2007), this method entails data collection and analysis, integration of findings, and drawing of conclusions using both quantitative and qualitative methods in a single study. This method combines the elements of both quantitative and qualitative research approaches for the acquiring of in-depth corroboration and understanding of the study (Johnson *et al.*, 2007). This method of research is further illustrated in the interactive flow diagram in Figure 8-2.

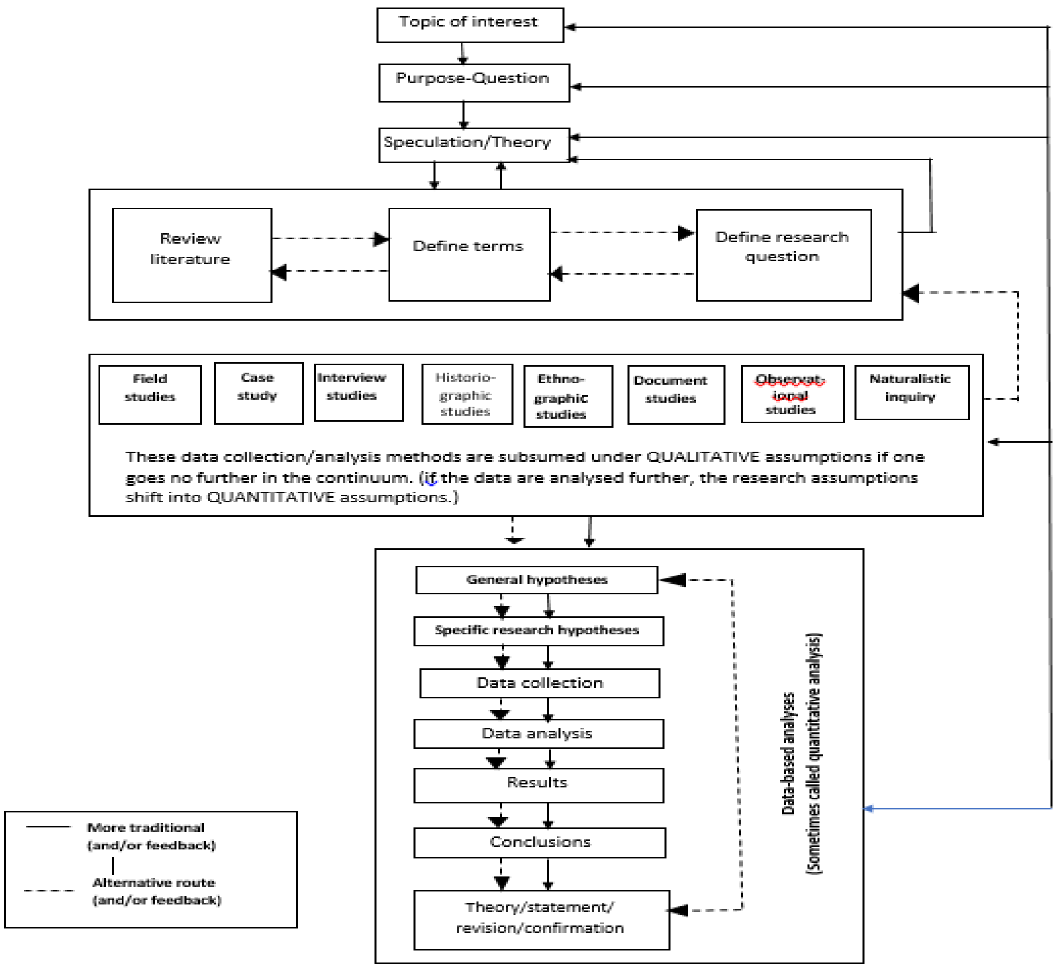

Figure 8-2 Interactive flow methods for research methods

(Source: Newman and Ridenour, 2008:31)

The advantages of mixed methods can be summarised as (a) enables both explanatory and confirmatory research questions to be addressed enables simultaneously; (b) enables stronger inferences from views from two methods; and (c) allows for combination of both complementary and/or divergent views (Polit and Beck, 2012b, Venkatesh *et al.*, 2013). Furthermore, mixed methods compensate for the weaknesses of other methods, and also eliminate any form of bias therein (Greene, 2007), thereby resulting in a better understanding of the study (Creswell and Clark, 2017).

Problem-solving requires a complete understanding of the problem, its research design method should not be limited to a particular research paradigm (Love *et al.*, 2002). Therefore, this study adopts a mixed-method research design where both quantitative and qualitative research methods are engaged. In this study, a theoretical conceptual model is developed by reviewing the literature systematically. A Delphi research method (a combination of quantitative and qualitative methods) was implemented to refine the conceptual model. Using a questionnaire, a quantitative research method was thereafter used to validate the refined conceptual model.

8.7 RESEARCH STRATEGIES

A research strategy is a blueprint that stipulates how the objectives of a study should be achieved and research questions answered. It links the methods of data collection and its analysis to the research philosophy (Thornhill *et al.*, 2009). Research strategies are determined by the direction of the research, which could be either explanatory, descriptive, or "exploratory or formulative" (Thornhill *et al.*, 2009, Sekaran and Bougie, 2016, Thakur, 2012). A study is termed as explanatory if it is experimental in nature and if it explains the relationship between variables (Thornhill *et al.*, 2009). Descriptive studies adopt the deductive process where generalised knowledge are investigated for specific conclusions. It provides an accurate description of the study unit with maximum reliability and minimum bias by testing non-causal but specific hypotheses (Thakur, 2012, Thornhill *et al.*, 2009). The "exploratory or formulative" research design adopts an inductive process where specific conclusions are generalised to develop hypotheses. Its purpose is to gain more understanding of a concept by throwing more light on a research problem via the administration of open questions (Sekaran and Bougie, 2016, Thakur, 2012, Thornhill *et al.*, 2009).

The commonly used strategies in research include narrative inquiry, action research, case studies, grounded theory, surveys, archival research, and experiments. Each strategy with its advantages and disadvantages is used either as a quantitative or qualitative research design or in both (Thornhill *et al.*, 2009, Yin, 2009). Only the survey strategy is discussed below as it is exclusively and principally linked to a quantitative design (Thornhill *et al.*, 2009). Other strategies are explained in detail in Mongkol (2018) and Zulu and Haupt (2019).

8.7.1 Surveys

In surveys, a sample that represents the population of study is obtained using a statistical technique when the entire population cannot be used (Fellows and Liu, 2015, Thomas, 2003). Survey instruments are useful for obtaining the status of a variable but not how individual variables fit into a pattern within the study (Jankowicz, 2005, Thomas, 2003). It is a widely-used method because of its lower cost, anonymity, and objectivity when compared with other strategies (Frankfort-Nachmias and Nachmias, 2007, Thornhill *et al.*, 2009, Thakur, 2012). However, the use of surveys could lead to inconclusive results due to its susceptibility to sampling error. Sampling error may arise if the samples do not present a true reflection of the entire population (Thornhill *et al.*, 2009, Thakur, 2012). It is therefore important to select an appropriate sampling technique for each given task. Data obtained during surveys are analysed using inferential and descriptive statistics which are, in turn, used to establish the relationships between variables in form of a model (Thornhill *et al.*, 2009).

8.8 TIME HORIZON

The time horizon of a study is the duration or timeline at which a study is undertaken (Thornhill *et al.*, 2009). The time horizon is underpinned by two reasons, namely research reasons and pragmatic reasons. Pragmatic reason is the amount of time available for the research while research reason is the type of information expected from the study (Thornhill *et al.*, 2009). Two types of time horizons are available for carrying out any research namely, longitudinal and cross-sectional time horizons. (Sekaran and Bougie, 2016, Thornhill *et al.*, 2009).

Longitudinal studies are used in the study of a phenomenon over time (Sekaran and Bougie, 2016, Thornhill *et al.*, 2009). This implies that data are collected at different times during the study and changes in the variables are reported. (Sekaran and Bougie, 2016, Thornhill *et al.,* 2009). It gives a “diary” perspective of a phenomenon or system by collecting relevant data over a defined period of time (Sekaran and Bougie, 2016, Thornhill *et al.,* 2009). This approach helps to detect cause-and-effect relationships. The drawback, however, is that its time consuming and costly (Sekaran and Bougie, 2016).

Cross-sectional studies provide a “snapshot” of the research at a particular time. It is therefore referred to as a ‘one-shot’ study. In cross-sectional studies, data collection is done only once over a period of time, mostly in days, weeks, or months. This is done to ensure that the outcomes of the study are valid for the time the data was collected (Sekaran and Bougie, 2016, Thornhill *et al.*, 2009).

The cross-sectional time horizon was adopted for this study because the research objectives could be achieved, and the research questions answered for a single occurrence of the research variables. Given the huge time and cost requirements that plagues the longitudinal time-horizon, the approach was not adopted in this study.

8.9 DATA COLLECTION METHODS

The choice of a survey method in any research is a crucial step that determines the instrument design. The data collection approach adopted by a researcher will be dependent on whether the study is implemented using a quantitative or a qualitative method. A quantitative method which is a positivist approach includes survey, observation, and experimentation where the data are quantified, and then analysed using statistical analysis (Hair *et al.*, 2007), while a qualitative method is an interpretivist approach which includes non-directive interviewing, role-playing, participant observation, and episodes. Data collected is therefore interpreted and examined qualitatively (Cohen *et al.*, 2013). Each method has its pros and cons so the choice of a method depends on the characteristics of the participants, the time available for the study, the skill-level of the researcher, and the cost allocated for the study (Sekaran and Bougie, 2016). The next section discusses some widely used collection methods.

8.9.1 Interviews

Interviews are meaningful conversations between two or more people wherein an interviewer seeks to gather information from interviewee(s) (Bogdan and Biklen, 2007, Maykut *et al.*, 1994). An interview entails a researcher (interviewer) asking participant(s) oral questions systematically and purposefully to obtain information related to the research problem (Hair *et al.*, 2007, Thomas, 2003, Thakur, 2012). The participants therefore share knowledge and experience on the phenomenon being studied (Maykut *et al.*, 1994).

It could be in a face-to-face interaction form and can assume a structured, semi-structured, or unstructured format (Thomas, 2003, Thakur, 2012). A major advantage of this method is that it allows for the collection of a comprehensive set of data. It also allows interviewees to respond in a preferred language (Cohen *et al.*, 2013). Furthermore, it allows the researcher to have a direct view of the participants' body language and emotions which provides additional information on the core responses being provided (Patton, 2014). An interview is often time-consuming and does not allow for anonymity (Judd Charles *et al.*, 1986, Thakur, 2012, Thomas, 2003, Sekaran and Bougie, 2016).

8.9.2 Questionnaires

Questionnaire is a set of organised questions, directed at participants, and used in obtaining information regarding a research problem. It is the ideal method of data collection when the data and method of analysis are known (Sekaran and Bougie, 2016, Thakur, 2012). A large amount of data can be collected over a short period of time using questionnaires (Thomas, 2003). However, administering the questionnaires requires supervision as participants may omit some questions. Moreover, the use of questionnaires provides respondents with no opportunity for questions or clarifications. Also, no explanations for responses received can be obtained (Judd Charles *et al.*, 1986, Thakur, 2012). Questions could either require open or closed responses, or a mixture of both (Judd Charles *et al.*, 1986, Thakur, 2012, Thornhill *et al.*, 2009). Open responses are answers provided in the participants' own words, leading to insightful and unanticipated responses (Thakur, 2012). However, open responses are prone to bias and are difficult to code or analyse (Judd Charles *et al.*, 1986, Thakur, 2012, Thornhill *et al.*, 2009). In questionnaires with closed responses, both questions and the answers are provided to the participants (Judd Charles *et al.*, 1986, Thakur, 2012). It is easy to administer and analyse, however, alternative answers which are not captured in the set of answers provided may be left out (Judd Charles *et al.*, 1986, Thakur, 2012, Thornhill *et al.*, 2009). There is a need to subject questionnaires to some reliability tests before they are administered (Nuramo and Haupt, 2017). This process is known as a pilot survey.

8.9.3 Observation

Observation as a form of data collection is the act of observing participants in a research setting. Trained researchers can probe participants to reveal embedded thoughts and ideas (Thornhill *et al.*, 2009). An observation could be done using (a) a participant observation form, wherein a participant joins a study group to collect data; and (b) a direct observation form, which involves the observation of a research subject (Rugg, 2006).

8.10 SAMPLING

The study of and accessibility to a given population may not always be financially viable. Researchers, therefore, adopt a sample of the population to minimise costs and uncertainties (Du

Plooy, 2009). Researchers may also not be able to observe each individual in the study population, so data is collected from a portion of the population to make inferences about the study population (Kobo and Ngwakwe, 2017). Sampling is therefore a systematic selection of a manageable and representative number of ‘objects’ or people (referred to as ‘a sample’) to take part in a study. A sample should be the correct and precise representation of the entire population (Thornhill *et al.*, 2009). More importantly, the number of elements in a sample should be sufficient to represent the study population to achieve a generalised characteristics of the study population (Judd Charles *et al.*, 1986, Frankfort-Nachmias and Nachmias, 2007, Sekaran and Bougie, 2016, Thakur, 2012).

Sampling methods can be categorised into two different groups, namely non-probability sampling methods and probability sampling methods (Frankfort-Nachmias and Nachmias, 2007, Hair *et al.*, 2007, Thakur, 2012, Thornhill *et al.*, 2009). The non-probability sampling method has been regarded as the most feasible method to adopt in the applied sciences where practical situations are being researched (Abowitz and Toole, 2010). In non-probability sampling, the chances that every element in the population will be selected is not equal. This implies that some elements have higher chances of selection compared to others. The probability that an element will be selected is also not known (Hair *et al.*, 2007, Sekaran and Bougie, 2016). In probability sampling methods, the elements in the study population have equal and known chances of selection. As such, its characteristic difference from the study population may be known (Frankfort-Nachmias and Nachmias, 2007, Hair *et al.*, 2007, Thakur, 2012, Thornhill *et al.*, 2009). The probability sampling method is, however, considered as more expensive and time-consuming as every element in the study population must be known (Hair *et al.*, 2007, Thakur, 2012, Thornhill *et al.*, 2009).

Due to time and cost constraints, this study adopts the non-probability sampling. Moreover, the benefits of the non-probability sampling far outweigh those of the probability sampling method (Hair *et al.*, 2007, Judd Charles *et al.*, 1986).

Request for gate keeper’s letter and permission to participate in this research was sent through emails to the research directorates of the 26 public universities in South Africa. Six of the universities agreed to participate and issued gate keeper’s letters. Therefore these universities offering building-related programmes, were selected to participate in this study. The sample comprised undergraduate students studying quantity surveying, civil engineering, property studies, human settlement and construction management at the six public universities.

8.11 DATA ANALYSIS

The choice of an appropriate method for data analysis is crucial to the success of any research. According to Mbachu (2002), the evaluation of the validity and reliability of findings is a critical step in all research endeavours. The choice of the analysis method depends on the following: the data distribution (Griffith, 2015); the research objectives and problems (Blaikie and Priest, 2019); the scale of the empirical data (Johnson, 2016); and the characteristics of the empirical data needed to address the research objectives (Mertens *et al.*, 2017).

Raw data has no meaning until it is analysed and processed (Thornhill *et al.*, 2009). There are three types of data analysis namely univariate, bivariate, or multivariate analysis. Univariate analysis comprises a single variable and takes the form of measures of central tendency, frequency tables, dispersion, and histograms. Bivariate analysis involves determining the relationship between two variables (Bell *et al.*, 2018), while multivariate analysis entails the determination of relationships between three or more variables simultaneously (Bell *et al.*, 2018, Hair *et al.*, 2007). In this study, multiple variables impact the assessment design, therefore, Structural Equation Modelling (SEM) – a method based on multivariate analysis was adopted.

8.12 THE DELPHI APPROACH

The Delphi technique is used to obtain inputs from a group of experts known as panellists (Colton and Covert, 2007, Hasson *et al.*, 2000). It has been widely used across many disciplines, in an iterative structured manner, to seek expert opinion. It is mostly used when knowledge about a phenomenon or problem is incomplete (Giannarou and Zervas, 2014). The main features of Delphi approach are (i) anonymity between participants, and (ii) controlled and structured feedback. Participants are allowed to change their initial responses based on the feedback from several successive iterations (Hsu and Sandford, 2007, Keeney *et al.*, 2006). A detailed discussion of the implementation of the Delphi technique in this study is presented in chapter 9.

8.13 VALIDITY AND RELIABILITY OF THE SURVEY INSTRUMENT

It is important to ensure that a survey instrument and data collected are accurate in determining the underlying construct of the process or system under study (Hair *et al.*, 2007, Sekaran and Bougie, 2016). Therefore, attention must be paid to validity and reliability issues relating to the data and data collection method.

The use of mixed methods research is also a form of triangulation (Creswell and Clark, 2017, Dawson, 2007). Triangulation is a very important process in research especially when more than one method of research is used to complement each other (Abowitz and Toole, 2010, Fellows and Liu, 2015). Research has shown that the use of a mixed method increases the reliability and validity of the study, resulting in a "true" result (Abowitz and Toole, 2010). High validity and reliability levels typically increase the confidence of research findings (Alhajri, 2013).

8.13.1 Validity

The validity of a study can be described as the trustworthiness of the research design adopted. It indicates the degree of accuracy of the data collection instrument (Bell *et al.*, 2018, Frankfort-Nachmias and Nachmias, 2007, Hair *et al.*, 2007, Judd Charles *et al.*, 1986, Marczyk *et al.*, 2005, Sekaran and Bougie, 2016, Thakur, 2012). Criterion validity, construct validity, and content validity are the three broad and distinct types of validity (Bell et al., 2018, Hair *et al.*, 2007, Sekaran and Bougie, 2016). Criterion validity is a check on the ability of the measuring instrument to identify criterion-based responses from participants. Criterion validity is further divided into predictive validity and concurrent validity (Hair *et al.*, 2007, Sekaran and Bougie, 2016). Predictive validity compares responses based on a future criterion (*ibid*). Concurrent validity is established by comparing responses from a measuring instrument to valid responses obtained from another instrument (*ibid*). Content validity is the extent to which responses in a measuring instrument represent the construct. This is typically confirmed by experts on the subject matter (Bell *et al.*, 2018, Hair *et al.*, 2007, Judd Charles *et al.*, 1986, Sekaran and Bougie, 2016). Content validity is also suggested as one of the standard international procedure for testing content (Fernández-Domínguez *et al.*, 2016). Therefore content validity was implemented in this study by the use of Delphi survey. Content validity can also be confirmed using face validity – the extent to which responses in the measuring instrument tends to measure the construct (*ibid*). Construct validity is the degree to which the responses from the measuring instrument fit the theories that underpin the instrument construction, thereby reflecting the interest of the construct accurately (Hair *et al.*, 2007, Judd Charles *et al.*, 1986, Sekaran and Bougie, 2016). Construct validity is further divided into two: discriminant validity and convergent validity. Discriminate validity occurs when two measuring instruments that are expected to be uncorrelated based on theory are found to be empirically correlated (*ibid*). Convergent validity exists when two distinct measuring instruments produce highly correlated results in the study (*ibid*). The features of each of the validity types are summarised in Table 8-1.

Table 8-1: Summary of the validity types

Validity	Description
Content validity	Does the measure adequately measure the concept?
Face validity	Do "experts" validate that the instrument measures what the items suggest in measures?
Criterion – related validity	Does the measure differentiate in a manner that help to predict criterion variables?
Concurrent validity	Does the measure differentiate in a manner that helps to predict a criterion currently?
Predictive validity	Does the measure differentiate in a manner that helps to predict a future criterion?
Construct validity	Does the instrument tap the concept as theorised?
Convergent validity	Do two instruments measuring the concept correlate highly?
Discriminant validity	Does the measure have a low correlation with the variable that is supposed to be unrelated to this variable?

Adapted from: (Sekaran, 2003:208)

8.13.2 Reliability

Reliability expresses the ability of a survey instrument to quantify the parameters it is designed to measure (Hair *et al.*, 2007, Judd Charles *et al.*, 1986, Sekaran, 2003, Thornhill *et al.*, 2009). It also expresses the degree of accuracy of a measuring instrument based on responses from participants under the same condition at different times (Frankfort-Nachmias and Nachmias, 2007, Hair *et al.*, 2007, Thakur, 2012, Sekaran, 2003). Reliability enables an estimation of the amount of error while producing a valid conclusion (Marczyk *et al.*, 2005, Newman and Ridenour, 2008). Validity guarantees reliability while the prerequisite for validity is reliability (Mitchell and Jolley, 2012). The achievement of a generalised result and conclusion is a function of reliability (Ramada *et al.*, 2014). The adoption of Delphi technique in this study improved reliability because decisions were reached without the panellist meeting face to face, thereby eradicating group thinking or bias. The reliability of the process was also increased via multiple number of iterations and panel size.

Reliability can further be divided into consistency and stability. Consistency expresses the internal correlation of the items within a construct. The items are highly correlated if there is a strong relationship between them. This process can be confirmed by using either the split-half reliability or the inter-item consistency reliability (Hair *et al.*, 2007, Judd Charles *et al.*, 1986, Sekaran, 2003). The Kuder-Richardson formula is used for measuring dichotomous items; the Cronbach's alpha is used for measuring multiple items and it was used during data analysis in this study, and the split-half reliability is used for measuring the correlation between two halves of a scale. These formulas are all used for measuring inter-item consistency reliability (Hair *et al.*, 2007, Judd Charles *et al.*, 1986, Sekaran, 2003). Figure 8.3 shows how to measure the goodness of data and the various forms of reliability and validity.

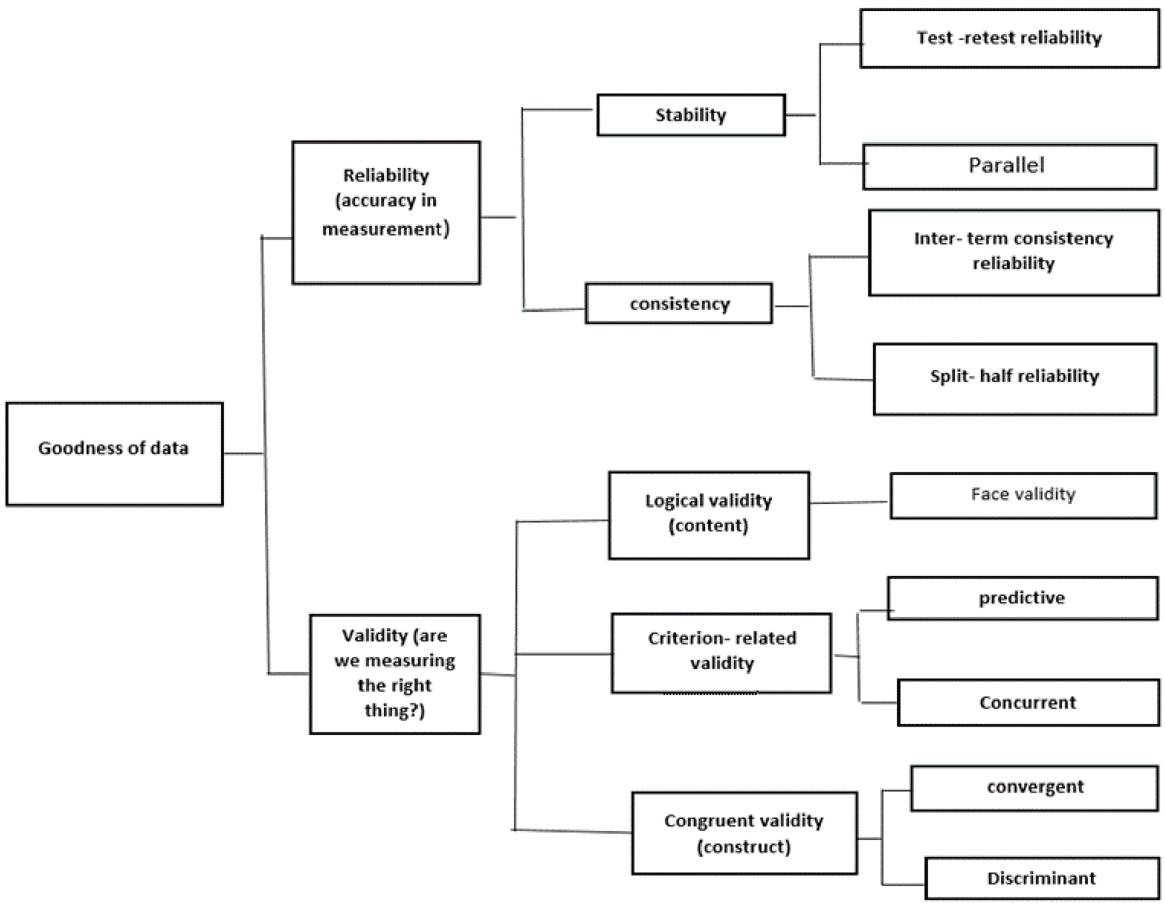

Figure 8-3 Goodness of data – Types of reliability and validity

(Sekaran, 2003:204)

Stability expresses the ability of the measuring instrument to produce the same response when administered over time. This is confirmed using 'test-retest reliability'. 'Test-retest reliability' measures the correlation of responses from the same instrument used at different times (Hair *et al.*, 2007, Judd Charles *et al.*, 1986, Sekaran, 2003). Stability can also be determined by parallel-form reliability when two sets of responses for the same concept are highly correlated (Hair *et al.*, 2007, Judd Charles *et al.*, 1986, Sekaran, 2003).

8.14 STRUCTURAL EQUATION MODELLING (SEM)

Multivariate analysis can analyse multiple variables at the same time to improve decision making and knowledge creation (Hair *et al.*, 2007). SEM is a multivariate data analysis method that can be used to forecast the complex relationships between constructs (Byrne, 2010). SEM uses the combination of factor analysis and multiple regression analysis to analyse the relationship between latent constructs or factors and measured variables (Raykov and Marcoulides, 2012). It adopts structural equations to graphically model the hypothesised relationships between constructs (Byrne, 2010). Subsequently, it determines the degree to which the theoretical model is related to the empirical data using a goodness of fit indices (Byrne, 2010).

8.15 ETHICAL CONSIDERATION

Anonymity and confidentiality are often required during the process of data collection. Anonymity eliminates the trackability of responses to participants while confidentiality ensures that responses provided by participants are not disclosed to third parties (Dawson, 2007).

Research instruments are often reviewed by relevant authorities to ensure adherence to relevant regulations before implementation takes place. This review process entails obtaining informed consent from the predefined participants of a study. Also, the participants must agree and volunteer to participate in the study.

The survey instruments used in this study was reviewed by the Humanities and Social Sciences Research Ethical Committee at the University of KwaZulu-Natal, South Africa. This committee issued an ethical clearance certificate before the survey instrument was adopted for data collection. A copy of this ethical clearance certificate with reference number HSSREC/00001561/2020 is attached as Appendix 1and an illustration of the methodological approaches adopted in this study is presented in Figure 8-4.

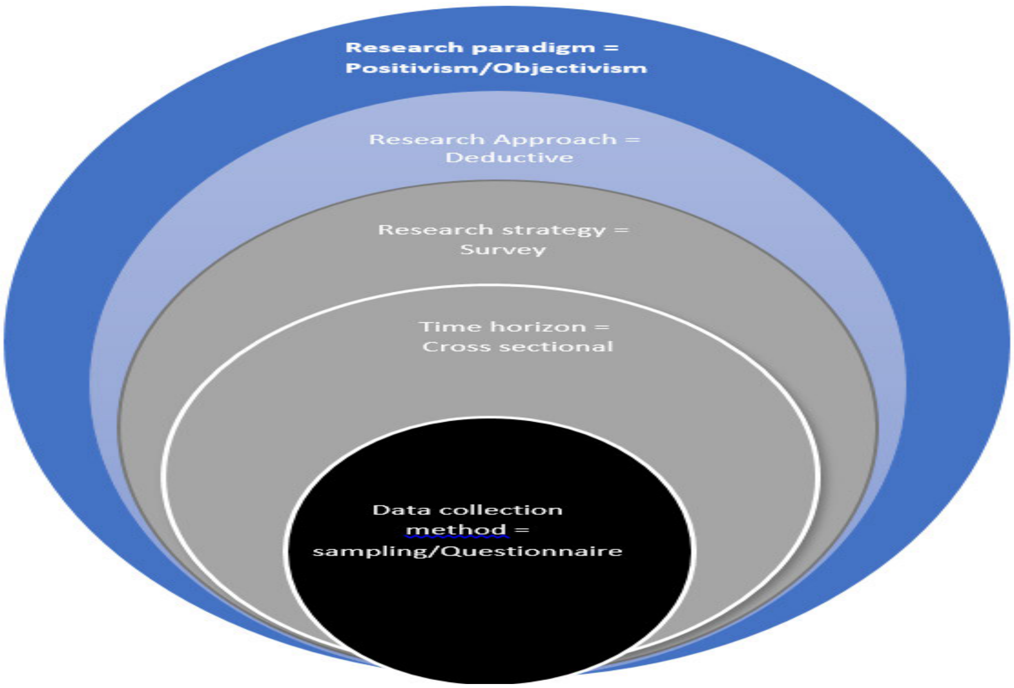

Figure 8-4 Research methodology adopted in this study

(Adapted from Saunders et al. 2012:67)

8.16 SUMMARY

This chapter presented the research methodology used in this study. The chapter entails a detailed discussion of the research philosophy, research approach, research design, research strategy, time-horizon, data collection methods, data sampling, and data analysis methods. Measures for ensuring validity and reliability presented. This study adopts a subjective ontological philosophy as students are viewed as social actors and are therefore independent of the class. The deductive research approach was adopted for hypotheses testing. This study adopts a mixed research design to compensate for the weakness of each approach, while a survey is utilised as the research strategy. A survey was used because due to the large number of students studying construction programmes in South Africa. A cross-sectional time-horizon was selected because it is cheaper, less time-consuming, and sufficient to achieve the outlined objectives of the study. Similarly, non-probability convenient sampling was used.

This chapter has also presented a brief discussion on the SEM technique and the ethical considerations for this study. A detailed implementation of the Delphi technique is presented in the next chapter (Chapter 9).

CHAPTER 9

DELPHI STUDY

9.1 INTRODUCTION

This chapter presents the implementation of the Delphi study. This includes its theoretical background, advantages, limitations, and its applications. The application of the Delphi approach in construction management research is also discussed.

9.2 BACKGROUND

The Delphi research method is named after a Greek legend which is an oracle at Delphi (Grisham, 2009). The Greeks pursued advice from the legend who uses a network of expert informers (Thangaratinam and Redman, 2005). The legend is considered as highly truthful based on the quality of data obtained from the network of expert informers (Cohen *et al.,* 2004). The Delphi research method was developed in the 1950s and has been used as a tool to aid decision-making and forecasting in various disciplines (Landeta, 2006). The RAND Corporation in the early 1950s sponsored its first use by the US Air Force (Giannarou and Zervas, 2014). The study aimed at collecting the most reliable consensus of military information from a group of experts through iterative rounds of questionnaires with controlled feedback after each round (Dalkey and Helmer, 1963, Linstone and Turoff, 2018). However, this technique was not in use for over ten years due to security reasons but was later introduced by Dalkey and Helmer in 1963 (Kauko and Palmroos, 2014, Keil *et al.,* 2013). This first non-military application was in planning economic development (Landeta, 2006, Linstone and Turoff, 2018, Meijering *et al.,* 2013). However, from the mid-90s, its popularity increased gradually, especially in academia (Habibi *et al.,* 2014).

The Delphi technique has been widely used in several fields including operations research, transportation, management science, health, and environment (Linstone and Turoff, 2018, Grisham, 2009). It is the most popular predictive technique wherein the opinions of experts in the field under investigation are taken as final (Landeta, 2006). The Delphi method is an adaptable and established research method used across the globe by several researchers and disciplines (Skulmoski *et al.,* 2007). According to van Beeck (2017), the applications of the Delphi technique is aimed at creative and reliable exploration of ideas or arriving at appropriate information for decision-making purposes. The technique is based on the assumption that ‘group judgements’ are more reliable than individuals' judgement and 'group judgements' are made up of opinions from the most reliable group (Giannarou and Zervas, 2014).

The Delphi technique is a systematic process aimed at gathering information on a specific issue using a group of experts who agrees on an issue through the iterative use of questionnaires (Harinarain and Haupt, 2014). The opinions of the expert panellist are anonymous; they do not meet physically and may be in different geographical locations (Shariff, 2015). Figure 9-1 illustrates the configuration of the Delphi technique. According to Skulmoski et al. (2007), the Delphi technique is suitable for studies where the information or knowledge of a particular phenomenon is incomplete. The study further states that the Delphi approach is well suited for studies aimed at understanding problems, solutions, and opportunities. The advantages and disadvantages of the Delphi technique should be taken into consideration when choosing an appropriate technique for information gathering and processing (Amos and Pearse, 2011).

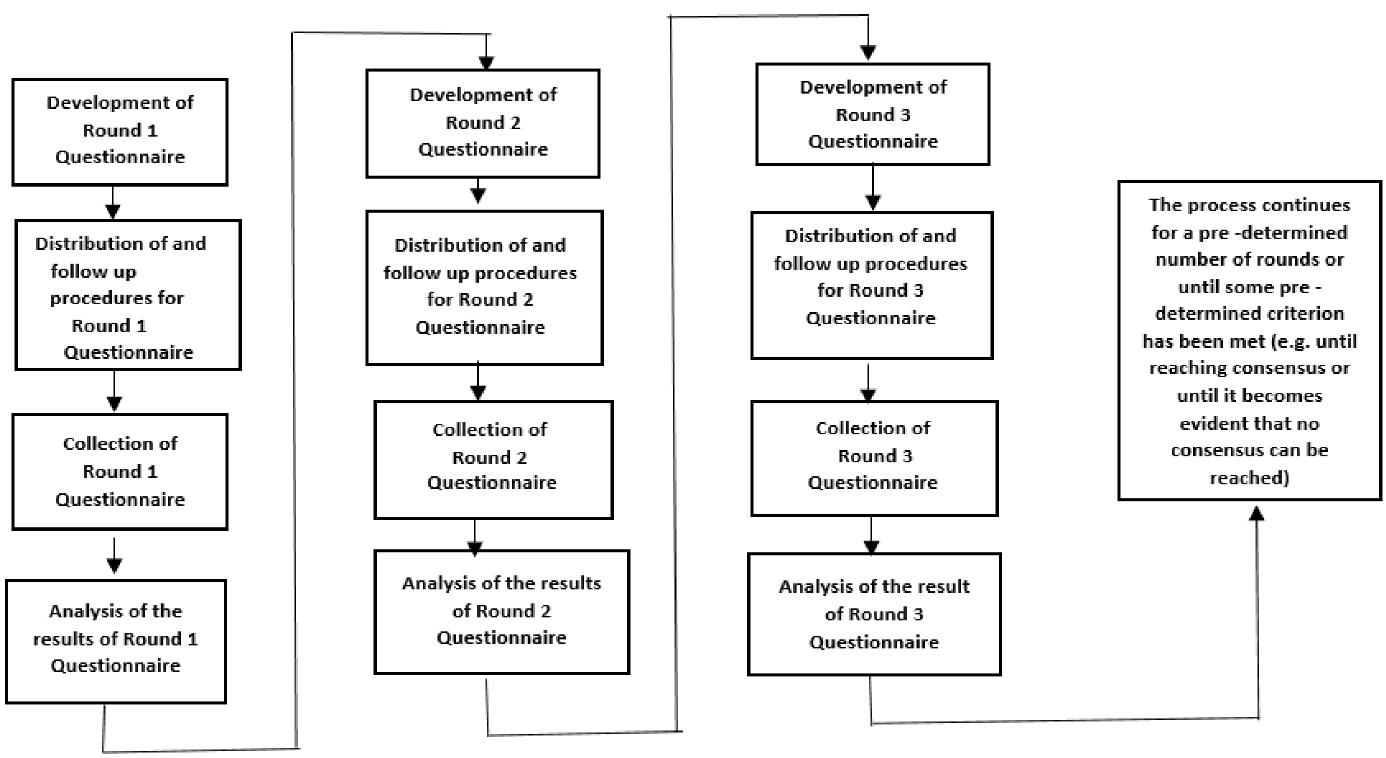

Figure 9-1: The Delphi process
[Adapted from: Sourani and Sohail, 2015:55)]

Although the Delphi technique was initially developed as a forecasting tool for use in the military, it has found application in many fields of study (information technology, business, education, and health care) (Skulmoski *et al.*, 2007). The Delphi technique has been used for different purposes including communication improvement, long-range forecasting, historical data retrieval, educational planning, policy development and analysis, curriculum structuring, and development modelling (Krijtenburg-Lewerissa *et al.*, 2019, Linstone and Turoff, 2018, Masud *et al.*, 2014). The Delphi technique can be particularly useful when there is a need to:

a. Assess uncertainty and highlight topics of concern quantitatively;
b. Acquire accurate information that is expensive to obtain or unavailable ;
c. Model a real-life concept wherein there is little quantitative evidence or where different viewpoints are involved;
d. Solve complex problems that need further judgmental analysis;
e. Allow for the combination of different perspectives to arrive at a collective conclusion; and
f. Define or study areas where there is a considerable lack of agreed knowledge and/or uncertainty or disagreement (Bendana *et al.*, 2008, Bradley and Stewart, 2002, Linstone and Turoff, 2018, Lucko and Rojas, 2010, McEachern *et al.*, 2005, Orndoff, 2005, Strasser *et al.*, 2019, Yeung *et al.*, 2009).

9.2.1 Advantages

The Delphi approach utilises experts to bring together, cost-effectively, the collective wisdom of expert panellists (Perrenoud, 2020). According to Agrawal and Pal (2019), it facilitates the sharing of information and group communication among panellists, paradoxically, and anonymously, allowing independent thinking. The experts are allowed to focus on key issues within the questionnaire, preventing them from being side-tracked (Shawahna, 2019). The combined adoption of iterative rounds and expert panellists assure content validity (Colton and Hatcher, 2004). It provides confidentiality and anonymity to the expert panellists preventing group thinking, group pressure, and dominance by influential individuals (Pezaro and Clyne, 2016). The Delphi approach can include a large panel size and participants from different geographical locations (Linstone and Turoff, 2018). Furthermore, the anonymous feature of the Delphi approach encourages participants to be open and free to express sincere opinions (Chalmers and Armour, 2018). The multiple iterative rounds also allow participants to receive feedback and re-evaluate their responses, thereby increasing content validation (Kim and Yeo, 2018). The survey is also self-administered and self-reported (Bowling, 2005, Harinarain and Haupt, 2014).

9.2.2 Disadvantages

The Delphi approach is regarded as time-consuming due to its iterative nature and may result in panellists losing interest (Bowling, 2005). The definition of a clear consensus may also be controversial as an agreement of range 51% to 70% can be taken as consensus (Polit and Beck, 2012b). Furthermore, there are no clear procedures regarding definitions of sampling techniques, panel size, and level of expertise (Hung *et al.*, 2008). Another concern with the Delphi survey is the high attrition rates which increase with the number of rounds (McIntyre *et al.*, 2020). An increase in the duration of a survey could be a challenge as a factor that is true now may not be true in a few months from the time of data collection (Shariff, 2015).

9.3 CHARACTERISTICS OF DELPHI

The main characteristics of a Delphi survey include iteration of rounds, expert panel, controlled feedback, anonymity, statistical summaries of group response, and consensus-building (Toppinen *et al.*, 2018, Vernon, 2009).

9.3.1 Iteration with controlled feedback

The Delphi survey is a repetitive process wherein a series of questionnaires are distributed over consecutive rounds (Landeta, 2006, Pandor *et al.*, 2019, Skulmoski *et al.*, 2007). Although there are no strict guidelines to determine the number of rounds to be undertaken. The most widely-applied number of rounds in the literature range between two and four (Gargon *et al.*, 2019). The participants are consulted at every round on the same question or issues with feedback that involves new information that expresses the group collective opinion. This repetitive process and feedback allow the participants the opportunity to change initial judgements or opinions without bias or fear (Festbaum *et al.*, 2020, Hasson *et al.*, 2000). The first round known as the 'thesis stage' allows for the development of ideas while the second round known as the 'antithesis stage' enables the evaluation and review of ideas against group summaries. The third round known as the 'synthesis stage' allows for a re-evaluation of ideas towards achieving a consensus (Shariff, 2015).

9.3.2 Expert panel

Expert panel refers to the number of experts participating in the Delphi survey (Polit and Beck, 2008). The experts are individuals who have the requisite qualification and experience in the area being researched (Flostrand, 2017). Research has shown that judgements made by a pool of intelligent experts are often better than those made by an individual expert (Giannarou and Zervas, 2014, MacCarthy and Atthirawong, 2003).

The selection of suitable experts is a critical step in a Delphi study as the success of the study is a function of the collective decisions made by the experts. According to Shariff (2015), there are three categories of experts namely (a) mandated expertise – individuals who have experience and knowledge related to their role and job description; (b) subjective expertise – individuals who possess knowledge because they are impacted by the subject of study; (c) objective expertise – individuals whose knowledge are based on their education and academic positions.

9.3.3 Anonymity

Interactions in a Delphi survey is completely an anonymous process (Colton and Covert, 2007, Grisham, 2009, Landeta, 2006). Anonymity allows participants to change their opinions without public knowledge and also enables experts to also re-examine their initial responses (Giannarou and Zervas, 2014, Skulmoski *et al.*, 2007). It also minimises the negative influence of committees such as group status, pressure, and dominancy of influential individuals (Ramaj-Desku *et al.*, 2020). However, anonymity could lead to a lack of accountability for views as the names of participants are not disclosed, therefore, limiting exploratory thinking and stimulation of ideas (Mullen, 2003).

9.3.4 Statistical group response

The instrument for a Delphi survey is designed in such a way that responses are processed statistically and quantitatively (Hasson *et al.,* 2000, Landeta, 2006, Skulmoski *et al.,* 2007). The group responses are represented in a statistical form, representing the group's opinion. The most popular statistical analyses implemented in Delphi studies may entail: the median, complemented with inter-quartile, quartiles range, minima, and maxima, or the mean complemented with range and/or standard deviation (SD) (Sourani and Sohail, 2015).

9.4 FAILURES IN THE APPLICATION OF A DELPHI SURVEY

Delphi technique is a simple and flexible method of data collection. However, it could lead to the collection of dubious data if not well designed (Skulmoski *et al.*, 2007). The following are common reasons for failures in the application of a Delphi survey:

a. The reliability and accuracy of the method is difficult to examine (Landeta, 2006);

b. The structure is over-specified and does not allow for looking at the problem from other perspectives (Linstone and Turoff, 2018);
c. The feedback process does not allow for enough interaction between participants (Landeta, 2006);
d. It is presumed that Delphi is a substitute for all other human communications regarding any subject matter (Landeta, 2006, Linstone and Turoff, 2018);
e. The process may be characterised by poor presentation, collation, and interpretation of participants responses if not well-managed (Linstone and Turoff, 2018);
f. The anonymity of the process may be compromised by any of the participants (Landeta, 2006);
g. Not exploring or ignoring disagreements in the group responses could lead to artificial consensus (Linstone and Turoff, 2018);
h. The process may be manipulated by the facilitator (Landeta, 2006);
i. The time requirements could be enormous (Landeta, 2006); and

Irrespective of the above limitations, the proper use of the Delphi technique has resulted in positive results (Landeta, 2006, Sourani and Sohail, 2015).

According to Landeta (2006), the following suggestions can be implemented to improve on its methodological limitations and weaknesses:

a. Participants should be selected based on their interest and potential contribution to the study;
b. Participants should understand the technique and must be knowledgeable in the area of study;
c. A pilot study should be carried out before the actual Delphi study to improve the quality of the research instrument;
d. Participants should be encouraged and motivated to participate and finish the Delphi survey;
e. The participants should be encouraged to give qualitative feedback to allow for better interaction and improved group opinion; and
f. The results of the study should be communicated to the participants.

To avoid failure in the application of Delphi survey in this study, all the suggestions by Landeta (2006) were adequately implemented.

9.5 STEPS IN DELPHI SURVEY

The Delphi survey can be classified into four distinct processes namely; (a) subject exploration; (b) acquisition of group opinion; (c) identification of fundamental differences in individual opinion; and (iv) final evaluation and feedback (Humphrey-Murto and de Wit, 2019, Linstone and Turoff, 2018). The steps are further illustrated in Figure 9-2 and are also discussed in detail in the following subsections.

9.5.1 Research problem identification

The suitability of the Delphi technique for a given study should be well-evaluated as the suitability of the technique is limited to research problems that are multi-objective in nature and requires expert judgment (Nworie, 2011). The nature of the study should therefore be examined before adopting the Delphi technique (Hasson *et al.*, 2000, Humphrey-Murto *et al.*, 2017). The research question to be answered in this study is what are the key design facets that will significantly affect the development of a model for the design of effective assessment in inquiry-based learning pedagogy in construction education in South Africa?

9.5.2 Role of researcher

According to Lyles (2020), the administrative skill of the facilitator or researcher contributes largely to the success of a Delphi survey. The duties of the facilitator include systematic identification and tracking of participants, sending of reminders, and analysing change in opinions methodically (Hasson *et al.*, 2000).

9.5.3 Ethical considerations

To ensure that a study complies with applicable regulations, research proposals need to be reviewed for ethical clearance by relevant ethics and research boards (Shariff, 2015). The Delphi survey used in this study was reviewed by the Humanities & Social Sciences, Research Ethical Committee at the University of KwaZulu-Natal and ethical clearance letter was issued before the commencement of the survey. The approved ethical clearance letter is attached in Appendix 1.

9.5.4 Selecting panel members

The experts are selected by purposive sampling technique rather than by random sampling (Nuramo and Haupt, 2017). The experts can be identified through recommendations from colleagues, snowballs, sampling, and searches on the internet and the literature (Bell *et al.*, 2018, Giannarou and Zervas, 2014).

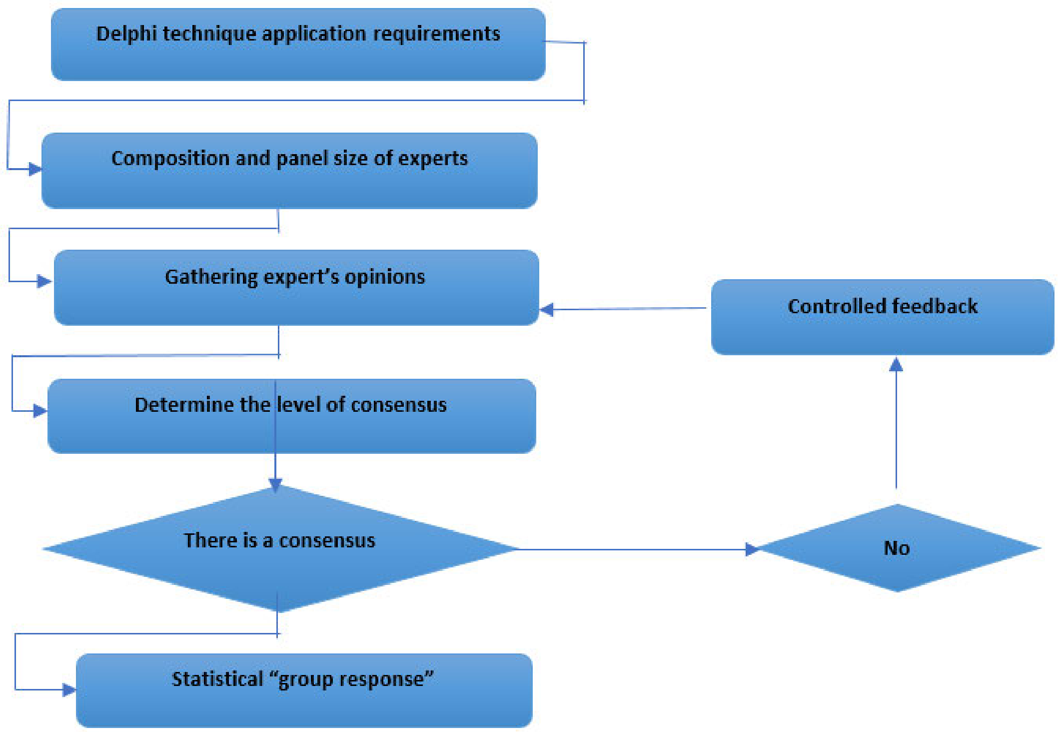

Figure 9-2: Steps in Delphi survey

[Source: (Habibi *et al.*, 2014:9)]

The process of identifying and selecting experts plays a very major role in formulating the panel of experts (Grisham, 2009). In this research, the identification and selection of potential experts were done using a set of criteria. The experts are to fulfil any three of the under listed criteria:

a. Knowledge of and experience in construction education or engineering education or IBL pedagogy;

b. Knowledge and experience within the construction or engineering sector;

c. Five years of construction education or engineering education experience;

d. An academic in construction management or related program;

e. A master's degree in construction management or related program;

f. Authored scholarly articles in the field of construction education, IBL, or related construction programmes; or

g. Presented conference papers in the field of construction education, construction-related programmes, or IBL pedagogy.

9.5.5 Number of panel members

There is no standard or consensus in determining the number of experts in a Delphi survey. According to Weidman *et al.,* (2011), there is no indication of the number of experts that should participate in a study in the literature. However, Weidman *et al.,* (2011), state that the minimum should be within six and seven experts. Given that the number of experts usually decreases in subsequent rounds, it is important to implement strategies to mitigate low response, and thereby retain the number of experts (de Mello Pereira and Alvim, 2015). Hallowell and Gambatese (2010) observed that most studies adopted between eight to sixteen members but recommended a minimum of eight members. In this study 32 qualified experts were identified and invited to participate, 19 experts accepted the invitation. Sixteen experts participated in the first-round, while 14 participated both in the second and third rounds. The specific number of experts should be determined by the characteristic of the study taken into consideration the availability, capability, and geographical locations of the experts (Hallowell and Gambatese, 2010).

9.5.6 Development of a Delphi survey instrument

Once the experts have been identified, the next step is to develop the survey instrument. The quantitative analysis of the responses should be taken into considerations while developing the survey instrument. An effective survey instrument must have the following elements:

a. The research questions should be easily understood by the experts as the instrument is designed to obtain expert information from the panellists (Bowling, 2005);
b. The data collected should be self-reported, representing the experience, perception, and knowledge of the experts;
c. The data should be self-administered, enabling the experts to complete the questionnaire themselves (Hanafin, 2004, Steele, 2005);
d. The questionnaire should comprise a combination of open-ended or closed-ended questions (Hanafin, 2004); and
e. The questionnaire should be concise, engaging, and well-written, and take into consideration the length, contents and response scale (Christie and Barela, 2005,

Skulmoski *et al.,* 2007). This is necessary to stimulate the participation of experts (Skulmoski *et al.*, 2007).

Following a comprehensive literature review, a structured questionnaire, aimed at enhancing the response rate of the experts was developed for this study. The questionnaire for the first-round was reviewed by two highly-experienced construction education experts, who are specialists in construction management and IBL pedagogy. The experts were asked to consider the key facets of IBL pedagogy and rate the impact and importance of each facet on assessment design using a 10-point Likert type scale. The importance scale comprised 1 to 10, representing ‘not important at all’ to ‘very important’ ratings, while the impact scale entailed 1 to 10, representing ‘no impact’ to ‘very high impact’ ratings. The questionnaire was sent to the experts via email in three rounds.

9.5.7 Data collection and analysis

The duration of data collection requires consideration while developing the research timelines as the iterative process often results in huge time demands. The experts should therefore be contacted to determine their interests before the survey commences. The questionnaires can be emailed or posted. It is important to follow up on the experts to encourage them to participate in the study (Kombo and Tromp, 2006). The data collection and analyses carried out in the first, second, and third rounds are, typically, identical. The first-round responses are analysed using qualitative methods. The ideas and themes from the first round are used to develop questionnaires for the second-round. The third-round questionnaire is based on the responses from the second-round questionnaire. This process continues until consensus is achieved (Skulmoski *et al.*, 2007).

In this study, 16 construction education experts participated in the first round. However, only 14 responded. These responses were collected and analysed using appropriate statistical analysis methods. The summary of the responses from the first was thereafter sent out to the 14 experts. All the 14 experts participated in the second round, representing a 100% response rate. The second round provided the experts with an opportunity to change their first-round responses based on the group’s opinion in the first round. The responses from the second round were also analysed and used to develop the third-round questionnaire. Similar to the second round, all the participants responded to the questionnaire, representing a 100% response rate. At this stage, a consensus was achieved at the third iteration, consequently, the Delphi survey was stopped. Detailed analyses of the responses received during the three rounds are presented in Chapter 10.

9.5.8 Criteria for attaining consensus

According to Christie and Barela (2005) and Giannarou and Zervas (2014), a consensus is attained on a given item in a Delphi survey when a certain proportion of the respondents fall within a certain range of median, mean or standard deviation value of the group responses. Attaining consensus is one of the main characteristics of the Delphi survey (Giannarou and Zervas, 2014). Christie and Barela (2005), suggested that if 75% of the participants could rate the item two points below and above the group mean on a 10-point scale, then a consensus has been attained. Giannarou and Zervas (2014) reviewed 32 empirical Delphi studies and recommended the use of more than one statistical measure in determining a consensus.

In this study, two criteria were adopted to attain a consensus and to consequently identify the key facets of IBL pedagogy that would be incorporated in developing a conceptual model for assessment design.

a. For the importance scale: the median should be 8 and above and at least 50% of the respondents should rate the element from 8 to 10.
b. For the impact scale: the median should be 8 and above and at least 50% of the respondents should rate the element from 8 to 10.

Given that IBL pedagogy, specifically in construction management programmes, is an emerging concept in South Africa, the measurement of learning within the confines of IBL pedagogy requires more attention. Taking this context into account, the criteria employed for attaining consensus was not strict as the researcher included influences at the borderline.

9.5.9 Validity and reliability of the Delphi instrument

Validity is the degree to which a technique measures what it is proposed to measure (Mohajan, 2017). As earlier stated, validity is categorised into two: content validity, and face validity.

a. Content validity

Content validity is the judgment of the panellists on the content of the questionnaire on the extent to which it examines the characteristics of the study from a logical perspective. The Delphi technique has been noted for its strong tendency in attaining content validity (Ghosh and Bowles, 2020). This form of validity can be improved by conducting a (pre)-test on the questionnaire, developing the questionnaire from published literature and knowledgeable individuals in the group, and paying attention to first-round responses (Shariff, 2015). The reviews/responses from the second and third rounds serve to improve the content validity of the questionnaire (Bowling, 2005).

b. **Face validity**

Face validity indicates the ability of an instrument to represent the appropriate concepts (Polit and Beck, 2012b). The measurement is subjective, focusing on the presentation and relevance of the questionnaire (Taherdoost, 2016). These include the questionnaire being clear, unambiguous, and readable (Feng and Yamat, 2019).

c. Reliability

Reliability is the ability of the questionnaire to produce similar or same results when administered consistently under similar conditions (Hasson *et al.*, 2000). According to Keeney *et al.* (2011), the Delphi technique improves reliability because decisions are reached without the panellist meeting face to face, thereby eradicating group thinking or bias. The reliability of the process can also be increased via the number of iterations and panel size.

9.5.10 Verification of the Delphi instrument

According to Hasson *et al.* (2000), attaining a consensus between the experts on a topic should not rule out the need for further verification. The verification and degree of generalisation of the final results have been recommended in the literature and were conducted in this study through the use of the SEM. This approach helps to strengthen, clarifies and gauge the transferability or generalisability of the findings (Hansson and Keeney, 2011).

9.6 SUMMARY

The implementation of the Delphi technique has been presented in this chapter. Aspects relating to its origin, application, process, and suitability for this study have been discussed extensively. The chapter has also presented the characteristics, limitations, and procedural steps adopted in developing the Delphi survey for this study. The application of the Delphi technique has also been illustrated. The next chapter will present the results obtained from the Delphi implementation in this study.

CHAPTER 10

RESULTS OF THE DELPHI STUDY

10.1 INTRODUCTION

This chapter presents and discusses results obtained from the Delphi survey. These include an analysis of demographic information of the experts as well as a descriptive statistical analysis of the three Delphi rounds implemented in this study.

10.2 DEMOGRAPHIC INFORMATION OF DELPHI PANELISTS

Thirty two potential individuals were identified using non-probabilistic purposive sampling to serve as experts in the Delphi survey. Letters of invitation were sent to the potential experts. However, only 19 experts accepted the invitation. Sixteen experts participated in the first-round, while 14 participated both in the second and third rounds. Table 10-1, Table 10-2 and Table 10-3 present a compilation of demographic information of the experts who participated in the Delphi survey. It can be observed from Table 10-1 that 57% and 43% of the participants are male and female, respectively.

Table 10-1: Gender composition and geographic location of Delphi panel of experts

Gender	Number of participants
Male	8
Female	6
Total	14

Table 10-2: Geographic location of Delphi panel of experts

Country (current base)	Number of participants
South Africa	4
United Kingdom	3
United States of America	2
Zambia	1
Nigeria	1
Ethiopia	1
Portugal	2
Total	14

Table 10-2 shows that the experts are from three (3) continents namely: Africa, Europe, and South America. The difference in geographical locations of the experts helps to prevent bias in the results and fosters anonymity in the process. All the experts met the criteria set for the selection of experts for participation in this survey. Each of the experts has a minimum of 10-year experience in construction/engineering education. The cumulative work experience of the experts was more than 230 years. Moreover, more than 80% of the panellists have previously worked on assessment and curriculum design projects.

Table 10-3 shows that the participants are well-qualified. All the experts hold a Doctor of Philosophy (PhD) degree in construction management or a related program. All the experts are also involved in teaching and research at various higher-education institutions and are well-experienced in the construction and engineering education sector.

Table 10-3: Professional and academic background of Delphi panel of experts

Demographic variables	Number of participants
Highest level of education	
MSc	0
PhD	14
Total	14
Work experience as an academic (years)	
10 – 20	10
21 - 30	2
Greater than 30	2
Total	14
Educational background	
Construction management and education	8
Engineering education	3
Pedagogical evaluation and development	3
Total	14
Exposure to curriculum and assessment design in construction/engineering programmes	14

10.3 RESULTS OF THE DELPHI STUDY

The Delphi survey was carried out to answer the research question stated below:

What are the key design facets that will significantly affect the development of a model for the design of effective assessment in inquiry-based learning pedagogy in construction education in South Africa?

In the development of the questionnaire, the research question was divided into two parts based on 'importance' and 'impact' as expressed as follows:

a. How important are the following influences in the design and development of assessment tools in an IBL pedagogy?
b. What is the impact of the following influences on the design and development of assessment tools in an IBL pedagogy?

The design Delphi questionnaire developed for this study is presented in Appendix 2. The sections below present results obtained from the three rounds of the Delphi survey.

10.3.1 Round one

In the first round, each of the experts was asked two categories of questions comprising 28 factors that influence assessment design. These design factors were to be rated using a 10-point Likert scale. A sample of the questionnaire used in the first round is presented in Appendix 4. The 28 factors were grouped into four and were presented to the experts for rating. The four groups are:

Thinking-related factors

a. Active and participatory learning
b. Inquiry cycle – propose, critique, reflect, iterate
c. Cognitive loading/engagement
d. Inquiry skill- critical thinking, problem-solving
e. Schemata construction

Teaching-related factors

a. Inquiry activities- explore, validate, categorise
b. Instructor’s role
c. Scaffolding/ active guidance
d. Instructional practice - Inductive approach
e. Evidence-based practice
f. Mastery goal structure
g. Lecturer challenge
h. Lecturer care
i. Classroom climate

Student-related factors

a. Student-centred pedagogy

b. Group dynamics/ collaborative discussion
c. Self-directed learning
d. Construction of knowledge
e. Formulating hypotheses
f. Prior knowledge
g. Self-efficacy

Operational-related factors category

a. Experiential learning/ processes
b. IBL /integrated Curriculum
c. Surface structures/ constructivist environment
d. Social constructivism approach
e. Modelling practice
f. Questions/ Problem driven
g. Technology

The rating was done based on their importance and impact on assessment design with IBL pedagogy in the construction education sector in perspective. The first-round questionnaire was emailed to 16 expert. However, only 14 experts (87.5%) responded. Table 10-4 presents a summary of the first-round responses. One of the experts withdrew from the survey due to an unexpected but personal event while the other expert provided no reason for withdrawing from the survey.

The responses from the first-round survey were analysed to determine the statistical median as well as the percentage of respondents who rated each factor/influence with 8 and above on10-point Likert scale. Two of the panel members requested for a rephrasing/renaming of some of the influences for better understanding.

Table 10-4: Summary of Delphi results for Round 1

	Importance		Impact	
	Median	% Response (8-10)	Median	% Response (8-10)
Thinking-related factors				
Active and participatory learning	9.0	93.0	9.0	86.0
Inquiry cycle – propose, critique, reflect, iterate	9.5	79.0	9.0	86.0
Cognitive loading/engagement	8.0	79.0	8.0	86.0
Inquiry skill- critical thinking, problem-solving	10.0	100.0	9.0	100.0
Schemata construction	8.5	64.0	8.5	57.0
Teaching-related factors				
Inquiry activities- explore, validate, categorise	10.0	86.0	8.5	71.0
Instructor's role*	7.0	50.0	7.0	43.0
Scaffolding/ active guidance*	7.0	50.0	8.0	57.0
Instructional practice - Inductive approach*	8.0	79.0	7.5	50.0
Evidence-based practice	9.0	71.0	8.5	79.0
Mastery goal structure*	7.0	21.0	7.0	21.0
Lecturer challenge*	7.0	14.0	7.0	21.0
Lecturer care*	7.5	50.0	7.0	36.0
Classroom climate*	8.0	57.0	7.0	43.0
Student-related factors				
Student-centred pedagogy	9.5	79.0	9.0	86.0
Group dynamics/ collaborative discussion	9.0	64.0	8.0	64.0
Self-directed learning	8.5	64.0	8.0	64.0
Construction of knowledge	8.5	64.0	8.0	64.0
Formulating hypotheses*	8.0	57.0	7.0	43.0
Prior knowledge*	7.0	29.0	7.0	43.0
Self-efficacy	8.0	64.0	8.0	64.0
Operational-related factors				
Experiential learning/ processes	8.5	79.0	8.0	64.0
IBL /integrated Curriculum	8.5	71.0	8.0	71.0
Surface structures/ constructivist environment	8.0	64.0	8.0	57.0
Social constructivism approach	8.0	64.0	8.0	57.0
Modelling practice	8.0	64.0	8.0	64.0
Questions/ Problem driven	9.0	79.0	9.0	86.0
Technology*	7.0	36.0	6.5	43.0

*Influences did not attain a consensus

In this study, two criteria were adopted to attain a consensus and to identify the key facets of IBL pedagogy that would be incorporated in the conceptual model for assessment design. The criteria include:

a. For the importance scale: the median should be 8 and above and at least 50% of the respondents should rate the influence from 8 to 10.
b. For the impact scale: the median should be 8 and above and at least 50% of the respondents should rate the influence from 8 to 10.

As indicated in Table 10.4, the following 10 factors did not meet the above consensus criteria: Instructor's role; Scaffolding/ active guidance; Instructional practice - Inductive approach; Mastery goal structure; Lecturer challenge; Lecturer care; Classroom climate; Formulating hypotheses; Prior knowledge; and Technology.

According to the consensus criteria, the group median of the influences was either less than 8 or less than 50% of the respondents gave a rating of 8 and above (for importance and impact) on the 10-point Likert scale.

The second round of questionnaires was sent out to the 14 respondents after analysing and summarising the first-round results.

10.3.2 Round two

In the second round, the panellists were provided with the group median for each influence in the first round as well as their responses in the first round. This approach was necessary to allow the panellists to have an overview of the central tendency of the group responses and to allow them to make changes on their first-round ratings if deem necessary. The sample of the questionnaire used in round two can be found in Appendix 5. The panellists were asked to provide an open-ended explanation or reason if their second-round response changes significantly different from the group median. The summary of the second-round responses is presented in Table 10-5.

All the 14 panellists who participated in the first round also participated in the second-round survey. Statistical analysis was executed on the responses. The summary of the second-round results was sent out to the 14 panellists together with the third-round survey instrument.

As highlighted in Table 10-5, nine elements did not meet the criteria for a consensus – either the group median of the influence must be equal to or higher than 8, or more than 50% of the respondents must provide a rating of 8 and above (for importance and impact) on the 10-point Likert scale.

Table 10-5: Summary of Delphi results for Round 2

	Importance		Impact	
	Median	% Response (8-10)	Median	% Response (8-10)
Thinking-related factors				
Active and participatory learning	9.0	100.0	9.0	93.0
Inquiry cycle – propose, critique, reflect, iterate	10.0	100.0	9.0	86.0
Cognitive loading/engagement	8.0	100.0	8.0	93.0
Inquiry skill- critical thinking, problem-solving	10.0	100.0	9.0	100.0
Schemata construction	9.0	79.0	9.0	86.0
Teaching-related factors				
Inquiry activities- explore, validate, categorise	10.0	100.0	8.5	86.0
Instructor's role*	7.0	43.0	7.0	36.0
Scaffolding/ active guidance*	7.0	43.0	8.0	79.0
Instructional practice - Inductive approach	8.0	86.0	8.0	71.0
Evidence-based practice*	7.0	79.0	9.0	86.0
Mastery goal structure*	7.0	29.0	7.0	14.0
Lecturer challenge*	7.0	29.0	7.0	14.0
Lecturer care*	8.0	71.0	7.0	29.0
Classroom climate*	8.0	71.0	7.0	43.0
Student-related factors				
Student-centred pedagogy	10.0	100.0	9.0	93.0
Group dynamics/ collaborative discussion	9.0	93.0	8.0	86.0
Self-directed learning	9.0	93.0	8.0	93.0
Construction of knowledge	9.0	93.0	8.0	93.0
Formulating hypotheses*	8.0	64.0	7.0	43.0
Prior knowledge*	7.0	29.0	7.0	36.0
Self-efficacy	8.0	79.0	8.0	86.0
Operational-related factors				
Experiential learning/ processes	9.0	86.0	8.0	71.0
IBL /integrated Curriculum	9.0	79.0	8.0	71.0
Surface structures/ constructivist environment	8.0	71.0	8.0	64.0
Social constructivism approach	8.0	79.0	8.0	71.0
Modelling practice	8.0	79.0	8.0	86
Questions/ Problem driven	9.0	93.0	9.0	100.0
Technology*	7.0	21.0	7.0	14.0

*Influences did not attain a consensus

As indicated in Table 10.5, the following 10 factors did not meet the above consensus criteria: instructor's role; scaffolding/ active guidance; evidence-based practice; mastery goal structure;

lecturer challenge; lecturer care; classroom climate; formulating hypotheses; prior knowledge; and technology. These factors were included in the third round for further study.

10.3.3 Round three

In the third round, the panellists were provided with the group median for each influence analysed in the second round as well as their responses. The sample of the questionnaire used in round three can be found in Appendix 6. As done in round 2, the panellists were asked to provide an open-ended explanation or reason for any significant difference from the group median. The summary of the third-round responses is presented in Table 10-6.

As highlighted in Table 10-6 and similar to results obtained in round two, nine elements did not meet the criteria for a consensus. Either of the two following criteria must be met:

Criterion 1: the group median of the influence must be equal to or higher than 8;

Criterion 2: more than 50% of the respondents must provide a rating of 8 and above (for importance and impact) on the 10-point Likert scale. This Delphi survey was terminated on the third since consensus has been achieved.

Table 10-6: Summary of Delphi results for Round 3

	Importance		Impact	
	Median	% Response (8-10)	Median	% Response (8-10)
Thinking-related factors				
Active and participatory learning	9	100	9	93
Inquiry cycle – propose, critique, reflect, iterate	10	100	9	93
Cognitive loading/engagement	8	93	8	86
Inquiry skill- critical thinking, problem-solving	10	100	9	100
Schemata construction	9	86	9	76
Teaching-related factors				
Inquiry activities- explore, validate, categorise	10	100	9	86
Instructor's role*	7	23	7	36
Scaffolding/ active guidance*	7	36	8	71
Instructional practice - Inductive approach	8	93	8	86
Evidence-based practice*	7	79	8	86
Mastery goal structure*	7	21	7	14
Lecturer challenge*	7	14	7	14
Lecturer care*	8	71	7	29

Classroom climate*	8	79	7	43
Student-related factors				
Student-centred pedagogy	10	100	9	93
Group dynamics/ collaborative discussion	9	93	8	86
Self-directed learning	9	93	8	93
Construction of knowledge	9	86	8	93
Formulating hypotheses*	8	64	7	43
Prior knowledge*	7	36	7	29
Self-efficacy	8	86	8	86
Operational-related factors				
Experiential learning/ processes	9	86	8	71
IBL /integrated Curriculum	9	79	8	71
Surface structures/ constructivist environment	8	71	8	78
Social constructivism approach	8	79	8	78
Modelling practice	8	79	8	86
Questions/ Problem driven	9	100	9	100
Technology*	7	7	7	7

*Influences did not attain a consensus

The results of the second and third round survey showed significant convergence with no major differences. Upon achieving a consensus in the third round, the nine influences, previously listed, were removed from the list. A conceptual model was thereafter developed based on the remaining influences in the Delphi survey. From the discussions and analysis in the preceding sections, eighteen influences presented in Table 10-7 were considered for further study.

Table 10-7: Summary of final Delphi survey result

	Round 1	Round 2	Round 3
Thinking-related factors			
Active and participatory learning	Accepted	Accepted	Accepted
Inquiry cycle – propose, critique, reflect, iterate	Accepted	Accepted	Accepted
Cognitive loading/engagement	Accepted	Accepted	Accepted
Inquiry skill- critical thinking, problem-solving	Accepted	Accepted	Accepted
Schemata construction	Accepted	Accepted	Accepted
Teaching-related factors			
Inquiry activities- explore, validate, categorise	Accepted	Accepted	Accepted
Instructional practice - Inductive approach	Not Accepted	Accepted	Accepted
Student-related factors			

Student-centred pedagogy	Accepted	Accepted	Accepted
Group dynamics/ collaborative discussion	Accepted	Accepted	Accepted
Self-directed learning	Accepted	Accepted	Accepted
Construction of knowledge	Accepted	Accepted	Accepted
Self-efficacy	Accepted	Accepted	Accepted
Operational-related factors			
Experiential learning/ processes	Accepted	Accepted	Accepted
IBL /integrated Curriculum	Accepted	Accepted	Accepted
Surface structures/ constructivist environment	Accepted	Accepted	Accepted
Social constructivism approach	Accepted	Accepted	Accepted
Modelling practice	Accepted	Accepted	Accepted
Questions/ Problem driven	Accepted	Accepted	Accepted

10.4 DISCUSSION OF QUANTITATIVE RESULTS OBTAINED FROM THE DELPHI SURVEY

The Delphi survey was aimed at identifying and refining the facets of IBL pedagogy that are perceived to be important and have a significant impact on assessment design in construction education. As shown in Table 10.7, 18 facets/influences were selected for further study in the next analytical phase. The subsequent subsections discuss the results obtained from the Delphi survey for each category of factors.

10.4.1 Thinking-related factors

Active learning (AL) pedagogies like IBL encourage students to master course concepts when compared to the traditional lecture methods, especially in science-based programmes like construction management (Knudson, 2019, Knudson and Wallace, 2019, Riskowski, 2015). AL pedagogy has also been applied in other disciplines (Beichner *et al.*, 2007, Freeman *et al.*, 2014). AL has been recommended for adoption in all class activities wherein students are meant to showcase their experimental/practical and creative abilities (Devraj *et al.*, 2010). The use of thought-based AL activities needs to be introduced to students because it enables them to be responsible for their learning and also fosters critical thinking (Drew and Mackie, 2011, Welsh, 2012, White *et al.*, 2015). It is therefore necessary to motivate students to be active in all activities as the behaviour and thinking of student is significantly a function of their level of motivation (Guay *et al.*, 2010). According to Herrmann (2017), motivation is a theoretical concept that interpret the insistence, direction, force and beginning of goal-oriented behaviours.

The panellists in this study agreed that all the influences under thinking-related factors should be retained as they were found to have great importance and impact on assessment design in IBL pedagogy.

10.4.2 Teaching-related factors

The shift from behaviourism to constructivism, in the context of 21st-century teaching, has improved the quality of students by enabling them to think critically and solve complex problems (Jansen and van der Merwe, 2015). IBL offers a platform to organise learning around projects, challenging problems, and inquiry (Laksana, 2017), and consequently, allows for students to engage in problem-solving, design, investigative analysis, decision-making, and evidence-based activities (Panasan and Nuangchalerm, 2010).

Some teaching-related factors were removed from the nine influences considered in the Delphi survey. The factors were removed as their importance and impact on assessment design in IBL pedagogy were considered as insignificant. The insignificant factors that were removed include instructor role, scaffolding/ active guidance, evidence-based practice; mastery goal structure, lecturer challenge, lecturer care, and classroom climate.

10.4.3 Student-related factors

IBL pedagogy is known as a student-centred approach that emphasises the need to provide students with opportunities to engage and participate in activities while interacting with other students, the facilitator, and the subject content (Ali, 2019). Students, therefore, take ownership and responsibility of their learning, thereby facilitating classroom interactions (Swart, 2018). Self-directed learning, through interactions, can be enriched through collaborative group activities wherein students are expected to reach consensus and negotiate on how to learn and work together (Lasfeto, 2020). The organisation of learning activities towards the attainment of set goals is therefore the responsibility of the students (Du *et al.*, 2013). All teaching activities include assessments should be channel towards assisting students to construct their knowledge rather than the transmission of factual knowledge (Du and Kirkebæk, 2012).

Of the seven (7) student-related influences considered in this study, only five (5) influences were retained. Influences relating to the formulation of hypotheses and prior knowledge were removed as they did not meet the consensus criteria. Although the formulation of hypotheses and prior knowledge are important facets of IBL pedagogy, in this study, the Delphi survey showed that their impact and importance do not have a significant influence on assessment design.

10.4.4 Operational-related factors

According to Zulu and Haupt (2019), it is expected that a construction management curriculum should be interdisciplinary in its construct to enable graduates to not only acquire effective problem-solving and communication skills but also the ability to collaborate effectively with other professionals. The learning environment must therefore allow interaction, cooperation, and opinion-sharing among students (Yapici, 2016). The constructivist approach requires learning environments that allow for social interaction among students and also encourages physical activities. Furthermore, the availability of learning materials and sources increases the curiosity of students and makes the learning environment more appealing to them (Sluijsmans and Strijbos, 2010).

Although the integration of technology in any educational system enhances teaching and learning (Lawless and Pellegrino, 2007, Asad *et al.*, 2020), in this study, the Delphi study showed that the importance and impact of technology do not have a substantial influence on IBL assessment design.

10.5 DISCUSSION OF QUALITATIVE RESULTS OBTAINED FROM THE DELPHI SURVEY

According to Burchell *et al.* (2019), when responses differ from the median or mean of the group response, panellists should be allowed to provide a reason or an explanation for the difference in response. The reasons or explanation are to be kept confidential and the identity of the panellist withheld (Önaç and Birişçi, 2019).

In this study, the panellists were allowed to provide arguments or an explanation if the response submitted is two units below or above the group median. The summary of the qualitative responses from the panellist in the second and third rounds of the survey are presented in Appendix 7. The qualitative responses in the second and third rounds were found to be consistent. Consequently, the group mean values were used to select the significant influences/factors.

10.6 SUMMARY

This chapter has analysed and discussed the results from the three rounds of the Delphi survey implemented in this study. The panelists considered the importance and impact of 29 facets of IBL pedagogy on assessment design. Consensus was attained after three rounds of questionnaire distribution and 18 facets were selected as the most important with greatest impact on assessment design. The demographic information of the panellists was also presented and analysed. Chapter 11 presents the refined theoretical model and survey instrument.

CHAPTER 11

EFFECTIVE ASSESSMENT DESIGN CONCEPTUAL MODEL

11.1 INTRODUCTION

This chapter presents the design influences considered in developing an assessment design conceptual model for IBL pedagogy in construction education. The conceptual model (Figure 11-1) is discussed and relationships between the design constructs are hypothesised and outlined.

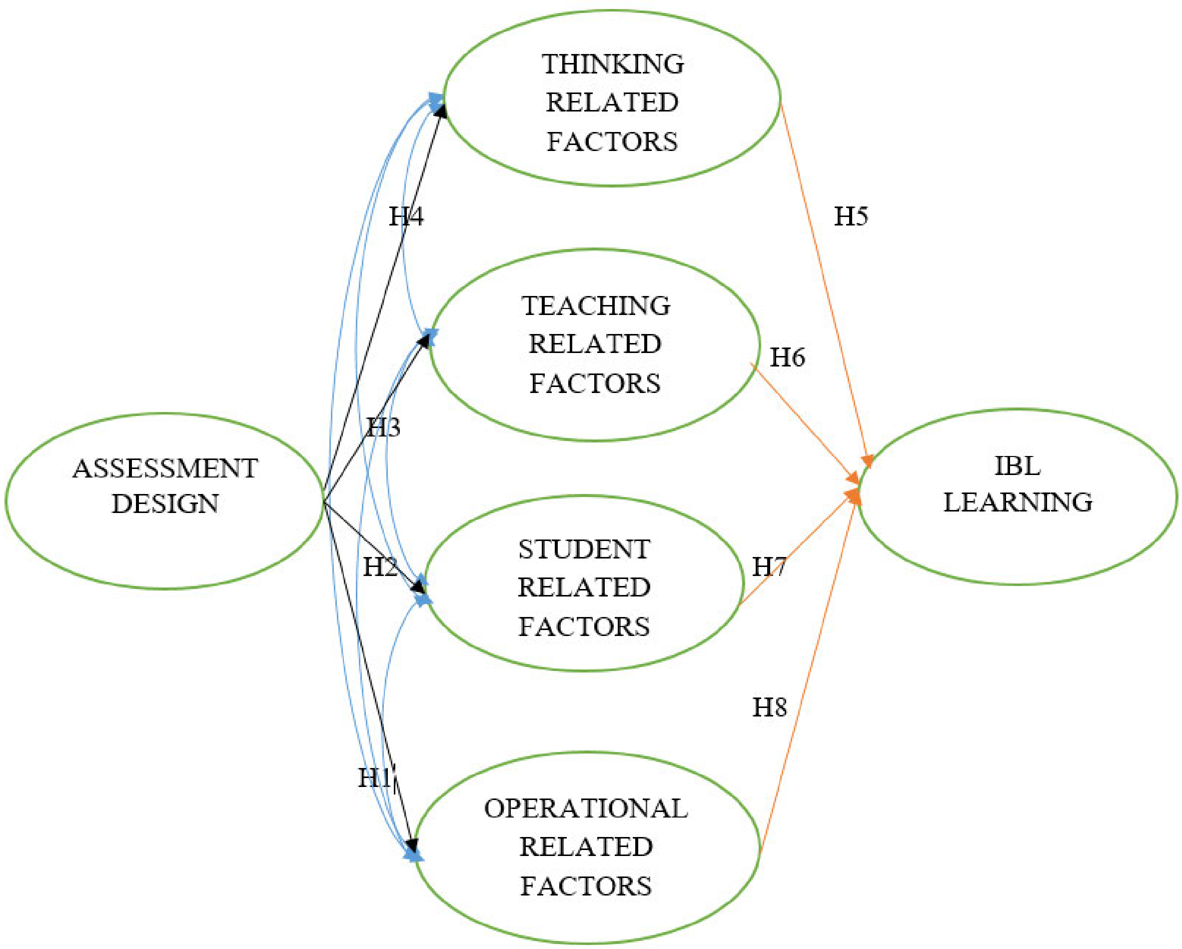

Figure 11-1: Conceptual model for effective assessment design considerations

Scientifically, a model can be viewed as a mean of characterising reality (Fellows and Liu, 2015). A model is developed to show and represent the relationship between a given set of variables in a simple and, not necessarily, in a detailed or complex manner (Hair *et al.*, 2010). In construction management, models can be in form of mathematical expressions or graphs (Fellows and Liu, 2015). In this study, a path modelling approach was adopted to express the model in a visually and comprehensible graphic form. The proposed conceptual model is shown in Figure 11-1.

The model, composed of lines and shapes, includes single-headed straight arrows, ellipses and two-way curved arrows. Ellipses represent latent variables or factors. Four lead variables (influences or factors) and the interrelationships between them are represented in the model. The interrelationships between the lead variables were shown by two types of lines where single-headed straight arrows indicate a direct influence between two variables while the curved two-way arrow lines signify co-variation among the variables.

The six variables indicated in the model are drawn from the result of the Delphi study. The basic assumption of the conceptual model was that both students and the facets of IBL pedagogy plays a lead role during assessment design in IBL pedagogy. Following the reduction in numbers of IBL facet/ indicators (based on the importance and impact on assessment design), the indicators and lead factors were further analysed for better depiction and understanding of assessment design and learning.

Table 11-1 presents the lead factors and the corresponding indicators/influences considered in developing a student survey instrument and conceptual model. The table comprises 4 lead factors and 18 corresponding indicators.

Table 11-1: Lead factors and indicators/influences

1. Thinking related factors
a. Active and participatory learning
b. Inquiry cycle – propose, critique, reflect, iterate
c. Cognitive loading/engagement
d. Inquiry skill – critical thinking, problem solving
e. Schemata construction
2. Teaching related factors
a. Inquiry activities – explore, validate, categorise
b. Instructional practice – inductive approach
3. Student related factors
a. Student-centred pedagogy
b. Group dynamics/ collaborative discussion
c. Self-directed learning
d. Construction of knowledge
e. Self-efficacy
4. Operational related factors

a.	Experiential learning/ processes
b.	IBL /integrated curriculum
c.	Surface structures/ constructivist environment
d.	Social constructivism approach
e.	Modelling practice
f.	Questions/ problem driven

11.2 HYPOTHESES

Ideas generated and tested in research are known as hypotheses (Shelke, 2019). Hypotheses are possible solutions or tentative answers to a research problem or question (Chigbu, 2019). Although a hypothesis is further subjected to validation processes, it plays an important role in a scientific inquiry as it leads to the development of new theories, resolution of anomalies and creation of useful illustrations of real world objects (Schulz and Pinkwart, 2016). A research that is based on previous studies and theories requires formulation of a hypothesis for testing (Fellows and Liu, 2015). The process of validating results from collected data with theoretical explanations is referred as hypothesis testing (Thornhill *et al.*, 2009). The hypothesised relationships between the independent and dependent variables in this study are shown in Figure 11-1.

The eight hypothesised relationships between the different variables in the conceptual model are stated below:

H1: A positive relationship is predicted between "assessment design" and "thinking related factors"

H2: A positive relationship is predicted between "assessment design" and "teaching related factors"

H3: A positive relationship is predicted between "assessment design" and "student related factors"

H4: A positive relationship is predicted between "assessment design" and "operational related factors"

H5: A positive relationship is predicted between "thinking related factors" and "IBL learning"

H6: A positive relationship is predicted between "teaching related factors" and "IBL learning"

H7: A positive relationship is predicted between "student related factors" and "IBL learning"

H8: A positive relationship is predicted between "operational related factors" and "IBL learning"

11.3 SUMMARY

The proposed conceptual model for IBL pedagogy in construction education has been presented and discussed in this chapter. The influences/constructs employed in developing the model were derived from the literature and validated by the Delphi study. The chapter has also presented the hypotheses, which are a function of the relationships between the variables. Validation of the conceptual model using results obtained from the student survey is implemented and presented in the next chapter.

CHAPTER 12

RESULTS FROM STUDENTS SURVEY AND MODEL VALIDATION

12.1 INTRODUCTION

Results from the students' survey are presented in this chapter. These results were used to validate the theoretical model developed in the previous chapter. A descriptive statistical analysis as well as validity and reliability tests were thereafter carried out. A structural equation model (SEM) was developed and validated using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).

12.2 ADMINISTRATION OF STUDENT SURVEY

12.2.1 Questionnaire development

This study adopted a structured questionnaire for data collection from undergraduate students studying construction education at six universities in South Africa. Questionnaires are one of the most popular methods of data collection (Ebert *et al.,* 2018). Questionnaires were used due to the nature of data that characterises this study, and also to reduce misunderstandings and misinterpretations in responses obtained (Colton and Covert, 2007).

The questionnaire used in the student survey was developed from extensive literature review and findings from the Delphi survey (refer to appendix 8). The questionnaire was divided into two sections. Section A provides background information while Section B allows for rating of impact and importance of the facets of IBL pedagogy on assessment design using a 5-point Likert type scale. Students were asked to indicate their level of agreement by ticking a box (Mshayisa, 2020).

12.2.2 Pilot study

It is important to conduct a pilot study to evaluate the appropriateness of the questionnaire, and identify problems associated with the data collection strategies and methods (Doody and Doody, 2015, Hertzog, 2008). The sample size of a pilot study depends on the objectives and nature of the research (Haque and Jan, 2019). A sample size of between 10 and 15 is recommended for a feasibility study (Hertzog, 2008), while a size of 30 participants is recommended for a scale development or preliminary survey (Johanson and Brooks, 2010).

Considering the purpose of the pilot study, the survey instrument was developed and reviewed by 15 students studying construction-related programmes in one of the universities. The review was carried out to evaluate the survey instrument in terms of length, clarity, readability, completeness, and general structure. The survey instrument was thereafter administered to all students studying construction-related programmes at the six participating universities. All the students showcased a good understanding of the instructions as depicted by their responses. The language was further simplified as ten of the students had limited understanding of the terms and grammar used in describing some of the facets of IBL pedagogy. The students also confirmed that that there are no intrusive or sensitive questions in the survey and that they were comfortable with the questions. One student opined that the questions are similar. The time taken to complete the questions was between 10 minutes and 25 minutes. The feedback from the students were integrated into the final questionnaire and was thereafter sent to them. Some questions were revised grammatically. Questions that were similar and have the same meanings were restructured to portray different meanings.

12.2.3 Final student survey instrument

Following the pilot study, a final version of the survey instrument was designed and developed. In designing the questionnaire, the following were taken into consideration: (i) the layout; (ii) the structure, and (iii) the organisation of questions. These factors influence the response rate during the data collection process (Root and Blismas, 2003). To improve the response rate, caution was taken in designing the layout of the student survey (Ji *et al.*, 2020). A sample of the final students' survey instrument can be found in Appendix 8. Gate keeper's letters from the participating universities (refer to Appendices 3a, 3b, 3c, 3d, 3e and 3f) coupled with ethical clearance letter from the University of KwaZulu-Natal (UKZN) was presented to relevant authorities of each participating university. Consequently, an online survey link was sent to the students.

12.2.4 Sampling

Upon establishing the data collection method, the next step was to determine the characteristics and minimum number of students who will participate in the survey. The process of determining the number of students is known as sampling. It is important to ensure that the sample size is an adequate representation of the population under study (Ramezan *et al.*, 2019).

The non-probability convenient sampling method was adopted in this study to increase the questionnaire's response rate. The questionnaires were thereafter distributed through a link sent to the phones or emails of students. The research population adopted comprises undergraduate students in construction-related programmes from six universities in South Africa. These programmes include construction management, quantity survey, building, construction studies, property development, human settlement, and civil engineering.

12.2.5 Data collection

The survey was carried out between 19 September and 21 October 2020. Relevant authorities of the selected universities were approached through emails to send the link to the questionnaire to students in construction-related programmes. The number, academic level (year) and department of the students were obtained. A follow-up was done with the heads of department or relevant lecturers through direct phone call to enhance the participation of students in the survey.

As illustrated in Table 12-1, a total of 4906 student questionnaires were sent to the six universities. However, a total of 563 completed questionnaires were received, signifying a response rate of 11.4%. According to Gill and Johnson (2010), for a population size of 5000 participants with variance (*P*) of 50%, confidence level of 99% and error margin of 5, a sample of 583 participants is recommended. Consequently, a sample of at least 560 participants is required to fulfil the requirements of SEM. Kline (2015) also recommended 200 participants as typical sample size for SEM. A sample size of between 100-150 participants could be used for "well-behaved" data and smaller models (Schumacker and Lomax, 2004). The number of responses received is therefore sufficient for analysis in this study.

Questionnaires for university 1, 2 and 4 were administered to students via email through the assistance of the lecturers from relevant departments. However, questionnaires for university 3, 5 and 6 were administered through designated personnel responsible for sending messages to students in each university. The questionnaires were sent to the emails addresses of the students.

Table 12-1: Questionnaire response rate

		Number of questionnaires distributed	Number of questionnaires received	Received in percentages for the entire population (%)	Received in percentages in each university (%)
Valid	University One	1430.00	186.00	33.00	13.00
	University Two	138.00	29.00	5.20	21.01
	University Three	40.00	8.00	1.40	20.00
	University Four	995.00	92;00	16.30	9.25
	University Five	1205.00	137.00	24.30	10.95
	University Six	1098.00	111.00	19.70	10.10
	Total	4906.00	563.00	100.00	11.48

12.3 DATA PREPARATION

12.3.1 Data screening

Data screening was carried out to prepare the data for analyses, thereby ensuring that the data is useable, reliable, and valid for testing (Hair *et al.*, 2007). Four screening procedures were followed to ensure that the data is clean and ready for use. These include identification of missing data, identification of outliers, normality and multicollinearity.

12.3.2 Identification of missing data

It is important to identify missing data in any study as the presence of missing data leads to biasness, and consequently weaken the generalisation of the results (Kwak and Kim, 2017). Missing data also lead to loss of information, reduction in statistical power and maximisation of errors (Peng *et al.*, 2006). The entire data sets are usually used for statistical procedures (Cooksey, 2020), therefore, missing data needs to be computed before being subjected to analysis. Furthermore, to compute estimates, both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) require no missing values in the data set. Otherwise, the algorithm governing the analyses of data will not initialise (McNeish, 2017). It was therefore necessary to scrutinise the data set for any missing data, and decide on whether to exclude those variables, exclude responses (especially if missing variables are more than 10% of the responses) and/or supply/impute the missing values. In this study, Microsoft Excel was used to identify missing data using the formula =COUNTBLANK (range). Considering that the 563 students responded to all the questions in the survey, no missing data was identified. This outcome can be attributed to follow-up done by the subject lecturers and university personnel responsible for sending emails to students, emphasising the need to answer all questions in the questionnaire.

12.3.3 Outliers

Outliers include unengaged responses and univariate/multivariate outliers. Unengaged responses were identified using the standard deviation functionality in Microsoft Excel coupled with visual inspection on SPSS. Univariate/multivariate outliers were identified using SPSS descriptive analysis.

a. Unengaged responses

Unengaged responses are one-type of an outlier. Data was checked for unengaged responses where respondents would provide the same response and/or respond in the same pattern throughout the questionnaire. Considering that the response rate was high enough, about 15 respondents who had responded in a similar manner were removed as unengaged responses.

b. Univariate outliers

There were a number of outliers which fell between 1.5 and 3 interquartile range (IQR) in the data. Detected variables were normalized and kept for further testing. The study conducted by Tabachnick and Fidell (2013) indicates that 1.5 IQR is probably not an accurate measure for outliers. 2.2 IQR was suggested as a more valid measure. The data had one extreme outlier in variable (ACT_1) which fell outside 3IQR and denoted by the asterisk. ACT_1 was however not removed but left to be monitored closely to assess its influence on the analysis.

12.3.4 Normality

Data was tested for normality issues, paying much attention to skewness and kurtosis. Number of theories are used to detect normality issues. Skewed data can lead to bias in the results (Guo *et al.*, 2019), while extreme kurtosis reduces variance of variables (Cain *et al.*, 2017). The data needs to be well-distributed, as poor data distributions may lead to poor prediction of variance. Any variables above the absolute value is considered irrational (Tabachnick *et al.*, 2007).

There are different views by different researchers on the acceptable values for skewness and kurtosis. Sposito *et al.* (1983) considered skewness value of 2.2 as irrational while Gonçalves *et al.* (2020) states that for larger samples above 300, the absolute value for skewness and kurtosis must range from -2 to 2, and -7 to 7, respectively. The sample size in this study is above 300, and the data was well within the indicated limits.

12.3.5 Multicollinearity

Multicollinearity occurs when two or more variables are highly linearly related (Daoud, 2017). This outcome could however undermine the statistical significance of an independent variable. Multicollinearity analysis was performed, and none of the variables were found to be highly linearly related.

12.4 OVERALL CRONBACH ALPHA (RELIABILITY TEST)

After cleaning the data, analysis was conducted with the sample size of 563 responses. Overall Cronbach Alpha was conducted to ensure the reliability of the data.

Table 12-2: Case processing summary

		N	%
Cases	Valid	563.0	100.0
	Excluded[a]	0.0	0.0
	Total	563.0	100.0

[a]Listwise deletion based on all variables in the procedure

Table 12-3: Reliability statistics

Cronbach's Alpha	N of Items
0.964	95.000

Both Table 12-2 and Table 12-3 indicate that the overall Cronbach Alpha is 0.964 among 46 items for a total number of 563 respondents. These results indicate a strong internal consistency, as supported by Bell *et al.* (2018), Creswell (2014) and Sekaran and Bougie (2016), who all argued that for data to be consistent, Cronbach Alpha must be more than 0.6.

12.5 SKEWNESS AND KURTOSIS

As previously mentioned in Section 12.4.6, any variable whose skewness and kurtosis value is above the absolute value is considered irrational. However, in this study there were a number of variables that had kurtosis values greater than 2.2. These variables were not discarded since none of them was above 5. Skewness values, on the other hand, were within the 2.2 as indicated by Sposito *et al.* (1983).

Table 12-4: Descriptive statistics of leading factors and test for skewness and kurtosis

	N		Mean	Median	Standard deviation	Skewness	Std. Error of Skewness	Kurtosis	Std. Error of Kurtosis
	Valid	Missing							
ACTPRTLN 1	563	0	3.980	4.00	.655	-.591	.103	1.385	.206
ACTPRTLN 2	563	0	3.980	4.00	1.012	-1.035	.103	.724	.206
ACTPRTLN 3	563	0	3.600	4.00	1.138	-.543	.103	-.497	.206
ACTPRTLN 4	563	0	4.080	4.00	.864	-.845	.103	.536	.206
ACTPRTLN 5	563	0	4.070	4.00	1.008	-1.222	.103	1.374	.206
COGLDG 1	563	0	3.770	4.00	.919	-.390	.103	-.394	.206
COGLDG 2	563	0	3.250	3.00	1.042	-.044	.103	-.562	.206
COGLDG 3	563	0	2.910	3.00	1.007	.169	.103	-.448	.206
COGLDG 4	563	0	2.740	3.00	.987	.218	.103	-.271	.206
COGLDG 5	563	0	3.430	3.00	1.045	-.301	.103	-.334	.206
COGLDG 6	563	0	3.360	3.00	1.059	-.168	.103	-.544	.206
CONKNW 2	563	0	4.170	4.00	.815	-1.201	.103	**2.272**	.206
CONKNW 3	563	0	4.150	4.00	.794	-.994	.103	1.673	.206
CONKNW 4	563	0	4.040	4.00	.943	-1.018	.103	1.058	.206
CONKNW 5	563	0	4.040	4.00	.843	-1.069	.103	2.000	.206
CONKNW 6	563	0	4.130	4.00	.815	-1.350	.103	**3.162**	.206
EXPLNPR_1	563	0	4.130	4.00	.784	-1.263	.103	**3.147**	.206
EXPLNPR 2	563	0	4.090	4.00	.830	-1.148	.103	**2.364**	.206
EXPLNPR 3	563	0	3.870	4.00	.821	-.805	.103	1.572	.206
EXPLNPR 4	563	0	4.120	4.00	.806	-1.006	.103	1.815	.206
EXPLNPR 5	563	0	4.170	4.00	.774	-1.224	.103	**2.896**	.206
EXPLNPR 6	563	0	4.100	4.00	.822	-1.263	.103	**2.804**	.206
IBLIC 1	563	0	4.060	4.00	.876	-1.031	.103	1.402	.206
IBLIC 2	563	0	4.150	4.00	.892	-1.200	.103	1.792	.206
IBLIC 3	563	0	3.990	4.00	.912	-.910	.103	1.081	.206
IBLIC 4	563	0	3.910	4.00	.885	-.730	.103	.836	.206
IBLIC_5	563	0	4.280	4.00	.892	-1.452	.103	**2.400**	.206
INQCYC 1	563	0	3.830	4.00	.803	-.196	.103	-.321	.206
INQCYC 2	563	0	4.150	4.00	.791	-1.108	.103	2.072	.206
INQCYC 3	563	0	3.910	4.00	.845	-.664	.103	.729	.206
INQCYC 4	563	0	4.150	4.00	.802	-.816	.103	.575	.206
INQCYC 5	563	0	4.260	4.00	.799	-1.324	.103	**2.736**	.206
INQCYC 6	563	0	4.040	4.00	.857	-1.010	.103	1.530	.206
INQSKL 1	563	0	4.180	4.00	.837	-.925	.103	.941	.206
INQSKL 2	563	0	4.180	4.00	.895	-1.387	.103	2.426	.206
INQSKL 3	563	0	4.060	4.00	.895	-1.084	.103	1.636	.206
INQSKL_4	563	0	4.280	4.00	.799	-1.296	.103	**2.578**	.206
INSTRPR 1	563	0	4.050	4.00	.833	-.795	.103	.675	.206
INSTRPR 2	563	0	4.090	4.00	.803	-.959	.103	1.545	.206
INSTRPR 3	563	0	4.110	4.00	.921	-1.316	.103	1.971	.206
INSTRPR 4	563	0	4.300	4.00	.861	-1.533	.103	**2.823**	.206
MODPR 1	563	0	4.020	4.00	.919	-.915	.103	.661	.206

MODPR 2	563	0	4.190	4.00	.901	-1.437	.103	**2.500**	.206
MODPR 3	563	0	4.240	4.00	.847	-1.386	.103	**2.426**	.206
MODPR 4	563	0	4.100	4.00	.917	-1.357	.103	2.241	.206
MODPR 5	563	0	4.270	4.00	.928	-1.521	.103	**2.299**	.206
MODPR 6	563	0	4.150	4.00	.930	-1.263	.103	1.617	.206
QSTPR 1	563	0	3.880	4.00	.933	-.674	.103	.258	.206
QSTPR 2	563	0	3.900	4.00	.910	-.851	.103	.849	.206
QSTPR 3	563	0	4.010	4.00	.859	-.821	.103	.748	.206
QSTPR 4	563	0	4.120	4.000	.843	-1.222	.103	**2.410**	.206
QSTPR_5	563	0	4.000	4.000	.862	-.842	.103	.932	.206
SCHCON 1	563	0	4.350	5.000	.893	-1.578	.103	**2.528**	.206
SCHCON 2	563	0	4.220	4.000	.932	-1.440	.103	2.182	.206
SCHCON 3	563	0	4.150	4.000	.882	-1.350	.103	**2.476**	.206
SCHCON 4	563	0	4.140	4.000	.885	-1.160	.103	1.678	.206
SCHCON 5	563	0	4.320	5.000	.920	-1.649	.103	**2.856**	.206
SLFDIR 1	563	0	3.660	4.000	.997	-.709	.103	.194	.206
SLFDIR 2	563	0	3.600	4.000	1.042	-.628	.103	-.081	.206
SLFDIR 3	563	0	3.870	4.000	.946	-.997	.103	1.113	.206
SLFDIR 4	563	0	3.330	4.000	1.223	-.394	.103	-.844	.206
SLFEFF 1	563	0	3.900	4.000	.912	-.873	.103	.997	.206
SLFEFF 2	563	0	4.180	4.000	.835	-1.298	.103	**2.530**	.206
SLFEFF 3	563	0	4.090	4.000	.831	-1.029	.103	1.645	.206
SLFEFF 4	563	0	4.150	4.000	.816	-1.073	.103	1.872	.206
SLFEFF 5	563	0	4.120	4.000	.900	-1.169	.103	1.647	.206
SLFEFF 6	563	0	4.080	4.00	.868	-1.007	.103	1.245	.206
SOCCON 3	563	0	3.950	4.000	.895	-.924	.103	1.135	.206
SOCCON 4	563	0	4.060	4.000	.879	-.963	.103	1.054	.206
SOCCON 5	563	0	3.910	4.000	.923	-.993	.103	1.246	.206
SURSTR 1	563	0	3.920	4.000	.945	-.755	.103	.427	.206
SURSTR 2	563	0	3.850	4.000	.976	-.873	.103	.576	.206
SURSTR 3	563	0	3.730	4.000	.969	-.683	.103	.174	.206
SURSTR 4	563	0	3.730	4.000	.983	-.769	.103	.263	.206
SURSTR 5	563	0	3.720	4.000	.953	-.624	.103	.001	.206

12.6 DESCRIPTIVE ANALYSIS

This section presents the demographic information of the students' survey. The analysis was carried using Statistical Package for Social Science software (IBM SPSS Statistics 27.0). The descriptive statistical analysis implemented in this study include mean and standard deviation as well as percentages of respondents' profile including gender, programme and year of study. These analyses allow for a check on the fairness and exclusion of bias in the responses received.

12.6.1 Respondents background information

The gender profile of the respondents is presented in Table 12-5. The table shows that 53.3% of the students are male while 46.7% are female. This aligns with the total gender composition of the study population, showcasing a good representation thereof. Moreover, the distribution between the male and female genders can be regarded as “near equal”, indicating no gender bias.

Table 12-5: Gender composition

		Frequency	Percent
Valid	Male	300.0	53.3
	Female	263.0	46.7
	Total	563.0	100.0

Table 12-6 indicates the distribution of the sample using the years of study. The table shows that the 1st year students are the largest group in the study population with a percentage of 43.7%, followed closely by the 2nd year students with a percentage of 36.60%, while the 3rd and 4th year students have a percentage of 16.3% and 3.4% respectively. The 1st year students are usually the largest group of students in South African universities due to high intake of students. Moreover, some of the students do repeat this level. Progression to subsequent levels of study is also rarely 100% as some students drop out or fail, and do not proceed to next level of study, consequently, resulting in a decrease of number of students in subsequent levels. The 4th year students are the smallest group as only three of the selected universities have the 4th level of study. The 4th year students typically study towards a Bachelor of Technology (B-Tech) or Honours degree.

Table 12-6: Year of study

		Frequency	Percent (%)
Valid	1st Year	246.0	43.7
	2nd Year	206.0	36.6
	3rd Year	92.0	16.3
	4th Year	19.0	3.4
	Total	563.0	100.0

Table 12-7 outlines the construction education programmes that were involved in this study. The table shows that 45.3% of students are from the department of Civil Engineering while 33.4 % are from building/construction management. Students from the departments of quantity surveying, property studies and human settlement constitute 15.8%, 2.1% and 3.4% respectively. Majority of the students are from the departments of civil engineering and building because a large number of students often characterises these programmes in the 1st and 2nd years of study.

Table 12-7: Programmes of study

		Frequency	Percent
Valid	Building Construction/Construction Management	188.0	33.4
	Civil Engineering	255.0	45.3
	Quantity Surveying	89.0	15.8
	Property Studies	12.0	2.1
	Human Settlement	19.0	3.4
	Total	563.0	100.0

Table 12-8: Institution

		Frequency	Percent
Valid	Institution One	186.0	33.0
	Institution Two	29.0	5.2
	Institution Three	8.0	1.4
	Institution Four	92.0	16.3
	Institution Five	137.0	24.3
	Institution Six	111.0	19.7
	Total	563.0	100.0

Table 12-8 indicates that 4 out of the 6 institutions that participated in this study were fairly represented within the scale of responses. The four ranged between 20% to 33% representation (institution one: 33%, institution five: 24%, institution four: 16% and institution six: 20%). The remaining two institutions were not very well-represented (institution two: 5% and institution three: 1%).

12.6 2 Cross-tabulations (comparison)

The relationships between the variables – year of study, gender, programme and year of study were analysed using cross-tabulation analysis – an important step in studying the relationships between variables (Momeni et al., 2018). Table 12-9 shows that, at every academic level except for year 3, more male students participated in this study. The table also indicates that year 1 students represent 43.7% of the respondents and the year 2 students are 36.6% of the respondents. This outcome indicates that 80.3% of the respondents are year 1 and year 2 students. This is due to the large classes of year 1 and year 2 students in most universities.

Table 12-9: Cross tabulation of year of study and gender

Year		Gender		Total
		Male	Female	
1st Year	Count	130.0	116.0	246.0
	% within Year	52.8%	47.2%	100.0%
	% within Gender	43.3%	44.1%	43.7%

2nd Year	Count	117.0	89.0	206.0
	% within Year	56.8%	43.2%	100.0%
	% within Gender	39.0%	33.8%	36.6%
3rd Year	Count	40.0	52.0	92.0
	% within Year	43.5%	56.5%	100.0%
	% within Gender	13.3%	19.8%	16.3%
4th Year	Count	13.0	6.0	19.0
	% within Year	68.4%	31.6%	100.0%
	% within Gender	4.3%	2.3%	3.4%
Total	Count	300.0	263.0	563.0
	% within Year	53.3%	46.7%	100.0%
	% within Gender	100.0%	100.0%	100.0%

Table 12-9 also indicates that, not only was the gender distributed fairly, but also the programme of study. Percentages above indicate 33.3% (male) to 33.5% (female) in the Building Construction/Construction Management, 46.0% (male) to 45.0% (female) in Civil Engineering, 14.0% (male) to 18.0% (female) in Quantity Surveying, 3.0% (male) to 2.0% (female) in Property Studies, and 4.0% (male) to 3.0% (female) in Human Settlement.

Table 12-10: Cross tabulation of programme and year of study

Programme		Year				Total
		Year 1	Year 2	Year 3	Year 4	
Building Construction/ Construction Management	Count	72.0	65.0	50.0	1.0	188.0
	% within Programme	38.3%	34.6%	26.6%	0.5%	100.0%
	% within Year	29.3%	31.6%	54.3%	5.3%	33.4%
Civil Engineering	Count	105.0	104.0	30.0	16.0	255.0
	% within Programme	41.2%	40.8%	11.8%	6.3%	100.0%
	% within Year	42.7%	50.5%	32.6%	84.2%	45.3%
Quantity Surveying	Count	55.0	28,0	4.0	2.0	89.0
	% within Programme	61.8%	31.5%	4.5%	2.2%	100.0%
	% within Year	22.4%	13.6%	4.3%	10.5%	15.8%
Property Studies	Count	6.0	2.0	4.0	0.0	12.0
	% within Programme	50.0%	16.7%	33.3%	0.0%	100.0%
	% within Year	2.4%	1.0%	4.3%	0.0%	2.1%
Human Settlement	Count	8.0	7.7	4.0	0.0	19.0
	% within Programme	42.1%	36.8%	21.1%	0.0%	100.0%
	% within Year	3.3%	3.4%	4.3%	0.0%	3.4%
Total	Count	246.0	206.0	92.0	19.0	563.0

	% within Programme	43.7%	36.6%	16.3%	3.4%	100.0%
	% within Year	100.0%	100.0%	100.0%	100.0%	100.0%

Table 12-10 shows the cross-tabulation of programme of study with year of study. The sample consisted of only 1st to 4th year building construction/construction management students, 1st to 4th year civil engineering students as well as 1st to 3rd year property studies and human settlement students.

The human settlement programme is offered at only one of the six participating universities. The university does not offer an honours degree in human settlement, therefore no 4th year human settlement students participated in this study. The distribution across the years of study is therefore low (2.4%, 1.0%, 4.3% and 0.0%). The participating universities do not have 4th year students in the property studies programme. This is because the 4th year offers a specialisation in either quantity surveying or construction management. The distribution of building construction/construction management between the 1st and 2nd year is balanced (38.3% and 34.6% respectively). The distribution for civil engineering is also balanced between the 1st and 2nd years of study (41.2 and 40.8%). Construction management/quantity surveying has a smaller number of 3rd and 4th year students (4.5% and 2.2% respectively) compared to 1st and 2nd year students (61.8% and 31.5% respectively).

Considering the need to identify the relationship between assessment and learning in IBL pedagogy in this study, the opinion of students on the assessment design in construction related programmes is not influenced by the distribution of the students across the year of study and programme. Therefore, the sample adopted in this study adequately and justly represents the population of study.

12.7 FACTOR ANALYSIS

To conduct an analysis on the correlation matrix, a number of issues were considered. According to Tabachnick and Fidell (2013), it is essential to examine the correlation matrix of the measured variables, and if no correlation is found in excess of .30 in absolute value, there will be no need to analyse the matrix.

This study applied two types of factor analysis to test the hypothesis. These analyses include exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).

12.7.1 EFA

Researchers often have no idea whether or not items or variables have distinct patterns. Factor analysis can be implemented in an exploratory way to reveal patterns among the inter-relationships of items (Matsunaga, 2010). According to Yong and Pearce (2013), exploratory factor analysis is a statistical technique that is used to reduce data to a smaller set of summary variables and to explore the underlying theoretical structure of the phenomena. It is used to identify the structure of the relationship between the variable and the respondent.

According to Maskey *et al.* (2018), the following can be tested using exploratory factory analysis:

a. Adequacy: This is used to measure the appropriateness of the data for factor analysis (0.80 or above is the ideal figure while the worst would be 0.50 and below;
b. Convergent validity: This is used to measure how well the data correlate;
c. Discriminant validity: This measures the difference between the factors/groupings; and
d. Reliability: This measures consistency. The lower threshold for reliability is 0.60 while Cronbach Alpha ≥ 0.70 confirms reliability.

A dimension reduction process was implemented in this study to reduce the data into a smaller set of variables. The dimension reduction factor analysis process involves deciding on descriptive, extraction, rotation, scores and options.

12.7.2 Kaiser-Meier-Olkin and Bartlett's test of sphericity

Kaiser-Meier-Olkin (KMO) measure of sampling and Bartlett's tests are essential to test if the data collected from the student survey is appropriate to conduct factor analysis. Kaiser and Rice (1974) indicated that factorability of a matrix can be considered if it is above 0.50. The KMO measure of sampling adequacy is indicated in Table 12-11 (*ibid*):

Table 12-11: Kaiser-Meyer-Olkin (KMO)

Marvellous	.90s
Meritorious	.80s
Middling	.70s
Mediocre	.60s
Miserable	.50s
Unacceptable	Below .50

For this study the KMO measure of sampling adequacy was 0.922 as shown in Table 12-12 below, and therefore indicating a marvelous matrix.

Table 12-12: KMO and Bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.922
Bartlett's Test of Sphericity	Approx. Chi-Square	31740.058
	Df	2850.000
	Sig.	0.000

It was also essential to consider individual items and their contributions to the relationships in the matrix, and potential solutions. Brzoska and Razum (2010) suggests that variables that exhibit a correlation less than 0.3 with other variables must be deleted. Values between 0 and 0.3 indicate a weak positive (poor) linear relationship.

12.7.3 Adequacy test

The extracted communalities and total variance results that depict the adequacy of tests are presented in **Table 12-13**.

Table 12-13: Total variance

Factor	Extraction sums of squared loadings			Rotation sums of squared loadings[a]
	Total	% of Variance	Cumulative %	Total
1	21.102	28.137	28.137	14.605
2	3.636	4.848	32.985	14.990
3	3.262	4.349	37.334	12.033
4	3.545	4.726	42.060	11.370
5	1.441	1.921	43.981	7.319
6	1.825	2.433	46.414	12.552
7	1.772	2.363	48.777	6.739
8	1.578	2.104	50.881	3.387
9	1.270	1.694	52.575	14.550
10	1.286	1.715	54.289	6.759
11	1.160	1.547	55.836	11.765
12	1.162	1.550	57.386	8.014
13	1.003	1.338	58.724	7.781
14	.812	1.083	59.807	8.240
15	.795	1.060	60.867	10.820

[a]When factors are correlated, sums of squared loadings cannot be added to obtain a total variance;
Extraction method: Maximum likelihood

The Total Variance Explained (TVE) must be greater than 50%. However, values above 60% are typically preferred. The TVE obtained in this study is 60.8% and can therefore be regarded as valid and acceptable. Whilst the extraction defaults to eigenvalues greater than 1, the data had to be compressed to a fixed number of 15 factors as other factors do not make any significant contribution to the analysis. Factors with less than 0.4 were suppressed, as recommended by Pituch and Stevens (2015) to produce meaningful results.

12.7.4 Extraction process and rotation method

EFA adopts a more than one method for factor extraction. These include principal components, unweighted least squares, generalised least squares, maximum likelihood, principal axis, alpha and image factoring techniques (Zulu and Haupt, 2019).

In this study, Maximum Likelihood (ML) and Promax with Kaiser normalisation rotation method was used for extraction purposes. This extraction method was preferred because it maximises differences between factors and provide model fit estimates. It is also compatible with Amos, which will be used for the CFA and structural model. Theobald and Wuttke (2008) argue that the ML extraction method enables simplification of the factor structure, and ultimately fosters better interpretation.

12.7.5 Pattern matrix

The ML extraction method produced a clean structure upon discarding some variables. INQSL was dropped as it had average variance extracted (AVE) score of 0.386 which is below the marginally accepted threshold of 0.40. GRPD and STPD were also dropped as they share the same loading factor with INQAC. GRPD and STPD both fall under the construct – “Student”, whilst INQAC falls under “Teaching”. INQAC was retained as it is the only construct under “Teaching” besides INSTR. “Student”. However, three other factors. SOC_1, SOC_2 and CONK_1 were dropped as they had factors below the accepted threshold of 0.50. Table 12-14 shows the pattern matrix of the retained factors. See appendix 9 for the key.

Table 12-14: Pattern matrix of retained factors

Pattern matrix[a]															
	Factor														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MOD 3	.963														
MOD 5	.854														
MOD 2	.840														
MOD 1	.744														
MOD 6	.725														
MOD 4	.724														
SLFE 4		.885													

SLFE 5		.865													
SLFE 6		.811													
SLFE 2		.782													
SLFE 3		.719													
SLFE 1		.561													
INQC 4			.840												
INQC 3			.756												
INQC 2			.739												
INQC 5			.717												
INQC_6			.712												
INQC 1			.610												
SCHC 3				.888											
SCHC 2				.788											
SCHC 4				.780											
SCHC 1				.743											
SCHC 5				.695											
SUR 4					.880										
SUR 5					.868										
SUR 3					.800										
SUR 2					.691										
SUR 1					.520										
IBLIC 2						.860									
IBLIC 5						.813									
IBLIC 3						.800									
IBLIC 4						.754									
IBLIC 1						.752									
EXPL 4							.788								
EXPL 5							.772								
EXPL 6							.685								
EXPL 3							.540								
EXPL 2							.512								
EXPL 1							.483								
COGL 6								.744							
COGL 3								.709							
COGL 5								.705							
COGL 4								.686							
COGL 2								.590							
COGL 1								.479							
INQAC 3									.789						
INQAC_2									.740						
INQAC 1									.739						
INQAC 4									.720						
INQAC 5									.545						
QST 3										.853					
QST 1										.738					

QST 2										.688					
QST 5										.643					
QST 4										.461					
CONK 5											.905				
CONK 6											.880				
CONK 4											.850				
CONK 3											.596				
CONK 2											.518				
SLFD 3												.817			
SLFD_4												.740			
SLFD 2												.689			
SLFD 1												.496			
ACT 1													.924		
ACT 2													.788		
ACT 5													.779		
ACT 3													.705		
ACT 4													.548		
INSTR 2														.847	
INSTR 1														.755	
INSTR 3														.665	
INSTR 4														.570	
SOC 4															.806
SOC 5															.727
SOC 3															.530

Extraction method: Maximum likelihood; Rotation Method: Promax with Kaiser Normalisation
[a]Rotation converged in 8 iterations

12.7.6 Reliability and validity tests

The reliability and validity for loaded items was assessed. This was done to further establish if the factors are high enough and meet the acceptable threshold. According to Chinomona (2015), convergent validity exists when the item loads on their constructs without cross-loading at factors 0.50 after factor analysis.

AVE and composite reliability (CR) were further calculated using Microsoft Excel formula, and all constructs, except for “Active Participatory Learning” which fell below the marginally acceptable construct of 0.40 (Table 12-15). Other constructs fell above 0.4, as indicated in Table 12-15 (See appendix 9 for the key), especially when other validity measures were met (*ibid*). Alpha values in Table 12-15 range between 0.691 and 0.933, therefore indicating an acceptable to very good level of reliability. A general accepted rule is that an α value of 0.6 – 0.7 indicates an “acceptable” level of reliability, and an α value of 0.8 or greater indicates a “very good” level of reliability. It is important to note that values higher than 0.95 may not be necessarily good, as it might be an indication of redundancy (Streiner, 2003). None of the values are lower than 0.6 or higher than 0.95.

Table 12-15: Results of AVE, CR and Alpha analysis

N=563		Mean	Std. Deviation	Communalities	Factor Loading	AVE	CR	Alpha
THINKING RELATED FACTORS	Active and participatory learning							
	ACT 1	3.980	.689	.777	.924	0.383	0.743	0.691
	ACT 2	3.980	1.012	.610	.487			
	ACT 3	3.600	1.138	.336	.548			
	ACT 4	4.080	.864	.469	.548			
	ACT 5	4.070	1.008	.528	.478			
	Inquiry cycle							
	INQC 1	3.830	.803	.440	.610	0.536	0.873	0.891
	INQC 2	4.150	.791	.609	.739			
	INQC 3	3.910	.845	.634	.756			
	INQC 4	4.150	.802	.668	.840			
	INQC 5	4.260	.799	.710	.717			
	INQC 6	4.040	.857	.634	.712			
	Cognitive loading							
	COGL 1	3.770	.919	.338	.479	0.434	0.818	0.822
	COGL_2	3.250	1.042	.422	.590			
	COGL 3	2.910	1.007	.606	.709			
	COGL 4	2.740	.987	.546	.686			
	COGL 5	3.430	1.045	.528	.705			
	COGL 6	3.360	1.059	.564	.744			
	Schemata construction							
	SCHC 1	4.350	.893	.613	.743	0.611	0.886	0.906
	SCHC 2	4.220	.932	.687	.788			
	SCHC 3	4.150	.882	.843	.888			
	SCHC 4	4.140	.885	.690	.780			
	SCHC_5	4.320	.920	.572	.695			
TEACHING RELATED FACTORS	Inquiry activities							
	INQAC 1	4.010	.874	.548	.739	0.506	0.835	0.822
	INQAC 2	3.940	.964	.533	.740			
	INQAC 3	4.250	.831	.625	.789			
	INQAC 4	4.000	.906	.550	.720			
	INQAC 5	3.740	1.021	.341	.545			
	Instructional practice							
	INSTR 1	4.050	.833	.493	.755	0.514	0.805	0.832
	INSTR 2	4.090	.803	.751	.847			
	INSTR_3	4.110	.921	.694	.665			
	INSTR 4	4.300	.861	.522	.570			
S	Self-directed learning							

	SLFD 1	3.660	.997	.464	.496	0.484	0.785	0.805
	SLFD 2	3.600	1.042	.575	.689			
	SLFD 3	3.870	.946	.703	.817			
	SLFD 4	3.330	1.223	.581	.740			
	Construction of knowledge							
	CONK 2	4.170	.815	.538	.518	0.588	0.872	0.898
	CONK 3	4.150	.794	.571	.596			
	CONK 4	4.040	.943	.649	.850			
	CONK 5	4.040	.843	.846	.905			
	CONK_6	4.130	.815	.802	.880			
	Self-efficacy							
	SLFE 1	3.900	.912	.500	.561	0.605	0.900	0.917
	SLFE 2	4.180	.835	.682	.782			
	SLFE 3	4.090	.831	.701	.719			
	SLFE 4	4.150	.816	.765	.885			
	SLFE 5	4.120	.900	.719	.865			
	SLFE 6	4.080	.868	.707	.811			
OPERATIONAL RELATED FACTORS	Experiential learning							
	EXPL 1	4.130	.784	.594	.483	0.412	0.802	0.890
	EXPL 2	4.090	.830	.596	.512			
	EXPL 3	3.870	.821	.496	.540			
	EXPL 4	4.120	.806	.661	.788			
	EXPL 5	4.170	.774	.702	.772			
	EXPL 6	4.100	.822	.589	.685			
	Iblic							
	IBLIC 1	4.060	.876	.692	.752	0.635	0.897	0.907
	IBLIC 2	4.150	.892	.788	.860			
	IBLIC 3	3.990	.912	.652	.800			
	IBLIC 4	3.910	.885	.683	.754			
	IBLIC 5	4.280	.892	.712	.813			
	Surface structure							
	SUR 1	3.920	.945	.540	.520	0.583	0.871	0.899
	SUR 2	3.850	.976	.584	.691			
	SUR 3	3.730	.969	.727	.800			
	SUR 4	3.730	.983	.782	.880			
	SUR 5	3.720	.953	.739	.868			
	Social constructivism							
	SOC 3	3.950	.895	.537	.530	0.486	0.734	0.835
	SOC 4	4.060	.879	.744	.806			
	SOC_5	3.910	.923	.686	.727			
	Modelling practice							
	MOD 1	4.020	.919	.619	.744	0.660	0.920	0.933
	MOD 2	4.190	.901	.761	.840			
	MOD 3	4.240	.847	.827	.963			
	MOD 4	4.100	.917	.691	.724			

	MOD 5	4.270	.928	.785	.854			
	MOD 6	4.150	.930	.663	.725			
	Questions							
	QST 1	3.880	.933	.598	.738	0.474	0.813	0.880
	QST 2	3.900	.910	.661	.688			
	QST 3	4.010	.859	.723	.853			
	QST 4	4.120	.843	.557	.461			
	QST 5	4.000	.862	.581	.643			

12.8 CFA

CFA was carried out after the EFA to further evaluate the relationship between the survey data and the proposed conceptual model. CFA is a statistical technique used to verify the factor structure of a set of observed variables (Harinarain and Haupt, 2014). The analysis allows a researcher to test the hypothesis on whether there is a relationship between observed variables and their underlying latent constructs.

Table 12-16: CFA reliability and validity

N=563		Factor Loading	AVE	CR	Alpha
THINKING RELATED FACTORS					
	ACT 1	.924	0.399	0.750	0.691
	ACT 2	.788			
	ACT 3	.705			
	ACT 4	.548			
	ACT 5	.779			
	INQC 1	.610	0.581	0.892	0.891
	INQC 2	.739			
	INQC 3	.756			
	INQC 4	.840			
	INQC 5	.717			
	INQC 6	.712			
	COGL 1	.479	0.439	0.823	0.822
	COGL 2	.590			
	COGL 3	.709			
	COGL_4	.686			
	COGL 5	.705			
	COGL 6	.744			

	SCHC 1	.743	0.664	0.908	0.906
	SCHC 2	.788			
	SCHC 3	.888			
	SCHC 4	.780			
	SCHC 5	.695			
TEACHING RELATED FACTORS	INQAC 1	.739	0.495	0.829	0.822
	INQAC 2	.740			
	INQAC 3	.789			
	INQAC 4	.720			
	INQAC 5	.545			
	INSTR 1	.755	0.565	0.837	0.832
	INSTR 2	.847			
	INSTR 3	.665			
	INSTR 4	.570			
STUDENT RELATED FACTORS	SLFD 1	.496	0.529	0.817	0.805
	SLFD 2	.689			
	SLFD 3	.817			
	SLFD 4	.740			
	CONK 2	.518	0.641	0.898	0.898
	CONK_3	.596			
	CONK 4	.850			
	CONK 5	.905			
	CONK 6	.880			
	SLFE 1	.561	0.655	0.919	0.917
	SLFE 2	.782			
	SLFE_3	.719			
	SLFE 4	.885			
	SLFE 5	.865			
	SLFE 6	.811			
OPERATIONAL	EXPL 1	.483	0.569	0.887	0.890

	EXPL 2	.512			
	EXPL 3	.540			
	EXPL 4	.788			
	EXPL 5	.772			
	EXPL 6	.685			
	IBLIC_1	.752	0.559	0.835	0.907
	IBLIC 2	.860			
	IBLIC 3	.800			
	IBLIC 4	.754			
	IBLIC 5	.813			
	SUR 1	.520	0.642	0.899	0.899
	SUR_2	.691			
	SUR 3	.800			
	SUR 4	.880			
	SUR 5	.868			
	SOC 3	.530	0.635	0.734	0.838
	SOC 4	.806			
	SOC_5	.727			
	MOD 1	.744	0.702	0.934	0.933
	MOD 2	.840			
	MOD 3	.963			
	MOD 4	.724			
	MOD 5	.854			
	MOD_6	.725			
	QST 1	.738	0.476	0.819	0.880
	QST 2	.688			
	QST 3	.853			
	QST 4	.461			
	QST 5	.643			

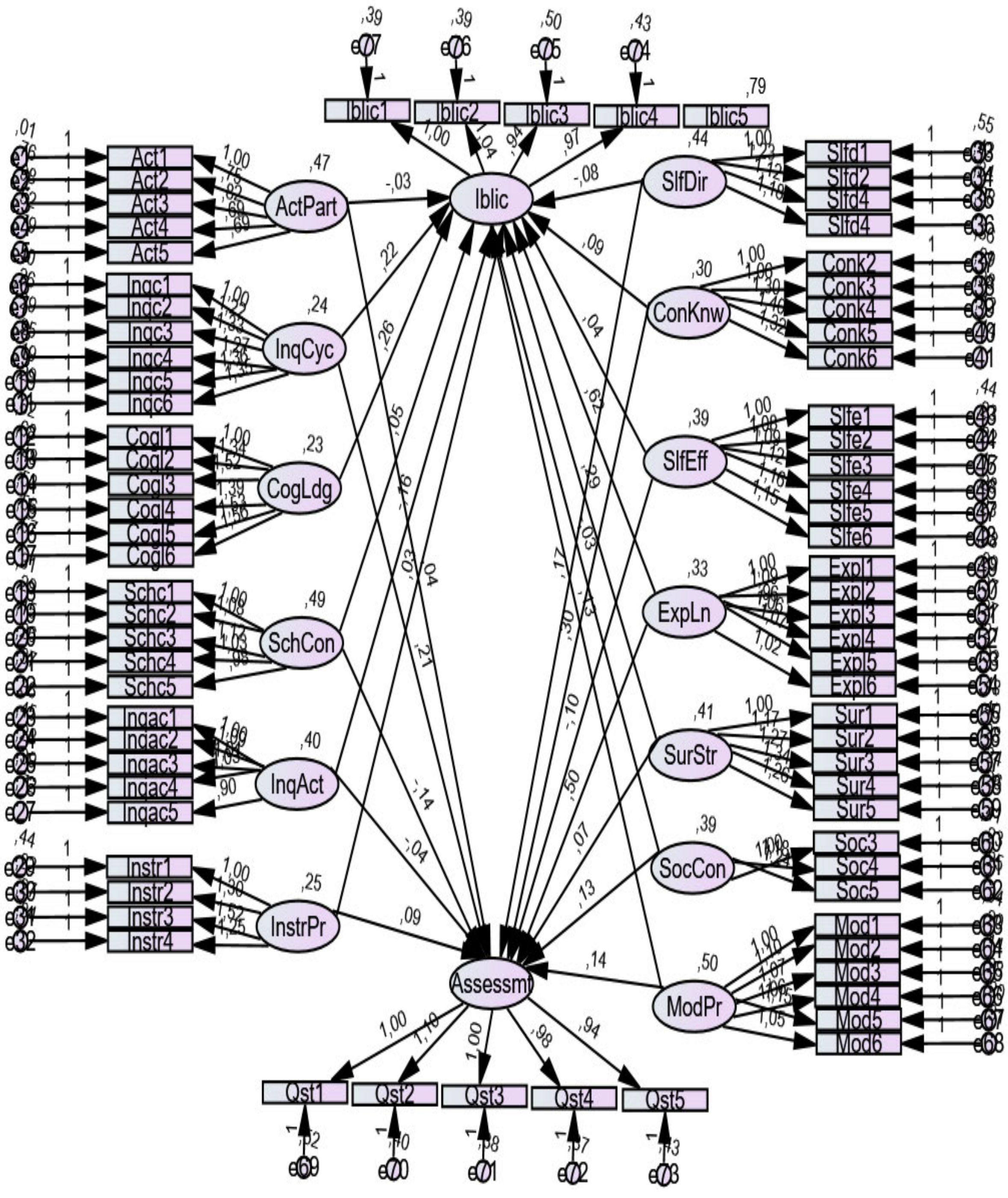

Figure 12-1: Initial conceptual assessment design model

From Table 12-16, there is no significant difference between the values of CR and AVE obtained via CFA and those obtained via EFA (refer to Table 12-15). Instead, the factors increased slightly, except for INQACT which dropped slightly. ACTPART was dropped as it remained below the marginally accepted threshold. ASSESSMT (QST), COGLDG and INQACT fell below the 0.5

accepted threshold. These variables were however kept and observed since their CR fell well over 0.8. To improve validity, INQAC_5, QST_4, COGL_1, 2 and 5 were removed. The AVE for ASSESSMT (QST), COGLDG and INQACT improved from 0.476, 0.439 and 0.495 to 0.512, 0.520 and 0.542 respectively. As depicted in Table 12-17, there are no more validity concerns in the model.

Table 12-17: Improved results from CFA reliability and validity tests

	CR	AVE	MSV	MaxR(H)
SlfDir	0.817	0.529	0.050	0.830
InqCyc	0.892	0.581	0.027	0.900
ExpLn	0.888	0.570	0.100	0.893
SurStr	0.899	0.642	0.068	0.911
CogLdg	0.761	0.520	0.021	0.786
SocCon	0.839	0.636	0.042	0.854
SchCon	0.907	0.663	0.045	0.918
ConKnw	0.898	0.640	0.124	0.924
ModPr	0.934	0.702	0.044	0.939
InqAct	0.825	0.542	0.007	0.829
SlfEff	0.919	0.655	0.059	0.925
InstrPr	0.837	0.565	0.011	0.856
Iblic	0.868	0.568	0.100	0.871
Assessmt	0.806	0.512	0.124	0.816

CR: composite reliability; AVE: average variance extracted; MSV: maximum shared variance; MaxR(H): maximum reliability

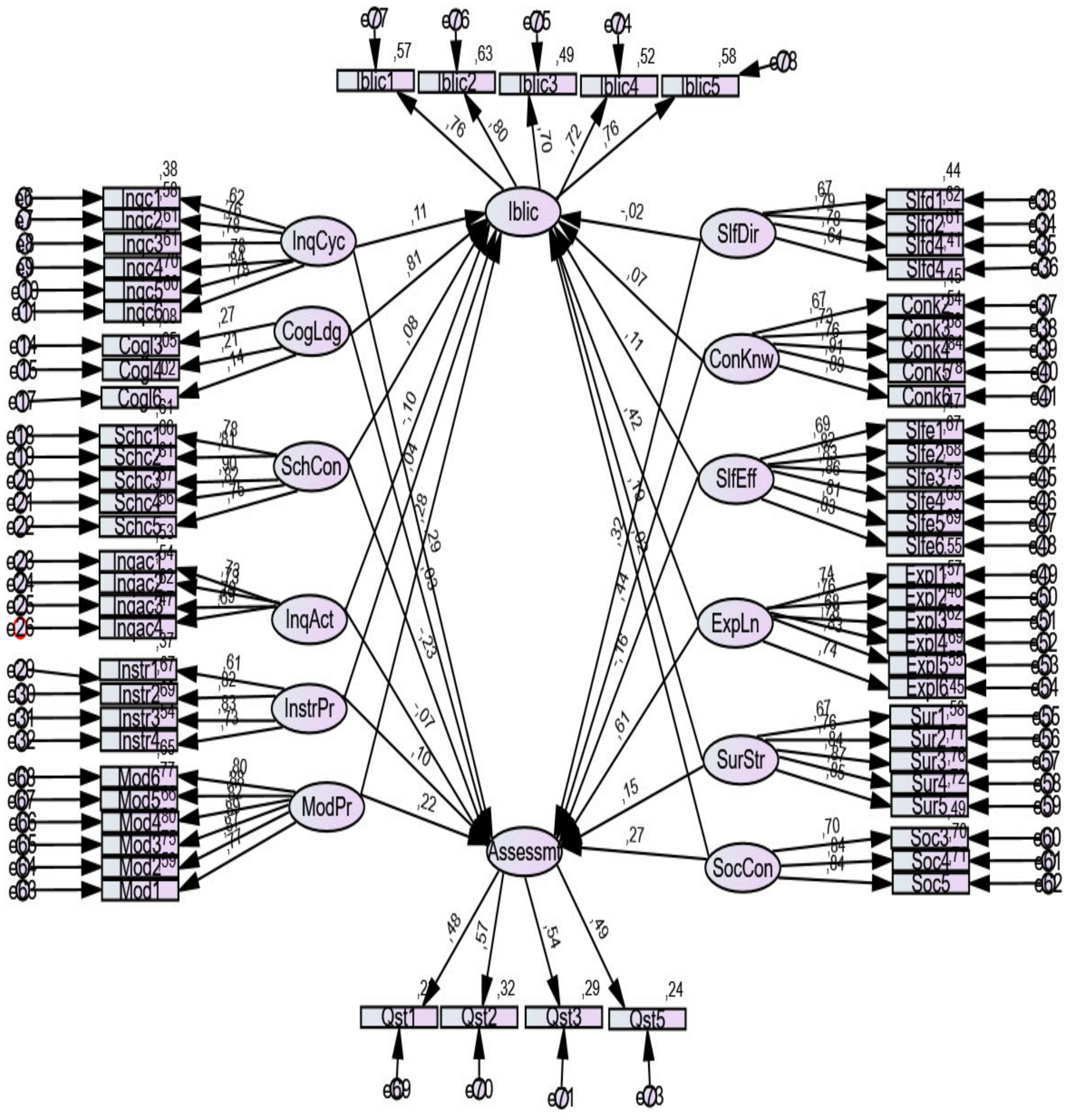

Figure 12-2: The modified conceptual assessment design model

12.9 MODEL FIT INDICES

An important step in model development is determination of the model fit of the structural model to demonstrate sufficient exploration of alternative models. Methods for assessing model fit include evaluating modification indices, residuals, and standard fit measures using techniques like comparative fit index (CFI), root mean-square error of approximation (RMSEA), goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI) and comparative fit index (CFI). Table 12-18 presents the criteria for assessing model fit. It must be noted that a model may not necessarily be the best fit, but one that is just good enough.

Table 12-18: Model fit indices and the recommended cut-offs

Measure	Name	Description	Cut-off for good fit	References
X^2	Model Chi-Square	Assess overall fit and the discrepancy between the sample and fitted covariance matrices. Sensitive to sample size	p-value >0.05	Harinarain and Haupt (2016); Hooper *et al.* (2008); Hsu *et al.* (2012); Zulu and Haupt (2019)
(A)GF1	(Adjusted) Goodness of Fit	GFI is the proportion of variance accounted for by the estimated population covariance. Analogous to R^2. AGFI favors parsimony.	GFI ≥ 0.95 AGFI ≥ 0.90	Ainur *et al.* (2017); Zulu and Haupt (2019)
(N)NFI TLI	(Non) Normed-Fit index Tucker Lewis index	An NFI of 0.95 Indicates the model of interest improves the fit by 95% relative to the null model. NNFI is preferable for smaller samples. Sometimes the NNFI is called the Tucker Lewis index (TLI)	NFI ≥ 0.95 NNFI ≥ 0.95	Harinarain, (2013); Harinarain and Haupt (2016); Hsu *et al.* (2012); Zulu and Haupt (2019)
CFI	Comparative Fit index	A revised form of NFI. Not very sensitive to sample size. Compares the fit of a target model to the fit of an independent, or null model	CFI ≥ 0.90	Harinarain, (2013); Harinarain and Haupt (2016); Hooper *et al.* (2008); Hsu *et al.* (2012); Zulu and Haupt (2019)
RMSEA	Root Mean Square Error of Approximation	A parsimony-adjusted index. Values closer to 0 represent a good fit.	RMSEA < 0.08	Harinarain, (2013); Harinarain and Haupt (2016); Hooper *et al.* (2008); Hsu *et al.* (2012); Zulu and Haupt (2019)
(S)RMR	Standardised Root Mean-	The square-root of the difference between the residuals of the sample	SRMR > 0.5	Harinarain, (2013);

	Square Residual	covariance matrix and the hypothesised model. If the items vary in range (i.e. some items are 1-5, others 1-7) then RMR is hard to interpret, better to use SRMR		Harinarain and Haupt (2016); Hooper *et al.* (2008); Hsu *et al.* (2012); Harinarain and Haupt (2016)
AVE (CFA) only	Average Value Explained	The average of the R^2s for items within a factor	AVE > 0.5	Alsari and Nawafleh (2019); Sugant and Srilakshminarayana (2018)

Kline (2015) suggests that a minimum of 4 indices be used to assess the fitness of a model. The model developed in this study were assessed using chi-square, RMSEA, CFI and SRMR and an interpretation of their estimates are stated below.

a. Chi- square (p-value): 0.000 - does meet the threshold (p value below 0.050)
b. RMSEA: 0.075 - Acceptable - meets the threshold of <0.080
c. CFI: 0.941 - Acceptable - meet the threshold of >0.900
d. SRMR: 0.585 - Acceptable - meet the threshold of >0.500

12.10 HYPOTHESIS TESTING

The conceptual model for this study is built around eight hypothesised relationships between different variables. These are:

H1: A positive relationship is predicted between “assessment design” and “thinking related factors”

H2: A positive relationship is predicted between “assessment design” and “teaching related factors”

H3: A positive relationship is predicted between “assessment design” and “student related factors”

H4: A positive relationship is predicted between “assessment design” and “operational related factors”

H5: A positive relationship is predicted between “thinking related factors and “IBL learning”

H6: A positive relationship is predicted between “teaching related factors” and “IBL learning”

H7: A positive relationship is predicted between “student related factors” and “IBL learning”

H8: A positive relationship is predicted between “operational related factors” and “IBL learning”

Table 12-19: Structural model statistics

H1: A positive relationship is predicted between assessment design and thinking related factors					
Proposed hypothesis			Estimate	P-value	Outcome
Assessmt	<---	InqCyc	.293	***	Could not be rejected
Assessmt	<---	CogLdg	.033	.441	Accepted
Assessmt	<---	SchCon	-.230	***	Could not be rejected
H2: A positive relationship is predicted between assessment design and teaching related factors					
Proposed hypothesis			Estimate	P-value	Outcome
Assessmt	<---	InqAct	-067	.102	Accepted
Assessmt	<---	InstrPr	.105	.051	Accepted
H3: A positive relationship is predicted between assessment design and student related factors					
Proposed hypothesis			Estimate	P-value	Outcome
Assessmt	<---	SlfDir	.323	***	Could not be rejected
Assessmt	<---	ConKnw	.442	***	Could not be rejected
Assessmt	<---	SlfEff	-.161	***	Could not be rejected
H4: A positive relationship is predicted between assessment design and operational related factors					
Proposed hypothesis			Estimate	P-value	Outcome
Assessmt	<---	ExpLn	.613	***	Could not be rejected
Assessmt	<---	SurStr	.146	***	Could not be rejected
Assessmt	<---	SocCon	.271	***	Could not be rejected
Assessmt	<---	ModPr	.221	***	Could not be rejected
Proposed hypothesis			Estimate	P-value	Outcome
H5: A positive relationship is predicted between thinking related factors and IBL learning					
Proposed hypothesis			Estimate	P-value	Outcome
Iblic	<---	InqCyc	.105	.007	Could not be rejected
Iblic	<---	CogLdg	.812	***	Could not be rejected
Iblic	<---	SchCon	.079	.041	Could not be rejected
H6: A positive relationship is predicted between teaching related factors and IBL learning					
Proposed hypothesis			Estimate	P-value	Outcome
Iblic	<---	InqAct	.098	.056	Accepted
Iblic	<---	InstrPr	.040	.314	Accepted
H7: A positive relationship is predicted between student related factors and IBL learning					
Proposed hypothesis			Estimate	P-value	Outcome
Iblic	<---	SlfDir	-.025	.538	Accepted
Iblic	<---	ConKnw	.070	.067	Accepted
Iblic	<---	SlfEff	.109	.050	Accepted
H8: A positive relationship is predicted between operational related factors and IBL learning					
Proposed hypothesis			Estimate	P-value	Outcome
Iblic	<---	ExpLn	.423	***	Could not be rejected
Iblic	<---	SurStr	.194	***	Could not be rejected
Iblic	<---	SocCon	-.024	.539	Could not be rejected
Iblic	<---	ModPr	.278	***	Could not be rejected

The hypotheses above were either accepted or rejected based on the p-value. A p-value less than 0.050 (typically ≤ 0.050) is not statistically significant. A p-value higher than 0.050 (> 0.050) is statistically significant and indicates strong evidence for the null hypothesis. This implies that the null hypothesis must be retained, and the alternative hypothesis rejected.

12.11 SUMMARY

In this chapter, the results from the students' questionnaire survey were discussed and analysed. The data used was screened before using it for analyses. The data was screened for missing data, outliers, normality and multicollinearity, thereby making it clean and ready for use. The process ensured that the data is useable, reliable, and valid for testing.

The KMO measure of sampling and Bartlett's tests were implemented to check the suitability of the data and the data had a marvellous matrix. EFA and CFA reliability analyses were carried out on the data to test the hypotheses and validate the assessment model developed in this study. The developed model was evaluated for model fit using the model chi-square, RMSEA, CFI and SRMR. The model passed three of the four model fit tests. The Chi- square (p-value) value did not meet threshold. This outcome may be due to the sample size as it is sensitive to the sample size.

CHAPTER 13

DISCUSSION OF STRUCTRURAL EQUATION MODEL RESULTS

13.1 INTRODUCTION

This chapter discusses the assessment design structural model that was validated in the last chapter. The discussion of the validated model is done by correlating each factor in the conceptual model with its associated hypotheses and linking it to evidence from the literature.

13.2 DISCUSSION OF VALIDATED STRUCTURAL EQUATION MODEL RESULTS

From the analysis of the path model, all the hypothesised relationships were found to be significant. There were four relationships between the four intervening variables and the independent variable. Similarly, there were four relationships between the dependent variables and the four intervening variables. These eight relationships are discussed in the following sections.

13.2.1 Assessment design and thinking related factors

The relationship between assessment design and thinking related factors was found to be positive and significant. This relationship is an indication that thinking related factors should be taken into consideration when designing an assessment tool for an IBL pedagogy. In a study conducted by Vajravelu and Muhs (2016), the combination of skills tests and homework was successfully used in a large undergraduate calculus course for a small group problem-solving. Although, some instructional procedures and techniques may be effective for novices, some not be effective for more proficient students (Persky and Robinson, 2017). Consequently, it is important that proficiency levels and cognitive levels of students be continuously and accurately monitored during assessment design. Traditional assessment tools are usually not appropriate for this purpose. Besides being slow and time-consuming, they do not always provide reliable evidence for diagnostic purposes (Chen *et al.*, 2018).

13.2.2 Assessment design and teaching related factors

The relationship between assessment design and teaching related factors (inquiry activities, instructional practice, and evidence-based practice) was found to be positive and significant. This relationship is an indication that teaching related factors must be taken into consideration when designing an assessment tool for an IBL pedagogy. The design of assessment tools based on theoretical knowledge may relieve students of time wastage, obtaining uncertain results, and the trouble of searching for solutions to previously solved problems (Bumbuc and Macovei, 2019). Higher productivity may be obtained if an assessment is designed in such a way that students intellectual capabilities are used as an evidence of learning and to improve knowledge in the field of study (Mueller *et al.*, 2015).

13.2.3 Assessment design and student related factors

The relationship between assessment design and student related factors was found to be positive and significant. This relationship is an indication that the student related factors are critical in designing an assessment tool for an IBL pedagogy. The paradigm shift to flipped classrooms, collaborative learning, flexible learning and student-driven learning has also resulted in the shift in assessment design from "assessment solely designed and implemented by the lecturer" to "assessment designed for student empowerment and engagement" (Boud and Falchikov, 2007, Wanner and Palmer, 2015). Consequently, there is an increase in the use of assessment centred on students in higher education (Wanner and Palmer, 2018). The use of self and peer-assessment develops key capabilities and enhance student learning such as making them more responsible for their learning, having a better understanding of their own judgement and values, assessment criteria and subject matters, and developing the ability to develop critical reflection skills (Boud, 2013, Falchikov, 2013, Thomas *et al.*, 2011).

13.2.4 Assessment design and operational related factors

The relationship between assessment design and operational related factors was found to be positive and significant. This relationship is an indication that operational related factors should be considered when designing an assessment tool for an IBL pedagogy. There is an interactive relationships between content, pedagogy and assessment and each forms part of a curriculum (Shneor and Flåten, 2020). As illustrated in Figure 13-1, what is taught is influenced by how it is taught, and how and what is assessed is also influenced by the teaching pedagogy. These interaction should be considered during assessment design in IBL pedagogy to avoid curriculum overloaded with content or an overbearing assessment (Harlen, 2013).

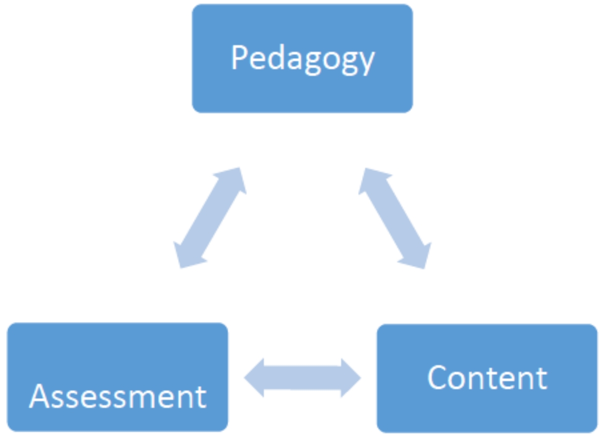

Figure 13-1 Interaction between pedagogy, content and assessment

(Harlen, 2013:26)

13.2.5 IBL and thinking related factors

The relationship between IBL learning and thinking related factors was found to be positive and significant. This relationship is an indication that thinking related factors have an impact on learning in IBL pedagogy. Active and participatory learning pedagogy help students to develop more abstract, complex, and powerful knowledge which enable them to solve a wide range of practical problems (Kinchin, 2016). Furthermore, students become self-motivated and autonomous in their learning activities (Johnson and Cuevas, 2016). This enables students to acquire fundamental concepts and problem solving skills; making them meta-cognitively aware while also improving their critical thinking (Tachie and Molepo, 2019). IBL pedagogy enhances higher thinking and participatory learning among students through the use of ill-structured problems with more than one solution while employing a student centred approach (Osman, 2018). In this pedagogy, students are stimulated with problems to seek the knowledge required to find possible solutions to the main problem in a scenario (Lower-Hoppe *et al.*, 2020). Consequently, this approach increases students' retention of information and motivation because the students are actively solving problems using critical thinking skills (Schmid and Bogner, 2017).

13.2.6 IBL and teaching related factors

The relationship between IBL learning and teaching related factors was found to be positive and significant. This relationship is an indication that teaching related factors have an impact on learning in IBL pedagogy. Lecturers are expected to act as facilitators while transmitting knowledge to students while students are expected to assimilate the knowledge in a constructive way without misconception (Rossano *et al.*, 2016). To this end, it is necessary to adopt an appropriate method to teach the content. An inductive method of teaching also known as inquiry teaching help students to acquire knowledge through self-experience (Laksana, 2017). This approach motivate students to solve real-world problems through inquiry activities (Jayasingh *et al.*, 2016). The use of case studies and evidence-based practices makes students to be involved and develop interest in the subject (Selcen Guzey and Aranda, 2017). In IBL, students are required to analyse, acquire information, provide and develop solutions (Rodríguez *et al.*, 2019), and also design products and technologies, showcasing their ability to think and sustain learning (Kalsoom and Khanam, 2017).

13.2 7 IBL and student related factors

The relationship between IBL learning and student related factors was found to be positive and significant. This relationship is an indication that student related factors have an impact on learning in IBL pedagogy. IBL pedagogy is an effective catalyst for enhancing positive shifts in learning strategies and processes (Bell, 2010). This pedagogy enables students to make meaningful contributions towards the issues, challenges and problems they are exploring, helping them move toward deeper learning and meaningful engagement (Gholam, 2019). Apart from developing process skills and knowledge, students also develop self-confidence while working alone or with others to solve problems or questions (Núñez and León, 2015). Such pedagogy produces engaged, lifelong and productive students and citizens (Činčera *et al.*, 2020).

13.2.8 IBL learning and operational related factors

The relationship between IBL and operational related factors was found to be positive and significant. This relationship is an indication that operational related factors have an impact on learning in IBL pedagogy. Learning in IBL revolve around problem solving as factors influencing the actions, activities and decisions made by lecturers, students and other stakeholders also impact on learning positively (Estivill-Castro, 2019). Instruction in IBL pedagogy begin with integrative complex problem, while learning of the individual procedures and concepts occurs within the context of that problem (Wells, 2019). This approach creates schema or an organisational structure for integrating understanding. According to Noe and Kodwani (2018), school/institutional learning that occurs in this context is deeper and richer, and transfers much easily to the work environment.

It also gives a clearer understanding of the contextual limitation and relationship of the procedures and concepts (Duffy and Raymer, 2010).

13.3 SUMMARY

In this chapter, the findings of the previously developed and validated structural equations models have been discussed. The literature was used to confirm that factors related to thinking, students, teaching and operation have impacts and positive influences on assessment design in construction programmes using inquiry pedagogy. It was also confirmed from literature that these factors must be taken into consideration when designing assessment for learning in IBL pedagogy. The summaries of the findings in this study are discussed in the next chapter and recommendations for future study outlined.

CHAPTER 14

CONCLUSION AND RECOMMENDATIONS

14.1 INTRODUCTION

This chapter presents the outcomes, conclusions, originality and limitations of this study. Areas for further study are also suggested and concluding remarks stated.

14.2 RESEARCH OBJECTIVES

Assessment plays a vital role in student learning. It is a pointer to aspects of importance in the course. Assessment also influences students' learning style and approach to learning. To improve students' learning, it is important to evaluate assessment design processes. Assessing students' knowledge and reasoning patterns is a vital aspect of research on science teaching. Assessment tools must therefore provide reliable and valid inferences about students' conceptual progress and facilitate guidance in evaluating instructional efficacy and targeting instruction. There should be linkage between instruction and assessment using assessment tools that correspond with appropriate instruction-based activities for teaching of the targeted skills. It is therefore necessary to consider underlying cognitive processes and the impacts of adopted pedagogy on instruction and learning during assessment design. This view can be achieved by approaching assessment design from the perspectives of impact and importance of the facets of the pedagogy on learning.

The key research question of this study was: "What are the key design facets that will significantly affect the development of a model for the design of effective assessment in inquiry-based learning pedagogy in construction education in South Africa?"

This key research question was further divided into three research questions, each with a corresponding research specific objective. The findings of this study with respect to these specific research objectives are discussed in the following sections.

14.2.1 Research objective 1

The first objective was to identify the key design constructs for assessment design in IBL pedagogy. To achieve this objective, constructs with the most significant impact and importance were identified from an extensive review of the literature and through the application of Delphi technique.

The 4 leading factors and 28 elements identified from the literature review were presented to a panel of 14 experts in the Delphi study. The members of the panel rated the impact and importance of the elements in a three-round iteration process before consensus was reached. The Delphi study shows that 18 elements have significant impact and importance on assessment design in IBL pedagogy.

The 18 elements/influences were categorised into 4 leading factors as follows:

a. Thinking related factors;
b. Teaching related factors;
c. Students related factors; and
d. Operational related factors

All influences/factors categorised under thinking related factors meet the criteria for consensus and were retained. Under the teaching related factors three influences were retained and five influences were retained under the student related factors while six influences were retained under the operational related factors. Following this refinement, the leading factors and the retained elements/influences were used to develop a conceptual model.

The developed model had six leading factors and 18 corresponding measuring elements. The leading factors include assessment design, thinking related factors, teaching related factors, student related factors, operational related factors and learning in IBL. These leading factors represent the three types of variables in the model namely dependent, intervening and independent variables. The model had one dependent, four intervening and one independent variables. The research objective was achieved, and the accompanying specific research question was answered.

14.2.2 Research objective 2

The second objective was to determine the relationships between the different constructs in the development of assessment design model in IBL. This objective was achieved through the quantitative data collected from students studying in construction programmes in six universities in South Africa using a structured questionnaire. SEM was used to validate the conceptual model using the data collected from the students. The SEM results confirmed that the six variables in the model have eight direct relationships between them.

The independent leading factor, assessment design was found to have direct significant influence on all four intervening leading factors. The dependent leading factor learning in IBL was also found to have significant direct relationship with all four intervening leading factors. The research objective was achieved, and the accompanying specific research question was answered.

14.2.3 Research objective 3

The third objective was to establish how the constructs of IBL pedagogy can be used for assessment design in construction education. Based on the review of literature and results from the Delphi study as well as responses received from students via the structured questionnaire/survey, it was concluded that assessment design in IBL pedagogy should be based on the theory of constructivism. Identifying the important antecedents to effective learning and teaching in IBL is also of critical importance. The identified antecedents or influences should be carefully combined to develop assessment tools that meet the learning needs of students leading to high-quality professional development. The tools should encourage collaboration among students, enabling them to be tenacious towards learning. Tools must also foster a shift in students from memorising contents and concepts to being able to create knowledge using higher-order thinking skills.

The study also shows that assessment in an IBL environment needs to be based on the analysis of documents such as research reports and the observations of the engagement of students. There is a need to develop or adopt multiple assessment methods as IBL pedagogy requires a critical analysis and assembly of multiple forms of evidence. The research objective was achieved, and the accompanying specific research question was answered.

14.3 CONTRIBUTIONS OF THE STUDY

The findings from this study is of critical importance in measuring learning through an IBL-based assessment design, specifically in the context of construction education students. The contributions from this study can be classified into three – academic, practical and methodological contributions.

14.3.1 Academic contributions

This study gives a clearer understanding of assessment design factors in IBL pedagogy, establishing the relationships between key factors when applied in an inquiry construction education programme. It also broadened the knowledge of how learning in IBL pedagogy can be effectively assessed and measured. As recommended in section 14.5, this study set a good precedent for further research with regards to measuring learning in the IBL pedagogy.

14.3.2 Practical contributions

The findings of the study offer direction to assessment designers, lecturers and other stakeholders in construction related programmes in South Africa on how to improve the measuring of learning in IBL pedagogy. The identified and validated key influences/design factors can be integrated in assessment design practice. The validated model in this study can be used by assessment designers to develop assessment tools that measure learning and the skills needed in the industry. The model also provides a clear direction to university management, programme developers, policy makers, curriculum developers and relevant statutory bodies to develop appropriate instructional practices, policies, regulation and guidelines to improve the standard of learning in construction education.

14.3.3 Methodological contributions

The research instrument used in this study was validated by a two-step research methodology. Content validation was the first step. This process involved the use of Delphi technique to validate the instrument content wise. The research instrument was further validated by a pilot study involving students from one of the participating universities. Exploratory factor analysis and confirmatory factor analysis were also carried out to validate the constructs used in this study. This was the second step adopted in this study. SEM was used to analyse the factors and to determine the relationships between the different variables in the proposed model. The combined use of these methodologies is not common in construction-related studies.

14.4 LIMITATIONS OF THE STUDY

Research studies are often characterised by areas of limitation and challenges (Naoum, 2012). The following statements define the scope and limitation of this study:

a. The student survey was carried out during the COVID-19 pandemic. As a result, the questionnaire was distributed electronically. This approach affected the response rate and limited the opportunity for students to seek clarity;
b. Non-probabilistic convenience sampling technique was adopted for data collection. Consequently, only students willing and available online responded to the questionnaire;

c. Each construction programme has its peculiarities with regards to curriculum content. In this study, the disparity between these programmes was not taken into consideration;
d. A structured questionnaire was used to collect data used for this study. This approach eradicated the opportunity for personalised individual opinions and may allow for some form of bias in the responses received;
e. The conceptual model developed and validated in this study was from students in only six universities in South Africa. The inclusion of all universities in the study would have provided a clearer picture;
f. The demographic information of students was stated, the impact of assessment design was not considered; and
g. The results from this study were collected only from the Delphi study and responses of students via the structured questionnaire. No assessment tool was developed and evaluated to assess its effect on learning and the efficiency of the model.

14.5 RECOMMENDATIONS FOR FURTHER STUDY

The results from this study has contributed to the body of knowledge in the area of assessment design in IBL pedagogy and measuring of learning in construction programmes. It can be deduced from the results that further research is necessary. The recommendations for further studies are based on the results, limitations and delimitation of this study. The areas for further study include the following:

a. This study can be replicated in future studies by using a more representative sample with already validated questionnaire. A different methodology can also be adopted to validate the results from this study;
b. Other factors like learning styles and approaches to learning can be considered in future studies;
c. Future studies can also include how lecturers can effectively use the developed assessment model to develop assessment tools in IBL pedagogy. The necessary skills needed (by lecturers) for development of effective assessment tools can also be studied; and
d. As assessment is part of a curriculum, the design of a curriculum that is aligned with the developed assessment model can also be studied; and

e. North America, Asia and Australia and New Zealand can also be included in further study for more diverse opinion.

14.6 SUMMARY

This study has attempted to provide a basic and well-defined assessment model for the development of assessment tools in construction education programmes in South African universities. The assessment model provides a foundation for the development of appropriate assessment tools that measure learning in IBL pedagogy. The recommendations based on the results from this study could be used in further studies to improve the results obtained. Furthermore, the model developed in this study can be adopted by policy makers, lecturers, curriculum developers and other stakeholders in providing effective assessment tools in IBL pedagogy, thereby improving the quality of education in construction education.

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APPENDICES

APPENDIX 1 – UKZN ETHICAL CLEARANCE LETTER

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

27 August 2020

Mr Adesoji Tunbonsun Jaiyeola (216077051)
School Of Engineering
Howard College

Dear Mr Jaiyeola,

Protocol reference number: HSSREC/00001561/2020
Project title: Development of assessment design model for inquiry based learning pedagogy in construction education in South Africa
Degree: PhD

Approval Notification – Expedited Application

This letter serves to notify you that your application received on 02 June 2020 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted **FULL APPROVAL**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

This approval is valid until 27 August 2021.
To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

All research conducted during the COVID-19 period must adhere to the national and UKZN guidelines.

HSSREC is registered with the South African National Research Ethics Council (REC-040414-040).

Yours sincerely,

[redacted]

Professor Dipane Hlalele (Chair)

/dd

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