An exploration of mathematics teacher educators' understanding and practices of formative assessment: A case of three Colleges in Ghana

by

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Declaration

I, Justice Enu declare that this thesis: An *exploration of mathematics teacher educators' understanding and practice of formative assessment: A case of three Colleges in Ghana*, is my own work and that no part of it has been presented for another degree in this university or elsewhere. The works used or quoted from other sources have been acknowledged by means of complete references.

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Dedication

This work is dedicated to my late sister, Augustina Efua Enu.

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List of Abbreviations

Acronyms	Full meaning of acronyms
AFL	Assessment for Learning
AOF	Assessment of Learning
FA	Formative Assessment
MKiTs	Mathematical Knowledge of Teachers
MTE	Mathematics Teacher Educator
NaCCA	National Council for Curriculum and Assessment
NCTM	National Council of Teachers of Mathematics
NTECF	National Teacher Education Curriculum Framework
NTS	National Teacher Standards

Abstract

Teacher educators play a significant role in the preparation of pre-service teachers to become assessment-literate and able to practice after their training. In this respect, an exploration of teacher educators' understanding, and practices of formative assessment (FA) will provide an insight into the kind of assessment practices that their students are exposed to. There is a lack of evidence on teacher educators' understanding of FA and its implementation in mathematics modules, especially in the Ghanaian context. This thesis therefore uses a qualitative approach underpinned by an interpretivist research paradigm to explore mathematics teacher educators' (MTEs) understanding and practices of FA within a system of activity in mathematics modules. The objectives that guided this study were: to explore MTEs' understanding and practices of FA in mathematics; determining how MTEs implement FA in mathematics modules; and finally, exploring why MTEs adopt FA techniques in their instruction. The qualitative, interpretive study was framed using activity theory and was located at three teacher colleges in the Central Region of Ghana.

To triangulate the data, multiple types of data were generated from six MTEs after they signed a consent form to participate in the study. Data were generated through the administration of semi-structured interviews, lesson observations and perusal of textual materials. Thematic coding and interpretive strategies were employed to analyse the data generated. The analysis and the subsequent findings were established based mainly on participants' responses from the transcribed semi-structured interviews, lesson observation transcripts and document analysis.

The findings of this study revealed that MTEs understand FA as an ongoing activity that forms an integral part of teachers' pedagogical practices and occurs before, during and after teaching and learning. Significantly, they also recounted that the main role of FA is to gain evidence about students to enhance the instruction and learning process. The study also demonstrated that teacher educators were able to implement some FA techniques with success, while other techniques were implemented in a disjointed manner. Questioning was found to be the principal technique that teacher educators employ in gathering information about students' learning and for checking their instructional methodology.

The findings of the study further established that the ultimate reason which informs teacher educators' decision to adopt FA strategies is their wish to amend and enhance students' mathematics performance, and to forestall it from further deteriorating. However, while teacher educators adopt FA techniques in their teaching, lack of material resources and college assessment policy seem to be a roadblock to the efficient implementation of FA in mathematics. Knowledge of these inhibiting factors is useful to college management and heads of mathematics departments in order to address MTEs' challenges in FA and to minimise these barriers for effective implementation of FA techniques in the mathematics modules.

CHAPTER 1

BACKGROUND AND AIM OF THE FIELD STUDY

1.1 Introduction

Educators, researchers and policy makers are in search of classroom practices that support students' learning and achievement (Sato, Wei, & Darling-Hammond, 2008). Formative assessment (FA) has therefore been identified as having the potential to improve students' learning outcomes (Black & Wiliam, 1998a; McMillan, 2007b). According to Cauley and McMillan (2010) FA is a process of generating information about students learning, where the instructional strategy might be modified where necessary based on the evidence gathered.

After interrogating different forms of assessment, Black and Wiliam (1998a) aver that assessment forms part of teachers' classroom practices and therefore has the potential to improve learning as well as students' achievement when used effectively. Ten years later, Cauley and McMillan (2010) still insist on the same argument – that it is through FA that we can see where there is a need for modification of instructional strategies to enhance learning. Rao and Sun (2010) argue that it is imperative for teachers to have skills in and understanding of assessment techniques, and to use assessment data to account for the context within which learning occurs to ensure that teaching is both supportive and challenging.

Teacher educators are responsible for training teachers and equipping them with skills and knowledge to become effective practitioners in the school setting. Therefore, teacher educators' knowledge on assessment issues is not only vital for planning and designing teaching and learning activities, but also for addressing the learning needs of students. This is vital for equipping pre-service teachers with the necessary knowledge to become master craftspersons of assessment in their classrooms when they become classroom practitioners. These arguments and suggestions set the context for the study into teacher educators' understanding and practices of FA in mathematics modules.

This chapter provides a synopsis of the background context of the study. The chapter also provides a brief account of how assessment can be used to rectify mathematical errors, which is an important facet of FA. A detailed description of the rationale and purpose of the study, critical research questions that the study seeks to address and significance of the study regarding mathematics education are presented. The chapter goes on to provide a preview of the methodological design adopted for the study, and concludes with a summary of the structure of the thesis.

1.2 Background of the study

Effective and sound assessment practice begins with the instructors' or teachers' knowledge of assessments (Oduro-Okyireh, Akyina, Ansah-Hughes, & Torkornoo, 2015). Therefore, among aspects of teachers' mathematical knowledge in teaching (MKiT), as advocated by Rowland and Ruthven (2011) , there is a need for teachers to develop practice-based knowledge in the course of teaching. The development of practice-based knowledge is necessary for the implementation of appropriate FA techniques in the classroom, that aim to assess for learning purposes rather than assessing of learning. There is no clearly agreed upon definition of FA that all researchers adhere to (Filsecker & Kerres, 2012); FA has been defined in various ways in the literature by many assessment specialists depending on the perspective the writer may be viewing assessments from. For example, Mellati and Khademi (2018) defined FA as a process in which teachers control both content and assessment procedures and can adjust their instructional activities in accordance with the evidence gathered in the classroom. It provides data about instructional units in progress and students in action (Marsh, 2007). According to Hanna and Dettmer (2004) FA is a way in which instructors gather data about their teaching and their students' learning. Black and Wiliam (1998a) assert that FA is "all those activities undertaken by teachers or by their students, which provide information to be used as feedback to modify the teaching and learning activities they engage in". Sutton (2010 , p. 3) states that FA is an "ongoing process conducted both formally and informally, by which information and evidence about student's learning is absorbed and used to plan the next step, or guide a given task".

Admittedly, what all these definitions have in common is that they refer to FA as assessment which is aimed at gathering data to enable teachers to make informed decisions about instruction, and providing feedback to students to enhance teaching and learning. However, no clear direction is

given by authors as to how FA could be practised in the classroom by teachers. This study too is by no means trying to give directions as to how FA could be practised, rather it is more concerned with exploring the knowledge of FA among those who are expected to implement it (instructors, i.e. teacher educators). However, knowledge of something does not always transfer into practice. Therefore, in this study the aim is not only to explore their knowledge of FA but to understand how that knowledge is transferred into practice to enhance teaching in mathematics. Understanding their knowledge and practices has the potential to enlighten all education stakeholders as to how FA can be used or needs to be practised in order to improve learning, as the literature emphasises that FA has the potential to improve learning in mathematics classrooms.

Understanding teacher educators' knowledge and practices of FA is therefore of great importance, especially in the context of Ghana where FA has not been one of the dominant assessment strategies in the classroom regardless of being included in the relevant policy documents.

1.3 Problem statement

In Ghana, continuous assessment was introduced into the curriculum in 1987. The aim was to ensure prompt teaching towards gaining conceptual understanding through diversifying forms and use of assessment tasks (Quansah, 2005). Continuous assessment is an ongoing process of gathering and interpreting information about students for instructional decisions (Bichi & Musa, 2015). Continuous assessment was introduced in Ghana to give more attention to formative evaluative activities, which had been considered as missing in the teaching and learning discourse, mainly due to the established culture of external examination (Akyeampong, 1997). Furthermore, introduction of continuous assessment was driven by the goal not only to use assessment for grading but to provide feedback to learners and teachers. In a nutshell, the aim was to inform the process for learning, rather than to assess the process of learning. Although there are policies in Ghana which emphasise the need for implementation of FA, the actual practice of implementation rests in the hands of teacher educators and teachers.

Anecdotal evidence from most colleges of education in Ghana has shown that assessment of students is more inclined towards assessment of learning. Teacher educators are more oriented towards assessment of learning because assessment practices in Ghana have predominantly been examination oriented (Oduro-Okyireh et al., 2015) with emphasis placed on the student's grade,

instead of assessing to inform learning. Hence, over the years classroom instruction has been driven by examinations just to maximise students' grades. It is therefore imperative to explore teacher educators' understanding and practices of FA and the extent to which their practices align with policy in order to understand the effectiveness of the policy.

Continuous assessment involves two types of assessment: 1) FA; and 2) summative assessment. Assessment for formative purposes is intended to assist learning by improving learning outcomes or informing teaching and learning practices, i.e. for making adjustments to teaching methods during instruction. Assessment for summative purposes helps determine whether a student has achieved a certain competency at the end of a course (Black & Wiliam, 1998a). In Hong Kong Berry (2008) posits that the learning component of assessment has been emphasised and communicated clearly to schools in the curriculum guidelines, but this may not easily be applied as action in the classroom. This situation may not be different in Ghana. Although the formative process has been acknowledged in the school curriculum of Ghana, this conception of FA seems still to be missing from the existing practice in the classroom. Clark (2011) indicated that teachers must create an enabling environment that permits maximum interaction in the classroom and ensures that effective FA may take place. Teachers need to have the skills, attitude, and knowledge for effective implementation of FA in the classroom (Ho, 2015), since teachers' knowledge is an important prerequisite for quality teaching.

Arrafi and Sumarni' (2018) study of teachers' FA literacy and practices found that teachers' understanding of FA is inadequate; this prevents them from implementing FA in the classroom (Bennett, 2011). Similarly, Watson (2006) noted that teachers have trouble in using FA effectively to guide teaching. In support of Bennett (2011) and Watson's (2006) positioning, Husain (2013) argued that teachers' lack of knowledge on the use of FA techniques might hinder the effective implementation of FA in the classroom As noted from the above literature, there is plethora of research exploring in-service teacher knowledge of FA. The focus of these studies has been at school level, and there is a dearth of research exploring teacher educators' knowledge and practice of FA in mathematics modules.

In-service teachers are a product of teacher colleges, and when they become practitioners, they mostly implement the skills and knowledge acquired while they were pre-service teachers;

therefore, it is imperative to explore the knowledge and practices of teacher educators. Although in Ghana education policies support the inclusion of FA, literature exploring how this is understood and implemented in the context of Ghana is limited. Teacher educators and teachers draw from what has been researched in other countries to inform their practice. However, if we are to improve teaching and learning in Ghana, it is critical that we research the knowledge and practices within the context of Ghana. While I agree that it is critical to draw from outside expertise, understanding how education policies are understood and implemented within the country is critical not only for the curriculum implementers but for the country as whole.

Although policies on the inclusion of FA were introduced in 1987, to date there has been limited research on the knowledge and practices of teacher educators with regard to implementation of FA. This study therefore explored how Ghanaian mathematics teacher educators (MTE) infuse the knowledge and practice of FA in their classroom. Since this study will be focusing on Ghanaian teacher educators whose practice-based work is informed by policy, the researcher will refer to the definition of FA as used by Black and Wiliam (1998a) and the guidelines as stated in the National Teachers' Standards (NTS) and the National Teacher Education Curriculum Framework (NTECF) for Ghana.

1.4 Definition and purpose of assessment

Naturally, assessment is part of the everyday world of every individual. People make decisions based on the information available to them which they see as relevant for the purposes of their decision. In the context of education, assessment forms an integral component of the instruction and learning process; therefore, assessment and instruction cannot be viewed or understood in isolation (Hernández, 2012). According to Broadfoot (2012), without assessment teachers and students would have no way of knowing whether or what learning is taking place. In other words, assessment is a way of finding out if learning has taken place, a process which requires teachers' understanding and skills in other to ensure effective implementation. Moss (2013) posits that assessment is "undeniably one of the teachers most complex and important tasks". This section therefore presents the definition and purposes of assessment. It begins with definitions of assessment provided by various authors as highlighted in the literature, followed by the purposes of assessment with a particular focus on FA.

Assessment has several purposes:, including diagnosis, evaluation and grading, but these are not ends in themselves (Rowntree, 2015). This implies that assessment purposes are means towards further ends. According to Hernández (2012) assessment is about grading and reporting on students' achievements as well as giving students support in their learning. Lambert and Lines (2013) observed that assessment "is the process of gathering, interpreting, recording and making use of information about pupils' responses to educational task". In an older study similar sentiments were raised by Gullo (2005), who posits that assessment is a procedure used to determine the degree to which an individual child possesses a certain attribute. Assessment is a process for gathering information to make decisions about young children. The process is appropriate when it is systematic, multidisciplinary, and based on the everyday tasks of students.

The best assessment system is comprehensive in nature; that is, the assessment yields information about all of the developmental areas: motoric, temperament, linguistic, cognitive, and social/emotional (Mindes, 2003, cited in Gullo, 2005, p. 6). In addition, Brink (2017) conceived that assessment is an ongoing process, not a once-off event. The definitions given by these authors indicate that assessment is a process of gathering and analysing information about students which is aimed at providing feedback on their progress, strengths, and weakness. In contrast, Black and Wiliam (1998a) note that assessment comprises an integral part of teachers' classroom practices, and its effective use has the potential to significantly improve learning and students' achievement. Cowie and Bell (1999, p. 101) adopted a narrower definition as "the process used by teachers and students to recognize and respond to student learning in order to enhance that learning". The definition of assessment given by Cowie and Bell (1999) and Black and Wiliam (1998a) suggests that assessment is an integral facet of classroom exercises and calls for both the instructor and the students to collaborate, reflect, dialogue and share responsibilities based on the learning project.

From the above definitions, I define assessment as a tool used in gathering evidence about all aspects of classroom activities; instructional modification may then be made, based on the evidence. According to Neibling (2014) definitions of assessment may be similar across the literature, but in the educational context its purposes vary. Implementing effective assessment requires teachers' knowledge and understanding of the purposes of assessment. Gardner, Harlen,

and Hayward (2010) observed that information generated from assessment has dual purposes: for improving performance and for accountability. The next paragraph discusses the purposes of assessment with more focus on the formative purposes of assessment.

Assessment can be meant for formative or summative purposes (Brookhart, 2011). This author reiterated that the summative purposes of assessment mean that the teacher plans assessment for grading, reporting accountability or placement decisions. Abell and Siegel (2011) remarked that this purpose of assessment provides documentation of students' learning at particular points in time, most typically at the end of a unit of study or course. They further explained that information from summative assessment is often the basis of course grades. To Davies and Hill (2009) a key summative purpose of assessment within schools is for tracking and analysis of student progress in order to inform teachers' decision making regarding ongoing teaching plans. Another is for streaming classes and class placement options, as well as informing the advice given by teachers to students when they move from one year level to the next (Black, Harrison, Hodgen, Marshall, & Serret, 2011).

Airasian and Russell (2008) note that parents and students use assessments to monitor academic progress, judge teacher quality, evaluate the students' strengths and weaknesses, and make educational and career decisions. In contrast, Coffey, Hammer, Levin, and Grant (2011) aver that assessment designed for formative purposes is aimed at helping teachers to address their students' thinking during instruction. School assessment is necessary for instructional decision making, and an aspect of this is feedback to teachers (National Council of Curriculum and Assessment, 2018). Teachers needs to 'diagnose' the condition and effect of their instruction and remediate aspects which have not been very effective.

A formative purpose means teachers should plan assessment where both teachers and students can use the results, primarily as a way to get feedback for students on a range of performance indicators (Brookhart, 2011). The use of FA provides immediate feedback, that enables teachers to gauge students' progress towards mastering instructional objectives (McMillan, 2007a; Siegel & Wissehr, 2011). Hence, it is worth noting that assessment is driven by aims, objectives and learning outcomes. In terms of metacognitive purposes of assessment, teachers use it to make students

evaluate and regulate their own learning and to enhance their understanding (Abell & Siegel, 2011). FA has a development orientation, as teachers assess the learning progress of their students and make instructional adjustments or students adjust their way of learning in response to their progress (Black & Wiliam, 1998a; Popham, 2009). As concluded by Black (2013, p. 176), "Formative and Summative purposes of assessment can be so intertwined that they are mutually supportive rather than conflicting." In other words, in assessing their students, teachers can make use of assessment information formatively, summatively or both. It is worth noting that these purposes of assessment are linked to one's views of the values of learning and assessment. However, to place this term within the current study, the focus of teachers' knowledge of the purpose of assessment is in relation to its formative purposes, where assessment provides feedback to teachers and students as they engage in the learning process, on the basis of which instructional modifications could be made.

In Earl and Katz's (2006) study three distinct but interrelated purposes of assessment were identified:

- Assessment for learning (AfL): assessment to inform decisions about learning progress;
- Assessment as learning (AaL): assessment which offers students the opportunity to evaluate their own learning; and
- Assessment of learning (Aof): assessment to report on what learning has been achieved, usually occurring at the end of a block of learning.

The policy of assessment in Ghana calls for both assessment for learning and assessment of learning; however, recently more emphasis has been placed on assessment for learning, further stressing that instructors need to implement it to enhance learning. What seems to be missing even now are measures to ensure that it is being implemented.

This study by no means aims to provide measures to ensure implementation of assessment as documented in the policy document; rather, its aim is to explore instructors' (teacher educators') knowledge and how they enact their knowledge in practice – because while this form of assessment is emphasised in policy, it seems to be absent in practice. Details about the distinct forms of assessment as described by Earl and Katz (2006) in relation to Ghana education policy on assessment are discussed in Chapter 2 (section 2.4).

1.5 Teachers' beliefs or conceptions about formative assessment

According to McMillan (2003), teachers' beliefs (Oduro-Okyireh et al., 2015) about assessment affect their classroom assessment practices. Thomas , Deaudelin, Desjardins, and Dezutter (2011) explored elementary teachers' formative evaluation practices, and found that teachers' conception of FA can be grouped into three aspects: 1) time, 2) form, and 3) the role of the actors. In terms of time, the authors observed that the participating teachers conceptualised FA as an integral component of the teaching and learning process. They also found that teachers believe that implementation of FA is a continuous process, which is cyclical and takes place during instruction. Similarly, in Malaysia a study by Arumugham, Abdullah, and Mahmud (2017) explored secondary school teachers' conceptions of FA, and noted that they believe that FA is a measuring tool and not a learning activity for students. Black, Harrison, and Lee (2003) opined that teachers conceptualised FA as assessment for improving students' learning. They observed that it can be performed by giving students useful feedback and using effective peer and self-assessment practices. This finding is consistent with the finding of Harris, Irving and Peterson (2008) that teachers frequently associate FA with students' improvement. In general, most teachers believed that the primary goal of FA is to assist teachers to identify students' strengths and weaknesses in order to help them to improve.

It is interesting to note from the above studies that while some teachers view FA as an integral part of learning, others view it as a means to an end. The aforementioned studies explored beliefs of teachers about FA, not their knowledge and practices of FA in their classrooms which this study is aiming to explore. Beliefs can be informed by what we know or what we think we know, or by our experiences or vice versa. By exploring Ghanaian MTEs' knowledge and practice of FA we can come to understand their beliefs.

1.6 Assessment as a tool for rectifying mathematical errors

Students' errors or mistakes are an important dimension of FA. Errors made by students enable teachers to make decisions about how to discuss their errors with them to help them overcome such mistakes. The behaviourist theory noted that students' errors are premised on carelessness, unsureness, or unique situational conditions. However, Radatz (1980) argued that students' errors occur as a result of previous experience in the classroom. Therefore, feedback on students' work

is key in helping them to minimise their errors during learning and assessment. Wragg (2003) notes that "if students are to learn from their assessment, then corrections of errors and discussion of their work is essential". Errors provide the potential for learning, since teachers are likely to adjust their instructional strategy to meet the learning needs of their students; this modification of instructional approach will emanate from mistakes made by the students. According to Glendon and Clarke (2006) mistakes help in the acquisition of knowledge. Similary, student mistakes can foster understanding and knowledge building during the process of learning (Seifried & Wuttke, 2010).

Undoubtedly, student errors can be seen as having formative purpose. This is because modification of the instructional approach might arise from the evidence generated during classroom instruction. This simply means that students' errors affect the decisions of the class teacher, because their (teachers') belief in relation to student errors determines the feedback they give to their students. Heinze (2005) explained in his study that teachers' instructional goals affect students' motivation and learning outcomes, and therefore how teachers handle students' errors or mistakes during instruction is very important. Unlike assessment of learning (summative), assessment for learning (formative) not only aims to understand what students know, it also focuses on what students do not know and what can be done to improve their knowledge and address barriers to learning.

Mistakes or errors made by students may arise from different contexts; for example, through assignments, tests and oral questioning during instruction. Oral questioning, which is an informal FA technique, aids teachers to determine what their students know and their understanding of what they have been taught. Reflecting on how one can learn from errors, Cauley and McMillan (2010) argued that through effective informal FA techniques such as informal observations and oral questions posed to students during instruction, teachers are able to identify specific students' misunderstandings and provide feedback to help them correct their errors. Informal FA has been found to be the quickest way of ascertaining students' progress (Bell & Cowie, 2001; Black & Wiliam, 1998a; Cauley & McMillan, 2010; Gullo, 2005; McMillan, 2007b).

In conclusion, in light of how crucial FA is in the learning process, teachers should be skilled and knowledgeable enough about classroom assessment tools in order to be able to deal with students' errors and mistakes.

1.7 Rationale of the study

The current study is deemed necessary from two perspectives: (1) in terms of curriculum provision and based on the personal experience of the researcher as a teacher educator in a college of education; and (2) to address the gap in the research on mathematics education.

1.7.1 Curriculum provision and personal experience as a mathematics teacher educator

Teacher education in Ghana started as far back as 1848, at Akropong-Akuapem in the Eastern region, with the intention of preparing human resources for evangelism by the Basel Mission (Asare- Danso, 2014). Teacher education has undergone enormous changes since independence. For example, the Anamuah-Mensah Committee of 2002 was formed to review the educational system in response to societal needs. Its recommendations brought changes, especially in the teacher training system, by calling for an upgrading of teacher training institutions to colleges of education.

Unfortunately, the reform did not meet the standard of education required in the country. Therefore, in 2015 the Transforming Teacher Education and Learning programme was launched by the then government, with technical and financial support from the British Government. The programme was aimed at transforming the delivery of pre-service teacher education in Ghana by improving the quality of teaching at the teacher colleges. It saw the creation of two policy tools: 1) the National Teachers Standard (NTS) for pre-service teachers; and 2) the National Teacher Education Curriculum Framework (NTECF) to guide teacher educators, in-service teachers, pre-service teachers, and other stakeholders in the education sector. This saw a restructuring of the content and the assessment regime of the teacher colleges. Some of the major issues relating to assessment contained in these documents are as follows:

1) Teacher educators are to keep regular, detailed, and legible records of students' assessment, both ongoing formative and summative assessment, and use it to inform planning and teaching on a daily basis.
2) Teacher educators need to prepare pre-service teachers to become assessment literate, so that they understand and apply the principles and procedures for sound classroom assessment of learning (summative) and assessment for learning (formative).

3) Pre-service teachers also need to know how to use the information from their assessment to support their learning.

The provisions in the NTS and the NTECF are consistent with the position of the National Council of Teachers of Mathematics (NCTM) (2000). The NCTM postulates that assessment should be more than merely a test at the end of instruction to see how students perform under special conditions; instead, it should be an integral part of instruction that informs and guides teachers as they make instructional decisions (NCTM, 2000, p. 3). As evident in the policy, there is a strong emphasis on FA to enhance teaching and learning, which suggests that classroom practices should reflect what is stated in the policy. Although the curriculum and national standards for teachers' colleges in Ghana stipulate the inclusion of FA, this does not necessarily mean that this is implemented. Therefore, this study aims to explore MTEs' knowledge and implementation practices of FA when preparing pre-service teachers to become assessment literate.

Mathematics teacher educators facilitate the teaching and learning of mathematics (Zaslavsky, 2009). As a mathematics educator and an assessment officer for the Mathematics and Information and Communication Technology disciplines, I had the opportunity to be directly involved in the planning and organisation of assessment activities in one of the teacher training colleges. Through my experience as a mathematics educator and my involvement in assessment issues over the past six years, I have observed that although teacher educators engage in assessment activities, the emphasis is on assessment of learning instead of assessment for learning as specified in the curriculum policy. The major issue with facilitation of mathematics is that there is a great deal of focus and attention on summative assessment, with little emphasis on FA practices and strategies which have the potential to help and improve students' learning outcomes.

This situation is similar to that shared by Noori, Shafie, Mashwani, and Tareen (2017), who studied Afghan English as a foreign language (EFL). Lecturers' (teacher educators') assessment practices in the classroom were examined and it was found that lecturers practice summative assessment more than FA in their classes. Their study focused on EFL teacher educators, while this study focused on MTEs to understand their knowledge and practices regarding FA.

1.7.2 Research gap on formative assessment in mathematics education

'Formative assessment' is currently a widespread term in the education sector and is considered to be one of the strategies used in enhancing students' achievement. Emerging studies have indicated that the practice of FA is well understood and implemented in countries like the United Kingdom, Australia, New Zealand and many more (Black & Wiliam, 1998a; Cowie & Bell, 1999; McMillan, 2007b). However, FA has been misunderstood and its implementation is posing a challenge in countries whose assessment practices have predominantly been examination–oriented, with emphasis placed on students' grades instead of assessment for learning, and Ghana is no exception here. Kanjee (2009) observed that teachers still face challenges in implementing FA in the classroom, because there is still a major influence of summative assessment on FA. Kanjee and Mthembu (2015) conducted a study on Foundation Phase teachers' assessment literacy in South Africa, which showed that Grade 1, 2 and 3 Foundation Phase teachers have very low understanding of FA. Husain (2013) observed that FA implementation in the classroom may be compromised if teachers lack knowledge on the usage of FA techniques.

In Ghana most earlier studies in the field of assessment investigated the general assessment practices of teachers, with only glimpses of FA. For example, Oduro (2015) explored teachers' assessment practices in the mathematics classroom and observed that in-service teachers use both summative and FA during mathematics lessons, with summative assessment being the main form of assessment technique. A review of literature on this phenomenon in the context of Ghana has shown that limited studies have been conducted in this area and specifically in mathematics. Oduro-Okyireh et al. (2015) studied high school teachers' FA practices in the Ashanti Mampong Municipality. A total of 80 in-service teachers participated in the study and the authors found that about half of them lacked a conception of FA and its sub-concepts. As in other countries, studies in Ghana focused on in-service teachers at school level, not on MTEs at college or university level. One could argue that in-service teachers tend to practice what they have been exposed to as teacher trainees. However, without empirical research one cannot be certain that prior to being in-service teachers, pre-service teachers are exposed to FA practices or not. This study therefore aims to explore MTEs' knowledge and practices of FA.

This study aimed to add to the body of knowledge about teachers' knowledge and practices of FA, but from a different dimension by looking at teacher educators' knowledge and practices, which have not been explored much in the literature. As mentioned, studies in this area are limited in Ghana, even though policies emphasise the inclusion of FA in teaching and learning. Little is known about instructors' knowledge and practices in implementing what is purported in the policy.

The few studies conducted in Ghana on teacher educators' knowledge of FA focused on social science and English but not on mathematics. Bordoh, Bassaw, and Eshun (2013) explored the evaluation of pre-service teachers' learning using FA in social studies. Their study focused on FA techniques which teacher educators used to assess pre-service teachers in social studies. Ankomah and Oduro (2004) focused on challenges lecturers experience in attempting to promote students' learning through FA in English.

While there is a growing literature on teachers' assessment practice, there is dearth of studies on teachers' understanding and practices of FA in mathematics. Therefore, this study will add to the literature and provide new knowledge about teacher educators' understanding of FA and its influence on their practice in mathematics modules.

1.8 Research questions and objectives

The primary purpose of the study was to explore MTEs' knowledge of FA, how their understanding translates into practice and what informs their understanding and practice of FA in mathematics. With this in mind, the study is aimed at achieving three objectives in order to understand the phenomena being studied:

1. To explore mathematics teacher educators' understanding of FA in mathematics.
2. To determine how mathematics teacher educators enact FA in mathematics modules
3. To explore why mathematics teacher educators employ the FA techniques that they do.

As pointed out earlier, the purpose of this research was to explore MTEs' knowledge and practices of FA in mathematics modules. The study was informed by activity theory and tried to answer three key research questions:

1. What are mathematics teacher educators' understanding of FA in mathematics?
2. How do mathematics teacher educators enact FA in mathematics modules?
3. Why do mathematics teacher educators use the FA techniques that they do?

1.9 Significance of this study

The study of MTEs' knowledge, and practices of FA has many benefits. In the first place, the study would provide insight into teacher educators' knowledge and practices of FA in mathematics instruction. Secondly, the findings of the study could be of great importance in considering the new assessment regime in the colleges of education. The outcomes of the study will have the potential to shed some light on whether teacher educators' knowledge and practices of FA are in line with what is set out in the policy documents. In a nutshell, the results may provide insight for the development of a policy document which will give guidance to educators as to how FA is to be implemented in mathematics modules.

1.10 Preview of the research strategy

An overview of the research design and methodology is presented in this section. A comprehensive description of the research design and methodology and the reasons for choosing the methodology is presented in the fourth chapter of this thesis.

1.10.1 The research paradigm

The study is underpinned by the interpretive paradigm. According to Cohen, Manion, and Morrison (2011) the interpretive paradigm aims at gaining an understanding of the subjective world of human experience. The interpretive paradigm was deemed appropriate to understand the actual situation with regard to the FA practices of teacher educators in the classroom; this is a social context in which the reality of a phenomenon can be constructed and accommodate multiple perspectives and versions of truths. Klein and Myers (1999) observed that the interpretive

paradigm helps us to understand human thoughts and actions and enables in-depth probing and deeper insight into the phenomenon under study.

1.10.2 Research approach

This is a qualitative study and the phenomenon being examined in the study is MTEs' understanding and practices of FA in mathematics modules. A qualitative design was selected for the study because of its realistic approach, that seeks to understand the real-world setting. Moutong and Prozesky (2001) reiterate that qualitative study tries to produce results which are arrived at from real-world settings where the phenomenon of interest is revealed naturally.

1.10.3 Research style

In order to carry out in-depth enquiry into the phenomenon, this study was positioned within the case study approach. Yin (2014) observed that the case study is a preferred strategy when 'How?' and 'Why' questions are posed. In line with Yin's position, the study seeks answers as to how MTEs enact FA in mathematics and why FA happens in mathematics in the way that it does. Mathematics educators from three different contexts were selected and studied to ascertain their understanding and practice of FA, hence making this a multiple case study.

1.10.4 Data generating technique

The purpose of generating data in research is to collect information in order to enhance understanding of the phenomenon under investigation. For this study data were generated through semi-structured interviews, lesson observations, field notes and analysis of teachers' course outlines and students' assessment scripts, to answer the three critical research questions in order to meet the objectives of the study.

1.10.4.1 Semi-structured interviews

Semi-structured interviews for data generation allow "probing and clarification of answers" (Maree, 2016, p. 87); thus the researcher was able to ask the participants for clarification if he did not understand the response. They also allow for follow-up questions about the phenomena under study (Rubin & Rubin, 2013). Teacher educators participated in a one-on-one semi-structured interview conducted in conference halls of the selected Colleges of Education which were chosen

by the participating educators. With permission from the participants, the interviews were audio recorded. Tessier (2012) argues that audio recording permits replaying of the tapes, which offers the researcher the opportunity to revisit the event more than once. Questions were formulated from the literature to explore teacher educators' understanding of FA.

1.10.4.2 Lesson observation

Data were also generated by observing participants' lessons. Hennink , Hutter, and Bailey (2020) posit that observation enables the researcher to systematically observe and record people's behaviour, actions, and interactions. Observation allows the researcher to gather 'live' data from naturally occurring social situations (Cohen et al., 2011, p. 456). Each participant was observed three times for at least one and a half hours each time. The rationale of the lesson observation was to obtain first-hand information about how teacher educators in Colleges of Education in Ghana enact and use FA in the context of mathematics pedagogy. There was a follow-up debriefing after each observed lesson, to discuss any questions or ideas that arose from the observation with the participant teacher educator.

1.10.4.3 Analysis of teachers' course outlines and students' assessment scripts

According to Maree (2016), when text or documents are used as a data gathering technique, the researcher focuses on printed communications that could potentially provide justification for and explanations of the phenomenon being studied. Documents analysed in this study include teacher educators' course outlines and students' assessment scripts. Issues selected for analysis from teacher educators' course outlines include: 1) Are learning intentions and criteria for success explicitly described in the outline?; and 2) Was there any evidence of how students were going to be assessed? By using the students' assessment scripts, the analysis looked at evidence of the nature of feedback that the teacher educators gave to their students.

A summary of the data generating methods is presented in Table 1.1 that follows.

Table 1.1: Summary of data generating methods

Critical research questions	Method/instruments	Participants
1) What are mathematics teacher educators' understanding and practice of FA in mathematics?	Semi-structured interview Interview protocol Audio recorder	Mathematics teacher educators
2) How do mathematics teacher educators' enact FA in mathematics modules?	Observation protocol Video recorder and field notes	Mathematics teacher educators
3) Why do mathematics teacher educators' use FA techniques?		Mathematics teacher educators

1.11 Concept clarification

Key concepts supporting this study, namely formative assessment, assessment practices, teacher educator, and error are explained in this section.

***Formative assessment*:** FA researchers describe assessment as formative when teachers provide feedback to gauge students' learning towards mastering instructional objectives. According to the National Council for Curriculum and Assessment (NaCCA) (2018) of Ghana, FA provides "feedback and information during a teaching and learning process while teaching is taking place and while learning is occurring" (p. 34). In this study the concept of FA refers to all learning activities undertaken by teachers and students during mathematics pedagogy, with the aim of supporting students' learning of mathematics, where feedback is essential in improving teaching and learning (Black & Wiliam, 1998a).

***Formative assessment strategy*:** An activity or instructional tool that is used by teachers to give students an opportunity to demonstrate their thinking and to collect information about students' understanding (Kang, Thompson, & Windschitl, 2014). For the purposes of this study the term formative assessment strategy is used synonymously with formative assessment technique.

***Assessment task*:** Any activity that students participate in to demonstrate their understanding of the learning goal (Kang et al., 2014).

***Assessment practice*:** A way of implementing or conducting assessment; for example, observations, tests, self-assessment, questioning and so on.

***Teacher educator*:** A teacher educator is someone who teaches at a teacher education institution or supports students' field work in schools, and contributes substantially to their development towards becoming competent teachers (Koster, 2002).

***Errors*:** Errors are symptoms of underlying misconceptions; it is a systematic response based on the misconceptions.

1.12 Organisation of the thesis

This study explored MTEs' knowledge and practices of FA and aimed to determine how they enact FA in mathematics modules. The entire thesis consists of seven chapters and includes reference and appendices.

Chapter 1: Background and aim of the field study

This chapter provides a brief overview of the background to and rationale for the study. The objectives and the critical research questions for the study are also introduced. Chapter 1 also highlights the definition and purpose of assessment, teachers' beliefs about FA, as well as how assessment can be employed in addressing students' mathematical errors. This chapter also outlines the significance of the study in the discourse on mathematics, a preview of the research strategy and clarification of concepts.

Chapter 2: Review of related literature

This chapter presents the relevant literature that support the methodological and theoretical basis of the study. The review is based on literature on classroom assessment in mathematics, perspectives of FA and the FA policy of Ghana. The chapter also presents related literature on teachers' understanding and practices of FA, the role of assessment in the teaching of mathematics,

and strategies for FA practices. The review also highlights the impact of FA and what is considered quality in assessment, and concludes by presenting a summary of the literature review.

Chapter 3: Theoretical orientation of the study

The theoretical framework provides the lens to zoom deeper into the phenomena of the study and the means to understand the data collected. This chapter presents the theoretical framework which underpin the study. The study is informed by activity theory. Details on the choice of the theory and its appropriateness for the study is outline in this chapter.

Chapter 4: Contextualisation and methodology

The fourth chapter discusses the study context and the research methodology and procedures undertaken to conduct this study. The chapter presents the design of the study and the research approach employed in the study. A discussion on the process of piloting, access negotiation to study site, sample and sampling method, data analysis process and issues of trustworthiness is also presented.

Chapter 5: Teacher educators' understanding of formative assessment

Chapter five aims to answer the first critical research question of the study on teacher educators understanding and practices of FA. The chapter focuses on analysis data based on the questions framed during the interview sections of the data production stage. In addition, this chapter presents a discussion on the extent of alignment between the findings established in the study on MTEs understanding of FA and Ghana's policy of FA.

Chapter 6: Lesson presentations: In search of teacher educators' assessment practices

The sixth chapter focuses on participating teacher educators lesson presentations with the aim of generating information on their assessment practices and to answer the second critical research question.

Chapter 7: Enactment of and rational for using formative assessment strategies

Chapter seven builds on chapter six. This chapter therefore discusses how teacher educators implement FA in the context of mathematics and the grounds for using FA techniques in their instructions. In this chapter data derived from lesson observation, interviews and textual materials are also discussed.

Chapter 8: Synthesis, Discussion and Recommendations

The chapter is the concluding chapter of the study. The chapter presents the summary of the study together with discussion and interpretation of the findings against the activity theory framework. Contributions and implications of the findings to the teaching and learning of mathematics are also discussed in this chapter together with recommendations for future research.

1.13 Conclusion

The introductory chapter of the study provided the background to the study, definition of assessment and the rationale of the study. In addition, the chapter also provided a brief account of research on teachers' belief towards mathematical errors as well as teachers' conception of FA. The chapter also provided an overview of the research study and concluded with preview of the chapters to follow. The next chapter engage and present the review of literature on FA.

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Introduction

The previous chapter provided the background and rationale to the study and introduced the critical research questions. The chapter concluded with a preview of the research plan and the methods used. This study was designed to explore MTEs' understanding and practices of FA. Against this backdrop, this chapter provides a detailed account of related literature concerning assessment in general and specifically FA. Boote and Beile (2005) posit that a review of literature is an evaluative account of studies related to a selected domain of knowledge; it provides a theoretical basis for further research by identifying and articulating relationships between the findings of earlier studies and the current study at hand (Budden, 2016).

The literature review seeks to analyse and synthesise the body of research related to the works of authorities who have contributed to knowledge with regard to FA. Literature on classroom assessment in mathematics, perspectives of FA, FA in the context of Ghana, teaching and learning of mathematics, the role of assessment, and teachers' knowledge and practice of FA, were elaborated on and discussed. Finally, the review looked at FA strategies and the impact of FA on learning, as well as assessment quality.

2.2 Classroom assessment in mathematics education

Assessment is an essential issue in the teaching and learning of mathematics and requires careful consideration by mathematics educators. Reform in mathematics education has captured the attention of policy makers and educational practitioners. Topical among the issues which have emanated from the reform were how to assess students' attainment and how to assess improvement that may result from curricular and instructional reforms (Silver, 1992). Assessment has been defined by some academics as an administrative process in which information regarding students' academic progress is provided (Hove & Hlastshwayo, 2015). Others have regarded assessment

more as a tool for supporting students' learning, rather than an administrative process (Bell & Cowie, 2001; McMillan, 1997). However, the NCTM (2000, p. 3) reported as follows:

> Assessment should be more than merely a test at the end of instruction to see how students perform under special conditions; rather, it should be an integral part of mathematics instruction that informs and guides teachers as they make instructional decisions. They also point that assessments should not merely be done to students; rather, it should also be done for students, to guide and enhance their learning.

This implies that assessment should be understood as a tool for learning mathematics. This position was supported by Kilpatrick (1993), who advocated for a change of assessment practice in mathematics education. He noted that "the challenge for the 21st century as far as mathematics educators are concerned, is to produce an assessment practices which does more than measuring a person's mind and assign a mind treatment" (p. 44). This view changes the focus of assessment from a practice meant to measure some endpoint status, such as the competency of an individual (Boulet, 2008), or making a judgement in accordance with specific standards (Taras, 2009), to an assessment practice which has the potential to improve students' learning outcomes (Heritage, 2011).

According to Oduro (2015) assessment in mathematics should elicit, assess and respond to students' mathematical understanding and problem-solving skills. The NCTM (2014) mooted that assessment should provide evidence of proficiency with important mathematics content and practices, include a variety of strategies and data sources, and provide feedback for students, instructional decisions and programme improvement. The NCTM (2014, p.89 ?) posited that assessment should serve four distinct functions in school mathematics, and should provide evidence to enable educators to:

> (1) Monitor students' progress to promote students' learning; (2) Make instructional decisions to modify instruction to facilitate students' teaching; (3) Evaluate students' achievement to summarize and reports understanding at a specific time; (4) Evaluating programs to make decisions about the instructional programme.

In the *Principles and Standard for School Mathematics* (2000, p. 2), the NCTM noted that assessment should "support the learning of important mathematics and furnish useful information

to both teachers and students". The goal of assessment is to evaluate mathematical programmes to assess their quality and to determine students' mathematical achievement (Wiliam, 2007b). Similarly, Burkhardt and Swan (2012) held that assessment in mathematics should reflect the mathematics which is important to students and valued.

It is therefore important to note that the methods or tools adopted by mathematics educators in their modules are essential to understand teacher educators' assessment practices in mathematics. The literature has shown that assessment in mathematics education in most schools around the world involves testing and grading (Bezuk et al., 2001; Lissitz & Schafer, 2002; Van De Walle, 2001). In addition, Dandis (2013) and Susuwele-Banda (2005) indicated that mathematics educators mainly use written examinations (tests) and quizzes to assess their students in mathematics. Senk, Beckmann, and Thompson (1997) explored the assessment and grading practices of 19 high school mathematics teachers and also found that tests and quizzes were the most frequently used assessment tools. On this premise, the Department of Education and Science of England (1982, as cited in Niss (2013), expounded as follows:

> Examinations in mathematics which consist only of timed written papers cannot, by their nature, assess ability to undertake practical and investigational work or ability to carry out work of an extended nature. They cannot assess skills of mental computation or ability to discuss mathematics nor, other than in very limited ways, qualities of perseverance and inventiveness. Work and qualities of this kind can only be assessed in the classroom and such assessment needs to be made over an extended period.

Therefore, there is a need for multiple assessment techniques that assess what students know and what they do not know.

Birgin (2011) recommended that alternative assessment tools, such as portfolios, students' journals, self-assessment, and peer and group assessment are useful in determine what students know and where they are in their learning. McMillan (2007a) also averred that there are different forms of assessment practices that are used by mathematics educators, such as observation, interview, projects and many more. Wiliam (2007b) opined that students' mathematical understanding and mathematical thinking can be enhanced via observation, interview, self-assessment, reflective journals, portfolios, performance tasks and projects. This indicates that

students' mathematics thinking cannot be assessed through one short test. This point suggests that mathematics educators should adopt multiple assessment techniques and carefully consider assessment which focuses on students' learning and has the potential to improve students' mathematics thinking and understanding.

Although various studies advocate for different forms of assessment due to its importance in the process of learning, little is known as to whether, how or which type of assessment is being implemented. Teacher educators, as the people responsible for training pre-service teachers, are those who need to lead by example. Therefore, the aim of this study is to explore teacher educators' knowledge and practices of FA in mathematics modules.

2.3 Perspectives on formative assessment

Bennett (2011) reported that the effectiveness of an innovation can be documented meaningfully if the innovation is clearly defined. This means that definition is very important for conceptual understanding and aids educators in knowing what needs to be implemented. Hence, this section discusses scholarly viewpoints on FA. In this study the term FA is used synonymously with assessment for learning.

FA refers to all assessment activities undertaken by teachers and their students during the teaching process, with the intention of supporting students' learning through feedback (Black & Wiliam, 1998a; Mkhwanazi, 2014). It is a process of gathering information about students' learning and the use of this information to modify instruction in response to feedback (Cauley & McMillan, 2010). FA is a process in which teachers control both content and assessment procedures and can adjust their instructional activities in accordance with the evidence gathered in the classroom (Mellati & Khademi, 2018). According to Prashanti and Ramnarayan (2019), FA is the process used by teachers to recognise and respond to students' learning in order to enable and enhance it. The procedure utilised by teachers and students to recognise and react to student learning in order to enhance that learning is called FA (Bell & Cowie, 2001). The above definitions indicate that FA is simply an ongoing activity which takes place during teaching and learning processes, in which responsibilities are shared between the instructor and students in order to elicit information about the classroom activities.

Black and Wiliam (2009) note that both teacher and students are involved in generating information to help in determining the next steps of instruction. Similarly, Popham (2008) posits that both teachers and students can derive instructional changes from FA; specifically, "assessment elicited evidence of students is used by teachers to adjust their instructional procedures or can be used by students' to adjust their current tactics of learning" (p. 6). According to McMillan (2007b), the goal of FA is to improve students' motivation and learning, which can be attained through some continuous circular processes involving: 1) evaluations of students' work, 2) provision of feedback to students, and 3) instructional correctives. It is worth noting that the ultimate goal of FA is to gauge students' learning, diagnose weaknesses and adjust instruction as and when needed.

In addition, Coffey et al. (2011) mentioned that the aim of FA is to help teachers to address their students' thinking during instruction. Through FA gaps in students' learning are identified, which gives the teacher an opportunity to modify or make adjustments to the instruction with the primary aim of supporting teaching and learning. Shermis and DiVesta (2011) assert that FA is premised on the inference that assessment is not an end in itself, but can be used constructively to identify where and when to improve instruction by teachers. This assertion means that teachers can change their approach to instruction but maintain the strategy that yields positive results during instruction and learning.

FA can be categorised as informal or formal, and the distinction can be made on the basis of the way the information is gathered, how it is perceived and the purposes of the assessment (Shermis & DiVesta, 2011). This gives credence to the point that the rationale for assessing and the belief held by the teacher in relation to assessment will inform him/her the form of assessment to be adopted in the classroom. For York (2003) informal and formal FA are distinguished by context. According to Cowie and Bell (1999) FA can be planned or interactive and the two forms are classified based on the processes employed in each. These two major forms of FA are discussed in the following sections.

2.3.1 Formal formative assessment

According to Shermis and DiVesta (2011) formal FA is carried out deliberately to provide feedback on curriculum matters; for example, feedback on students' readiness, diagnosis, remediation, and placement. This simply means that formal FA requires: (a) deliberate and planned gathering of information, (b) interpreting the information on the basis of the assessment goal, and (c) acting upon the information to modify or restructure the instruction, curriculum or system (Shermis & DiVesta, 2011). Formal FA is also known as planned FA (Bell & Cowie, 2001). According to Bell and Cowie (2001) planned FA is used to generate permanent evidence of students' thinking and can be organised at the beginning or at the end of a topic. Cowie and Bell (1999) produced a model of planned FA (*Figure 2.1*).

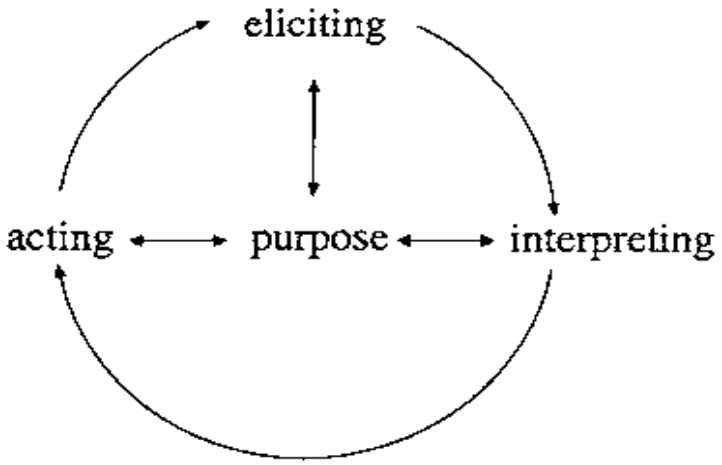


Figure 2.1: **Planned formative assessment (adapted from Cowie and Bell, 1999, p. 103).**

According to them eliciting of information, interpreting it, and acting upon the information denote the process of planned FA. In the planned FA the information collected, interpreted and acted upon are determined by the purpose of the assessment (Cowie & Bell, 1999). This suggests that there should be a purpose for assessing students, since the information obtained enables the teacher to plan how best to support subsequent learning of the students. Similarly, McMillan (1997) argues that formal FA is a planned activity in which students' knowledge and understanding are assessed, and the evidence generated is used in providing feedback and planning of instruction by the teacher (p. 120). He reiterated that there is always some measure of time between the assemblage of data

and the interpretation, that permits the instructor to reflect and determine the next most appropriate instructional activities. Based on the different perspectives of FA, it can be construed that FA is more than just a method to assess students' knowledge of a particular concept, but also to capacitate both the instructor and the students for further learning.

2.3.2 Informal formative assessment

This form of FA takes place during an interaction between the instructor and the students. Cauley and McMillan (2010) referred to informal FA as an ongoing assessment conducted primarily through informal observation and oral questions posed to students when content has been delivered or reviewed. Eisenkraft (2004), as cited in Ruiz-Primo (2011), conceived that everyday learning activities are potentially informal FA, which provides evidence of students' learning in a different mode. According to Ruiz-Primo (2011) evidence from learning activities can be accumulated within a class and information can involve one or two sources of evidence. Some of the evidence which informal FA uses comes from everyday activities such as "students' questions, students' oral responses, students' written responses in a handout, student-to-student conversation and observation of students conducting practicals" (Ruiz-Primo, 2011, p. 15). Nineteen years ago Bell and Cowie (2001) termed this interactive FA and described it as incidental ongoing FA which arises out of learning and cannot be anticipated; its aim is to improve learning by intervening or mediating in the students' learning. The process involved in interactive informal FA is described in Figure 2.2.

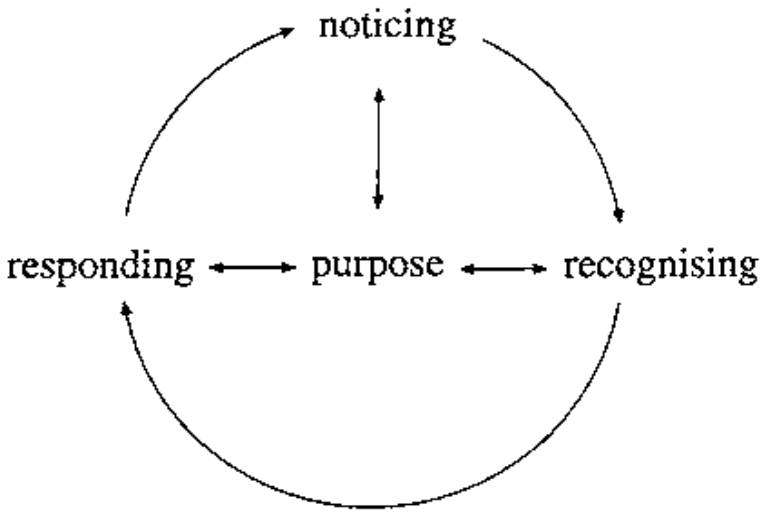


Figure 2.2: Interactive formative assessment (adapted from Cowie and Bell, 1999, p. 104).

Cowie and Bell (1999) observed that instructors might plan or prepare to carry out an interactive informal FA, but they cannot plan or determine exactly what they and their students will be doing and the time such an activity will occur. As presented in Figure 2.2, these authors explained that the interactive FA process involves teachers noticing, recognising and responding to students' thinking, and this process is teacher–student-driven rather than curriculum-driven. For example, as an instructor you must notice whether students appear disengaged or enthusiastic about the topic, recognise their difficulty and respond by looking at the best way of getting each student to the place they need to be.

Similarly, Ruiz-Primo and Furtak (2007) describe informal FA as "ESRU" cycles: the teacher elicits a question; the student responds; the teacher recognises the student's response; and then uses the information collected to support students' learning. According Ruiz-Primo and Furtak (2007), an incorrect response by a student or an unexpected question can inform the teacher about students' misunderstanding of classroom activity and can trigger an assessment event. What can be noticed from Cowie and Bell's (1999) definition and that of Ruiz-Primo and Furtak (2007) is that informal FA happens concurrently during instruction. This suggest that while an instructor is teaching, he or she will be assessing at the same time, because noticing and recognising students' difficulties or problems happens in the process of teaching, and within that process one needs to respond to the issues. In addition, Yorke (2003) defined informal FA as a form of assessment which takes place in the course of an event and is not specifically stipulated in the curriculum design. Informal FA is therefore not curriculum-specific, and materialises as a result of classroom interaction between the teacher and students. Therefore, it worth noting that informal FA does not happen in a vacuum; rather, it is an ongoing process and takes place during instruction because of interaction between teachers and students.

2.4 Formative assessment policy in the context of Ghana

This section discusses FA in the Ghanaian context as enshrined in the National Curriculum framework of Ghana in order to explore teachers' knowledge of FA and how their knowledge informs their practices in the classroom.

Berry (2008) argues that assessment should not only be considered as an end-of activity, which checks if learning expectations have been met. There has been a call on educators to adopt an assessment technique with the prime aim of improving learning, and FA has been identified as that technique. The National Council of Curriculum and Assessment (NaCCA, 2018) of Ghana stated that FA "provides feedback and information during a teaching and learning process, while teaching is taking place, and while learning is occurring" (p. 34). The NaCCA explained that FA measures students' progress as well as the teachers' own progress in the content delivery in a manner that ensures that learning is taking place.

According to the NaCCA the purpose of FA in Ghana's schools is to improve learning and to shape and direct the teaching-learning process; this is consistent with the literature (Black & Wiliam, 1998a; Cauley & McMillan, 2010). FA tools and techniques come in many forms, depending on the topic. The NaCCA (2018, p. 34) listed and recommended to teachers in Ghana FA tools and techniques like:

- Observations during in-class activities.
- Homework exercises as a review of class discussions and signal for future teaching and learning activities.
- Reflection journals that are reviewed periodically during the semester or term.
- Question and answer sessions, both formal (planned) and informal (spontaneous).
- Progress review meetings between the teacher and student at various points in the semester or term.
- In-class activities where students informally present their results.

It is expected that teachers make use of these FA strategies during classroom instruction. This means that teachers are supposed to have a clear understanding of FA, in order to ensure effective implementation in the classroom. It is against this backdrop that this study seeks to explore teacher educators' understanding and practices of FA in mathematics modules.

Furthermore, the NaCCA (2018) mooted that in the Ghanaian classroom FA should be understood as *assessment for learning (AfL),* an assessment practice that describes approaches within the formative purpose of assessment. Assessment for learning is designed to give teachers information to modify and differentiate teaching and learning activities (Earl & Katz, 2006). In assessment for

learning, teachers use assessment as an investigative tool to find out what their students know and can do, and to determine gaps in the students' learning. According to Perumanathan (2014), assessment for learning encompasses strategies that teachers engage in during teaching and learning. Swaffield (2011) argued that assessment for learning supports and develops students' learning and enables students to become autonomous and self-regulated learners. In support of Swaffield's position, Clark (2012) remarked that:

> Assessment for learning is beneficial when it provides students support to monitor their progress towards reaching a desirable goal through closing the gap between their current learning status and desired outcome.

Within the context of education in Ghana, assessment for learning (AfL): 1) comprises two phases – diagnostic assessment and FA; 2) can be based on a variety of information sources (e.g. portfolios, teachers' observation, conversation, etc.); 3) involves giving verbal or written feedback that is primarily descriptive, emphasises strength and identifies challenges; 4) demands of teachers that they check on students' understanding and adjust their instruction to keep them on track; 5) involves giving no grades or scores and record-keeping that is primarily anecdotal and descriptive; and 6) occurs throughout the learning process (NaCCA, 2018).

Assessment for learning includes the function of assessment known as FA, but is wider in scope since it also includes diagnostic and evaluation assessment. Chappus (2003), as cited in Balan (2012, p. 32), argued that:

> … it is tempting to equate assessment for learning with the term FA, but they are not the same. Assessment for learning is about far more than testing more frequently or providing teachers with evidence so they can revise instruction, although these are part of it, in addition we now understand that assessment for learning must involve students.

According to the New South Wales education department (2007), as cited in Mercy (2012), assessment for learning is an essential and integral part of the teaching and learning process that

reflects the belief that all students can improve. This indicates that the primary focus of assessment for learning is promoting students' learning, and this arises during instruction. In contrast to assessment for learning is assessment of learning (Aof), and the purpose of this kind of assessment is usually summative and mostly done at the end of a task, unit, or course. Assessment of learning is an evaluative activity meant to measure some endpoint status, such as competency of an individual (Boulet, 2008). The assessment is a single process which makes a judgement in accordance with specific criteria and standards; this is summative assessment, and is always the first part of any assessment process (Taras, 2009).

According to Wilson (2018) an assessment activity is summative when it provides a summary of what a student knows, understands or can do, and not for providing feedback which is used to modify the teaching and learning activities in which the students is engaged. Assessment of learning can be inferred as an assessment process designed to determine whether students have acquired specific knowledge or skills, based on a specific benchmark or criteria at the end of an instruction process, and on that basis judgement is made. Harlen (2007) moots that the cardinal purpose of assessment of learning is to summarise what has been learned. Summative assessment is generally used in measuring students' accountability.

According to Etsey and Gyamfi (2017) assessment as learning (AaL) is the process of developing and supporting students' metacognition (knowledge of one's own thought processes). With assessment as learning, students look at their own learning and reflect on their own abilities. Etsay (2016) argued that assessment as learning helps students to take responsibility for their own learning and to monitor future directions. Berry (2014) opined that assessment as learning and assessment for learning both emphasise the role of assessment in support of learning. Berry explained that assessment as learning focuses on the role of the students and encourages active engagement by students, while assessment for learning emphasises the role of the teacher in promoting learning. Etsey and Gyamfi (2017, p. 14) argued that "through the process of assessment as learning, students are able to learn about themselves as learners and become aware of how they learn. They reflect on their work on a regular basis and decide what their next learning will be".

All of these forms of assessment are needed in the process of teaching and learning, and all are emphasised and captured in the assessment policy of Ghana. However, the practices of teacher

educators have been more inclined towards assessment of learning that is summative. Drawing from evidence in the literature about the importance of forms of assessment other than assessment of learning, it is imperative to understand how these other forms of assessment are understood and practised by teacher educators.

2.5 Teaching and learning of mathematics: The role of assessments

Classroom instruction tends to benefit both teachers (Heritage, 2010a) and students (Kingston & Nash, 2011) when instruction is aligned with assessment. Assessment is a key element of teaching and learning (Brown, 2004), and therefore poor alignment between instruction and classroom assessment may impact negatively on students' attitudes and motivation and the classroom climate (McMillan, 2013). Biggs (1999) argued that "what and how students learn depends largely on how they think they will be assessed". Similarly, Adams and Hsu (1998), as cited in (Hemje, 2014), mooted that "teachers gain information to improve students' learning in mathematics and assessment is a primary factor in determining what and how students learn".

McTighe and O'Connor (2005) argued for classroom assessment, stating that classroom assessment guides students' learning. This is an indication that assessment provides the lens for understanding students' learning. In the context of effective mathematics instruction, assessment is a process whose primary purpose is to gather data that support the teaching and learning of mathematics (NCTM, 2014). Undoubtedly, classroom assessment plays an integral role in the teaching and learning process and mediates the interaction between teachers and students in the classroom. Assessment needs to be seen as an indispensable accompaniment to lifelong learning (Wiliam, Lee, Harrison, & Black, 2004), implying that assessment has to move from the exclusive domain of assessors into the hands of learners (Sethusha, 2012).

According to Shepard (2001), assessment must be transformed in two fundamental ways in order to help students' learning: 1) the content and character of assessment must be improved significantly, and 2) the gathering and uses of assessment information and insights must form part of the ongoing learning process. The first point raised by Shepard is consistent with the general argument that assessment content and format should derive thinking and reasoning which is the focus of learning (Resnick & Resnick, 1992). In addition, for assessment to have a place in the

ongoing learning process, Wiliam et al. (2004) remarked that teachers must introduce FA into their classroom practices.

Smith and Gorard (2005), in agreement with Wiliam et al. (2004), add that assessment can only be formative if it feeds back into the teaching–learning process, and that in order for students to improve, effective feedback should enable them to know exactly what they have to do to close the gap between actual and desired performance. Boud (2000) suggested that renewed focus be placed on the role of FA, in order to focus learners' attention on the process and to permit them to learn how to make the processes their own. The key principle emphasised here is that FA has to be intimately connected with the process of teaching and learning (Black & Wiliam, 2009). In support of this, Raveaud (2004) posits that assessment does not stand outside teaching and learning, but stands in dynamic interaction with it. This gives credence to the fact that, if assessment is to guide learning, then it must reflect the criteria (learning goals) which are set out in a learning sequence.

2.6 Teachers' knowledge and practices of formative assessment

Over the years, teacher educators have developed programmatic initiatives which help in the goals of educating prospective teachers (Zeichner, 2005). Teacher educators play significant role in the preparation of pre-service teachers in becoming assessment literate and able to practice after training. Hence, an exploration of teacher educators' understanding, and practices of FA will provide insight into the kind of assessment practices their students are exposed to. Teachers need a better understanding of FA in order to be able to implement it effectively in the classroom to enhance learning. Cassim (2010) notes that the beliefs and understanding that teachers hold about teaching, learning and assessment inform their classroom practices.

2.6.1 Teachers' Knowledge of formative assessment

Yao (2015) observed that teachers feel assessment represents a transitional stage in the teaching and learning process, and marks the end of one learning session and the beginning of another. However, Kumator (2017) opined that assessment that supports students' learning does not need to occur as the end product of instruction, but instead needs to occur prior to learning, during learning and after learning. This view is in support of Cowie and Bell's (1999) idea of interactive assessment. Vandeyar and Killen (2007) explored educators' conceptions and practices of

classroom assessment in post-apartheid South Africa, and concluded that educators need to be trained in the pedagogy of assessment since they cannot use assessment strategies which they do not understand or lack the skills to implement. Similarly, Hariparsad (2004) stated that teachers have a surface understanding of assessment practices, and this affects their beliefs about classroom assessment. If teachers need to be trained on how to make assessment interactive, then it means that the people responsible for training student-teachers (pre-service teachers) should have expertise in that. It is for this reason that this study aims to explore teacher educators' knowledge and practice of FA.

Amoako, Asamoah and Bortey (2019) investigated senior high school Mathematics teachers' knowledge of FA and their knowledge was found to be low. Arrafii and Sumarni (2018) also examined teachers' understanding of FA in the context of English Language. The study adopted a self-designed questionnaire named the Teacher FA Literacy Questionnaire (TFALTQ) for data generation. Using a case of 243 teachers, the authors found that teachers had a poor understanding of FA. Similarly, Arumugham et al. (2017) studied Malaysian 10 secondary school teachers' understanding of FA and found that they did not have in-depth understanding of FA.

According to Arumugham, Abdullah and Mahmud (2017), analysis of teachers' understanding of FA discovered three conceptions: 1) FA as testing and measuring method, 2) FA as a monthly grading, and 3) FA as an enrichment activity. Kanjee and Mthembu (2015) investigated Foundation Phase teachers' assessment literacy and understanding and use of formative and summative assessments in the classroom. Participants in their study were all females, and the results showed that the teachers demonstrated very poor understanding of FA. This implies that teachers are unable to use FA to support their students' learning. In another study Harris (2016) used interviews and lesson observations to examine how elementary mathematics teachers understand FA in relation to their classroom instruction. The result indicate that the teachers had some level of understanding of FA.

2.6.2 Teachers' practices of formative assessment

In 2014, the National Council of Teachers of Mathematics (NCTM)(2014) endorsed the integration of FA strategies in daily instruction. Thacker (2016) studied middle school teachers'

implementation of FA practices in semi -rural Northwest Georgia district in the United State of America by employing a transcendental phenomenological design and reported the following findings. Firstly, the study revealed that teachers' implementation of FA practices is evolving with experiences and social – cultural interactions. Thacker also found that teachers desire to know their students academically, socially, and emotionally through FA practices. Thirdly, the study established that teachers need to develop a common language and shared expectations for formative assessment practices. Cisterna and Gotwals (2018) in their study, aimed at what teachers can do when enacting FA, found that teachers were able to enact some components of formative assessment in a piecemeal fashion but tended to struggle with integrating FA practices to enact seamless science instruction. In addition, Furtak (2012) also established that teachers struggled to use students current ideas to support ongoing learning.

Knowledge and practices of assessment is an issue with teachers. The aforementioned studies mainly focused on either teachers' understanding of FA or teachers practices of FA. It is important to note that understanding is critical, but in the case of assessment it is not enough since assessment is part of teaching and learning. Therefore, understanding and practice should be explored together. Knowing teachers' knowledge of assessment is not enough – there is also a need to know how their knowledge translates into practice.

In this study the researcher opted to explore teacher educators' knowledge and practices of FA, because in most cases it is the practices learned from their instructors that teachers tend to emulate in the classroom. There is a high possibility that teachers' practices are informed by their instructors' practices. Therefore, understanding teacher educators' knowledge and practices of FA would provide insight into the way in which teachers at school level understand and practice assessment. This would inform policy developers about areas of development that are needed, not only for teachers but for teacher educators as well.

2.7 Key strategies for formative assessment practices

Kang et al. (2014) referred to FA strategy as an activity or instructional tool used by teachers to give students an opportunity to demonstrate their thinking and to generate information about

students' learning. This implies that FA strategies are instruments which provide valuable information to both teachers and students for checking understanding and for actions to be taken. Trumbull and Lash (2013) argued that any activity can serve a formative purpose if it provides an opportunity for generating information about students' understanding and to gauge progress.

Early research points to five main types of activities which FA is centred on, through evidence of their potential effectiveness and developed with and by the teacher in the classroom: a) sharing success criteria with students; b) classroom questioning; c) comment-only marking; d) peer and self- assessment; and e) formative use of summative tests (Black et al., 2003; Wiliam, 2009). FA strategies can be conducted before, during and after instruction (Magno & Lizada, 2015; McMillan, 2011). Strategies employed before instruction, according to Magno and Lizada (2015), serve as a diagnostic tool in determining the prior knowledge of students, to show how strong the connection is between their past skills and the prerequisite skills for the new lesson. During instruction FA strategies can be used in determining students' understanding of the learning goals and to make immediate instructional decisions based on the responses (Magno & Lizada, 2015). This means that teachers can tap the full potential of FA to enhance their students' learning, by adopting FA strategies at all three stages of instruction.

According to Bennett (2011), for effective implementation of FA there should be a theory of action which revolves around one big idea and five key strategies which emanated from the works of (Black & Wiliam, 1998a, 2009). The five strategies of FA as cited in Black and Wiliam (2009) include:

1. Clarifying and sharing of learning intentions and criteria for success.
2. Engineer effective classroom discussion, questions and learning tasks that elicit evidence of learning.
3. Providing feedback that moves learners forward.
4. Activating students as owners of their own learning.
5. Activating students as instructional resources for one another.

These strategies mentioned by Bennett (2011) were first laid out by (Leahy, Lyon, Thompson, & Wiliam, 2005), who argued that they are non-negotiable, and that exclusion of any one of the strategies will render implementation of FA ineffective in the classroom. The Keeping Learning

on Track® Programme (Educational Testing Service, 2010) observed that the big idea which needs to be considered during the implementation of FA is students and teachers using evidence to adapt teaching and learning to meet the immediate learning needs minute by minute and day by day.

The five strategies espoused by Bennett are useful in directing the instructional processes in order to answer the three critical questions of FA: 1) Where am I going?; 2) Where am I now?; and 3) How can I close the gap? (Black & Wiliam, 1998a). This approach is similar to Wiliam and Thompson (2008) framework for FA which is based on Leahy et al. (2005) five FA strategies and asks the following three questions: 1) Where is the student going?; 2) Where is the student right now?; and 3) How does the student get there? These are asked and answered from the perspective of the teacher, the students and the peers (Table 2.1).

Table 2.1: Aspects of formative assessment (adapted from Black and Wiliam, 2009, p. 5)

<table>
<tr><th></th><th>Where the student is going</th><th>Where the student is right now</th><th>How to get there</th></tr>
<tr><td>Teacher</td><td>Classifying learning goals and criteria for success</td><td>Engineering effective classroom discussion, questions and learning tasks that elicit evidence of learning</td><td>Providing feedback that moves students forward</td></tr>
<tr><td>Peer</td><td>Understanding and sharing learning intentions and criteria for success</td><td colspan="2">Activating students as instructional resources for one another</td></tr>
<tr><td>Student</td><td>Understanding learning goals and criteria for success</td><td colspan="2">Activating students as owners of their own learning</td></tr>
</table>

It can therefore be argued that the focus of Wiliam and Thompson (2008) framework is that teaching is adaptive to the students' needs; in other words, evidence about learning is used in adjusting instruction to meet the learning needs of the students. According to Black and Wiliam (2009) the five types of activities identified earlier can be seen as means of implementing these five FA strategies. For example, these authors suggest that classroom questioning is one means of enacting the second strategy, which deals with engineering effective classroom discussion and learning tasks that elicit evidence of learning. It is worth noting that these five strategies are essential in FA and increase students' academic performance when implemented successfully. Wiliam (2007a) also concurs that use of these strategies has direct impact on learning and supports students' performance. In addition, Bennett (2011) points out that FA enhances students' learning

when teachers are able to implement these strategies in the classroom effectively. The next five sections discuss these five FA strategies in more detail.

2.7.1 Sharing of learning goals and criteria for success

Determining goals and criteria for success drives the process of FA. This is to say, effective FA enactment begins with identification of clear goals for both the teacher and the students and determination of the criteria for success. Magno and Lizada (2015) argued that these goals may assume the form of learning competencies, standards and skills prescribed in a curriculum. FA is most effective when students have clear knowledge of what is expected of them from their teacher (Cauley & McMillan, 2010).

According to the Australian Institute for Teaching and School Leadership (2011), learning goals are descriptions of what students should know, understand and be able to do by the end of a learning period or unit. This body further explained that learning goals are the basis for tracking students' progress, providing feedback and assessing achievement. Northwest Evaluation Association (2016) argue that to enhance learning, the intentions of the learning need to be shared in clear terms prior to instruction. Clarke (2001) had earlier noted that teachers should share the learning intentions with their students at the beginning of a lesson, to increase the concentration level of the students and reinforce their understanding. This suggests that what a teacher wants his or her students to learn, know or be able to do should be clarified before starting the lesson. FA can therefore be tied to learning goals (Heritage, 2010b). This is because it provides guidance to teachers on what their teaching and learning activities seek to achieve and the basis for feedback. According to the NCTM (2014, p. 12) " Effective teaching of mathematics establishes clear goals for the mathematics that students are learning, situates goals within learning progressions and uses the goals to guide instructional decisions". Mathematics goals specify the kind of mathematics students are to learn and understand as a result of instruction (Wiliam, 2011). The standpoints of the NCTM (2014) and Wiliam (2011) indicate that teachers' classroom mathematics activities should be directed by the goals to be learned. Black and Wiliam (1998a) also observed that learning goals should be articulated clearly for students' understanding, and explained that learning goals can be achieved by students only if they understand these goals.

Sadler (1989) theory of FA stated that students must be able to answer three questions: Where am I going?; Where am I now?; and How do I close the gap? This point suggests that students need clear learning intentions in order to know where they are going. While in agreement with Sadler's theory, I am of the view that in the quest to make learning meaningful, teachers also need to ask themselves the same questions, so that they can answer them together with the students in the process of teaching and learning. Chappuis and Stiggins (2002) reported that students need concise learning targets to be able to answer the question 'Where am I trying to go?'. The authors opined that when students understand the goals they seek to achieve, the purpose of achieving such goals and the attributes of success, learning becomes much easier.

The literature has indicated that students with clear goals of learning are more committed and effective in the learning process (Black & Wiliam, 1998b; Chappuis & Stiggins, 2002). These clear goals of learning can be achieved when learning and assessment happen simultaneously, and these goals can be achieved through FA. Undoubtedly, the intentions of learning are crucial in the instructional processes. For example, teaching and learning activities which are planned and structured for instruction by the teacher to help students' learning are focused on the learning intentions. It must also be noted that, while questioning students during the instructional process, teachers should keep in mind the learning intentions. This simply means that all activities which go on during instruction, such as feedback, self-assessment and peer assessment, revolve around one central idea of the intentions of the learning (see Figure 2.3).

Furthermore, clear expectations give students the opportunity to set realistic, attainable goals (Cauley & McMillan, 2010). Using rubrics and providing exemplars are considered useful techniques to explain expected quality (Panadero & Jonsson, 2013). The use of rubrics increases students' self-efficacy (Andrade, Wang, Du, & Akawi, 2009; Panadero & Jonsson, 2013), a variable shown to be a strong predictor of academic performance (Richardson, Abraham, & Bond, 2012). This effect is probably based on handing out the rubric to students beforehand, as when learning goals become clearer then students have a better understanding of the learning target and how to achieve it (Fraile, Panadero, & Pardo, 2017). According to Moss, Brookhart, and Long (2011) "Students cannot regulate learning, use thoughtful reasoning processes, set meaningful goals, or assess the quality of their own work and that of their peers unless they understand what

success looks like in today's lesson"(p.66). This implies that one of the keys to improving student achievement is that they must be aware of what is required from them. Ngwenya (2012) posits that students need to understand the standard against which their work will be assessed. It is worth noting that when students know this, it allows them to become better assessors of themselves and their peers. It also gives them the opportunity to compare their learning to the learning goal in order to determine at which point they are in their learning. Students' trust in the assessment is influenced when criteria for assessment are determined and made known to them (Tillema, Leenknecht, & Segers, 2011).

Literature has shown that improving learning through FA also requires the active involvement of the students (Heritage, 2010b; Kollar & Fischer, 2010). According to Ngwenya (2012), to engage students fully in the learning process and to inspire them to accept responsibility for their own learning, teachers should move away from teaching to facilitation of active learning which promotes collaborative assessment. Collaborative assessment occurs when students and teachers co-create the criteria for assessment (Ngwenya, 2012). Students' involvement in determining the criteria for success or the assessment criteria facilitates their formative use of the criteria, rather than a single-minded focus on the final score (Reddy & Andrade, 2010). Reynek, Meyer, and Nel (2010) found that assessment was not a transparent process, and that 96.8% of the participants in their study never shared assessment criteria with their students. Ramsey and Duffy (2016) also found no evidence of teachers sharing criteria for success with their students during their study on FA in the classroom.

Research indicates that students should be well informed about the assessment criteria to be implemented before they start working on an assessment task (Black & Wiliam, 2009); however, the majority of teachers do not share specific assessment criteria with students prior to assessment tasks (Ngwenya, 2012). Without a precise description of where students are meant to be going, many of them will be doing things based on guesswork (Moss et al., 2011).

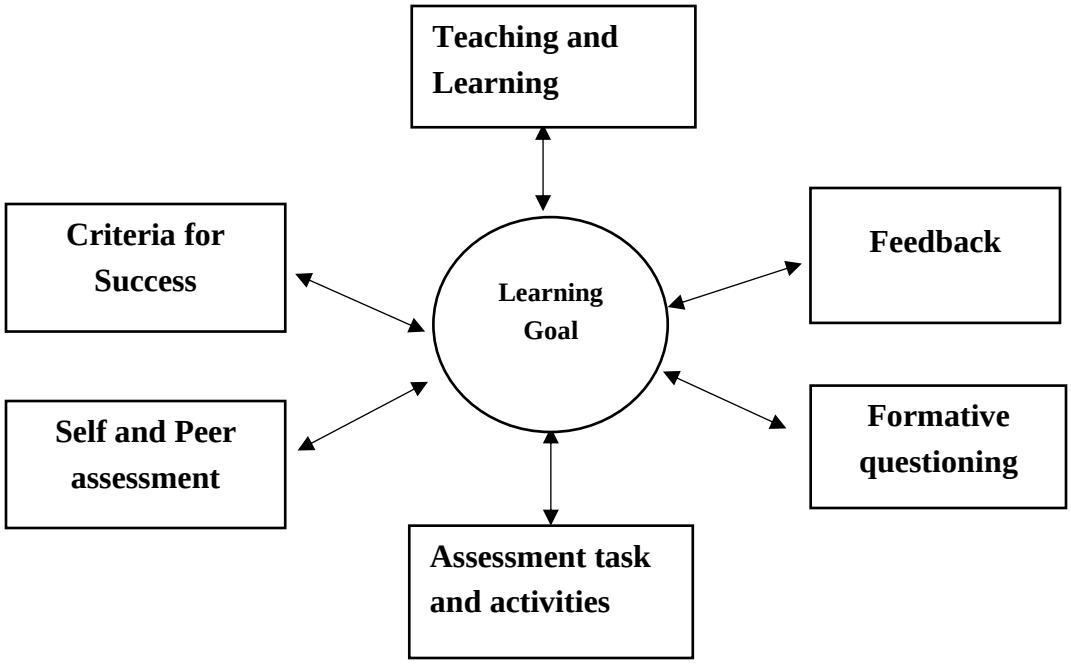


Figure 2.3: A model for learning goals (adapted from Hanover Research, 2014, p. 12).

2.7.2 Eliciting evidence of learning through questioning

Once the goal for learning is set, it is important to collect the right set of evidence about student progress towards these instructional goals. Black and Wiliam (2009) explained that classroom questions are one way of eliciting evidence about students' learning. Jiang (2014) conceived that formative questioning is the process of asking questions to check for students' understanding and evaluating responses for instructional adjustment. Questioning is therefore said to be an inseparable part of the classroom teaching and learning process (Babu, 2015) . In other words, it is and has been one of the routine classroom practices of teachers. The concept of questioning as a tool used in facilitating classroom discourse has a long history in the area of assessment. For example, the starting point of dialogue in the classroom is generally through question formulation by the teacher (Black & Wiliam, 1998a).

Strategies for eliciting evidence of students' learning should be planned in advance, although they sometimes occur spontaneously. A teacher planning his or her lesson may decide on the questions to use at a certain stage of the instruction to determine students' understanding of the mathematics concepts, and make instructional adjustments when necessary in light of the students' responses.

Lightbown and Spada (2013) argued that questions serve as instruments for exploring how much students have understood concepts. Heritage and Heritage (2013) echo this view by illustrating the role of classroom questions in generating evidence about students' learning and for the teacher's decision making. They posited that " open and respectful pedagogical questioning is a key resource in eliciting students' current learning status, and for making decisions about next steps in student learning" (Heritage & Heritage, 2013, p. 176).

Teachers utilise questioning as a formal or informal FA strategy in checking students' understanding. Ruiz-Primo and Furtak (2007) explained that students' questions or incorrect responses may be enough to trigger an informal assessment episode by the teacher. Questioning is the most frequently used instructional tool, and allows teachers to assess at what point the learners are during classroom discussion. Cuccio-Schirripa and Steiner (2000) stated that "Questioning is one of the thinking processing skills which is structurally embedded in the thinking operations of critical thinking, creative thinking and problem solving". According to Graesser and Person (1994), a question is defined as "a speech act that is either an inquiry, an interrogative expression, that is an utterance that would be followed by a question mark in print or both". A question is any sentence which has an interrogative form or function (Cotton, 1988). Questions define task, express problems and delineate issues (Elder & Paul, 1998). Although the above authors make reference to learners, questioning as a form of assessment is not only important at school level but also in all forms of learning, including at tertiary level.

Due to the social nature of classroom activities, information collected through informal FA is through conversations and these conversations are made possible through questioning. Black and Wiliam (2009) posit that questioning is used to start effective classroom discussion and to involve other students in the learning task. This helps in eliciting evidence of students' understanding. On a similar note, Chin (2007) states that questions provide feedback to the teacher about students' understanding. Weiss and Pasley (2004) extend the idea and argue that it is through questioning that misconceptions are revealed during the process of teaching and learning. Generally, when you interact with educators within school and tertiary levels about forms of assessment, you will rarely hear educators referring to questioning. Is this because it is not implemented, or because it is not conceptualised as a form of assessment? While in agreement with the above authors, it is critical

to take cognizance of the purpose of questioning, since all of the authors posit that its aim should be to elicit thinking and provide feedback. As Zepeda (2014) posits, questions can trigger responses which range from simple recall to abstract processes of applying, synthesising and evaluating information. It is therefore important to note that the art of thinking is driven by questions (Elder & Paul, 1998).

Questions differ in function and can be grouped into different categories. According to Feng (2014) teachers' questions can be classified into four types: yes/no, either/or, tag, and wh-questions (what and why). The yes/no questions seek to prompt new information, clarify, or confirm given information, whereas wh-questions are used to elicit particular kinds of information (Cele-Murcia & Larsen-Freeman, 1999). Babu (2015) found that 90% of teachers' questions are based on knowledge in the cognitive domain; almost 55% were closed, while 40% were yes/no questions. In order to elicit thinking, Feng (2014) suggested that questions can be grouped into six levels according to Bloom's taxonomy, i.e. knowledge, comprehension, application, analysis, synthesis, and evaluation. Bloom's taxonomy can be further classified into lower-level questions and high-level questions. Lower-level questions refer to those at the knowledge, comprehension and application levels of the taxonomy, while those that require complex application such as analysis, synthesis and evaluation are considered high-level questions (Feng, 2014).

Research has shown that teachers dominate in the classroom discourse by asking the highest number of questions, which tend to be of low order and mainly seeking knowledge, not eliciting deep understanding of the concept. For example, Wiliam (2007b) reported that the 1999 Trends in International Mathematics and Science Study (TIMSS) video found that there were 8 teachers' words for each student word. The author (Wiliam, 2007b) also reiterated that for a class of 25 students, the teacher speaks 200 times as much as any student. Almeida (2012) avers that if teachers ask huge numbers of questions per class, then the questions posed will constantly be the same. According to Tofade, Elsner and Haines (2013), teachers ask questions to help students to uncover what has been learned, to comprehensively explore the subject matter and to generate discussion. In contrast, Chafi and Elkhouzai (2014) believe that teachers use questions not to aid students' learning but rather to control and support their teaching. Kawalkar and Vijapurkar (2013) emphasise that "teachers' questions in the inquiry classroom not only explore and make students'

thinking explicit in the classroom but also serve to guide and scaffold it". Therefore, for effective classroom dialogue the questions should not always come from the teacher.

While the discourse of questioning is advocated in the literature, current studies have raised concerns about teachers' discourse in the process of questioning. Almeida (2012) avers that questions from students play a key role in students' learning and motivation. Almeida's reservation regarding teachers' questioning as a form of learning was in response to Saeed, Khan, Ahmed, Gul, Cassum and Parpio (2012) and Wiliam (2007), who found that in the process of teaching, assessing via questioning is always dominated by the teacher with students having to respond to teachers' questions. Such classroom discourse perpetuates teacher-centredness.

In contrast, Van der Walle (2007) advocates that questioning as a form of teaching and learning should be two-way and come from both the teacher and the students. Bolgomony (2007) found that encouraging students' questions or tasks enhanced their understanding. The first steps towards the filling of students' knowledge gaps is through them posing their own questions (Chin & Osborne, 2008). Almeida (2012) and Chin and Osborne's (2008) suggestions build Chin and Chia (2004) exploration of Grade 9 students' sources of inspiration for their questions and how these questions assist them in knowledge construction. Their study found that students' learning was driven by their questions. This suggests that the quality of students' thinking is determined by the kind of questions they ask during instruction.

2.7.2.1 Questioning in mathematics discourse

Questioning in mathematics is an important diagnostic tool for teaching as well as for measuring the academic progression and comprehension of students. According to Moyer and Milewicz (2002) students' knowledge construction and communication during mathematics lessons may be dependent on the teachers' questioning. By using questioning and other appropriate teaching strategies, mathematics educators can facilitate problem solving and critical thinking in students. Moyer and Milewicz (2002) posit that "Teachers who can question effectively at various levels within the cognitive domain such as knowledge, comprehension, application, analysis, synthesis and evaluation (Bloom, 1956) are better able to recognize the range and depth of children thinking". Teachers' questioning is indispensable because it is the prime source of mathematical questioning discourse which students can learn from and copy (Stolk, 2013).

Stolk (2013) study of the types of questions that comprise a teacher's questioning discourse in a conceptual-oriented classroom indicated that the focus of investigating teachers' questioning is to establish skilful use of questions which prompts students' thinking or engages students in developing mathematical understanding, against less skilful use of questions to improve pedagogy. Sahin and Kulm (2008) developed a framework for categorising teachers' questions, finding in their qualitative case study on two sixth grade teachers' questioning that the teachers use three different types of questioning: probing, guiding and factual questions. The authors remarked that guiding and factual questions are less skilful questions.

According to Kawanaka and Stigler (1999) guiding questions guide students to use mathematical concepts and procedures to solve problems. Ortenzi (2002) termed Kawanaka and Stigler's guiding questions leading or helping questions. According to Ortenzi (2002), through leading questions the teacher may lead students into convergent thinking – in the way that the teacher wants them to think. Sahin (2007) noted that guiding questions are at the centre of inquiry and problem-based instruction. Sahin and Kulm (2008) stated that guiding questions are like leading questions which can promote students' thinking. Through leading or helping questioning, teachers dispense direct information to assist students when they encounter difficulties during instruction (Sahin & Kulm, 2008). This suggest that one key characteristic of these questioning types (guiding, leading, or helping) is to support students during instruction, so they can also be considered as supportive questions.

In contrast, factual questions allow classroom teachers to check students' recall of specific mathematical facts or simple procedures, which enables the teacher to assess the knowledge of basic information before moving forward (Myhill & Dunkin, 2002). According to Myhill and Dunkin, factual questions invite predetermined answers; for example, 'What is five plus five?'. The authors indicated that 64% of teachers' questions required some factual predetermined answers. Sahin and Kulm (2008) defined probing questions as questions for clarification, justification, or explanation to extend students' knowledge. Similarly, Boaler and Brodie (2004) remarked that probing questions ask students to articulate, elaborate or clarify ideas to explain their thinking. The Maryland State Department of Education (1991) indicated that probing not only extends students' knowledge beyond factual recall and repeating learned skills, but also pushes

students to bring past experience or knowledge to bear to develop new concepts and procedures. Martino and Maher (1999) found that probing questions can be used to justify solutions to a problem and re-examination of students' original solution. Through probing questions, adequate explanation, justification and generalisation can be supplied by the students (Martino & Maher, 1999). Probing questions are a useful teaching method and enable teachers to explore students' thinking (Moyer & Milewicz, 2002).

During mathematical discourse, students' misconceptions and error patterns in mathematics are diagnosed through questioning (Ashlock, 2001). Teachers' questioning and students' explanations during mathematical conversations rely on verbal communication as the primary means for eliciting information. According to McCarthy, Sithole, McCarthy, Cho, and Gyan (2016) probing questions have a dual function: serving as the teacher's response to students' answers, and also as an assessment of students' understanding of the concept being learned. Teacher educators need to be mindful of the nature of the questions they ask during mathematics discourse, and are encouraged to ask questions that assist students to work together and make sense of mathematics.

2.7.3 Providing feedback that moves students forward

FA refers to all assessment activities undertaken by teachers and their students during the teaching process, with the intention of supporting students' learning through feedback (Black & Wiliam, 1998a; Mkhwanazi, 2014). To fulfill a formative purpose of assessment, Heritage (2010b) observed that assessment needs to provide actionable information for both teachers and students; this actionable information is called feedback. Ideally this information reveals something about students' progress towards the goals of learning, and the thinking processes and any misconceptions which the students may hold (Supovitz, 2012).

Literature on FA has found that promoting learning can be achieved through feedback that offers students the opportunity to take steps to move forward in their learning (Bansilal, James, & Naidoo, 2010; Black & Wiliam, 1998a; Heritage, 2011). Feedback is significant in the learning process and should not be seen in isolation from other instruction activities. Predicting students' responses to instructional tasks helps teachers to be prepared on how to provide feedback to students (Erbilgin, 2019). Hattie and Timperley (2007) review of studies on feedback suggested that it must answer

three major questions asked by a teacher and/or by a student, and these were called feedback questions:

- Where am I going? (What are the goals?)
- How am I going? (What progress is being made toward the goal?)
- Where to next? (What activities need to be undertaken to make better progress?)

When feedback is aligned to the intended goal of learning, it informs the students as to where they are and what they need to do next. Brookhart, Moss, and Long (2010) called feedback the "linchpin" that links the elements of the FA process (Brookhart et al., 2010, p. 41). Feedback is an integral component of FA and influences learning (Black & Wiliam, 1998a; Hattie & Timperley, 2007; Shute, 2008). This means that feedback serves as a link between assessment and learning. Hattie and Timperley (2007) defined feedback as information that is provided on one's performance or understanding by an agent, who could be a teacher, peer, parent, or oneself. In addition, Shute (2008) used the term '*formative feedback'*, which she defined as information communicated to a student, based upon which the student can alter his/her mindset with the sole purpose of improving learning. Similarly, the teaching development unit of Curtin University of Technology in Australia observed that "feedback is any response made in relation to students' work such as an assessment task, a performance or product and can be given by a teacher, an external assessor or a student peer" (Curtin University, 2011, p. 2).

One attribute emerges from the above definitions, which is provision of information mainly to students, the focus of which is to assist them to improve their performance. Drawing from Shute's (2008) definition, it can be argued that formative feedback as FA aims to improve learning. Unlike Hattie and Timperley (2007), Shute's definition of formative feedback aligns with FA while the previous authors' definition applies to any form of assessment. However, all authors in the field associate feedback with learning, thus suggesting that there can be no learning without assessment and no assessment without feedback. However, the individual understanding of the alignment between learning, assessment and feedback is crucial for proper implementation. Moreover, individual knowledge and practice are crucial in the effective implementation of the alignment between learning, assessment, and feedback.

According to Heritage (2011), feedback as a crucial component of FA has two aspects: first, feedback serves as an essential resource for teachers to shape new learning through adjustments in their instruction; and second, feedback as essential resource enables students to assume the responsibilities of their own learning. Heritage reiterated that feedback becomes more valuable when it aids and give clues to students for them to understand their present learning situation and act based on the information received. This position is supported by Wiliam (2007a), who posits that feedback becomes formative only if students use the feedback information to improve performance. In other studies it was observed that feedback bridges the gap between what is known and what is not known by the students (Hattie & Timperley, 2007; Sadler, 1989). This implies that feedback to students has a dual purpose: firstly, it informs them about their learning; and secondly, it gives direction on what to do next time or moving forward. However, the key aspect of formative feedback is FA, and key people in the success of FA and formative feedback are the instructors. It is therefore necessary explore instructors' (teacher educators') understanding of FA. The study will not just explore their understanding but also their practice, since their knowledge and practice are crucial for giving appropriate feedback.

Teachers' planning of instructional units is informed by feedback (Cowie & Bell, 1999). Threlfall (2005) explored the formative use of assessment and found that teachers could use feedback to make programmatic decisions. Through feedback, teachers can determine the effectiveness of their instructional activities. Feedback is an indispensable tool for improving teaching and learning. Learning without feedback is like archery practice in the dark (Cross, 1996). Feedback is therefore an essential element of the learning process. According to Shrivasta, Shrivasta, and Ramasamy (2014), assessment feedback is an important element of the instructional process. The authors opined that feedback encourages and enhances students' knowledge, skills, and achievement. This is consistent with Cauley and McMillan (2010) five key practices of FA: 1) provide a clear learning target, 2) offer feedback towards meeting the learning target, 3) attribute students' success and mastery to moderate effort, 4) encourage students' self-assessment, and 5) help students set attainable goals for improvement. The authors mooted that feedback is one of the FA techniques which enhances students' motivation and performance. One cannot argue against the importance of FA. However, knowing how important FA is for learning does not necessary translate into it being implemented in the process of teaching and learning. Therefore, this study aims to explore

how instructors, in this case teacher educators', understand and implement FA in mathematics modules.

Students' achieve their goals and improve their performance through feedback (Schartel, 2012; Thomas & Arnold, 2011). Students' goals fall into two categories: performance goals and mastery goals. Performance goals compare students with more successful peers, while in contrast mastery goals emphasise learning, understanding, mastering new skills and taking on challenges (Cauley & McMillan, 2010). It is worth noting that feedback is a significant tool in meeting learning targets and enhancing students' learning outcomes.

According to Glover and Brown (2006) the effectiveness of feedback can be realised when students make use of it to improve their subsequent work or learning. Gibbs and Simpson (2004) suggested that this is likely if feedback:

1) Is frequent, timely, sufficient, and detailed enough;
2) can be linked to the assessment task or criteria;
3) is understandable; and
4) focuses on learning rather than marks.

Gibbs and Simpson (2004) explained that feedback needs to be linked with the assessment task or criteria. Black et al. (2003) point out that feedback that focuses on what needs to be done has the potential of encouraging all (students) to believe that they can improve. This means that feedback should relate to the learning goals and the success criteria to ensure its effectiveness. Once the purpose of feedback and assessment criteria is understood by students, they improve their work (Wojtas, 1998). According to Weaver (2006) students tend to ignore teachers' feedback comments which lack guidance, or are vague and unrelated to the assessment criteria.

The notion that feedback is an important aspect of FA gives credence to two conditions for effective feedback as proposed by (Sadler, 1989). First, Sadler posits that feedback must identify gaps between the desired goal of learning and the students' present status in relation to achieving that goal. Secondly, feedback must provide an opportunity for students to take steps in closing gaps in their learning and understanding. Hattie and Timperley (2007) detailed what constitutes

effective feedback by conceptualising it into a model (Figure 2.4) that distinguishes four categories. The model depicts how comments may be related to the three feedback questions: 1) Where am l going?; 2) How am I going?; and 3) Where to next? on four different levels – task, process, self-regulation, and self-feedback. Figure 2.4 shows the purpose of feedback and how it can be utilised in clarifying discrepancies or understanding.

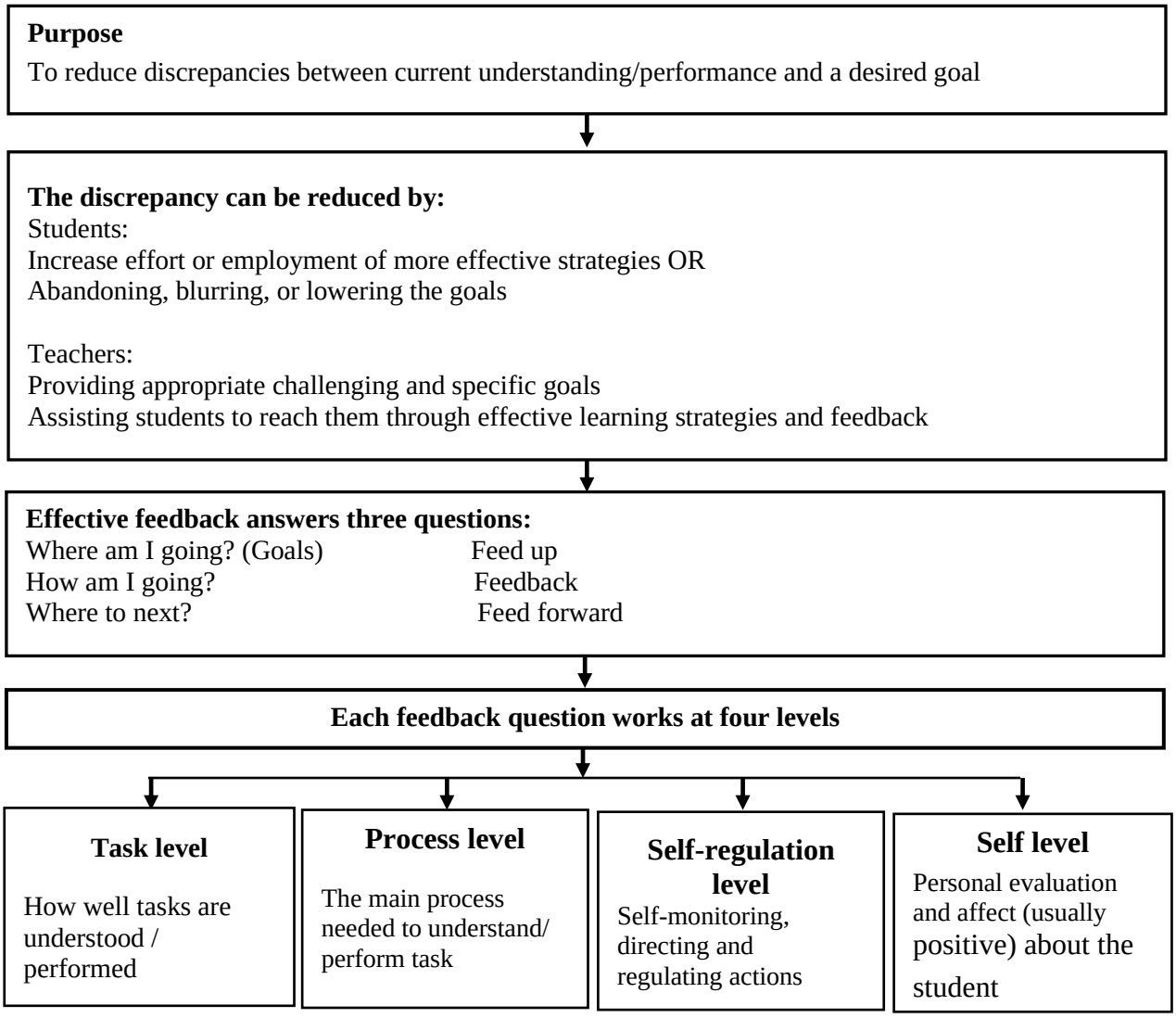


Figure 2.4: Model of feedback to enhance learning (adapted from Hattie and Timperley, 2007, p. 79).

Hattie and Timperley (2007, p. 90) stated that "the level at which feedback is directed influences its effectiveness". According to the authors, feedback about the task explains how well a task is

understood and performed and may include directions to acquire more, different, or correct information. Hattie and Timperley remarked that this kind of feedback is called corrective feedback or knowledge of result and is akin to correctness, neatness or other criteria related to task accomplishment. This suggests that task feedback tells one whether work is correct or incorrect. A deep understanding of learning involves the construction of meaning, and therefore the second level of the model is aimed at the processing of information or learning processes requiring understanding. This gives insightful information to the individual in order to improve their work. Self-regulation involves an interplay between commitment, control, and confidence. It addresses the way in which students monitor, direct, and regulate actions towards the learning goal (Hattie & Timperely, 2007). This is powerful in selecting and interpreting information in ways that provide feedback. Finally, feedback about oneself is the least effective among the four feedback levels highlighted by Hattie and Timperely. It usually contains little task-related information and is rarely converted into more engagement or commitment to the learning goal. As evident in the above literature, feedback improves learning and thus assessment without feedback is not formative. Therefore, in order to ensure appropriate feedback, FA should be at the core in the learning process.

In contrast Lee (2008) highlighted the following six procedures required of teachers in order to ensure effective implementation of feedback in the classroom: 1) telling student their strengths and weaknesses and what they need to do; 2) clearly communicating information to students on what they have learned; 3) clarifying good performance and promoting a close link between teaching, learning and assessment through feedback; 4) providing students with opportunities to act on teachers' feedback and improve their work; 5) encouraging students to be involved in managing their learning; and 6) using feedback to improve teaching.

The effectiveness of feedback depends on the quality of the feedback rather than its existence or absence (Black & Wiliam, 1998b). According to Eshun, Bordoh, Bassaw, and Mensah (2014), mere feedback is not sufficient for judging the guidance of learning. Feedback quality is emphasised by the characteristics and attributes towards its purpose of helping students to develop their understanding and improve their performance in relation to set goals (Walker, 2013). Contributing to the discourse, Brookhart (2017) said that for feedback to be useful it must be

accessible to students. In addition, she noted that high-quality external feedback helps students to troubleshoot their own performance and take action to close the gap between the intended and actual outcome. Brookhart (2017) identified four feedback strategies and explained that when a teacher makes a decision on a feedback strategy, then they are also deciding what they want to articulate to their students.

Feedback strategies vary in terms of timing, amount, mode, and audience. The desired impact of feedback on students' learning depends largely on when it is given. Timing of feedback is critical because if not given at the time that students need it, it might lose its impact. Lee (2013) argued that timely provision of feedback encourages and motivates students' learning, whilst Fairbrother (2010) believes that immediate feedback impedes students' ability to evaluate their learning. In her contribution to the debate, Brookhart (2017) opined that feedback may be immediate or slightly delayed in order to help students to hear it and use it.

Feedback can be delivered in many forms, because some kinds of assignment lend themselves better to written feedback and others to oral feedback. Table 2.2 summarises the strategies suggested by Brookhart (2017) to achieve high-quality feedback. Equally important in feedback is the need to groom students to have the same evaluative skills as their teacher. In this regard Yorke (2003) recounts that as well as focusing on the quality of feedback, there is a need for teachers to also strengthen their students' self-assessment skills.

Table 2.2: Feedback strategies

Feedback strategies can vary in …	In these ways ...	Recommendations for good feedback
Timing	• When given • How often	• Provide immediate feedback for knowledge of fact (right /wrong) • Delay feedback slightly for more comprehensive reviews of students' thinking and processing • Never delay feedback beyond when it would make a difference to the students • Provide feedback as often as is practical for all major assignments
Amount	• How many points made • How much about each point	• Prioritise – pick the most important points • Choose points that relate to major learning goals • Consider students' development level
Mode	• Oral • Written • Visual / demonstration	• Select the best mode for the message • Interactive feedback is best when possible • Given written feedback on written work or on assignment cover sheets • Use demonstration if 'how to do something' is a problem or if students need an example
Audience	• Individual • Group / class	• Individual feedback sends the message that 'the teacher values my learning' • Group / class feedback works if most of the class missed the same concept on an assignment, which presents an opportunity for re-teaching

Source: Adapted from Brookhart (2017, p. 13).

2.7.4 Activating students as owners of their own learning

Trends in literature on FA strategies have shown that teachers can pursue or activate students as owners of their own learning through self-assessment (Black & Wiliam, 2009; Cauley & McMillan, 2010; Heritage, 2011). Whenever one questions oneself, such as: 'How am I doing?', 'Is this right?', 'Should I go further?' after learning, this is said to be self-assessment. Although it can be argued that this sort of self-assessment is ad hoc in nature and peripheral to formal assessment procedures, it is commonly found in learning. Boud (2013) notes that, the act of questioning is the act of judging oneself and making decisions about the next step. According to

Black and Wiliam (2009), this is relevant to the development of students' own capacity to learn how to learn and to learners' autonomy.

Self-assessment is a cognitive strategy which focuses on students' learning rather than learning outcomes (Alquraan, Bsharah, & Al-Bustanji, 2010). According to Falchikov (2013), self-assessment deals with students assessing their own learning and thinking. This is consistent with the thoughts of Black and Wiliam (2009), who posit that self-assessment is an activity that might be used to actively involve students as owners of their learning. Similarly, McMillan and Hearn (2008) defined self-assessment as a process through which students: 1) monitor and evaluate the quality of their thinking and behaviour when learning, and 2) identify strategies that improve their understanding and skills. Boud (1991) proposed the following as the defining characteristics of self-assessment:

> … the involvement of students in identifying standards and or criteria to apply to their own work and making judgements about the extent to which they have met these criteria and standard.

It is worth noting that self-assessment goes beyond students grading their own work. Teachers are required to involve the students in the process of determining what is good work in any given situation. To the constructivist, learning is co-constructed; hence students' self-assessment in the teaching and learning process enables students to take ownership of their own learning. If students are asked and encouraged to delve into and talk about their own work, assessment can become more of a dialogue than a monologue and contribute to the educational development of students (Crooks, 2001). This encourages them to improve their learning approaches and provide more active engagement and increases competence, motivation, confidence and control over their learning (Klenowski, 1996). Similarly, Harlen and James (1996) pointed out that one feature of FA is that:

> … Students have to be active in their own learning (teachers cannot learn for them) and unless they come to understand their own strengths and weaknesses, and how they might deal with them, they will not make progress.

This places special attention on the role of the students and promotes the active engagement of students in the learning process. Students take responsibility for their own learning, and this can be done if the students have a clear picture of the goals that their learning is meant to attain. Thus, students have to know what it is they need to focus their learning on in order to evaluate themselves. Black and Wiliam (1998b) remarked that for FA to be productive, students should be trained in self-assessment so that they can understand the main purposes of their learning and thereby grasp what they need to do in order to achieve. Self-assessment does not mean that students develop their ideas in isolation from the views and judgements of others (Boud, 2013).

The role of self-assessment in the development of professional competence has been recognised, and Boud (2013) argues that one of the characteristics of effective learners is that they have a realistic sense of their own strengths and weaknesses. In Wiliam (2007a), students note that assessing their own work helps them to understand the material in a new way. Rolheiser and Ross (2001) provide a detailed overview of the effects of self-assessment on students' achievement:

> When students evaluate their performance positively, self-evaluation encourage students to set higher goals … and commit more personal resources or effort … to them. The combination of goals … and effort … equals achievement … A student's achievement result in self-judgment …, such as a student contemplating the question, "were my goals met?" the result of self-judgment is self-reaction …, or a student responding to the judgment with the question, "How do I feel about that?" Goals, effort, achievement, self-judgement, and self-reaction all can combine to impact self-confidence … in a positive way.

The credence that Rolheiser and Ross (2001) give to self-evaluation was based on the claim that students' learning will improve because: (i) self-evaluation will focus student attention on the objective measured, (ii) the assessment provides teachers with information which they would otherwise lack, (iii) students will pay more attention to the assessment, and (iv) student motivation will be enhanced.

According to Ward, Gruppen and Regehr (2002) self-assessment has consistently been associated with improving students' learning. For example, Lopez and Kosack (2007) reported that a relationship between performance and self-assessment over time resulted in the course grades of students showing a consistent increase across the unit tests. Similarly, Dochy, Segers and Sluijsmans (1999), in their review studies on the use of self-, peer and co-assessment in higher education, concluded that self-assessment improves performance and the quality of students' learning. The premise is that for students to be able to improve, they must have the capacity to monitor their own work.

2.7.5 Encouraging students to be instructional resources for one another

Peer assessment as a form of FA may be viewed as a counterpart of teachers' feedback. Peer assessment describes the practice whereby students rate their peers' work and provide feedback (Wen & Tsai, 2006). Similarly, Falchikov (2001) notes that in peer assessment students rate their peers and the process may involve activities such as peer feedback and peer learning. (Falchikov, 2001, pp. 2-3) further differentiated the related terms about peer assessment within her definition:

> In peer assessment, members of a class grade the work or performance of their peers using relevant criteria ... In peer feedback, students engage in reflective criticism on the work or performance of other students using previously identified feedback and supply feedback to them … In peer learning, students learn with and from each other, normally within the same class or cohort

Black and Wiliam (2009) argue that students can be actively involved as resources for one another by giving them an opportunity to evaluate and judge the work of their peers. This indicates that peer assessment can be understood as a process of give and take. This is because in peer assessment students give feedback reviews on the work of their colleagues and receive feedback reviews from their peers on their own work. According to Du Plessis, Marcis and Van Schalkwyk (2011), the learning process is enhanced when students learn more about themselves and how to improve their performance through peer assessment and self-assessment. Tighe-Mooney, Bracken, and Dignam (2016) added that through peer assessment any apprehensions that students might have about grading or being graded by their peers are minimised. Peer assessment enables students to build

up the skills and the confidence they require for effective self-assessment. The primary aim of peer assessment is to provide feedback to students. Heritage (2010b) reported that teachers are not the only people in the classroom who can give feedback during learning: peers are also a source of feedback for learning. Peer feedback may seek to confirm a result, provide suggestions for improvement or be corrective in nature.

Peer feedback is a learning element of peer assessment. Topping (2009) indicated that peer feedback occurs during the process of learning, supporting students to plan their own learning and to identify gaps in their learning for remedial action. This strategy does not require or involve students in assessing final grades; instead students point out the strengths and weaknesses of the work using design rubrics or criteria. According to Webb (1991) peer feedback is a form of collaborative learning where students learn from each other. Peer feedback is regarded both as a form of FA, the counterpart of teachers' feedback (Topping, 1998), and as a form of collaborative learning (Van Gennip, Segers, & Tillema, 2010). In Falchikov (2013) and Topping (1998) studies students reported that feedback received from their colleagues was more understandable and helpful than feedback from teachers. According to Ngwenya (2012), students accept peer feedback more actively than teachers' feedback. She noted that students regard teachers' feedback as authoritative judgement, and therefore accept it as it is without asking questions or challenging it. Contrary to the findings of Falchikov (2013), Ngwenya (2012) and Topping (1998) about the usefulness of peer assessment, Yang, Badger and Yu (2006) opined that students do not trust feedback from their colleagues (peers). It must be noted that at times students have reservations about the accuracy of feedback received from their colleagues, and therefore often ask their teachers for confirmation, perform self-correction or search for more information. This suggests that students tend not to use feedback received from their colleagues when there is no trust. Thus, for peer assessment and peer feedback to be regarded as an essential element of FA, students should be prepared to evaluate their colleagues based on criteria set by both the instructor and the students to ensure trust in the feedback.

2.7.6 Threat to formative assessment implementation

Formative assessment (FA) has been identified as classroom practices which teachers can employ to ascertain the progress of their students' learning and to identify learning gaps, in order to make instructional adjustments which lead to greater success for the students. According to Young and Jackman (2014) teachers have a positive attitude towards FA practices but are less confident when it comes to the enactment of FA strategies (Leahy et al., 2005). Literature has shown that teachers' lack of confidence when it comes to the implementation of FA techniques might be attributed to constraints such as reforms in education, change in curriculum, school context and learning culture (Adamson, 2011). Contributing to the debate, Hui, Brown, and Chan (2017) indicate that school curriculum, high stakes, summative and examination-oriented practices influence teachers' adoption and implementation of FA strategies. Drawing from the position and reasons presented by (Adamson, 2011; Hui et al., 2017), it can be argued that teachers' adoption and implementation of FA strategies are influenced by both internal and external factors. An external threat to FA implementation could be pressures from outside the classroom; for instance, if teachers are required to keep up with a fast-paced schedule and have to complete a prescribed module (course of study).

A shortage of teaching and learning materials affects effective implementation of classroom assessment practice (Kellaghan & Greaney, 2005). In other words, another threat that inhibits teachers' adoption and implementation of FA in the classroom is lack of material resources. FA in the classroom faces another serious challenge, that is represented by large classroom size (Izci, 2016; Jones & Webb, 2007; Sutton, 2010). It is worth noting that success in the implementation of FA at the classroom level heavily depends on how teachers understand FA. In view of this, Husain (2013) argues that the most important threat which hinders effective implementation of FA is teachers' lack of knowledge of FA and the use of FA strategies.

The foregoing review made it clear that FA adoption and implementation are impacted by various barriers. According to Alotaibi (2019) these obstacles are useful to school management for redress, by minimising these barriers to effective FA implementation.

2.8 Impact of formative assessment on learning

Students' learning outcomes are an indispensable part of FA strategy. Research has shown that FA affects the academic performance of students (William & Thompson, 2007; Black & Wiliam, 1998a). For example, Wininger (2005) studied the impact of FA of 71 undergraduate students in Educational Psychology, and found that students in the experimental group had a 9-point gain in performance, which is significantly better than in the control group (2-point gain). Similarly, 148 undergraduate students taking an introductory psychology course were given access to an online program on FA, and it was found that students who accessed the program received significantly higher scores in their final examination, with an effect size of 0.03 (Buchanan, 2000). Although literature has revealed positive feedback about FA in relation to learning, this positive feedback is based on the instructors' knowledge and practice. Knowing about FA is necessary – but knowing the extent to which the instructors know about and practice it during the process of teaching and learning is critical.

Wang (2007) explored the effective strategies of FA in an e-learning environment. A web-based FA was developed and named FA Module of Web-based Assessment and Test Analysis (FAM-WATA). FAM-WATA was used in assessing the performance of Grade 7 students. The system was a multiple-choice online FA unit made up of six effective FA strategies. Wang found that students who used FAM-WATA had a significant gain in learning, according to their post-test score. Self-assessment is one of the five practices of FA highlighted by (Black & Wiliam, 1998b). Velan et al. (2002) studied the impact of online self-assessment on students' academic performance, and noted that there was an improvement in students' performance.

In another study, Carrillo-de-la-Peña et al. (2009) conducted an investigation on FA and the academic achievement of pre-graduate students in health sciences. A total of 548 students belonging to three health science programmes were involved in the study. Carrillo-de-la-Peña et al. (2009) found that students who carried out mid-term FA achieved better marks and had a higher success rate on their final summative assessments. The authors also reported that success in the FA test was associated with better summative marks.

2.9 Assessment quality: What is considered quality in assessment?

Three aspects are important when we talk of quality in assessment: validity, reliability, and fairness. Validity and reliability are crucial for decision making about the quality of evidence collected in the classroom. According to Thompson (2013), validity and reliability are two essential aspects in evaluating an assessment process, be it examination of knowledge, a psychological inventory, a customer survey, or an aptitude test. Lian, Yew, and Meng (2014) remarked that validity and reliability are essential principles in educational measurement; therefore teachers needs to know, understand and put into practice such conceptual essentials in order to make better assessment decisions on students' learning and teaching.

Validity is considered an evaluative judgement about the degree to which the assessment results are appropriate for making certain educational inferences and decisions (Messick, 1993, as cited in Lian, Yew & Meng, 2014). Similarly, Bond (2003) posited that validity is the core of any form of assessment that is trustworthy and accurate. Maree (2010) added that validity of classroom assessment refers to the extent to which an assessment measures what it purports to measure. This implies that validity is the extent to which the information collected reflects or measures the attributes of what one wants to know about. Validity of assessment results can be high, medium or low or may range from weak to strong (Gregory, 2000), from which one can conclude that validity cannot be summarised by a numerical value, but can be observed in the assessment task that is administered. Validity of an assessment for learning depends on the extent to which the interpretation and use of assessment actually lead to further learning (Hargreaves, 2007). That suggests that in FA validity can be measured by the extent of improvement in learning.

Hamidi (2010) classified validity into three types: content validity, consequential validity and ipsative validity. Content validity is the extent to which the items in a test represent the domain to be measured (Salvia, Ysseldyke, & Witmer, 2012). According to Hamidi (2010), content validity is the correspondence between curriculum objectives and the objectives being assessed. Hence, if a test is to be used for making instructional decisions, then it is important that there is alignment between the test and the specific instructional or curricular areas that the test is meant to cover. The second type of validity noted by Hamidi (2010) is consequential validity. According to Tiekstra, Minnaert, and Hessels (2016), consequential validity gives credence to the way in which

assessment influences learning and teaching during the testing procedure. These authors regard consequential validity as aiding teachers to focus on classroom activities which support students' learning and are responsive to individual needs. Similarly, Shepard (1997), as cited in Hubley and Zumbo (2011), expanded on the work of Messick (1993) on consequential validity, and argued that this type of validity should include both the positive and negative social consequences of a test. Shepard noted that positive attributes of consequential validity include improved students' learning and motivation, and ensuring that all students have access to equal classroom content. The author also argues that a standardised test also has several negative consequences; notable among them are its use to reallocate state funds, and teaching students to pass the test instead of having conceptual understanding of the material. In contrast, ipsative validity, according to Hamidi (2010), takes into account students' performance, which is assessed formatively during class interaction by teachers and not by making use of their past performance as a criterion for judging their learning abilities. This form of validity places the students at the centre-stage of the assessment activity, and therefore provides diagnostic information on the progress of the individual (Lines, 2000). FA operates at the decision level of discourse and it issues a statement, not on the interpretations but on the consequences of decisions. Therefore, the validity of FA is related more to the earlier definition of test validity: that it does what it purports to do, which is improve learning.

The extent to which test scores are free from measurement error is referred to as reliability (Muijs, 2011). Thompson (2013) affirmed that reliability indicates the degree to which test scores are stable – or reproducible – and free from measurement error; this refers to the consistency of assessment scores (Moskal & Leydens, 2000). According to McClure, Sonak, and Suen (1999) reliability is an expression of the proportion of the variation among scores that are due to the object of measurement. An assessment is reliable when there is a finite distinction in students' scores or in judges' ratings across different occasions and by different judges (Brindley, 2003).

According to Moskal and Leydens (2000) two forms of reliability are considered in classroom assessment: 1) inter-rater reliability, and 2) intra-rater reliability:

> Rater reliability generally refers to the consistency of scores that are assigned by two independent raters and that are assigned by the same rater at different points in time. The

former is referred to as interrater reliability while the latter is referred to as the intrarater reliability.

The more the scores of assessment are consistent over different raters and times, the more reliable the assessment is thought to be (Moskal & Leydens, 2000). According to Brown, Bull, and Pendlebury (1997) the "major threat to reliability is the lack of consistency of the individual marker". Reliability is necessary, but is not a sufficient condition for a valid measurement. In other words, all valid tests are reliable and unreliable tests are not valid, while reliable tests may or may not be valid. In conclusion, it can be said that decisions based on assessment results could be trusted and defensible if the assessment is reliable.

The most important challenge in assessment is the issue of fairness (Kunnan, 2005). A fair assessment takes into consideration issues of access, equity and diversity. Lynch (2001) defined fairness of assessment as treating all students equally and giving everyone an equal opportunity to demonstrate their ability. Messick (1994) mooted that issues of fairness are at the heart of performance assessment validity. A fair and just assessment task provides all students with an equal opportunity to demonstrate the extent of their learning. According to Kunnan (2000) one of the best procedures to attain fairness in a test is where test writers are from different groups and are trained to explore all aspects of a test for its fairness. Fairness in assessment is fundamentally a sociocultural rather than a technical issue, and fair assessment cannot be considered in isolation from the curriculum and the educational opportunities of the students (Stobart, 2005). Tierney (2016), in support of Kunnan (2005), posits that fairness in assessment is complex and cannot be ensured through one's practice. In Hamidi (2010), four problems associated with assessment fairness were identified: 1) the performance called for on authentic assessment forms is often highly language-dependent, either oral or written; 2) the responses called for in performance assessment involve complex thinking skills; 3) authentic assessments are often used to measure students' in-depth knowledge in an area; and 4) the use of authentic assessment might worsen the problem with culturally unfamiliar content. If the content related to the subject matter is strange to them, the student may not be able to answer the questions contained in the assessment.

Despite the challenges regarding fairness in assessment, efforts can be made to achieve such fairness if certain conditions and strategies are put in place, depending on the purposes of the

assessment and the individual assessed. According to Tierney (2016, p. 8) “to achieve fairer in assessment, conditions and strategies for fairness should be considered proactively in the design and development of assessment tools and tasks, continually through assessment interaction and retrospectively in reviewing the assessment process”. This author also identified three conditions for fairer assessment. The first one is the opportunity to learn. According Tierney (2016) the opportunity to learn is a self-defining term that can vary considerably in breadth. It simply means exposure to test content or alignment between curriculum and assessment. The second condition necessary for achieving fairness in assessment is a constructive environment, which respectfully motivates students to take part and disclose their knowledge and learning through assessment (Tierney, 2016). Finally, fairness in assessment requires evaluative thinking, which involves asking questions, identifying assumptions, seeking evidence, considering explanations and critically evaluating assessment practices.

The issue of quality in assessment seems to be seen more in written assessment tasks, which can mislead one into thinking that it only applies to assessment of learning, while any form of assessment needs to ensure quality in order to improve learning. FA is crucial in the improvement of learning; therefore, ensuring quality in FA is paramount. In addition to what various authors posit as what entails quality in assessment, I posit that transparency in the assessment practices is of the utmost importance, and this aspect of quality in assessment can be more evident in FA. This is because FA is not meant for progression. For example, by using self-assessment a student can know in advance what they need to assess themselves on in order to report and reflect on their progress, which can be done by (among others) using journal reflections.

2.10 Chapter Summary

This chapter discussed classroom assessment in mathematics education and the concept of FA. Emphasis was placed on the two forms of FA and their impact on classroom learning. The relationship between teachers’ understanding and practices of FA was also explored. Discussion on teachers’ understanding and practices of FA revealed that they have little understanding of FA, and in the area of mathematics there is a dearth of studies on teacher educators’ understanding and practices of FA.

CHAPTER 3

THEORETICAL ORIENTATION OF THE STUDY

3.1 Introduction

This study explored MTEs' understanding and practices of FA. Related literature informing this study was introduced and discussed in the previous chapter. Osanloo and Grant (2016) argue that a framework should assist in identifying data relating to the context of the study. A framework is an important component of research that shapes the quality and scope of the study (Yamauchi, Ponte, Ratliffe, & Traynor, 2017). According to the American Educational Research Association, as cited in Yamauchi et al. (2017), the standards for reporting research and one criterion for judging the merits of educational research are grounded on the theoretical or conceptual framework. Maxwell (2012) asserts that a theoretical framework provides an explanation about a phenomenon under investigation. In this chapter, the theoretical framework within which this study was located is discussed.

Crossouard and Pryor (2012) argued that there is no single theoretical framework that informs FA. However, researchers like Taras (2010) and Black and Wiliam (1998a) indicated that a theory of FA should emphasise the active role of the students in knowledge construction. FA is a collaborative activity between students and their teacher in support of learning, and therefore the theoretical framework of FA should be understood within the social-cultural context (Black & Wiliam, 2009; Pryor & Crossouard, 2008). According to Black and Wiliam (1998a) FA is defined as " all the activities undertaken by teachers or their students which provide information to be used as feedback to modify the teaching and learning activities they are engaged in." This definition suggests that teacher educators and students collaborate, reflect, dialogue and share responsibilities to achieve the learning goal during classroom interactions. FA can therefore be viewed as a process consisting of a network of people who interact in a social context and work together in determining the next step of instruction through a series of actions, thereby making an activity possible.

Therefore, to meet the aim of this study and unpack the data for the purposes of answering the research questions, activity theory within the sociocultural perspective was employed as a lens for exploring teacher educators' understanding and practices of FA in mathematics modules. In

addition, the literature reviewed in Chapter 2 would be used to understand teacher educators' practices of FA. Activity theory is an elaboration of the sociocultural notion that all human learning, development, internalisation and externalisation take place in the form of activities (Engeström, Miettinen, & Punamäki, 1999; Frambach, Driessen, & van der Vleuten, 2014).

The chapter begins with an overview of the origin and development of activity theory within the sociocultural perspective, by examining the background and principles of the theory. The framework of activity theory in terms of its application to this study is also discussed. The final section describes the sociocultural perspective of learning, since FA is grounded on a theoretical framework within a sociocultural theory, emphasising the function of the teacher as a facilitator in students' learning.

3.2 An account of activity theory

Activity theory has its roots in the work of Vygotsky, a Russian psychologist, during the first half of the 20th century. Vygotsky viewed human activity as distinct from that of non-human entities, and mediated by tools, of which language is the most significant (Vygotsky, 1978). Lantolf and Appel (1994), as cited in Westberry (2009) noted that:

> Activity theory illustrates the role of society in shaping the minds of the individual and provides a unit of analysis for understanding human consciousness.

Similarly, Hasan and Kazlauskas (2014) note that activity theory provides a lens with which to tease out and better understand human activity. According to Groves and Dele (2004), as cited in Naidoo (2011), activity plays a crucial role in mathematics learning and development. Activity is a dialectic relationship between subject and object, and relates to "who is doing what and for what purpose" (Vygotsky, 1978). According to Naidoo (2011) activities are dynamic and are defined with the aid of the concept of the object. This means that activities are fuelled by the purpose or the motive behind them, which is in line with the classifying of assessment goals in FA.

Vygotsky (1978) posits that activity theory is centred on three core ideas: (1) humans act collectively, learn by doing, and communicate in and via their actions; (2) humans make, employ,

and adapt tools of all kinds to learn and communicate; and (3) community is central to the process of making and interpreting meaning, and thus to all forms of learning, communicating, and acting. Activity theory was chosen for this study because FA requires collaborative interaction between the teacher educator and the students in a social context with the aid of different FA techniques (tools). In activity theory the relationship between the subject (human doer) and object (the thing being done) forms the core of an activity (Hasan & Kazlauskas, 2014).

Engeström (2001, p. 133), in an article titled 'Expansive learning at work: towards an activity theoretical reconceptualization', mooted that activity theory has evolved through three generations: first-generation activity theory, which was founded by Vygotsky; second generation activity theory, as developed by Leontiev (1981) and Engestrom (1987); and third-generation activity theory, conceptualised by Engestrom (2001). Engestrom developed the activity system theory based on the idea that learning is a collaborative and authentic activity in support of the sociocultural perspective (Mkhwanazi, Joubert, Phatudi, & Fraser, 2014).

This study is centred within the parameters of second-generation activity theory, to understand teacher educators' knowledge and practices of FA in their mathematics classrooms in Ghana. The next section gives a brief overview of the three generations, with the aim of showing the suitability of the framework as the lens to understand FA as practised by MTEs

3.2.1 First-generation activity theory

The first-generation activity theory is centred on Vygotsky's idea of mediated action. This notion explains how people/subjects (individuals, groups) make sense of objects (or tasks) through the usage of tools. Rogoff (2008) and Ho (2015) explained that in the mediated process learning is viewed not as pre-fixed or individualistic, but as an internalisation of interaction with people and artifacts in the social world (see Figure 3.1). The cultural mediation of actions is commonly expressed as a triad of a subject, object and mediating artifact (Engeström, 2001), which stresses the social nature of human learning and the role of language as well as other tools in learning activities (Thorgeirsdottir, 2015).

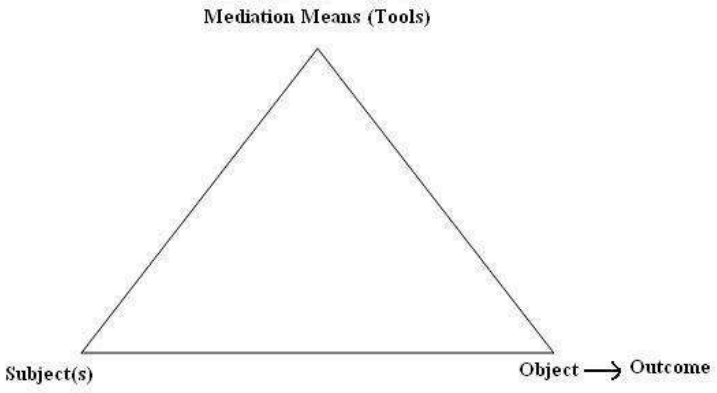


Figure 3.1: Vygotsky's model of the mediated act.

Engeström (2001) argued that mediated action involves artifacts such as a sign, symbols, text or cultural tools, and these tools fundamentally shape the mediated action. Engestrom (2007), as cited in Thorgeirsdottir (2015), further argued that language is the most important artifact in the mediated action, and pointed out that artifacts can be categorised into six types of artifacts: 1) descriptive; 2) narrative; 3) classification; 4) procedural; 5) explanatory; and 6) developmental. These artifacts were distinguished according to the processes involved in their use.

Naidoo (2011) noted that the most widely accepted tools are those that closely fit within the social and conceptual structure of the classroom. She argued that gestures, graphs, shapes, lines, and diagrams are visual representations and are regarded as tools. The tools mediate between subject and object. In FA artifacts like informal observation, questioning, quizzes, assignments and so on mediate between the subject (teacher educators, students) and the object. This mediated action perspective is understood as the interaction between actors, their mediational means and the environments. The notion of learning as a mediated process provides a starting point to explain teacher educators' understanding and practice of FA. Kaptelinin and Nardi (2012b) argued that mediation action deals with how humans behave in their environments rather than how animals act in their natural habitats. Ho (2015) mentioned that the mediating role of other people is reflected more specifically in Vygotsky's theory of the zone of proximal development (ZPD), and further expanded on in Rogoff's idea of "guided participation" in communities of practice. In the words of Vygotsky (1980, p. 86), the ZPD was defined as:

> The distance between the actual development as determined by independent problem solving and the level of potential development as determined through problem-solving under adults' guidance or in collaboration with more capable peers.

In the policy document in Ghana the emphasis on FA can be linked to Vygotsky idea of ZPD, because the aim of incorporating assessment is not to evaluate performance but to assist an individual to move from the actual development in order to reach their potential development before evaluating their holistic performance. Using the correct tools, as explained in activity theory, teachers or teacher educators in the process of implementing FA are expected not to instruct but to provide guided participation, as defined by Rogoff (2008). Using informal tasks like observation, quizzes, questioning and so on, teacher educators are involved in guided participation to guide the students to reach their potential development.

Trumbull and Lash (2013) noted that the zone of proximal development (ZPD), a concept is taken from Vygotsky, has been invoked by FA theorists as useful for understanding the gap between a student's actual understanding and the student's targeted or potential learning. Engeström (2001) avers that the mediation action model of Vygotsky did not demonstrate the relationship between the subject and their environment in an activity, because the unit of analysis remained individually focused. This restriction of the first-generation model created the need for the second-generation activity theory.

3.2.1.1 Zone of proximal development and scaffolding

According to Polly, Allman, Casto, and Norwood (2017) the concept of the ZPD is the most widely applied sociocultural concept in the design of learning experiences. Vygotsky, cited in Polly et al. (2017), defined ZPD as “the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers.” In other words, learning and development are best understood when the concentration is on the process rather than the result (Polly et al., 2017). This view is supported by Earl (2012) with reference to assessment. She proposed that by engaging deeply with the assessment process, learners can “become comfortable with reflection and the critical analysis of their learning” (Earl, 2012, p. 28).

FA is used to gauge students' learning, diagnose weaknesses, and adjust instruction as and when needed. Researchers of FA argue that FA identifies students' current level of knowledge relative to the desired goal in the ZPD (Sardareh & Saad, 2012; Shavelson, 2003). Shepard (2005), cited in Sardareh and Saad (2012), asserted that "FA collects and uses information about students' knowledge and performance to close the gap between students' current learning state and the desired state by pedagogical action" (p. 349). FA helps to form or shape students' learning during instruction. Within the context of the sociocultural perspective this help, or support aimed at improving learning is called scaffolding.

According to Polly et al. (2017) scaffolding concerns itself with natural processes that support a learner in successfully completing a task within the ZPD. Scaffolding is described as teachers` support given to the learner when they are in the ZPD, so that they can move to the next step in their learning (Sardareh & Saad, 2012). Teachers and peer assistance and scaffolding help students to move their learning forward when in their ZPD. FA and scaffolding are considered complementary concepts (Sardareh & Saad, 2012; Shepard 2005). According to FA researchers, FA practices a process of scaffolding (Brookhart et al., 2010; Pryor & Crossouard, 2008); FA has also been equated to scaffolding by Torrance and Pryor (1998). Torrance and his colleague argued that FA is the same as scaffolding because FA takes the form of teaching more than assessment.

Researchers have labelled assessment as formative when teachers provide students with constructive feedback that supports their learning (Black et al., 2003; Brookhart, 2017; Heritage, 2010b). Feedback, which is an important characteristic of FA, is noted to be an example of scaffolding. Wass and Golding (2014) explained in their work 'Sharpening a tool for teaching: the zone of proximal development', that the feedback given to students as they complete a task is an example of scaffolding. Similarly, Wass, Harland, and Mercer (2011) indicated that scaffolds might include the opportunity for peer support that teachers offer to students, where students can observe and replicate how a peer solves problems and obtain peer feedback. According to Trumbull and Lash (2013) and Hattie and Timperley (2007), feedback takes on a formative role when it provides information about the gap between a student's current understanding and the desired level of understanding. It is very effective when it is focused at the right developmental

level of the students and aids the students in recognising ways to close the learning gap (Hattie & Timperley, 2007).

In addition, Kawalkar and Vijapurkar (2013) emphasise that “teachers’ questions in the inquiry classroom not only explore and make students’ thinking explicit in the classroom but also serve to guide and scaffold it” (p. 2004). Questions teachers ask and the way they are asked impact students’ thinking as they engage in the process of knowledge construction (Chin, 2007; Kawalkar & Vijapurkar, 2013). The sociocultural perspective of learning acknowledges that “activities do not exist in isolation, but they are part of broader systems of relations, social structures, in which they have meaning” (Willis, 2009, p. 1). According to Willis (2009), within the sociocultural paradigm learning is viewed as the process of participating in a community of practice, where expertise is developed in social and cognitive ways through the use of tools.

3.2.2 Second-generation activity theory

The second-generation activity theory moved away from the individual as the unit of analysis – which was the limitation of first-generation activity theory – to a focus on collective human activity, and includes both mental and observable activities (Yamagata-Lynch, 2010). Building on the work of Vygotsky (1978), the authors Barab, Kling, and Gray (2004), as cited in Westberry (2009) notes that "activity theory represents the basic relationship involving a subject (individual or group) motivated by a need to transform an object (a goal, objectives or purpose) and employing a cultural artifact (physical or mental tool) in the process". Vygotsky's representation of activity fails to account fully for the relationship between an individual and the environment. Engestrom rectifies this by contextualised activity, by defining an activity system using six components: subject, objects, tools and artifacts, community, rules, and division of labour (Foot, 2014). Foot further explained that these components are depicted as nodes of intersection in a triangular form (See Figure 3.2).

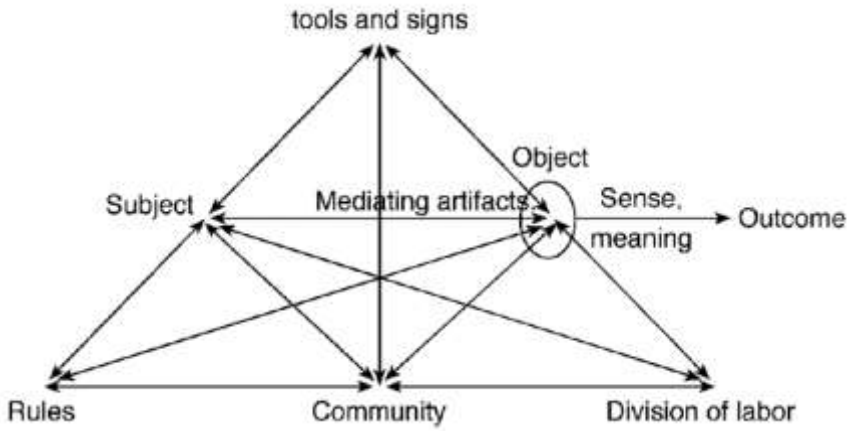


Figure 3.2: The structure of a human activity system (adapted from Engeström, 2001, p. 135).

In this conceptualisation individual actions are fixed within and obtain meaning from a community of people who are directed towards the same object (Westberry, 2009). This author also points out that all activities are object-oriented; in order words, they are forms of doing, directed towards an object. This suggests that every activity is directed towards something and guided by an objective. According to Yamagata-Lynch (2010) "the object of the activity system is the task that gives motive force to collective activity and contributes to the outcome".

Naidoo (2011) observed that the model designed by Engestrom comes with two relationships: subject-community and community-object, and that both are mediated. Naidoo remarked that the subject-community relationship was mediated by rules, suggesting that rules required for the activity system need to be in place to ensure the existence of the relationship between the subject and the community. Uden (2007) also remarked that the relationship between subject-object is mediated by tools. This indicates that the subject (individual) in the activity system requires tools to work towards the realisation of the object. The community-object relationship is mediated by a division of labour, which explains that each member within the community has a responsibility to be carried out in the activity system. It should be noted that the model shows interrelatedness among the components, with constant mediated actions. This study adapts the second-generation activity model as a lens for understanding teacher educators' knowledge and implementation of FA in the context of mathematics.

3.2.3 Third-generation activity theory

According to Engeström (2001) the third-generation activity theory is expansion of a unit of analysis from a single activity system to multiple (minimum two) interacting activity systems (see Figure 3.3). Engestrom's third-generation activity theory was intended to develop a conceptual tool to understand dialogues, multiple perspectives, and networks of an interrelated system (Artefact, 2015; Engeström, 2001). The third activity system addresses the situation where there is more than one activity system influencing that under interrogation. Ord et al. (2013) conceived that when two activity systems are consolidated, they have the potential to create a shared object. Engeström (2001) remarked that object one moves from an initial state of unreflected, situationally given 'raw material' to a collectively meaningful object constructed by the system (object 2) and a potentially shared or jointly constructed object (object 3). To place this within the current study, it can be observed that FA is aimed at improving learning. Teachers gather evidence about students' learning (gaps), and on the basis of the evidence the students and teachers collaborate, dialogue and share responsibilities in order to determine the next step of instruction through a purposeful activity system. In order words, the learning process is co-constructed, based on the diagnostic information gathered.

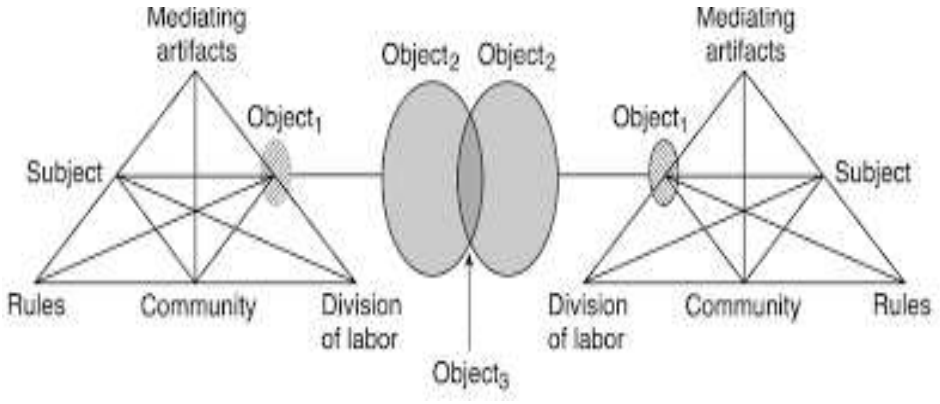


Figure 3.3: Two interacting activity systems as a minimal model for the third generation of activity theory (adapted from Engeström, 2001, p. 136).

The activity system may be summarised with the help of five principles (Engeström, 2001). A collective, artifact-mediated, and object-oriented activity system and its network relations to other activity systems is the prime unit of analysis. One of the fundamental issues regarding activity theory is the relationship between activeness as opposed to passivity. Hence, activity systems

realise and reproduce themselves by generating actions and operations (Artefact, 2015). The remaining four principles are: human activity is endlessly multifaceted in views, traditions, and interests (multivoicedness of activity system); an activity system takes shape and gets transformed over lengthy periods of time (historicity of the activity system); contradictions as the driving force of change in the activity system; and cycles of expansive transformations in activity systems. The third-generation activity theory offers a useful perspective, by expanding the field of vision from the inner workings of an individual activity system to the relationship between two or more activity systems (Westberry, 2009).

3.3 Principles of activity theory

The section to follow first presents the principles of activity theory from a theoretical perspective, as explained by different scholars. Thereafter the components of activity theory in relation to this study are illustrated.

According to Naidoo (2011) activity theory is made up of a set of rudimentary principles, and these principles may be used as a basis for more specific theories. These principles originated from Leontiev's theoretical framework. Kaptelinin and Nardi (2012a) provide five principles of Leontiev theoretical framework and highlighted as follows:

- Object-orientedness;
- The hierarchical structure of the activity system;
- Tool mediation;
- Internalisation and externalisation; and
- Development.

It is worth noting that each principle does not exist in isolation, but as part of an integrated scheme (Naidoo, 2011). These principles are discussed in the next sections.

3.3.1 Object-orientedness

The principle of object-orientedness, according to Kaptelinin and Nardi (2012a), states that all human activities are directed towards their object /goal and that the goal of an activity differentiates one activity from another. Activities do not exist as an isolated entity and are directed at something.

According to Naidoo (2011) goals direct how individuals interact with the world, but they do not characterise human activity. Objects motivate and direct activities and around them (objects), and human activities are coordinated and crystallised when completed (Kaptelinin & Nardi, 2012a). Considering FA as an activity system, the object which directs the assessment process is to enhance students' learning through the provision of feedback. Again, in the mathematics classroom the interaction of individuals within the activity system is structured and organised around the object.

3.3.2 Hierarchical structure of an activity system

According to Hasan and Kazlauskas (2014) an activity must always be understood in the context of its cultural and historical environment. In 1981 Leontiev saw activities in a hierarchical system as goal-oriented actions and underlying operations (see Figure 3.4). This implies that activities comprised actions or a chain of actions, and these actions comprised operations. Leontiev created a distinction between immediate goals and overall goals of activity, by representing activity as a three-tiered hierarchy – activity, actions, and operations. The overall motive which transforms the object (purpose) into an outcome at the highest level of the hierarchy is the activity. Westberry (2009) asserts that "activity is composed of actions of which individuals are consciously aware and they are often associated with skills and knowledge". She further notes that the actions in the structure are composed of operations which are automatic routines influenced by conditions in the settings.

Hasan and Kazlauskas (2014) illustrated these abstract concepts by using the example of changing gears when learning to drive. The authors reported that in the first lesson in learning to drive a manual transmission car, the object (purpose) is to practice changing gears without even starting the engine. The person learning to drive is instructed to make conscious actions with the goal of moving the clutch and gear-stick as required. Hasan and Kazlauskas (2014) explained that the learner does not have to think 'How do I move my hand or foot?', these are unconscious operations determined by the conditions (the position of the gear-stick, and so on), and once mastered, new activity begins. In the case of FA the activity is the collaboration of students in the mathematics classroom to accomplish a task, and one of the actions is the provision of oral feedback and adjusting instruction to address learning gaps by the teacher educator; when students reflect on the feedback received, this leads to correction of mistakes through self-regulation, which is the

operation. This hierarchical system, where activities comprise actions or chains of actions and these actions comprise operations, is depicted in Figure 3.4.

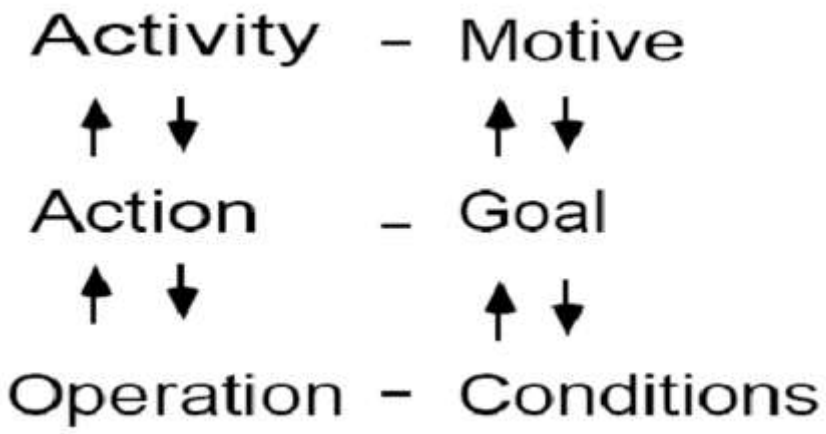


Figure 3.4: The hierarchical structure of an activity system (adapted from Hasan and Kazlauskas, 2014, p. 10).

Naidoo (2011) explained that the border between activity and actions is always indeterminate, because there is a likelihood of movement in both directions. According to Naidoo, while Figure 3.4 represents the hierarchical nature of an activity, it also intimates the reciprocal nature of the activity, action, and operation. Kuutti (1996) reported that activity may become action and action may become an operation. This implies that the hierarchical structure of an activity system is not permanent, due to the fact that all levels have the potential to be changed. Table 3.1 provides some examples of the varying structure of an activity. This is to provide an initial grasp of how the levels work and to concretise the framework for the reader. It defines characteristics of motivation, goals, and conditions within a contextual scenario.

Table 3.1: Example of activities, actions, and operations

Activity level (Motivation)	Working on group assignment	Planning a party
⇅ **Action level (Goal)** ⇅	Arranging a meeting. Navigating through the internet for academic literature and evaluating pieces of literature. Writing of the solution	Decorating the venue with balloons and decorations. Ordering of food. Transporting the food by car.
Operational level (Conditions)	Typing of agreed information. Selecting appropriate wording.	Blowing up balloons. Pinning up decorations. Telephoning the caterer to order the food. Changing gears when driving to pick up the food.

Source: Adapted from Naidoo (2011).

3.3.3 Tool mediation

Mediation is one of the fundamental concepts of Vygotsky's theory and emphasises the influence of culture on an individual's mind and action (Li, 2015). According to Anastasakis (2018), Vygotsky's idea of mediation was mostly concerned with psychological tools that mediate specific mental operations, rather than physical tools that mediate activity as a whole proposed by Leontiev's framework. It is obvious that the concept of mediated tools is significant, because tool mediation breaks down the boundaries between an individual's mind and their culture and shows how individuals use and create these tools (Thorgeirsdottir, 2015). All key distinctive features of humans, such as language, society, culture and the use of tools, involve mediation (Kaptelinin & Nardi, 2012a). Kaptelinin and Nardi (2012a) state that human relationships with the "objective" world are mediated by tools, which shape the way people interact with reality and reflect the previous experiences of people as well as their knowledge of how the tools should be used (see Figure 3.5). The authors further indicated that tools not only shape the external behaviour of the individual, they also influence the mental functioning of the individual.

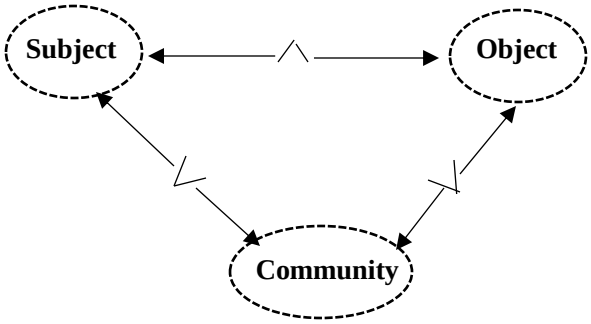


Figure 3.5: Three-way mediated interaction between subject, object, and community (adapted from Kaptelinin and Nardi, 2012a, p. 34).

In this study, the subject – MTEs – engage and interact with the students at whom the activity is directed (community), with the aim of accomplishing the object of the activity. The object of this study is teacher educators' practice of FA to enhance the teaching of mathematics as well as all learning activities within the mathematics classroom, and each of the interactions within the structure is mediated. The relationship between the subject and community is mediated by rules of behaviour, which are explicit or implicit norms and conventions governing the social interaction, while the relationship between community and object is mediated by the division of labour. The subject is directed towards the designated learning activity (object) by artefacts.

3.3.4 Internalisation and externalisation

The principle of internalisation and externalization, according to Kaptelinin and Nardi (2012a), states that human activities are distributed and dynamically redistributed along external and internal dimensions. In other words, human activities contain both internal and external components. The concepts of internalisation and externalisation refer to the processes of mutual transformation between internal and external components of activity (Kaptelinin & Nardi, 2012a). According to Frambach et al. (2014) "the process in which individuals continuously influenced and formed by their environment is defined as internalization". Frambach and her colleagues argued that individuals constantly engage in internal reconstructions of external operations. In contrast, externalisation concerns itself with the process where individuals construct and shape their environment: a continuous creation of new tools for transforming the social and cultural

environment (Frambach et al., 2014). According to Kaptelinin and Nardi (2012a) external components become internal during the process of internalisation; for instance, when a child uses his fingers (external) to count (internal). In externalisation the opposite process takes place; for example, when a person uses paper and pencil (external) to capture an idea (internal). Externalisation and internalisation are motivated and mediated by artifacts.

3.3.5 Development

This is the last principle that underpins activity theory. The principle of development states that activities develop over time, and consequently requires that activities should always be analysed in the context of their development (Anastasakis, 2018). In activity theory development is both an object of study and a strategy in research (Kaptelinin & Nardi, 2012a). As an object of study, Kaptelinin and Nardi (2012a) assert that it constitutes a multifaceted phenomenon that can be analysed at different levels, while as a research strategy development requires analyses of the object of study in the dynamics of its transformation over time. An example here is when each teacher educator reviews the object of assessment over time, and combines different assessment tools to encourage mathematical development within each student; this constitutes development as a research strategy in activity theory.

3.4 Contradictions within activity theory

Engeström (2001) posits that a fundamental analytical concept of activity theory is the notion of Cultural-historical contradictions and tensions, which occur within an activity and between multiple interrelated activities and promote dialectical transformation. According to Engeström and Sannino (2011) contradiction stands for opposite forces: “Contradiction generally refers to the proposition which asserts apparently incompatible or opposite things – A or not A”.

Kuutti (1996) avers that contradictions are central components of the activity system and manifested as problems, tensions, conflicts or breakdowns within the activity system or between different activity systems. Instead of seeing contradictions as problems or conflict, Engeström (2001) observed that they should be recognised as “ historically accumulating structural tensions within or between activity system” (p. 137) which have transformative power and a significant

effect on organisational change (Engeström & Sannino, 2011). Engeström and Sannino (2011) argued that contradictions should not be equated with paradox, tensions, inconsistency, conflict, dilemma or a double-bind.

Karanasios, Riisla, and Simeonova (2017) conceived that contradictions and tensions "provide a lens for understanding how deviance from established rules and norms occur". When tensions are intensified and occur within an activity system, individuals tend to move away from the established norms. For example, in the educational context, when the Ministry of Education introduces a new Curriculum into the school system, and when teachers who are going to implement it lack understanding of how to use it, then contradictions could develop which will lead some teachers to question the process and deviate from the expected norms. According to Engestrom, in some cases, this developed into a collective endeavour to change the activity system, a process he called "expansive transformation" (p. 137). He explained that this transformation is attained when "the object and motive of the activity reconceptualized to embrace a radically wider horizon of possibilities than in the previous model of the activity" (Engeström, 2001, p. 137).

3.5 Associating activity theory with the current study

In an activity system regular and recurring patterns of activity are called its practice (Greeno & Engestrom, 2006). Activity theory is therefore considered suitable to explore as a framework, given that the learning collaboration for this study involves a subject and a learning community. In the study described in this report, the researcher adapted activity theory (Engeström, 2001), a sociocultural perspective which examined the relationship between human learning and social context (Tsui, Edward & Lopez -Real, 2009) cited in Islam (2012) to explore how FA is understood and enacted in the context of mathematics by teacher educators in the teacher Colleges of Education in Ghana.

3.5.1 Components of the activity system with reference to the study

This section presents a description of the various components of the activity system and their relationship within the context of the present study.

3.5.1.1 The outcome of the activity system

Outcome refers to " the end result of the activity" (Yamagata – Lynch, 2010, p.2). In the context of this study, the desired outcome of formative assessment is successful teaching and learning of mathematics since formative assessment activity aims to improve teaching and learning of mathematics.

3.5.1.2 The subject of the activity system

Hasan and Kazlauskas (2014) note that the subject (human doer) in an activity system is basically a person or group who engages in the activity. In other words, the subject refers to individuals who engage in the activity to achieve the outcome. In the context of this study, the subject refers to MTE's who facilitate mathematics learning. The MTEs' initiate the assessment process and through active engagement with students generate evidence about the teaching and learning process, to be able to determine the next step of the instruction. The subject of the actively system can collectively be referred to as a community.

3.5.1.3 Community of the activity system

Yamagata – Lynch (2010) described the community of the activity system as the social group that the subject belongs to or identifies with while participating in the activity. This to say the subject is located within the community of people sharing same objectives. In the case of this study, the community of the activity system includes the subject, students and other mathematics teacher educators who directly or indirectly share same objectives and attainment of the outcomes of an activity.

3.5.1.4 Rules of the activity system

The relationship between the subject and the community is mediated by rules (Foot, 2014). This suggests that rules regulate the actions of the subject towards an object. According to Ryder and Yamagata-Lynch (2014) rules provide guidance as to acceptable interaction among subjects. In other words, rules refer to the norms, conventions and social interactions that affect the actions of the subject. Adapting the notion of rules within the context of this study indicates that teacher educators must use the guidelines on assessment enshrined in the National Teacher Education Curriculum Framework (NTECF) of Ghana and the National Teaching Standards (NTS) as a

reference point when planning, designing, and evaluating assessment in relation to the intention behind the assessment. The rules also include assessment criteria, common practices pertaining how classroom discourse and interactions are regulated and all mathematics rules.

3.5.1.5 Object of the activity system

According to Ryder and Yamagata-Lynch (2014) the object defines the reason why the subject participates in the activity. Framing the object within this study suggests the aim or the goal of the activity system. Within the formative assessment activity system, the object refers to mathematics teacher educators formative assessment practices in mathematics module. Foot (2014) pointed out that a motive for change emerges out of a linkage between the need and the object, and this is when the need is consciously recognised.

3.5.1.6 Tools of the activity system

Khoza (2012) referred to a tool as anything that communicates information during the activity system. Tools mediate the object of the activity. Naidoo (2011) averred that learning occurs as individuals interact with each other, and the interactions are mediated by tools. Tools take part in the transformation of the object into an outcome, which can be desired or unexpected (Murphy & Rodriguez-Manzanares, 2008). They can be external and material (e.g. a textbook) or internal and symbolic (e.g., language). In this study tools refer to the different assessment strategies or techniques which are used during student-teacher interaction with the aim of facilitating teaching and learning of mathematics. In addition, physical resources of the teacher colleges form part of the tools. Hasan and Kazlauskas (2014) posit that an activity both mediates and is mediated by the physical and psychological tools used as well as the social context of the activity.

3.5.1.7 Division of labour in the activity system

The subject shared responsibility with the community (Students and other MTE's) for the achievement of the outcome. This was recognised through a division of labour, whereby the subject and students responded with respect to the role they played and the responsibilities they shared in the activity system. According to Murphy and Rodriguez-Manzanares (2008) the division of labour involves the division of tasks and roles among members of the community and the division of power and status. For effective formative assessment, mathematics teacher educators

must guide the formative assessment process, ensure students participation, and ensure that students act on the feedback given. In this study activities which were considered vital to MTEs for supporting mathematics learning includes: marking students assessment scripts, involve the students in the assessment process, writing comments about students work (feedback), communicating feedback. However, the student's responsibility is to engage actively in the formative assessment process and act upon the feedback provided by the teacher educator.

This suggests that the subjects in this study assumed different roles and responsibilities in making the activity process effective and successful. It is worth noting that the activity system is not static, and the elements within it may change places over time. The interplay between the elements of an activity system provide opportunities for new learning and for change (Wilson, 2014). The model that follows (Figure 3.6) emerged from this study.

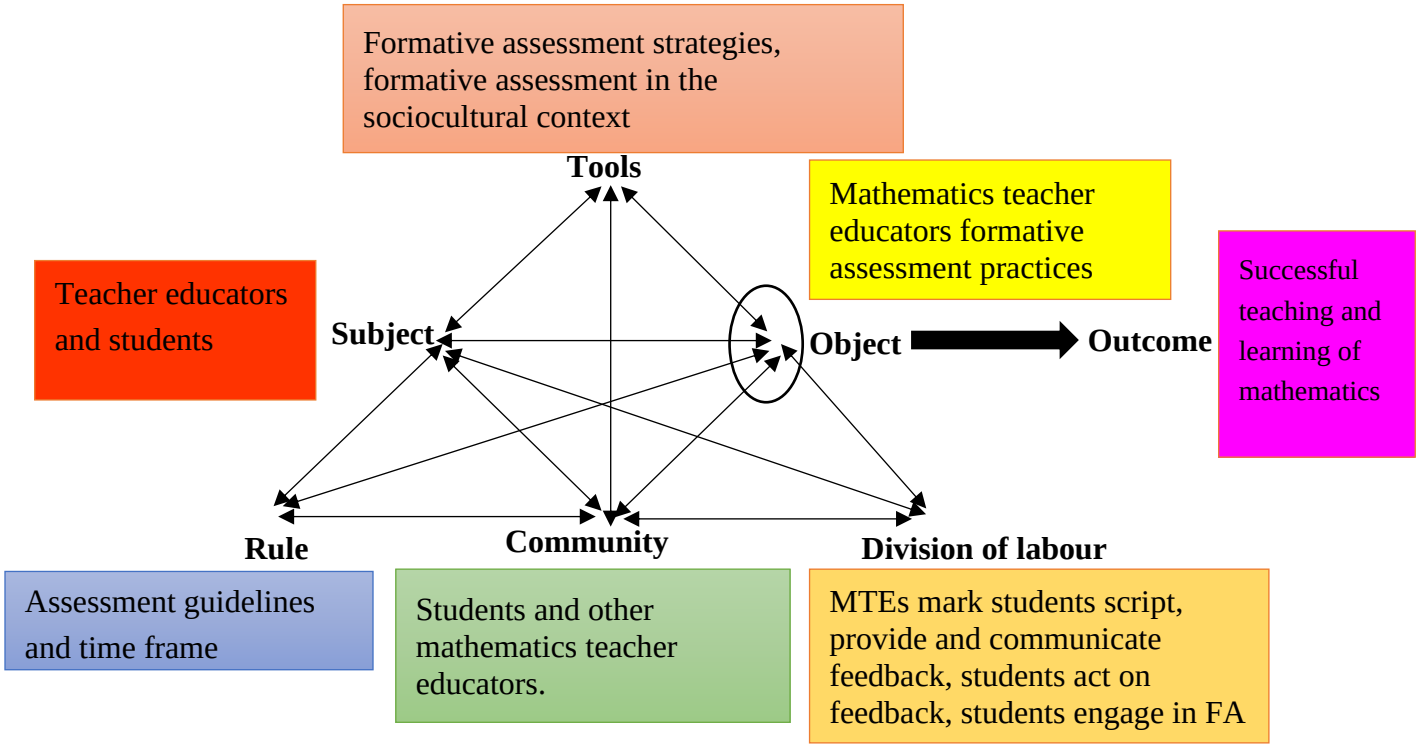


Figure 3.6: Formative assessment as an activity system (adapted from Engeström, 2001, p. 135).

While division of labour as explained in activity theory involves interaction between members of the community, in this study the focus is more on the MTE than students, because the aim is to understand their knowledge and practices. Therefore less attention would be given to how students learn from FA. However, since their learning should reveal the success of the division of labour, part of the observation stage would be to watch how this interplay takes place in the classroom setting.

3.6 Sociocultural perspective of learning

The sociocultural perspective examines the relationship between human learning and social context, an approach derived from Vygotsky's cultural-historical theory, which focuses on the interactive influence of cultural contexts on human development and learning as appropriation through participation in the social world (Tsui et al., 2008). According to Bryman (2016) sociocultural theories are based on a social constructivist paradigm, which views knowledge development as a social phenomenon that is shared and interactive in nature. Similarly, Wang , Bruce, and Hughes (2011) asserted that in the context of a sociocultural perspective of learning, human cognition is developed through social activities as the individual interacts with other people, objects and events. It is worth noting that one attribute identified in the articulation of various views on the sociocultural perspective of learning by researchers is the importance of the context of the subject.

The sociocultural view of the practice of FA has been supported and documented by researchers of FA (Black & Wiliam, 2009; Pryor & Crossouard, 2008; Sardareh & Saad, 2012). According to Sardareh and Saad (2012) social constructivism believes that “FA of students’ learning is of great worth to the learner”. So, FA is considered an interactive process in which teachers and peers help learners to use their ZPD to progress to the next stage of their learning (Sardareh & Saad, 2012). The ZPD is the area where learning takes place through the process of “scaffolding” (Heritage, 2010a). They further noted that assessment is not unidirectional but rather involves both the teacher and students in a reciprocal activity to move learning forward within a community of practice. This suggests that FA from the sociocultural viewpoint emphasises social interaction between the teacher and his students in other to accomplish the assessment task.

3.7 Chapter summary

This chapter explored the theoretical position of this study, and commenced with a detailed account of activity theory, including the three generations of the activity system. This was followed by discussions on the principles of activity theory and contradictions within the activity system. Subsequently, activity theory and its application to this study were explained and discussed. Furthermore, the study was intended to analyse teacher educators' understanding and practice of FA, and a key notion that was evident in this study was activity theory as an elaboration of the sociocultural view that human learning and development takes place in the form of activities (Frambach et al., 2014). The chapter also presented a comprehensive discussion on the sociocultural perspective of learning, since FA is attributed to the social and cultural context of the learners (Pryor & Crossouard, 2008). The next chapter discusses the research design and methodology for this study.

CHAPTER 4

CONTEXTUALISATION AND METHODOLOGY

4.1 Introduction

Theories that underpin the study were discussed in the previous chapter, and this chapter discusses the research design and methodology. The chapter begins by describing the methodological approach of the study. The study is located in the interpretive paradigm, and the chapter examines why the interpretive paradigm is most suitable for the study. This is followed by setting the scene and establishing the context of the study. The case study and data generating methods used during the process of the study are elaborated on, including how selection of participants was carried out. The researcher draws on the theoretical frameworks to inform the research design for the study and to delineate how it pertains to the methods for data generation and procedures for data analysis. Finally, the chapter highlights the question of research rigour, regarding the trustworthiness, credibility, and dependability of this study, as well as its limitations, and finally the ethical considerations and how they were dealt with are outlined.

4.2 Methodological approach

To identify the appropriate methodology for the study, I revisited the overarching research questions which guided the study:

1. What are mathematics teacher educators' understanding of FA in mathematics?
2. How do mathematics teacher educators enact FA in mathematics modules?
3. Why do mathematics teacher educators use the FA techniques that they do?

The aim of the study is to explore MTEs' knowledge and practices of FA; an exploratory qualitative case study was therefore deemed appropriate in order to engage deeply with MTEs' knowledge and implementation of FA. Grove, Burns, and Gray (2012) defined exploratory study as a study conducted to gain new insight, discover new ideas and/or increase knowledge of a phenomenon. A qualitative case study design was therefore adopted for this study because the aim

was to get an in-depth understanding of MTEs' knowledge of FA and how their knowledge informs their practice in the natural mathematics classroom, since their knowledge of FA will determine how they enact it in the classroom. Merriam (2009) noted that the case study is a design that is appropriate to consider for understanding and interpreting observations of phenomena in education.

4.2.1 Research paradigm underpinning this study

Rehman and Alharthi (2016) defined a paradigm as a basic belief system and theoretical framework with assumptions about 1) ontology, 2) epistemology, 3) methodology, and 4) methods. Simply put, a paradigm is a way of understanding the reality of the world and investigating it. Blaikie (2010) conceived a paradigm as "assumptions made about the nature of social reality and the way in which we can come to know this reality". A paradigm defines one's perspective and shapes an individual's understanding of how things are connected (Cohen, Manion, & Morrison, 2011). This study was an exploration of MTEs' knowledge and practice of FA. The aim was to understand how MTEs connect theory to practice when assessing students in the context of mathematics in the Colleges of Education in Ghana. Driven by the belief that there are multiple truths to explain phenomena, and that the best response for understanding the phenomena being studied is drawn from the participants' perspective, the researcher therefore adopted an interpretive paradigm to guide the study. The interpretive researcher focuses on the participants' interpretations of the situation. Therefore, in this study the researcher's aim was not to pass his ideas of FA to the participants; rather, to understand participants' interpretation of knowledge and use of FA was in the foreground of this study. According to Klein and Myers (1999) the interpretive paradigm helps to understand human thoughts and actions and enables an in-depth probing and deeper insight into the phenomenon under study.

The interpretive paradigm is supported by observation and interpretation; to observe is to compile information about an event, while to interpret is to make meaning of the data by drawing inferences or by judging the match of the information and some abstract pattern (Aikenhead, 1997). Creswell and Plano Clark (2011, p. 8) argues that interpretive research "tends to rely on the views of the participant of the phenomenon being studied", which is in contrast to the positivist paradigm which holds that the sole path to prove that a statement and reality are true is by scientific methods. To

explore teacher educators' understanding and practice of FA, an interpretive paradigm provides a context that allows me to examine what the participants in my study have to say about their experiences, since it is a social context in which the reality of a phenomenon can be constructed and feasible in accommodating multiple perspectives and versions of truths. The interpretive paradigm was also selected based on its assumptions which are valid for this study. For example, Maree (2016) points to teachers' "subjective experience and on how they construct the social world by sharing meanings and how they interact with or relate to each other". According to Willis , Jost , and Nilakanta (2007),(cited in Thanh & Thanh, 2015), the idea of multiple perspectives arises from the belief that external reality is variable. Willis and his colleagues further note that "different people and different groups have different perceptions of the world" (p. 194). In this study, data were generated from different MTEs with different experiences in terms of teaching and contexts. The phenomena being explored were MTEs' understanding and practices of FA; therefore, one should expect multiple perspectives, since the participants would have different experiences influenced by their context and experiences.

As mentioned earlier, the theoretical position which the design of this study followed was interpretivism, which made use of a qualitative methodological approach to determine the actual reality regarding the study. Characteristics of interpretivism as incorporated in this study are categorised into the purpose of the study, ontology (the nature of reality), epistemology (nature of knowledge and relationship between the inquirer and the inquired into) and the methodology used, as presented in Table 4.1 below.

Table 4.1: Characteristics of interpretivism in relation to the study

Feature	Description
Purpose of the study	Exploring mathematics teacher educators' knowledge of FA and how they translate it into practice in mathematics modules
Ontology	• Reality can be explored, and constructed through human interactions, and meaningful actions. • Inquire how people make sense of their social worlds in the natural setting through daily routines, conversations, and writings while interacting with others around them. • In my view reality is a construct of an individual. Hence the nominalist position was adopted for the study; that is, to assume the condition of being normal and not to impose my understanding of the phenomena since human experiences and social context shape reality.
Epistemology	• The event is understood through the mental processes of interpretation that are influenced by interaction with social contexts. • Subjective, descriptive, and interpretive positions were adopted for the study. Through interaction between the researcher and the participants, subjective evidence is assembled, based on the individuals' view or understanding of the phenomena, and this is how knowledge is known – via the experiences of individuals.
Methodology	• Observation • Semi-structured interview • Focus group discussion

Source: Adapted from Thomas (2010).

4.2.2 Research approach

Researchers believe that the interpretive paradigm predominantly uses qualitative methods (Nind & Todd, 2011; Willis et al., 2007). A qualitative approach often gives rich reports that are necessary for interpretivist researchers to fully understand the context (Willis et al., 2007, as cited in Thanh and Thanh, 2015). The focus of the study was to explore MTEs' knowledge and practices of FA; it was therefore necessary to closely examine what the participating teacher educators know about FA and how they practice it.

Newby (2010) observed that qualitative research is concerned with different understandings that people bring to their experiences and the ways in which they choose to respond to them. Similarly,

Astin and Long (2014) aver that qualitative researchers aim to gain an understanding of the social world from the participants' perspective. It is on the basis of this premise that the researcher chose a qualitative approach for this study.

Maree (2016) notes that qualitative research views research as a process rather than an event, and thus makes provision for some form of fluidity during the execution of the study. In this study, the researcher did not visit the research sites to collect data on a once-off basis, since the study was a process. The researcher spent almost a month at the study sites to get an in-depth understanding of MTEs' knowledge and practices of FA through gathering data at different points and different times of the study. Furthermore, Creswell and Poth (2016) state that the qualitative research approach focuses on understanding the meaning that an individual or a group ascribes to a social or human problem, and generates words for data analysis rather than numbers. It was based on these highlighted reasons that the qualitative approach was considered to be appropriate for this study, because the aim was to explore teacher educators' understanding of FA and how their understanding translates into practice. Denzin and Lincoln (2011) defined qualitative research as the study of a phenomenon in a natural setting and interpretation of the phenomena for understanding in terms of the meaning that individuals bring to them. The emphasis on natural settings confirms that meaning is constructed from participants' experiences and knowledge. Therefore in the study, the researcher adopted a qualitative approach because the key concern was to understand teacher educators' knowledge and practices of FA from their own perspective, not the researcher's.

4.2.3 Research style

A case study refers to "an empirical inquiry about a contemporary phenomenon which is set within its real-world context especially when the boundaries between phenomenon and context are not evident" (Yin, 2014, p. 27). Moreover, Creswell and Poth (2016) describe a case study as a qualitative approach in which the researcher explores a real-life, contemporary case or multiple cases over time through an in-depth collection of data. This study was positioned within a case study approach to carry out an in-depth inquiry into MTEs' understanding of FA and how their understanding translates into practice in mathematics. Yin (2014) observed that a case study is a preferred strategy when 'how' and 'why' questions are posed in a study. Consistent with Yin's

view, Blome and Schoenherr (2011) claim that the benefit of the case study is the richness of information and the ability to answer 'how' and 'why' questions which are valid for this study. The choice of this research style was based on the notion that it enables the researcher to observe, describe and interpret data on how MTEs construct and act within their social context. The hallmark of a good qualitative case study is that it dispenses an in-depth understanding of the case, and to achieve this requires collection and integration of different research strategies, ranging from interviews, to observations, textual materials and audiovisual materials (Creswell & Poth, 2016). On this basis, I used different data sources to capture MTEs' thoughts on and experiences of FA. The study documents a case study of MTEs' knowledge and practices of FA in mathematics modules.

The study of MTEs' knowledge and FA practices is a case of six mathematics teacher educators in three Colleges of Education. Merriam and Tisdell (2015) notes that a case study includes an " in -depth description and analysis of a bounded system" (p.38). A bounded system according to Creswell (2013) includes a particular group of people in a specific setting at a certain point in time. Therefore, this approach is more relevant because the researcher conducted the study at three Colleges of Education, a bounded system and explored in depth MTEs understanding of FA and how their understanding translates into practice in mathematics modules. Yin (2014) provides a classification of case studies based on their purpose. He identified three categories of case study: descriptive, explanatory, and exploratory. The descriptive case study gives a narration of phenomena in a research study, as well as the contextual factors in which the phenomena occurred (Yin, 2014). An explanatory case study seeks to give details of what happens in a particular case, why it happens and often involve verifying existing theory. Burns and Grove (2014) defined exploratory study as a study conducted to gain new insight, discover new ideas and or increase knowledge of a phenomenon. The exploratory case study was applied to this study, as the researcher sought to investigate mathematics teacher educators knowledge and practice of FA. This case employed individual semi -structured interviews, observations, and documents analysis in exploring the phenomena with the hope of acquiring a deeper insight into MTEs' knowledge and practices of FA.

4.3 Context, participants and sampling procedure

The focus of this study was mathematics teacher educators' knowledge and implementation of FA in mathematics modules. This section outlines the context of the study followed by how the participants of the study were selected.

This study was conducted in the Central Region of Ghana. This region occupies 4.1% of Ghana's total land area, making it the third smallest after the Greater Accra (the seat of government) and Upper East regions. According to Ghana Statistical Service (2016) the total population of the region stood at 2,437,798, with 1,187,127 (48.7%) males and the remaining 51.3% representing females. The research sites for the study were three (3) teacher Colleges of Education. The rationale behind the selection of teacher colleges was that teacher educators in the colleges prepare pre-service teachers for the basic schools, and therefore their assessment practices in the classroom will inform what these pre-service teachers do after graduation when they become in-service teachers in the classroom. Three Colleges were chosen from the Central Region on the grounds of their closeness and familiarity to the researcher. The selected colleges were assigned pseudonyms (Oswald College, PhilNeri College, and Roberkeyta College) due to ethical considerations. The staff and students in the colleges are made up of people of different cultural backgrounds, with the most dominant ethnic group in these colleges being the Akan.

The study focused on MTEs in the Colleges of Education. To obtain data for the study, six MTEs from three Colleges participated: Sekyi and Emily from Roberkeyta College; Wilson and Fordjour from Oswald College; and Anani and Peprah from PhilNeri College. Pseudonyms are used to protect the identity of these educators. Based on the recommendation of their heads of department, two teacher educators from each selected teacher college who had taught at the college for at least two years, who had experience in teaching in the Diploma programme, and who had transitioned to teaching in the new Bachelor of Education programme, were invited to participate in the study. The rationale for selecting two participants from each college was to ensure that each College of Education was represented in case one of them had to withdraw from the study. Those who were recommended and agreed to participate in the study were given an informed consent letter to sign.

According to Schreiber and Asner-self (2011), as cited in Njie and Asimiran (2014), in a qualitative study the size of the sample is not the most highly considered issue – the richness of the views on a particular situation that are unearthed matter more than the numbers. Similarly, McMillan and Schumacher (2001) noted that the insights generated from qualitative inquiry "depends more on the information richness of the case and the analytical capabilities of the researcher than on sample size" (p. 404).

The selection was accomplished using a purposive sampling technique. This technique has been well described by Patton (2015) as follows:

> The logic and power of purposeful sampling lie in selecting information-rich cases for in-depth study. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the inquiry Studying information-rich cases yields insight and in-depth understanding.

This involves the identification and selection of individuals or groups of individuals that are knowledgeable and well informed about a phenomenon of interest (Cresswell & Plano Clark, 2011). Similarly, Yin (2011) defined purposeful sampling as "selection of participants or sources of data to be used in a study based on their anticipated richness and relevance of information about the critical research questions" (p. 311). It is the most frequently used sampling technique in qualitative studies and seeks cases that can provide rich information. The researcher does not intend to generalise the findings of this study to other Colleges of Education and purposive sampling was therefore considered suitable for it. The choice of this technique emanates from the fact that the researcher wanted teacher educators involved in the teaching and learning of mathematics and likely to be knowledgeable and informative about assessment to take part. The researcher believes that these teacher educators will provide information about their understanding of FA in their mathematics modules. Maree (2016) pointed out that purposive sampling is usually used in qualitative research, since participants are selected based on some defining attributes that make them suitable for the study. The advantage of purposeful sampling is that "Any common patterns that emerge from a great variation of particular interest and value in capturing the core experience and central shared dimensions of setting or phenomenon" (Patton, 2015, p. 242).

4.3.1 Profiling of teacher educators

This section gives a brief account of the teacher educators who participated in the study, who were assigned pseudonyms to ensure anonymity. Table 4.2 provides information about each participant, including qualifications, years of experience in teaching and whether they attended professional development work on assessment. Participants were also asked about the module they were handling at the time of the study. In terms of qualifications, participants were asked whether they have a master's degree under their belt, since the minimum grade which qualifies an individual to teach in the Colleges of Education in Ghana is higher education at master's degree level. All six participants indicated that professional development for teacher educators is organised every week, and that one of the themes they had undertaken was on assessment.

Table 4.2: Profile of the participants

	Emily	**Sekyi**	**Wilson**	**Fordjour**	**Anani**	**Peprah**
Gender	Female	Male	Male	Male	Male	Female
College	Roberkeyta	Roberkeyta	Oswald	Oswald	PhilNeri	PhilNeri
Qualifications	M.Ed.& M.Phil	M.Ed.& M.Phil	M.Ed.	M.Ed.	M.Ed.	M.Phil
Teaching experience	20 years	26 years	20 years	20 years	32 years	22 years
Module taught	Methods of Teaching Basic School Mathematics	Methods of Teaching Basic School Mathematics & Algebra 1	Further Algebra	Trigonometry	Methods of Teaching Basic School Mathematics	Algebra 1

4.4 Data generation procedures

4.4.1 Negotiating access into the Colleges

Carrying out research studies in schools can be considered an obstruction to the daily routines of the school and therefore involves obtaining permission from the relevant authorities (gatekeepers). Before entry into the Colleges of Education, the researcher first saught permission from each of

the principals (Heads of the teacher colleges). The researcher made a telephone call to each principal of the selected colleges, which was followed by a letter (see Appendix C) to them requesting written permission after receiving positive verbal responses. The letter contained details of the study and related ethical issues as well as the purpose of the study and how it would be conducted in the college.

After visiting the colleges, the researcher met with the Heads of Departments (HoDs) and members of the mathematics unit to brief them on the study. I assured them of confidentiality, anonymity, and the right to withdraw from the study at any time without any negative consequences. They were also made to understand that participation is voluntary; therefore teacher educators who agreed to participate in the study were given an informed consent letter to sign. The procedure used in negotiating access into the various colleges and to the participants is presented in Figure 4.1

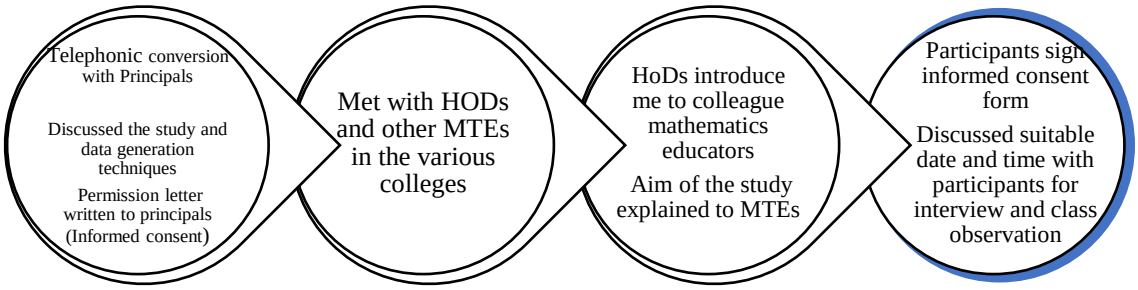


Figure 4.1: Procedures for negotiating access to the colleges and the participants.

The main aim of data production for the study was to gather information on teacher educators' understanding of FA and how their understanding informs their practices in mathematics modules. In this section, the data collection techniques that inform the process of data generation and were used in the study have been briefly mentioned. Data were generated through the following research methods: semi-structured interview, focus group discussion (FGD), lesson observation, and textual (document) analysis. Texts such as teacher educators' course outlines and students' marked scripts were also analysed.

The first phase of data production for the study started in the second week of January and ended in the third week of March 2019. Data generation was discontinued by the researcher after he had visited only two of the selected colleges, because the fourth week of March was a revision week towards the writing of end-of-semester examinations. The researcher continued data collection on 9 May after resumption of the second semester, and ended it in the third week of June 2019. In all, the study lasted for 12 weeks, with four weeks spent at each research site.

There were four cycles of visits to each of the colleges after access was gained to them through permission from the relevant authority. The first visit was for a semi-structured interview with the individual participating teacher educators and the other three visits were to observe how these teacher educators enacted FA in their mathematics modules while FGD was conducted after the second phase of data generation (lessons observation)

The methods used to generate data in this study are summarised in Table 4.3.

Table 4.3: Summary of data generating methods

Critical research questions	Data collection technique and instruments	Participants	Rationale	Limitations
RQ1: What are mathematics teacher educators' (MTEs) understanding of formative assessment (FA) in mathematics?	Semi-structured Interview **Instrument:** Audio recorder	MTEs	To obtain MTEs' knowledge of FA	The interviewee may feel uneasy (stage fright) and might hold back relevant information. Or they might respond in a way that they think will impress the interviewer. Therefore, class observation would follow.
RQ2: How do MTEs enact FA in mathematics?	Observation **Instruments:** Semi-structured observation schedule and video camera	MTEs	To obtain first-hand information on how MTEs implement FA in mathematics	Observer biases and observer effects. A researcher may be seen as intrusive. Therefore, mutual trust will be fostered through spending time with individual participants in their settings to avert this problem.
RQ3: Why do MTEs use the FA techniques that they do?	Interview and FGD **Instrument:** Audio recorder	MTEs	Individual interviews will be used to bridge the gap between their knowledge (obtained in the first part of data collection) to their practice, collected via observation. Focus group interviews will be used to understand common or different views about FA which will shed some light on the MTEs' practices and broaden the spectrum of discussion from one-on-one to a group discussion	The interviewee might keep repeating information. While this might seem redundant, it will shed some light on their observed practices. In the focus group, some MTEs might not participate. Rather than asking questions, the researcher will bring extracts from newspapers articles and so on about FA to start off the discussion, and use the think-pair-share strategy to ensure full participation.

In the next section the methods of data collection (interview, observation, FGD) used in this study are explained in detail. The critical research questions of the study were answered by generating data from interviews, observation, an FGD and document review.

4.4.2 Semi-structured interviews

Warren and Karner (2015) remark that an interview is a social interaction based on a conversation. An interview is where "knowledge is constructed in the interaction between the interviewer and interviewee" (Kvalve & Brinkmann, 2015, p. 4). According to Santiago (2009), an interview can be structured, semi-structured or unstructured. She contends that a structured interview is formal and is used to gain particular information in a quantitative study. Lincoln and Guba (1985), as cited in (Cohen et al., 2011), pointed out that the structured interview is useful when the researcher is aware of what he /she does not know and is therefore in a position to frame questions to supply the knowledge required. Rubin and Rubin (2013, p. 31) noted that in the unstructured interview the researcher has general questions in mind and formulates many others as the interview proceeds. This study used a semi-structured interview for data generation since it "allows probing and clarification of answers" (Maree, 2016, p. 87).

The semi-structured interview was chosen because of its flexibility in offering the researcher a chance to ask questions to clarify data obtained from other sources (Babbie, 2001). With a semi-structured interview, the researcher prepares a limited set of questions in advance and plans follow-up questions about the phenomena under study (Rubin & Rubin, 2013). The researcher opted for a semi-structured interview because the focus was not on imposing ideas but to find out from the participants how they infuse practice and theory; in that way, the interview becomes a co-constructed process between the researcher and participants. This allows participants to express their views rather than feeling directed to give answers that satisfy the researchers' questions. The MTEs explained what they know about FA and why they use it in their mathematics context. Low (2013) explained that a major characteristic of the semi-structured interview is that it addresses how and why questions from the perspective of subjective experience. In order words, a semi-structured interview offer researchers the opportunity to explore the opinions of individuals and how they give meaning to or interpret their experiences. According to Cohen et al. (2011), the

“interview is not simply concerned with collecting data about life: it is part of life itself, its human embeddedness is inescapable”. Creswell and Poth (2018) also cautions that in the process of an interview the researcher should avoid asking questions or saying anything that may be construed as prompting the desired response.

4.4.3 Observation

Observation is a research method that enables researchers to systematically observe and record people’s behaviour, actions, and interactions (Hennink et al., 2020). Burke and Larry (2017) defined observation as watching the behavioural patterns of people in certain situations to obtain information about the phenomenon of interest. Besides, Maree (2016) asserts that observation is an everyday activity whereby one uses one’s senses and intuition to gather data. A hallmark of observation as a data generating technique in the research process is that it offers an investigator the opportunity to gather 'live' data from naturally occurring social situations (Cohen et al., 2011, p. 456). The rationale for selecting observation as a data generating technique for the study was that it enables the researcher to observe the nature of FA practised by MTEs or how MTEs enact FA in their classroom. This was to get first-hand information on the extent to which mathematics educators in the Colleges of Education infuse FA in their lessons in mathematics modules, to cross-check for consistency with what they said they practice during the interview section (pre-observation stage). This is because what people do may differ from what they say they do, and observation provides a reality check (Robson, 2002). As the literature points out, observation is one of the most fundamental and highly important methods in all qualitative inquiry (Marshal & Rossman, 2006, p. 99).

Maree (2016) argues that “observation enables the researcher to gain a deeper insight into and understanding of the phenomenon being observed”. Observations can range from highly structured to semi-structured and unstructured (Parson & Brown, 2002). According to Cohen et al. (2011), there are four main types of observational research and each approach has its advantages and disadvantages. Consistent with (Cohen et al., 2011), Maree (2016) claims that the four main types of observational research are: complete observer or non-participant observation, observer as a participant, participants as observer, and complete participant observation. In this study, the researcher assumed the position of a complete observer and was not involved in the lesson. A non-

participant observer is also known as a naturalistic observer, where there is no interference by the researcher and no attempts to influence the variables (Beni, 2014). The advantage of non-participant observation is that the researcher is observing real life and it is less obtrusive (Maree, 2016). Lesson observation was video recorded in order to collect rich information and a detailed picture of the classroom activities. Wears (2000),(as cited in Asan & Montague, 2014), contends that it is difficult for researchers to capture all of the details in live settings, and video recording of the event is recommended to eliminate some of these challenges (Kumarapeli & de Lusignan, 2012). The rationale for the video recording was to have a backup so that information that might escape the sight of the researcher would be captured and cross-checked with the field notes.

4.4.4 Focus group discussion

Hennink (2013) posits that FGD involves a focus on specific issues with a predetermined group of people participating in an interactive discussion. Maree (2016) points out that focus group interviews are aimed at collecting in-depth qualitative data about the group's perceptions, attitudes, and experiences regarding a phenomenon. The FGD aims to "gain a broad range of views on the topic over 60 to 90 minutes and to create an environment where participants feel conformable to express their views" (Hennink et al., 2020, p. 136). The choice of FGD as a data-generating tool emanates from the fact that the focus group provides an opportunity to explore the phenomenon from a range of perspectives and to gain understanding of the issues from the perspective of the participants (Hennink, 2013). The purpose of the FGD was to give participants an opportunity to share ideas and talk about their views on FA, and shed some light on their practices to broaden the spectrum of discussion on FA from one on one to a group discussion. In the words of Maree (2016), through an FGD participants are able to build on each other's ideas and comments to produce an in-depth view of the phenomenon which is not attainable from the individual interview.

Hennink et al. (2020) posit that an ideal FGD should include six to eight participants. Consistent with their view, Krueger and Casey (2015) also mentioned that the number of participants for an FGD should be between six and eight. For this study, all six teacher educators were to participate in the FGD; however, on the day of the FGD only four of the teacher educators made themselves available. Participants from Roberkeyta College failed to turn up, and when contacted by the researcher they averred that they were attending an academic board meeting. The four participants

who were present were engaged in the FGD, since they mooted that they had a lot of tasks to complete before the semester ends and could not turn up a second time when rescheduling of the meeting was suggested. The number of participants therefore limits the discussion and gains in terms of diversity of perspectives, which are reduced as a result of the fewer (less than six) participants (Hennink et al., 2020). Participating teacher educators' responses during the FGD were attributed to the individual participants and not to the group.

Apart from the numerous strengths of the focus group method, it must be noted that group dynamics might be a challenge (Hennink et al., 2020). Hennink and his colleagues argued that some participants may either dominate or not contribute as a result of social pressure. Therefore, in order to minimise any social pressure, each participant was given postcards. Participants were asked to write their answers on the card and to post them on the wall. The researcher then picked up the cards and read the various answers for discussion.

4.4.5 Textual analysis

According to Maree (2016) when review of texts or documents is used as a data gathering technique, the researcher focuses on printed communications that could potentially provide justifications and explanations on the phenomenon being studied. A document is a "written text" (Ahmed, 2010, p. 2). Also, Bowen (2009) postulates that documents contain words or text and images that have been recorded without the involvement of the researcher, but with a relevant worth that can enhance a study. Document analysis as a data generation method is defined by Bowen (2009) as "a systematic procedure for reviewing or evaluating documents – both printed and electronic (computer-based and the internet – transmitted) materials".

Bailey (2008) described document analysis as the analysis of documents that contain information about the phenomenon to be studied. Documents used in the documentary study are classified into two: primary documents and secondary documents (Cohen et al., 2011; Maree, 2016). According to Fitzgerald (2012), the major difference between 'primary' and 'secondary' sources of documents lies in the question of authorship. Fitzgerald (2012) conceived that "primary documents are usually first-hand accounts produced by a witness to a particular event" (p. 299). Secondary

documents usually refer to commentaries or claims made on other data by other researchers (Gibson & Brown, 2009).

To support practice and supplement information obtained from the interview and lesson observation, a documentary analysis was undertaken. Analysing documents involves skimming, reading and interpretation, and combines elements of content analysis and thematic analysis (Bowen, 2009). Documents analysed in this study included teacher educators' course outline and students' assessment scripts. The course outlines were prepared individually by the teacher educators based on a common curriculum provided by the affiliated university. Copies of students college base assessment scripts (Formative assessment) were obtained from the participants upon request. In all a total of eight marked scripts (assignment and midterm quizzes) were obtained and analysed. Issues selected for analysis from the teacher educators' course outline include: 1) are learning intentions and criteria for success explicitly described in the outline?; and 2) was there any evidence of how students were going to be assessed? From the students' assessment scripts the analysis looked at evidence on the mode of feedback that teacher educators use to communicate with students.

Document analysis has both advantages and limitations. Bowen (2009) mentioned a lack of obtrusiveness and reactivity as the major advantages of document analysis. That is, document analysis is unaffected by the research process. According to Yin (2011) documents provide broad coverage; in other words, they cover a long span of time, many events, and many settings. It is also worth noting that document analysis is not always advantageous. There are some inherent limitations associated with document analysis, one of which is insufficient details (Bowen, 2009). According to Bowen (2009), some documents are produced for purposes other than research – they are created independent of a research agenda and therefore usually do not provide enough details to answer a research question.

4.5 Piloting research methods

Arain, Campbell, Cooper, and Lancaster (2010) posit that a pilot study is a small study conducted prior to the main study. In other words, a pilot study is a pre-testing of the data generating instruments. To explore MTEs' knowledge and practices of FA, a pilot study was conducted in

December 2018. The pilot testing was carried out to ascertain how well the instruments will work in the actual study and to identify ambiguities and difficulties among the items, if any. Yin (2011) remarked that a pilot study helps in improving plans for data production. Calitz (2009) states that a pilot test of questions helps to identify unclear or ambiguous statements in a protocol. Similarly, Van Teijlingen and Hundley (2002) remarked that pilot testing establishes whether replies can be properly interpreted in line with the information required. A College of Education in the Western part of Ghana was used as the pilot case, while the main study was conducted in the Central Region of Ghana. Two teacher educators with the same characteristics as the participants in the main study were interviewed and observed; participants were allowed to choose the setting for the interview. Jacob and Furgerson (2012) recommend that a setting that is most comfortable for participants should be selected for the interview. The interview lasted for approximately 25-30 minutes, consistent with Jacob and Furgerson (2012) who suggest that the interview time should not exceed 90 minutes.

The pilot study highlighted the need for close attention to be paid to participants and the ability to capture critical issues from participants for prompt questioning in order to gain a deeper understanding of the phenomenon.

4.6 Order of data generation for the main study

This section gives a synopsis on how data for the study were generated. To generate data to answer the critical research questions for the study, the steps outlined below were followed.

4.6.1 Stage 1: Interview before lesson observation

Data production for the study started with interviewing MTEs to ascertain their understanding of FA in mathematics modules. The interview before teachers' lessons gave the researcher the opportunity to ask teacher educators pertinent questions on FA for a deeper understanding of their knowledge on FA. Apart from the predetermined questions, probes and follow-up questions were used to encourage teacher educators to provide a rich description of their understanding and practices of FA. The interview took approximately 30 minutes and focused on teacher educators' views on FA, feedback, and assessment strategies they employ during instructional lessons. Interviews were conducted in the conference halls of the selected CoEs which were selected by the participating educators. Tessier (2012) argues that audio-recording permits replaying of the

tapes which offers the researcher the opportunity to encounter the event more than once. Audio-recording of interviews also allows for checking reliability (Mkhabela, 2016). To capture the exact words of the participants, the interviews were audio-recorded with the consent of the participants. However, notes were also taken during the interview in order to capture certain points or ask for clarification. Davidson (2009) argued that the translation of events into text may lead to data loss; therefore, in order not to under-represent the participants or lose the impulse behind the participants' responses, they were allowed to delete or add to the text in order to clarify and authenticate their responses.

4.6.2 Stage 2: Lesson observation

In other to answer my critical question two, *How do teacher educators enact FA in a mathematics module?*, a semi-structured observation schedule was designed and used to generate data. The schedule takes into consideration the five strategies for effective implementation of FA as proposed by Black and Wiliam (2009). Each participant was observed three times for at least one and a half hours. The rationale of the lesson observation was to obtain first-hand information about how teacher educators of Colleges of Education in Ghana enact and use FA in the context of mathematics pedagogy. There was a follow-up debriefing after each observed lesson to discuss any questions or ideas that arose from the observation with the participant teacher educator. The follow-up debriefing was unstructured and took place in the Colleges of the teacher educators and venues selected by participants. According to Jacob and Furgerson (2012), a setting that provides the most comfort to participants should be selected during the interview. Therefore, participating educators selected venues for the follow-up debriefing, as they did during the individual interview sessions.

4.6.3 Stage 3: Focus group discussion

After the individual interview and the lesson observation, an FGD was conducted to discuss how and why FA was being used by teacher educators in the context of mathematics modules. To prompt a discussion among participants, they were given questions to encourage them to talk about their understanding of FA as stipulated in the Ghanaian policy document and its practicality with regard to implementation. Maree (2016) indicates that focus group interviews are aimed at collecting in-depth qualitative data about a group's perceptions, attitudes, and experiences

regarding a phenomenon. The FGD was used as a follow-up to the data generated from individual participants, to understand the common or different views that teacher educators hold about FA, to shed some light on MTEs' practices and broaden the spectrum of discussion from one-on-one to a group discussion.

4.7 Data analysis and presentation

Cohen et al. (2011) describe data analysis as "making sense of data in terms of the participants' understanding of the phenomenon, noting patterns, themes, categories and regularities". Yin (2011) observed that many steps come into play in data analysis to ensure that the purpose of the research is addressed. The exploratory nature of the critical questions for the study supports an inductive approach to data analysis. Therefore, the use of activity theory as an interpretative lens has imposed a sociocultural perspective onto the data. Data analysis in qualitative research consists of preparing and organising the data for analysis, reducing the data into themes through the process of coding and condensing the codes, and representing and forming an interpretation (Creswell & Poth, 2018). Contrary to the previous authors, Simons (2009) noted that in terms of detailed analysis "there are no set rules or procedures to follow" since approaches in data analysis are diverse.

Despite differences in the number and names of steps proposed, Ho (2015) aver that most researchers are usually in agreement with the following four steps: transcribing, coding, categorising and identifying emergent themes. In this study, the researcher analysed the data gathered by immersing himself in the data by listening to and watching audio and video recordings, as well as reading and re-reading transcripts to consider the understanding and practices of FA of six different subjects (teacher educators) as a unit of activity, by asking questions of the data about how MTEs understand FA, what FA tools were used in practice by educators, and what rules influence how those tools were used. Data obtained from interviews, observations, field notes, and documents were analysed following three basic steps: organising and familiarising with data, coding and categorising, interpreting and producing the report. The steps for the data analysis were not linear but interconnected, forming a spiral of activities concerning the analysis and representation of the data (Creswell & Poth, 2018). The steps are described in the following sections.

4.7.1 Organising and familiarising with data

Data generated from the study, such as audio and video recordings, field notes, documents (teacher educators' course outline and students' assessment scripts) were first organised college by college. The researcher then immersed himself in the data by listening to and watching audio and video recordings, as well as reading and re-reading field notes for a general understanding of each case. This was followed by transcribing verbatim the interview and observation data from the oral to written form as notes which were typed out. Transcription is "the process of converting recorded materials into the text" (King, Horrocks, & Brooks, 2018, p. 193). According to King et al. (2018), before data transcribing qualitative researchers should make key decisions based on the methodological position of the study, availability of resources in terms of finance and time and potential threats to the quality of the transcripts. The authors reiterate that the decision includes who would transcribe and what guidance or training do they need to transcribe? In this study, data were transcribed by the researcher, as the process helped him to "become closely familiar with the data" (King et al., 2018, p. 193). Also, Widodo (2014) remarked that a researcher has the opportunity to carefully listen, pay attention and think deeply when recorded data are transcribed by the researcher himself. After completion of data transcription for the six participants, the researcher once again read the whole transcripts several times to become thoroughly familiar with the data. This was accompanied by a detailed textual analysis, starting with writing down initial ideas and comments on the transcript while reading through the transcribed data.

4.7.2 Coding and categorising

Coding was used to assist in analysing the data obtained from the interviews, field notes and observations. Coding refers to labelling and systematising of data (Tracy, 2019). This author also noted that coding is an active process of identifying data as belonging to or representing a phenomenon (Tracy, 2019). The researcher looked carefully for words, phrases, and sentences to define concepts. Teacher educators' documents and transcripts were organised by using pseudonyms to replace the participants' names and their colleges (see Table 4.4) to ensure confidentiality. Students were also known and identified by codes; for example, a student from Roberkeyta College of Education is assigned and named as $PST_{R1.}$ Throughout the process of coding the researcher constantly compared the data applicable to each code, and based on that codes were modified in some situations to fit the new data. The coding process leads to thematic

analysis, which is "a method for systematically identifying, organizing and offering insights into patterns of meaning across a data set" (Clarke & Braun, 2013, p.2) This approach allows the researcher to identify common and diverging issues about the phenomenon being explored from the perspective of the participants, to make sense of the commonalities and differences through codes. Guest, MacQueen, and Namey (2011) remarked that in thematic analysis codes are developed to represent identified themes. Therefore, data generated from the six MTEs were gathered, organised and analysed using Merriam (2009) description of " category construction". The researcher began the analysis by first identifying and coding segments of the data that are responsive to the critical questions. Codes that seem to align were then sorted and grouped together, forming categories. An example of a flowchart showing the process of coding into categories is presented in Figure 4.2

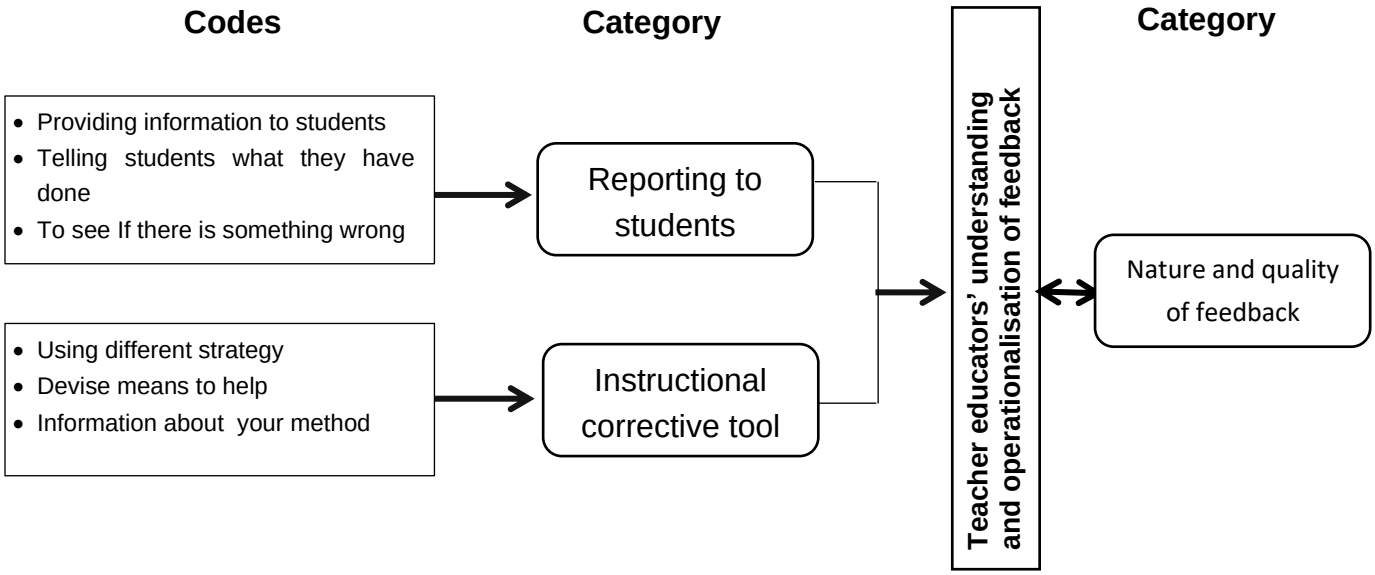


Figure 4.2: Flowchart showing codes inductively developed into categories.

FA is an activity system and a framework emerging from this study was used for organising the coding system. In addition to mapping the data generated onto the framework, the concept of contradiction was brought to bear on the data. Informed by early studies (Engeström & Sannino, 2011; Karanasios et al., 2017; Kuutti, 1996) on contradictions, data were considered in relation to tensions between various contextual factors and how these tensions affect teacher educators'

implementation of FA in the mathematics classroom. Karanasios et al. (2017) argue that contradictions and tensions "provide a lens for understanding how deviance from established rules and norms occur", since individuals tend to move away from an established norm when tensions are increased and occur within an activity system.

Table 4.4: Pseudonyms and coding used for participants and their colleges

Name of college	Code for college	Name of participants	Codes for participants
Roberkeyta college	RCOE	Sekyi	S
Roberkeyta college	RCOE	Emily	E
Oswald college	OsCOE	Wilson	W
Oswald college	OsCOE	Fordjour	F
PhilNeri college	PnCOE	Peprah	P
PhilNeri college	PnCOE	Anani	A

4.7.3 Interpreting and producing the report

MTEs' understanding, and practices of FA were described and interpreted through the lens of sociocultural theories. When all data had been categorised, analysis of the data regarding the research question began. The researcher summarises and presents the data generated from all six participants in detail in Chapters 5, 6 and 7 of this report. Data were not presented using a case-by- case approach, since the themes that emerged from teacher educators were similar and, in some situations, repetitive. According to Braun and Clarke (2006) an analysis should embrace a concise, coherent, and non-repetitive account of the data represented through the specific themes. The researcher used vivid examples or extracts from the data to capture the essence of the themes. Therefore, integral findings on data were presented to answer the research questions rather than present individual cases (Yin, 2011).

4.8 Quality considerations

Murphy and Yielder (2010) assert that the quality of research output can be measured by the concepts of validity and reliability, and the terms should be grounded in the worldview of the paradigm in which the research is being conducted. Validity and reliability criteria are used in

studies to judge or justify the quality of the study and to answer the essential question of how good the study is (El-Sherif, 2017). According to Healy and Perry (2000) the terms reliability and validity are more situated in the quantitative study than the qualitative study. Lincoln and Guba (1985), as cited in (Maree, 2016) described the validity and reliability of the qualitative study as trustworthiness.

4.8.1 Trustworthiness

Trustworthiness is a set of standards that honour participants ethically through researcher sensitivity to the phenomenon and the settings (Rossman & Rallis, 2016). In Sinkovics and Alfoldi (2012) trustworthiness was defined as a process of maintaining the soundness of the findings of a study and the soundness of the arguments that conclude it. Trustworthiness or rigour of a study refers to the degree of confidence in data, interpretation, and methods used to ensure the quality of a study (Polit & Beck, 2014). The researcher relied on tape recordings of the interviews, field notes and participants' authentication to ensure that data gathered for the study were trustworthy. Interview events were transcribed verbatim and copies were given to participants to clarify and validate their responses. Loh (2013) avers that trustworthiness consists of four components: (a) credibility, (b) dependability, (c) confirmability, and (d) transferability. Consistent with Loh (2013), Strauss and Myburgh (2001) explained that credibility, transferability, dependability, and confirmability ensure trustworthiness in a qualitative study. The sections that follow give an account of how the four components of trustworthiness were applied in this study.

4.8.1.1 Credibility

According to Wahyuni (2012) credibility deals with the accuracy of data in the context of social phenomena under study. In other words, credibility concerns itself with whether the study measures or tests what is intended to measure. Maree (2016) asserts that credibility can be established through the adoption of a well-established research method and research design that fit the research questions. Following Maree's view, the researcher adopted the exploratory case study design to investigate MTEs' understanding of FA and how their understanding translates into practice to ensure credibility of the study. In addition, Anney (2014) asserts that a qualitative researcher establishes the rigour of the inquiry by adopting the following credibility strategies: prolonged engagement, triangulation, member checking, peer examination, reflexivity, and

interview technique. Credibility was also enhanced via the development of an early familiarity with the participants. The rationale was to create trust that transcends the study in order for participants to have a feeling of togetherness and a good interpersonal relationship with the other participants. This provides a greater understanding of participants' culture and context (Anney, 2014).

In order not to underrepresent or misinterpret the participants, the researcher also adopted member checking. According to Yin (2011) member checking is the process of allowing the study participants to review and verify the data collected from interviews, participant observations, and documentation, to avoid the possibility of misinterpreting the data collected. Transcribed data and field notes were given to the participants to verify whether the answers presented represented what they had shared with the researcher. Member checking is a crucial process that any qualitative researcher needs to go through, because it is at the heart of credibility (Anney, 2014; Onwuegbuzie & Leech, 2007). The researcher used multiple sources of data, obtained from interviews, observations and documentation to ensure credibility. El-Sherif (2017) explained that using multiple data sources to come to a conclusion about a phenomenon is called triangulation. Triangulation "involves the use of multiple and different methods, investigators, sources and theories to obtain corroborating evidence" (Onwuegbuzie & Leech, 2007, p. 239). According to Anney (2014) triangulation helps the researcher to minimise bias, and cross-examines the integrity of participants' responses.

4.8.1.2 Transferability

Transferability refers to the degree to which the results of a qualitative study can be transferred to another context with other participants (Anney, 2014; Wahyuni, 2012). Thoma and Magilvy (2011) equated transferability in a qualitative study with external validity in quantitative research. In line with Anney (2014) and Wahyuni (2012), Thomas and Magilvy (2011) also defined transferability as the ability to replicate research methodology and findings to another context. However, Finfgeld-Connett (2010) argued that in a naturalistic study a researcher cannot forestall in advance the extent to which the findings of a study will be transferable to another context. Researchers are therefore required to provide thick responsive, thoughtful, and detailed descriptions of the study context to assist other researchers to judge the applicability of the research

in a similar context (Thomas & Magilvy, 2011). According to Bitsch (2005), ensuring transferability requires 'thick description' and purposeful sampling. Thick description is achieved by delineating the phenomenon under investigation in detail, such that conclusions can be transferred to other situations, settings, people and times (Amankwaa, 2016). Similarly, Anney (2014) asserts that thick description involves the researcher giving an in-depth account of the whole investigation process, from the design and methodology to the production of the final report of the study, which offers other researchers the opportunity to replicate the study in similar contexts.

In this study, transferability was endorsed through a thick description of the processes that give in-depth meaning about the phenomenon of FA. Detailed descriptions of the study context, the intentions of the study, data generation method and research design and rich descriptions with extensive use of teacher educators' voices links the data to the analysis, claims, and interpretations. Transferability was also sanctioned by choosing a purposive sampling technique in selecting the participants for the study. A detailed description of the research process and purposive sampling technique facilitate transferability in the study.

4.8.1.3 Dependability

Cope (2014) asserted that dependability refers to the consistency of data in a different context with similar conditions. To establish dependability, according to Amankwaa (2016), requires an inquiry audit with the aim of evaluating the research accuracy by examining whether data generated support the study findings, conclusions and interpretations. Dependability involves participants evaluating the findings and the interpretation and recommendations of the study to make sure that the findings are supported by the data received from the participants (Cohen et.al., 2011). To ensure qualitative research dependability requires an audit trail (Cope, 2014; Thoma & Magilvy, 2011). An audit trail involves an examination of the research process and products to validate the data, whereby an investigator accounts for every decision about the study such as how data were collected, recorded and analysed (Anney, 2014; Bowen, 2009). Thomas and Magilvy (2011) indicated that the audit trail is achieved by: (a) describing the purpose of the study; (b) discussing the sampling procedure to explain how and why the participants were selected for the study; (c) discussing the data collection method and the duration for data collection; (d) discussing the data

analysis procedure for the study; (e) discussing in detail the interpretation and presentation of the findings of the study; and (f) communicating the procedures used in ensuring the data credibility in the study.

Dependability was established by giving a detailed description of the methodology and the contexts of the study. For instance, the purpose of the study, sampling frame and sampling criteria, as well as the rationale for the partiicpants' selection, were discussed. In addition, the data collection method and the time for data collection were also discussed, together with the procedure for data analysis. Furthermore, the code-recode strategy was also adopted to ensure the dependability of the study. In this way data generated from the study were coded and recoded within two-week intervals to check for data consistency. The code-recode strategy involves the researcher coding the same data twice, and if the twice-coded results match or agree with each other, then the dependability of the result is enhanced (Ary, Jacobs, Razavieh & Sorensen, 2010). The code-recode strategy helps the researcher to gain an in-depth understanding of data patterns to improve the presentation of the participants' narratives (Anney, 2014).

4.8.1.4 Confirmability

Research confirmability is achieved when the credibility, transferability, and dependability of the study are established (Thoma & Magilvy, 2011). According to Tobin and Begley (2004, p. 392), confirmability is "concerned with establishing that data and interpretation of the findings are derived from the data and are not a creation of the researcher's imagination". Similarly, Cope (2014) explained that confirmability is achieved when the researcher demonstrates that the data represent participants' perspectives and are clear of researcher bias. Maree (2016) observed that confirmability can be increased in a qualitative study through triangulation. Triangulation involves the use of multiple and different methods, or different theories to obtain corroborating information (Onwuegbuzie & Leech, 2007). Carter, Bryant-Lukosius, DiCenso, Blythe, and Neville (2014) and Patton (1999) categorise triangulation as follows: (a) method triangulation, (b) investigator triangulation, (c) theory triangulation, and (d) data source triangulation. According to Polit and Beck (2014), method triangulation involves the use of multiple methods of data collection about the same phenomenon. Investigator triangulation concerns itself with two or more researchers engaging in the same study to provide multiple observation and conclusions (Carter et al., 2014).

In addition, Carter and her colleagues also observed that investigator triangulation brings both confirmation of findings and different perspectives, adding breadth to the phenomenon under investigation. Theory triangulation uses different theories to analyse and interpret data, while data sources triangulation involves the collection of data from different people, including individuals, groups and communities, to gain multiple perspectives about the phenomenon (Carter et al., 2014).

Confirmability was established in this study through method triangulation and data source triangulation. Data were generated through interviews, observations and field notes as well as document analysis. The researcher studying this human phenomenon generated data through interviews with individual teacher educators from different Colleges of Education, based on the purpose of the study which offered the researcher the opportunity to gain an in-depth understanding of teacher educators' understanding and practices of FA from multiple perspectives. Ho (2015) argued that another way of establishing the trustworthiness of data is awareness of the research limitations. Therefore, the limitations of the study are discussed in the next section.

4.9 Limitations

Realising the limitations of the research design is also an important means of establishing trustworthiness. Each study has its limitation and this study is no exception. The study was an explorative case study made up of small samples (six participants), hence the findings could not be generalised. During the data generation stage there was an industrial action (strike) by the College of Education Teachers Association of Ghana (CETAG) which lasted for a month, which caused a delay in the data production. However, none of these limitations can be construed to have negatively impacted the findings. The strike caused participants to be reluctant to participate because of the pressure of completing their course outline (syllabus) after the strike, and the researcher was forced to delay data collection, but in the end all participants ended up availing themselves for data generation. As the researcher is an examination officer, the issue of power dynamics had the potential to influence teacher educators' behaviour during the data collection process. To address this, every time that the researcher met with the participants, he assured them that his current position is that of a researcher, not an examination officer, and therefore data would be used solely for research purposes. In addition, the transcribed interview text was shared with participants to show them that the researcher’s ideas or beliefs were not infused into what they

said. Also, the site for the data collection process, mainly interviews, was chosen by participants and not the researcher to allow for flexibility on their part. According to Merriam (2009) "Prior belief about a phenomenon of interest is temporarily put aside, are bracketed, so as not to interfere with seeing or intuiting the elements or structure of the phenomenon".

4.10 Ethical issues

To ensure that all ethical issues were appropriately addressed, the researcher adhered to the ethics guidelines of the Humanities and Social Science Research Ethics Committee (HSS/1981/018D) of the University of KwaZulu-Natal. Right from the start of the study, the researcher involved the Colleges of Education where the study was conducted, by writing an official letter outlining the nature, process and purpose of the study to the Principals (Heads of Colleges of Education) requesting permission to conduct the study (**See Appendix C**). Once permission was granted, the researcher organised meetings with Heads of Departments and members of the mathematics units in their settings and explained to them the purpose of the study and how the information provided would be used for the specified aim of the study. The researcher sought consent from the teacher educators for their participation in the study. Teacher educators who voluntarily agreed to participate in the study were given a letter of informed consent to read and sign (**See Appendix D**). It was detailed in the letter of informed consent that participation was voluntary and that participants could withdraw from the study at any time they should wish with no consequences, but only needed to inform the researcher. The researcher also sought the consent of the participants to use an audio recorder and video camera for data generation. At the beginning of each of the data generation phases participants were always reminded of their rights, and also that they are under no obligation to answer any questions that they might not feel comfortable with. To maintain the anonymity of the selected Colleges of Education, they were assigned pseudonyms and identified as Roberkeyta College of Education, PhilNeri College of Education and Oswald College of Education. Pseudonyms also protected the identity of the participants and ensured that their details would not be made public. Participants felt at ease after all of the ethical issues surrounding the study were made known to them. The researcher also promised the Colleges to share the findings of the study with them once completed.

4.11 Chapter summary

This chapter presented the contextual and methodological approach followed in carrying out the study. The researcher began by providing a detailed discussion of the research paradigm underpinning the study, research approach, research style, data collection method, and the procedures for analysing data. In addition, the chapter provided a comprehensive discussion of the context of the study, participants, and sampling procedure. Finally, the chapter expounded on the quality considerations and limitations, and culminated with the ethical issues of the study. This chapter forms the anchor upon which the study rests. In the next chapter, the researcher presents an analysis of teacher educators' understanding of FA.

CHAPTER 5

TEACHER EDUCATORS' UNDERSTANDING OF FORMATIVE ASSESSMENT

5.1 Introduction

The purpose of the research study was to investigate MTEs' understanding and practices of FA in mathematics modules. In the previous chapter the research methodology was outlined, and the setting of the study described. The approaches employed for data generation and the method applied to analyse data were delineated and justified. The analysis for this chapter was informed by the literature review and research questions for the study. This study is underpinned by the following research questions:

1. What are mathematics teacher educators' understanding of FA?
2. How do mathematics teacher educators enact FA in mathematics modules?
3. Why do mathematics teacher educators use the FA techniques that they do?

The overarching research questions are explored in two chapters. This chapter will focus on teacher educators' understanding of FA (research question one), while the other two questions (research questions two and three) are discussed in the next chapter. In an attempt to answer the question, the researcher draws a connection and / or comparison between the findings established for the study and the related literature discussed in Chapter 2.

5.2 Results

To analyse teacher educators' understanding of FA, the researcher designed a system of themes describing aspects of FA from the literature. This was then followed by content analysis of teacher educators' responses and the constructs used by the teacher educators were compared with the themes from the literature. Table 5.1 documents the themes derived from the literature, matched with the empirical themes from teacher educators' interviews. The analysis was informed by Rowntree (2015) five dimensions of assessment: 1) Purpose or expected outcome (why assess?),

2) Content and/or skill (what to assess?), 3) Methods or means (how to assess?), 4) Interpretation, explanation and / or appreciation (how to interpret?), and 5) Response, communication and / or intervention (how to respond?). Rowntree (2015) argues that teachers' knowledge of assessment is determined by their understanding of the five assessment dimensions. These dimensions were adapted and narrowed to FA and compared with the themes that emanated from the data after content analysis. The results suggest that there are similarities between teacher educators' constructs of FA and Rowntree's dimensions of assessment (Table 5.1).

Table 5.1: Comparison of literature-based themes with the results of teacher educators' constructs

Literature-based themes	**MTEs' constructs from interviews**
Timing of administration	Assessment is continuous Part of the progress of teaching and learning Done as you are teaching Assessment is a day-to-day activity Activity done after teaching
Purposes of assessment	We assess for grading purposes Have a view of how learning has taken place
	Find out progress and understanding To see if what you are teaching is going well Evaluating teaching and learning Make decisions about students
Modes of assessment	Quizzes, class exercises, questions and answers, group work, presentations, observation
Interpretation on the use of assessment result	Gives information about your methodology Adopt a new instructional strategy Inform you whether to continue or go back Checking method of instruction
	Identifies students' difficulties Concept not well-formed
Assessment feedback	Motivate students Identify weaknesses Whether the assessment is done right or wrong What they have done well and what needs to be improved

Through the comparison, the researcher was able to generate four themes and related categories. Themes and categories were therefore employed to understand the MTEs' understanding of FA in

mathematics modules. Table 5.2 provides a summary of the themes and the related categories that emanated from the data, aligned with the research question and purpose of the study.

Table 5.2: Themes and related categories developed by content analysis of MTEs' interviews

Theme 1: Mathematics teacher educators' definition of formative assessment	
Category 1	Formative assessment is an integral part of teaching
Theme 2: Understanding assessment purposes	
Category 1	Formative assessment is a tool that informs teaching and learning
Category 2	Formative assessment is for evaluating achievement of learning outcomes
Theme 3: Formative assessment strategies that teacher educators exhibited knowledge on	
Category 1	Assessment methods are formal and informal
Theme 4: Mathematics teacher educators' conception of feedback	
Category 1	Feedback is reporting out to students
Category 2	Feedback is an instructional corrective tool

The analysis of data provided the researcher with four major themes, each with its unique category. These themes and relating categories provided the basis to explore MTEs in the Colleges of Education of Ghana and their understanding of FA.

5.3 Teachers educators' understanding of formative assessment

This analysis focuses on MTEs' understanding of FA in the context of teaching and learning. As mentioned in Chapters 1 and 2, exploring teacher educators' understanding of FA is important as it informs how teacher educators' translate their understanding into practice during teaching and learning of mathematics. Abell and Siegel (2011) conceived teachers' assessment knowledge as the knowledge and skills needed to develop and practice in order to investigate what students know and can do, interpret the result of assessments, and use the result to decide how to improve students' learning and programme effectiveness. This means teacher educators' assessment knowledge is valuable for effective and sound assessment practices (Oduro-Okyireh et al., 2015).

Teacher educators were asked what they knew about or their interpretations as far as FA is concerned. This was an important inquiry because the assumption in this study was that the way

teacher educators relate and practice assessment depends largely on their understanding and interpretation of assessment. Cassim (2010) argued that teachers' beliefs and understanding about pedagogy and assessment inform their classroom practices. Therefore, in this study, the researcher categorised teacher educators' understanding of FA according to the following themes which were generated during data analysis, as described under results section: *Mathematics teacher educators' definition of FA, Knowledge of assessment purposes, FA strategies that teacher educators' exhibited knowledge on, and Mathematics teacher educators' conception of feedback.* The next sections give a detailed description of the themes and related categories that transpired in Table 5.2 to explain how MTEs in the Colleges of Education in Ghana conceptualised FA.

5.3.1 Mathematics teacher educators' definition of formative assessment

Many definitions have been proposed by researchers as to what makes assessment formative. Havnes, Smith, Dysthe, and Ludvigsen (2012) argue that the misunderstanding and superficial implementation of FA in the classroom is a result of the wide range of inconsistent definitions. Therefore, understanding how teacher educators defined FA was important to help clarify the main characteristics that are important to its implementation. Teacher educators were asked to share their understanding of FA and how different it is from summative assessment. The researcher was of the view that teacher educators' responses will help in determining whether they understood the meaning of FA, its purposes, and the practices of FA in their classroom.

5.3.1.1 Assessment an integral part of teaching

Cauley and McMillan (2010) pointed out that FA should be thought of as a set of characteristics that are present in varying degrees in any situation. Therefore, in trying to explore the meaning that MTEs ascribe to FA, the researcher looked out for key characteristics of FA in the participants' responses. All six participants shared their understanding of FA and its functions. Five teacher educators involved in this study delineated and articulated that they viewed FA as an ongoing, progressive activity which forms an integral part of teachers' pedagogy. Emily and Peprah gave the following descriptions:

Formative assessment is continuous, it is not a one short, so it can be done before your lesson to see where they are, it can be done in between your presentation to see if they follow what you are teaching, or it can be done … (Emily)

… is the assessment that you conduct as part of the progress of the teaching and learning (Peprah).

FA was also seen as an ongoing, daily classroom activity by Anani, and Wilson, another participating teacher educator, shared the same view:

Formative assessment is the day-to-day assessment of people's achievement, class assignment, quizzes, group work, project that one is done on a daily basis (Anani)

A comment was made by tying the definition of FA with the usage of its specific technique by the teacher during instruction. This was evident in Sekyi's response:

… so, I see formative assessment as the questions you give during teaching. It could be that verbal questions, taking students' responses to give you a view of whether you are on track, …

This statement by Sekyi shows that in his understanding the form of assessment should align with the assessment strategy or technique. Cauley and McMillan (2010) argued that ongoing FA is conducted mainly through informal observations and oral questioning posed to students during the process of teaching and learning. Sekyi's response on FA therefore supports the position of (Cauley & McMillan, 2010).

Based on the responses, it can be established that MTEs consider an assessment as formative when it forms part of an ongoing instruction that provides information about students' understanding. This is in agreement with (Brink, 2017), who conceived that FA is an ongoing process and should not be viewed and seen as a single event.

In contrast, one participant, Fordjour, observed differences between assessment and instruction. Although it was not clearly stated, he remarked that FA is an assessment that is done after teaching, thereby separating assessment from teaching and learning. This is what Fordjour said:

> *Formative assessment is a form of assessment which is done after teaching a course or every topic …*

In supporting Fordjour's response Abell and Siegel (2011) conceived that assessment used primarily to see whether and what learning has occurred for students at a particular time, usually at the end of a unit of work or course, is called summative assessment. Based on his response, it can be said that Fordjour is missing the point of what constitutes FA.

Literature on assessment has shown that there are tensions and lack of clarity about the distinction between FA and summative assessment among researchers. For example, Taras (2009) argued that all assessments are summative in nature and that FA follows summative assessment and requires feedback, highlighting gaps for redress (Sadler, 1989; Taras, 2009). This means that(Taras, 2009) holds that FA is summative assessment plus feedback. Therefore, in order to establish whether teacher educators can distinguish between the two set of functions of assessment, they were also asked to share their views on the meaning of summative assessment. Data drawn from teacher educators' interviews revealed that all six participants alluded that assessment organised at the end of an instructional period is summative. The participants' understanding of assessment indicates that assessment plays only a marginal role in instruction and is isolated from the teaching and learning process. The respondents' understanding of assessment was in line with Abell and Siegel (2011), as indicated in the literature, that summative assessment is assessment which usually occurs at the end of a unit of work or course. For example, Anani revealed that:

> *Summative is the overall assessment and it is done at the end of the year or at the end of the term. For example, West Africa Senior Secondary Certificate Examination (WASSCE) and also end of semester examination. Summative assessment is conducted at the end of a learning period.*

In a similarly manner Wilson stated that:

> *Summative is done purely at the end of a programme. For instance, at the end of the semester we have the summative but for the formative it is before the end of the semester.* (Wilson)

Peprah and Fordjour commented as follows:

> *Summative is the final assessment. At the end of the semester or at the end of a unit, at the end of a course you assess the students for various reasons.* (Peprah)

> *As for summative, it is done at the end of the course. It is like the total assessment. For example, with summative assessment one has to teach unit 1, 2, 3 up to the last units before assessing the students based on all the units for the whole course.* (Fordjour)

In addition, Emily explained that summative assessment is an assessment which is conducted at a sitting and usually at the end of a semester or term. She also highlighted that the function of summative assessment is for promotion purposes:

> *Summative is one short or at the end of the semester or term for promotion.* (Emily)

It is evident that if assessment is done at the end of the semester or term, then the assessor cannot identify any gaps in instruction and close them. This means that unlike FA, students' misconceptions and levels of understanding can only be seen or identified at the end of the course or semester. This standpoint of teacher educators on assessment affirms the world view that teachers conduct assessment at the end of the teaching process, with the intention of reporting students' progress to parents, for qualification and for judging the effectiveness of teachers or schools and for ranking schools.

Black and Wiliam (1998a) argued that teachers lack clear understanding of the differences between FA and summative assessment. However, from the data there emerged a parallel view, where teacher educators believe assessment is formative or summative based on when they occur or are conducted in relation to their purposes. According to them, assessment is said to be formative when it is an ongoing activity that forms an integral part of teaching and occurs before, during and after teaching and learning with the primary aim of enhancing learning. This means that FA is designed to generate information about students' performance, and based on that information students' learning can be supported and the teaching modified (Black & Wiliam, 2009). In the case of summative assessment, teacher educators conceived that it is an assessment which occurs at the

end of a learning period. It is used for grading, promoting, and measuring how much of the subject content the student has understood. It is worth noting that for them (teacher educators), FA supports learning while summative assessment is employed for instructional review and accountability purposes. According to teacher educators, it is not about the type/method of assessment used, it is about the time of administering that assessment which determines whether it is formative or summative.

This finding contradicts Black and Wiliam (1998a) early position that teachers lack understanding about the distinction between the formative function and summative function of assessment. However, based on the teacher educators' constructs, the researcher argues that not distinguishing methods of assessment suitable to be administered for formative purposes or summative purposes can lead to confusion in one's understanding of FA.

5.3.2 Understanding assessment purposes

As discussed in Chapter 1, section 1.4, assessment is planned and designed for various purposes. This includes collecting evidence for measuring understanding and progress of instruction or aimed at analysing and deciding on the degree to which students have achieved towards learning goals. Teacher educators' knowledge of purposes of assessment relates to why a teacher chooses to assess students, and was of interest as this knowledge was likely to determine the purposes for which assessment is designed and used in the classroom. From the data, two purposes of assessment were identified, and therefore the researcher organised MTEs' understanding of assessment purposes into two: FA is a tool that informs teaching and learning; and 2) FA is for evaluating achievement of learning outcomes. These two purposes are discussed in the subsequent sections.

5.3.2.1 Formative assessment is a tool that informs teaching and learning

Briggs, Ruiz-Primo, Furtak, Shepard, and Yin (2012) note that FA can be seen as an umbrella term that covers various approaches to assessment intended to support learning that have different underlying learning theories. For formative purposes, teachers are to understand assessment as an integral part of classroom instruction and are to use assessment throughout their instruction to assess, monitor and support students' learning. Evidence generated from the assessment provides feedback to the teacher, and based on the information modifications can be made to instruction.

Data drawn from MTEs' interviews revealed that three of them (Wilson, Sekyi, and Peprah) in explaining the function of assessment in the mathematics context mentioned one assessment purpose for FA. According to these teacher educators, assessment is planned and used in gathering evidence about instruction:

> *…to measure whether whatever you are teaching is going on well or also the method that you are applying in teaching them is also going on well, …* (Sekyi)

> *I assess to find out their progress and understanding of the concept taught and to determine whether I am making progress in my teaching.* (Peprah)

Wilson believes the aim of assessing students is to gather information about the learning process so that, based on the evidence gathered, one can make an instructional shift in addressing the learning needs of students:

> *Assessment is done to have a view of how learning is taking place. Remedial to be done to help the students, …*

The comments made by Sekyi, Peprah and Wilson indicate that they consider FA as a means to inform teaching and learning. Although these three educators shared the same understanding that FA is for informing teaching and learning, they expressed themselves differently. As far as these teacher educators were concerned, the purpose of assessing students in mathematics modules is to inform pedagogical decisions. For example, Sekyi perceives assessment as an artifact that offers him the opportunity to evaluate his teaching methodology, while Peprah and Wilson viewed assessment as evidence gathering of students' understanding of the learned concept and their daily progress in meeting instructional goals. This belief is upheld by Oduro (2015), that assessment serves the purpose of guiding the pedagogical practices of the teacher as well as the teaching process, and also helps teachers to address their students' thinking during instruction (Coffey et al., 2011).

5.3.2.2 Formative assessment is for evaluating achievement of learning outcome

Gardner et al. (2010) observed that information generated from assessment has dual purposes: for improving performance and for accountability. In contrast, Abell and Siegel (2011) note that assessment has four purposes – diagnostic, formative, summative and metacognitive – and should be designed with one of these in mind.

Two MTEs (Anani and Emily) observed that assessment is about tracking and organising students' achievements against learning outcomes. According to Anani, the primary purpose of assessment is to gather information to report the progress of students by placing value on students' learning outcomes:

> *With assessment, we are trying to set a value on students' performance to determine their actual achievement. So, we assess to be able to know whether they have achieved what they have been taught, assessment is done for grading purpose …*

Emily also stated:

> *To test students' level of understanding of concepts.*

These comments from Anani and Emily suggest that planning assessment intends to capture how much learning has taken place. Some studies have argued that there is no formal learning on the assessed subject after summative assessment (Dixson & Worrell, 2016). This means that the summative nature of the mid-term quizzes has formative purposes and sets the stage for effective teaching and learning. Emily and Anani's conception seems to align with the position advanced by (Black & Wiliam, 2009) that summative tests provide teachers with the opportunity to gather evidence of students' learning, and when employed correctly can prompt feedback which moves learning forward.

Abell and Siegel (2011) posit that a key purpose of assessment within the school is for tracking and analysis of students' progress to inform teachers' decisions regarding ongoing teaching. Fordjour opined that assessment offers him the opportunity to gather evidence about his students and for decision making:

…., I assess in order to get information about the students and to make some decisions about the students.

Fordjour's response points to the intertwined nature of assessment, in that data produced can be interpreted and used for formative purposes or summative purposes or both. It is worth noting that Fordjour's response supports the position of Black (2013), who concluded that the formative and summative purposes of assessment can be so intertwined that they are mutually supportive rather than contradicting each other.

5.3.3 Formative assessment strategies that teacher educators exhibited knowledge of

The focus of this theme was to explore FA strategies that teacher educators know and employ in their daily teaching and learning of mathematics. According to Chappuis (2015, p. 6), FA strategies are an instrument or activity that "provides information of sufficient details to pinpoint specific problems such as misunderstanding so that teachers can make good decisions about what actions to take and with whom". These tools are used for collecting information to determine the extent to which students demonstrate desired learning outcomes. The kind of assessment strategy selected by a teacher depends largely on whether one is assessing for learning or assessing for grading. Therefore, to understand teacher educators' practices of FA in the context of mathematics teaching and learning, it was important to explore their knowledge of FA strategies. The questions invoked were: *Which formative assessment techniques are you familiar with? Which of them do you use in your assessment practices*?

5.3.3.1 Formative assessment methods can be formal or informal

Kenyon (2019) posits that FA strategies that teachers use can be either planned or unplanned. Formal FA is also known as planned FA (Bell & Cowie, 2001). According to Bell and Cowie (2001), planned FA is used to generate permanent evidence of students' thinking and can be organised at the beginning or end of a topic. Ruiz-Primo and Furtak (2007) argued that incorrect responses by a student or an unexpected question can inform the teacher about students' misunderstanding of classroom activity and can trigger an assessment event. This means that informal FA happens concurrently during teaching and learning, and the information gathered is used to build up a picture of students' learning which can inform the planned FA.

In agreement with the authors (Bell & Cowie, 2001; Kenyon, 2019; Ruiz-Primo & Furtak, 2007), MTEs who were involved in this study mentioned that they sometimes planned to do an FA and sometimes do not, but it spontaneously happens during the course of teaching. Teacher educators indicated in their responses, among others, that both formal and informal assessment strategies are used in gathering evidence about their students' learning and about their teaching methodology. For example, in the FGD Peprah remarked that:

> *Actually, they come in many forms, but we assess them by giving them class exercise, quizzes, project work, group work, and presentations.*

Fordjour stated as follows in the FGD:

> *We also assess them using classroom questioning and even observation*

These views shed by Peprah and Fordjour were agreed with by other participants. As far as these teacher educators are concerned, a variety of assessment strategies should be used in the classroom to demonstrate students' learning. These strategies mentioned by teacher educators are useful tools for formative purposes, since they use the information generated from these strategies to make instructional decisions.

Based on the above interview extracts, it seemed that while the teacher educators know that they need to plan FA, they are versatile in their approach to include informal strategies such as questioning. During the individual semi-structured interview, each educator highlighted some of the strategies they use in their pedagogical practices of administering FA.

Anani said:

> *I use quizzes and sometimes group work where somebody is very weak, the group will be able to help such students to be able to come up.*

Similarly, Wilson stated:

> *Questioning is used, presentations and quizzes. I think I can mention this few.*

Emily and Peprah also adopt similar assessment strategies to those pointed out by Anani and Wilson. While Fordjour used the same strategies mentioned by the other teacher educators, his response indicated that he uses a variety of strategies:

> *I think I use various forms of assessment in order to get information about the students. I use class exercises, group assignments, group discussions. Observation is also a form of assessment technique because, if you are teaching you can observe the students and then make some decisions about their behaviour in the class.*

Fordjour's response on the strategies used makes one question the connection between strategies and his definition of FA. His definition showed that he considered assessment to be summative, but the strategies he said he was using are more formative in nature. Fordjour's response suggests lack of alignment between conception of FA, purpose and strategies used.

Likewise, Sekyi also utilises different strategies to engage his students:

> *I know little ones like simple class exercise, do this [activity] for me to see whether it strike their progress. It could be presentations, it could even be quizzes, discussions, …*

Drawing a linkage between these MTEs' responses, one key attribute noted is that teacher educators believe in adopting multiple assessment strategies. They believe that a combination of assessment strategies (formal and informal) offers them the opportunity to be reflective in adapting teaching styles that are capable of meeting the needs of students. Based on the results, it could be argued that the participants in this study employ both formal and informal FA strategies as tools to gather instructional evidence. Drawing from McMillan (2013), who remarked that oral questioning, exercises, homework, and tests are examples of FA strategies used in gathering evidence about students' learning and performance, the results suggest that the teacher educators are of the same view.

5.3.4 Mathematics teacher educators' conception of feedback

Research has shown that FA necessitates feedback indicating strengths and weaknesses of the teaching and learning process (Bell & Cowie, 2001; Black & Wiliam, 1998a; Taras, 2009). Supovitz (2012), posits that feedback is something about a student's development towards goals

of learning, thinking processes and misconceptions. The literature indicates that FA refers to all assessment activities undertaken by teachers and their students during the teaching process to support students' learning through feedback (Black & Wiliam, 1998a; Mkhwanazi, 2014). This means that teacher educators' knowledge and understanding of feedback will determine the quality and nature of feedback that they enact in their modules. Data gathered from teacher educators revealed two perspectives on assessment information, which are: feedback is reporting back to students (section 5.3.4.1); and feedback is an instructional corrective tool (section 5.3.4.2).

5.3.4.1 Feedback is reporting back to students

The participants in the current study elicited Heritage's (2010b) assertion that assessment needs to provide actionable information for both teachers and students. Three teacher educators revealed that feedback is concerned with communicating assessment outcomes back to students. For example, Anani remarked that:

> *Without feedback, students will not know whether the assignment done is right or wrong or they have done the right quiz. It is about providing information to students on their shortfalls to be able to make a correction and move forward.*

Peprah was quoted as saying:

> *Feedback is about telling students what they have done well and what needs to be improved.*

In a similar manner, Sekyi explained that formative feedback enables individuals to make changes to his or her work based on the information received:

> *For instance, if you are working on an activity and you have been made to see that there is something amiss with what you are doing. Then certainly, as a human being, you need to improve upon what you were doing.*

These three teacher educators are of the same view that feedback is about providing valuable information to students on their work, regarding what they are doing right (correctness) or areas

that need to be worked on further, which allows them to see how they can improve. This is supported by Shute (2008), who conceived feedback as information communicated to a student and based upon which the student can alter his or her mindset with the sole purpose of improving learning. Regarding to Bansilal, James and Naidoo's (2010) conception of feedback and its purpose, the three teacher educators only focus on the aspect of a teacher giving feedback to students and not much on students giving feedback to teachers, as illustrated in Figure 5.1.

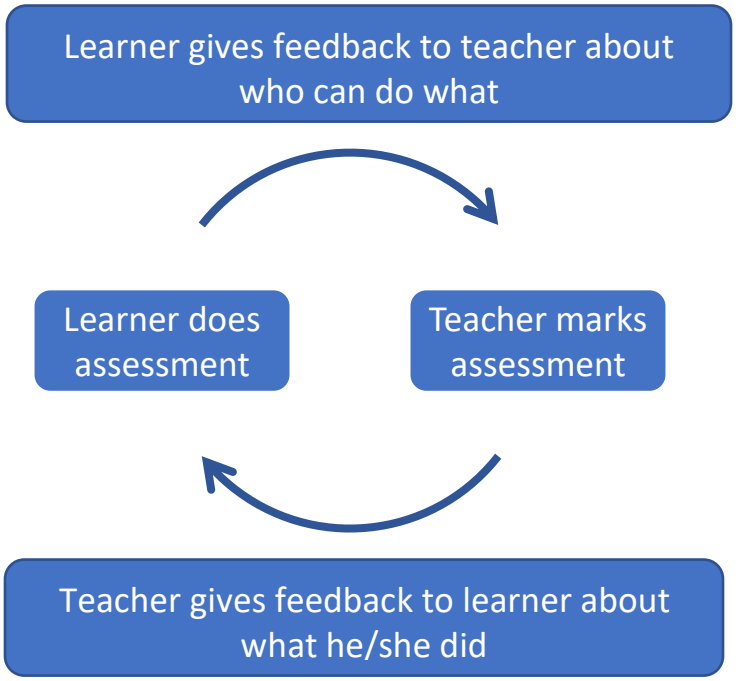


Figure 5:1: Purpose of feedback model (adapted from Bansilal et al.,2010).

Figure 5.1 illustrates that feedback is a two-way stream; however, the teacher educators' view is that of a one-way stream, from teacher to student.

5.3.4.2 Feedback is an instructional corrective tool

The literature has documented that feedback is crucial and forms an integral part of FA, which provides information to both teachers and students. FA refers to all assessment activities undertaken by teachers and by their students during the teaching process, with the intention of supporting students' learning through feedback (Black & Wiliam, 1998a; Mkhwanazi, 2014). In agreement with this position, three of the teacher educators considered feedback as an essential

resource for teachers to shape students' learning through adjustment in their instruction. For example, Emily said formative feedback offers her the opportunity to revisit her teaching methodology after identifying that the majority of her students have a score below certain pass marks on the assessment task:

> *if you teach and assess (give quizzes or exercises) and maybe 75% of the students are getting below half of the total marks, then it means there is something wrong. So, as a teacher, I have to restrategise by using a different strategy or method*.

Likewise, Wilson commented as follows:

> *… if I assess and the outcome tells me that particular understanding or concept has not been formed well, it helps me to quickly devise means to help them …*

Fordjour also responded that:

> *Maybe that is what I said early on that, it gives you some information about your methodology and the way the student perceives your lesson. After every unit you try to assess yourself about your method …*

MTEs Emily, Wilson, and Fordjour's responses suggest that these educators recognise the importance of assessment data gathered from students. Their comments portray that assessment evidence gathered from students is a critical tool for teachers' self-evaluation and for improving teachers' pedagogy. Although they express themselves differently, when one sums up their comments it can be observed that the responses point to one key component of assessment, which is teachers' self-assessment. This result therefore aligns with Oduro (2015), who explored assessment in a mathematics classroom in Ghana in a study of teachers' practices, and found that pupils' assessment results constitute an important factor in teachers' self-evaluation and improvement in their teaching methodology. Furthermore, in line with Bansilal et al. (2010), unlike the other three teacher educators Emily, Wilson and Fordjour's conception of feedback is that of teacher to student and student to teacher.

5.4 Alignment of teacher educators' understanding of formative assessment and Ghana's assessment policy

In this section the researcher describes and analyses teacher educators' understanding of FA with regard to the assessment policy on FA in response to the first research question. To establish whether teacher educators' conception aligns with assessment policy, three policy documents on assessment in Ghanaian education were consulted, as presented in Table 5.3. The researcher presents policy issues raised in the documents in relation to FA and compares them with findings of the study.

Table 5.3: Link between policy issues on formative assessment and findings from the study

Policy document consulted	Policy issue raised	Findings and interpretation
National Pre-tertiary Education Curriculum Framework (NaCCA, 2018)	***Definition of FA***	In this study teacher educators viewed assessment as an ongoing activity that forms part of teaching and learning
	FA provides feedback and information during a teaching and learning process while teaching is taking place and while learning is occurring	
National Pre-tertiary Education Curriculum Framework (NaCCA, 2018)	***Purpose of FA***	In this study, four teacher educators indicated that assessment could be used to gather evidence about the teaching and learning and to evaluate students' acquisition of knowledge
	FA serves the purpose of improving learning, and shaping and directing the teaching and learning process	
National Teachers' Standards for Ghana guidelines (National Teaching Council, 2017:30)	***FA strategies***	In this study, teacher educators recognised the importance of integrating and using multiple assessment methods and strategies
	Integrate a variety of assessment modes into teaching to support learning: examples, tests, quizzes, assignments/ homework, etc.	
National Pre-tertiary Education Curriculum Framework (NaCCA, 2018)	Good assessment uses multiple methods. Assessment should be Comprehensive	
National Pre-tertiary Education Curriculum Framework (NaCCA, 2018)	***Nature of feedback***	In this study, teacher educators' feedback on students' written work reports took the form of marks only
	Feedback should indicate what is good about a piece of work and why it is good; also what is not good and how the work could be improved	

The results in Table 5.3 show that the meaning of FA provided by the National Council of Curriculum and Assessment (NaCCA, 2018) is similar to the views held by the MTEs that FA forms part of the teaching and learning process. According to NaCCA, FA is a process which should occur during a teaching and learning process while teaching is taking place and while learning is occurring. This means FA should be viewed and understood as an integral part of teachers' pedagogical activities and should occur before teaching, during teaching and after teaching. This demonstrates that the policy provides the base for informing and improving teacher educators' assessment practices in mathematics.

In addition, the findings of this study suggest a close alignment between teacher educators' understanding and the statement highlighted in the National Pre-Tertiary Education Curriculum Framework and the National Teachers' Standards (NTS) for Ghana guidelines in relation to the purpose of FA. Table 5.3 revealed that FA is planned and designed to improve and shape teaching and learning of mathematics. This means that through the processes of assessment, information gathered aids the assessor to identify gaps in the teaching process, and based on this information support is given to students with the aim of enhancing their learning through instructional modification where necessary.

Teacher educators are required to employ FA techniques during their instruction, and it is thus imperative that these educators have a clear understanding of these techniques or strategies. As presented in Table 5.3 the Ministry of Education (National Teaching Council., 2017) in Ghana stated in the NTS document that teachers should incorporate a diversity of assessment modes into teaching to support learning. This view was reaffirmed by the NaCCA that a good assessment uses multiple assessment methods. These two statements align with each other and confirm statements in the literature (Siegel & Wissehr, 2011) that there is a need for teachers to adopt multiple assessment methods, because a single method of assessment will only measure some aspect of students' learning.

Matching these policy issues with teacher educators' conception on FA methods or strategy revealed that teacher educators recognised the importance of adopting a variety of assessment modes into daily practice in order to respond to students' learning needs. Teacher educators exhibited understanding of diverse methods of assessment by citing quite a number of them (for example, quizzes, presentations, observations). This demonstrates that teacher educators'

understanding of assessment methods are uniform with what is expressed in the two policy documents regarding assessment. Teacher educators' knowledge of these methods has the potential of helping them to take note of gaps in learning and to address these in the planning and delivery of the next set of instruction.

Table 5.3 further shows that the analysis resulting from teacher educators' knowledge regarding feedback suggests points of correspondence with some aspects of the assessment policy: understanding of assessment as a form of communication to learners (feedback on their learning); feedback to teachers on their teaching; and feedback to the curriculum designer (on the curriculum) and to district, regional and national education directorates (on the use of resources). According to the teacher educators, assessment creates the opportunity for teachers to provide feedback to students about their written work and to improve learning. This means that feedback is understood as a form of communication to students on a completed assessment task. In addition, teacher educators recounted that assessment feedback enables them to evaluate their teaching methodology and self-evaluate their teaching. Teacher educators' responses about the concept of feedback indicates that their (teacher educators') understanding was aligned with the requirement of the assessment policy (National Teaching Council, 2017).

By comparing teacher educators' responses to the assessment policy, the researcher argued that the understanding of teacher educators involved in this study of FA aligns with the assessment policies raised in the various documents consulted. For example, teacher educators mentioned that "formative is a daily activity which forms part of teaching", which indicates that they have an idea that FA should occur during a teaching and learning process, while teaching is taking place and while learning is occurring.

5.5 Conclusion

This chapter explored MTEs' understanding of FA. A system of themes detailing FA characteristics was developed from the literature and matched with constructs from teacher educators' interview responses. This aided the researcher in generating four themes, each with related categories: MTEs' definition of FA; understanding assessment purposes; FA strategies teacher educators' exhibited knowledge on; and MTEs' conception of feedback.

The understanding of FA of the six MTEs involved in this study in the context of Ghana was explored and analysed based on the four themes and the relating categories developed from the study by the researcher. In the realm of literature, the study established that MTEs understand FA as an ongoing activity that forms an integral part of teachers' pedagogical practices and occurs before, during and after teaching and learning. Significantly, they also recounted that the primary purpose of FA is to gather evidence about students to enhance the teaching and learning process.

On the issue of FA practice, MTEs conceived that FA methods can be formal or informal, and therefore mentioned the need to adopt multiple FA strategies to gather assessment information. Teacher educators also demonstrated sound knowledge of FA strategies and confirmed use thereof in their instructions. The study further demonstrated that MTEs understand formative feedback as a process of responding to students' work and as an instructional corrective tool.

The preceding discussions captured how teachers conceptualised FA. The researcher presented the dominant view held about FA by MTEs in the following areas: (i) MTEs' definition of FA; (ii) understanding of assessment purposes; (iii) FA strategies that teacher educators' exhibited knowledge on; and (iv) MTEs' conception of feedback. These views provide the basis for understanding how MTEs implement FA in mathematics modules, and reasons for adopting FA strategies in their classrooms.

CHAPTER 6
LESSON PRESENTATIONS: IN SEARCH OF TEACHER EDUCATORS' ASSESSMENT PRACTICES

6.1 Introduction

In this chapter the researcher presents data on teacher educators' observed lessons to generate evidence and explore how FA techniques are enacted during classroom instructions. The presentation draws on data collected from observing six teacher educators during their teaching sessions of the mathematics modules. Each teacher educator's lesson presentation starts with a synopsis of the classroom context in which their teaching of mathematics and assessment unfolds.

6.2 Description of teacher educators' instruction

This section gives an account of participating educators' lesson presentations. Each teacher educator, except for Anani, was observed three times to gather evidence on their classroom assessment practices. Lesson observation data were generated one after the other over a period of nine weeks. Emily, Wilson, and Anani's lessons were presented to second-year pre-service teachers completing Diploma in Education programmes. Fordjour and Peprah's lessons were presented to pre-service teachers pursuing a Bachelor of Education programme who were in their first year of study. Sekyi's first and third lessons were presented to Bachelor of Education first-year pre-service teachers, while his second lesson was presented to second-year Diploma in Education pre-service teachers.

6.2.1 Description of Emily's instruction

Emily was handling Methods of Teaching Basic School Mathematics, a module for second-year pre-service teachers. All of the 48 students were female. Emily's lesson was interactive, using group presentations and whole-class discussions. Emily conducted each of the mathematics lessons that were observed in a different way.

In the first observed lesson, Emily was teaching the addition of integers. She began by exploring the existing knowledge of her students through questioning, as per the excerpt from the transcribed lesson below:

Emily: Who is owing someone money?
Student: Madam, I.
Emily: Whom are you owing?
Student: …… [name withheld]
Emily: How much do you owe her?
Student: Five Ghana cedis [Ghc 5.00]
Emily: How much were you having …. [name withheld] before she borrowed the Ghc 5.00?
Student: Ghc 10.00.

This teacher-student interaction set the stage for the introduction of the day's lesson. Emily sought the prior knowledge of her students and based on that she mentioned that the topic for the lesson is integers and followed up by sharing the learning goals with her students. After introducing the lesson, Emily wrote a sum (see Example 1) on the marker board, and explained that the signs in front of the numbers 1 and 4 are called directional signs, whereas the sign in between the two numbers (+1) and (+4) is called an operational sign.

Example 1: $(+1) \pm (+4)$

She explained that the directional sign represents the position one needs to face when carrying out the activity. For example, a positive sign means to face the right direction or the positive direction, while a negative sign indicates facing the left direction. On the operational signs, Emily said a plus sign indicates forward movement, and a minus sign indicates a backward movement. With her guidance, students performed the activity. She then sketched a picture (see Figure 6.1) of the modelled number line on the board for the students.

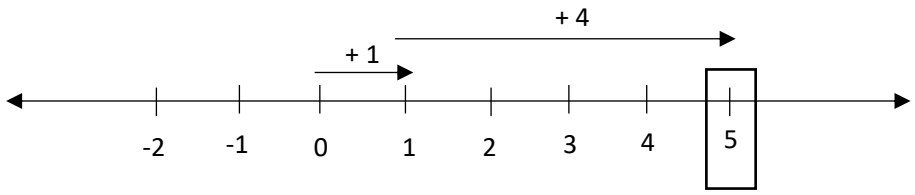


Figure 6.1: Emily's model number line of the sum (+1) + (+4).

The example was followed by an activity for her students to try their hand at. Emily asked her students to write an activity that they would use to teach a Grade 6 pupil (+3) + (-2) using the number line model.

After reading out the question to her students, she gave them 5 minutes to work on the activity. After this, she called a student to the board to record her solution for the entire class:

Emily: What was your answer?

Student: I had 1, madam.

Emily asks the class: Is she correct?

Students: Yes madam [answer in chorus].

Emily: Okay, write your solution on the board and explain how you arrived on 1.

Student: Madam, first, you assist learners in drawing a number line. Starting from 0, ask learners to turn in a positive direction and move 3 steps. Then let learners turn and face the negative direction and move 2 steps forward, landing on a positive 1.

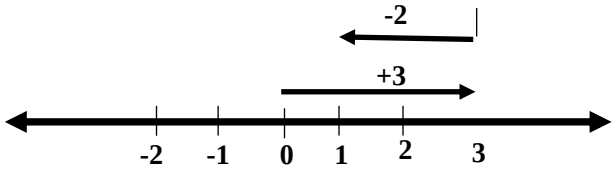


Figure 6.2: Student model number line for adding (+3) + (-2).

After engaging her students actively in the lesson through questions and answers, individual hands-on activity on the concept, she ended by summarizing the lesson through questions.

Emily's second observed lesson took place as scheduled. The date and time were agreed upon after the first observed lecture. She was teaching Number Basis this time round. Before the start of the lesson, Emily informed her students of the intention of learning (learning goals) for the day's lesson. After highlighting the goals for the units for the section, she wrote a mathematical sum on the board and asked "*Who can read* $43_5 + 32_5$?" One student said "*Madam, 43 Base 5 plus 32 Base 5.*" Another student said "*She is wrong; I disagree with her*," then Emily asked "*Why do you disagree with her answer*?" Emily asked. The student replied "Madam, the numbers are written in Base 5, and so we cannot have 40 or 30 as an answer." Emily asked "*So how should it be read*?" and the student said "*I think 4-3 Base 5 plus 3-2 Base 5*."

Emily explained further after the students had read further, and hinted that they should always be mindful of the Base of the question:

> *Ladies, since the question was given in Base 5, you have to be mindful of the numeral. So, for this question, the digits required are 0, 1, 2, 3, and 4. Numbers like 5 the Base you are working with, and above 5 should not be part of your result. So, you cannot have 30 or 40, as she said.*

The lesson continued with Emily assisting her students in solving the question. She asked her students to bring out their materials. Students placed bundles of sticks, thread, and some loose sticks on their table. Because the question was on Base 5, Emily assisted her students in having some bundles of 5 sticks and tied them with the thread. After they were done, she guided the students in solving the sum $43_5 + 32_5$:

> **Emily:** Select four bundles of 5 bundle sticks and 3 loose sticks representing the first addend. What should be the next step?
>
> **Student response:** Teacher will assist learners in picking three bundles of 5 sticks and 2 loose sticks to represent 32_2, the second addend.
>
> **Emily:** What should the learners do next with the selected bundle of sticks and loose ones?
>
> **Another student:** I think you ask learners to put the bundles of 5 sticks together and the loose ones also together.

The process continued until they arrived at the answer: one bundle of 5 bundles of 5 sticks and 3 bundles of 5 sticks. This was finally written mathematically as 130_5. She followed it up with the following examples for the students to work out:

a) $23_4 + 11_4$ b) $101_2 + 110_2$ c) $27_8 + 15_8$

Her third lesson was on the properties of operation and was presented by students via group presentations. Groups took turns to present aspects of the subject matter. The groups presented on the commutative property, associative property, and distributive property. Two groups presented on commutative property. One group presentation was on the commutative property of addition, while the other group's presentation was on the commutative property of multiplication. The same went for the associative property, while the last group presented on the distributive property. After each presentation, group members were questioned by other students. Emily was always the last person to comment on a presentation. After all the groups had finished presenting Emily said "This ends the lesson on properties of operation. I am not treating it again." She concluded the lesson by asking students a few questions to highlight key concepts learned on the day.

6.2.2 Description of Sekyi's instruction

Sekyi was handling two cohorts (level 100 and level 200) of pre-service teachers. The module for the level 100 cohort was Algebra 2, while the second years were doing Methods of Teaching Basic School Mathematics. Before the lesson, Sekyi noted that the algebra module is made up of 36 registered students. He further stated that the total number of students registered for Methods of Teaching Basic School Mathematics stood at 370 and had been divided into six groups; he handles one group out of the six.

In Sekyi's first observed lesson, he began with a brief summary of the quadratic equation, which seems to be the topic he discussed with his students in their previous meeting. In order to find out how much knowledge his students acquired from the previous lesson he gave them a question to activate their prior knowledge on quadratic equation before dealing with the new topic. He asked them to find the zeros of the equation $x^2 + 5x + 2 = 0$ using the method of completing squares through oral questioning.

Sekyi: How can we find the zeros of the $x^2 + 5x + 2 = 0$ using the method of completing squares?

Students: First we have to transpose the 2 to the other side of the equation

Another student: Then find half of the coefficient of x, square it and add to both sides of the equation.

The review continued to the end by arriving at the zeros for the equation. He then began the lesson for the day by sharing the learning intentions. Sekyi was teaching graphing of linear inequalities. He started by exploring students' existing knowledge on how truth set of inequality is represented on a number line, as per the transcribed excerpt below:

Sekyi: If you have the inequality $x > 1$ and represented on a number as shown [see figure 6.3a], what can be said about the representation?

Student: It means 1 is not part of the solution.

Sekyi: What if the line is represented like this? [See figure 6.3b]

Student: Sir, for that, 1 is part of the solution.

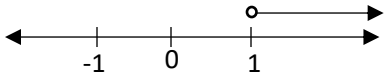


Figure 6.3a

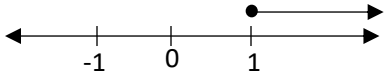


Figure 6.3b

6.3: Sekyi number line representation of $x > 1$ and $x \geq 1$

Based on the response, Sekyi introduced his students to how to graph inequalities on the Cartesian plane, by taking them through the strategies required in drawing inequalities and for shading the required region representing the solution for the given inequality. Some of the key things mentioned were:

1. Using broken lines when the giving inequality has one of the symbols less than or greater than ($< or >$). He explained that the points on this line do not form part of the solution set.
2. Using a continuous line for either less than or equal to symbol or greater than or equal to the symbol ($\leq or \geq$) and the points on the line forms part of the solution set.

After taking the students through the strategy with illustrations, Sekyi read out the question: *Show the required region represented by the linear inequality* $x + y > -2$. He worked out the example with his students and plotted the graph (Figure 6.4) on a graph board placed at the right corner of the lecture hall. After the plotting and guiding the students to shade the region which represents the solution for the inequalities, Sekyi asked his students to do the plotting in their graph books.

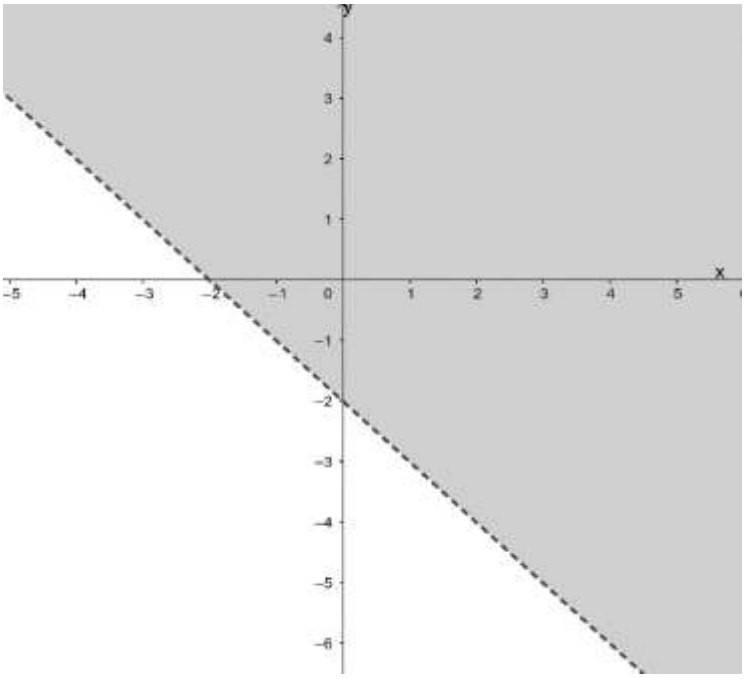


Figure 6.4: Sekyi's graph for the inequality $x + y > -2$

After illustrating the procedures involved through the example, Sekyi engaged his students in a series of hands-on activities with other inequalities symbols to ensure better conceptualisation of the topic. Sekyi also used self-test activities to test student understanding; for example, 'Plot the graph of the inequality $x + y \leq 4$ and shade the required region'. While students were working on the task Sekyi was moving around the lecture hall, observing as students worked on the task. After working for about 15 minutes, students voluntarily presented their results on the board for discussion. With just 2 minutes to end the lesson, Sekyi announced an impending quiz to be written the following week:

Sekyi: … the quiz will be based on units 4 and 5. (Field note).

Sekyi's second observed lesson was with level 200, where he was handling Methods of Teaching Basic School Mathematics modules. He was teaching the subtraction of fractions but began the lesson by reviewing the previous lesson on additions of fractions. After greeting the class, he wrote a fractional sum: $\frac{1}{2} + \frac{1}{3}$ on the board and asked his students to solve it using the paper-folding technique.

Sekyi: Show and explain how you will guide Grade 6 learners to find the sum of $\frac{1}{2} + \frac{1}{3}$ using a paper-folding technique.

Student: Sir, you first pick a strip of paper and fold it into two equal parts horizontally and shade one part representing $\frac{1}{2}$.

Sekyi: After shading the one part, what will be the next thing to do?

Another student: You then refold the paper vertically into three equal parts and shade one part for $\frac{1}{3}$. So, the answer is $\frac{5}{6}$.

A further student responded to his colleague by drawing her attention to the fact that it should be 4 out of 6, not 5.

Student: No, the answer is 5 out of 6 not 4. It can be observed that after the folding we had 6 equal divisions and when you check, one part is shaded twice, so we count that part 2 which gives 5 not 4.

Sekyi confirms the answer and asks her to show this by drawing on the marker board.

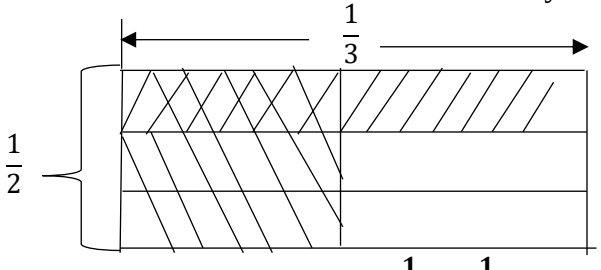


Figure 6.5: Diagram depicting $\frac{1}{2} + \frac{1}{3}$ using paper folding.

The lesson continued with the day's topic, subtraction of fractions. After the review on the addition of fractions, Sekyi worked out an example (see Example 2) with his students after explaining the subtraction concept.

> **Sekyi:** Describe how you will guide a Grade 6 student to solve $\frac{5}{7} - \frac{2}{7}$ using concrete material.

Although the premise of his question is to describe "how you will", the question was not directed at his students to do it. He used this question to demonstrate the teaching of the concept of subtraction of fractions.

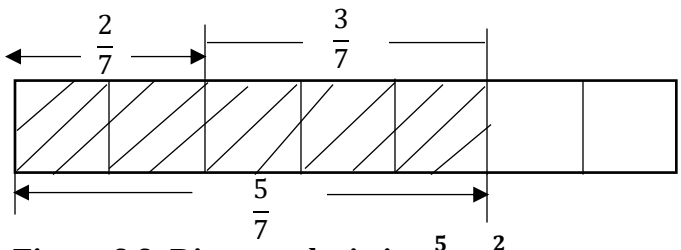


Figure 6.6: Diagram depicting $\frac{5}{7} - \frac{2}{7}$.

Although the question did not specify the exact material to be used, Sekyi utilised the paper-folding technique to explain. He noted after the student had folded the paper into 7 equal parts, assisting him or her to shade 5 parts, representing $\frac{5}{7}$. He then assisted the student in cancelling 2 of the $\frac{5}{7}$ of the shaded portion; the remaining shaded out of the 7 becomes the answer.

The explanation was not seen as convincing for some of the students. A student was observed whispering to her friend “I do not understand what he did”. The friend told Sekyi, but the said student denied having said it, and Sekyi then proceeded as if nothing had happened. He further used a number line and Cuisenaire rod to illustrate the procedure to his students. Realising that time for the lesson was almost up, he concluded by asking them to read on multiplication and division of fractions before the next lesson. He also wrote the following problems on the board for them to try them on their own using the Cuisenaire rod technique:

1. $\frac{1}{2} - \frac{1}{4}$
2. $\frac{1}{2} - \frac{1}{5}$

In his third observed lesson, Sekyi led his students (level 100) to discuss the questions for the midterm quiz, which they had written in the previous week. His third lesson therefore saw him giving feedback to students on their midterm quiz, as illustrated in the transcribed excerpt below.

> Student is asked to read out the question and reads as follows: Determine whether or not the indicator $y = -2$ is a solution to equation $3(y + 1) = 4y - 5$.
>
> **Sekyi:** Good, so what were you supposed to do?
>
> **Student:** Sir, the question asked that we indicate if $y = -2$…, so you can solve and compare the answer.
>
> **Sekyi:** You solve for what?
>
> **Student:** Sir you solve for y from the equation, and when you get y, let's say $y = 8$, then you compare it with $y = -2$.
>
> **Sekyi:** Is there another way of solving it?
>
> **Another student:** When you check, the equation involves a variable which is y, and you have been given y, you just have to substitute y [into the equation], and after that, you compare the right-hand side to the left to see if the values are the same.

Sekyi recommended and explained that the two methods could be used. However, he cautions his students to stick to instructions whenever they are writing a paper:

> *The question stated that determine whether or not …., so just solving and not concluding is not enough. What I have seen in the script I am marking is, most of you did not conclude, so be careful else you will lose marks in the final examination.* (Field note)

The discussion continued with the other questions up to the end of the instruction, with Sekyi activating his students as resources of their own learning. Students took charge of the instructional process, while Sekyi provided assistance when he saw that students were encountering difficulty

with an aspect. He concluded the lesson by telling them to try the questions again on their own, and assured them that he would return their scripts in due course.

6.2.3 Description of Wilson's instruction

The researcher observed Wilson three times over two weeks, each lesson lasting an hour. Wilson was teaching in a module titled Further Algebra, a level 200 module. Seventy-five students were registered, but the average number of students that was observed was about 60. Even with the 60 students, the lecture hall lacked sufficient space to accommodate them, and some were found standing in the windows outside the lecture hall.

On the first day of observation Wilson was teaching investigating number patterns. He began the session by reviewing the previous lesson on how to generate a 3 x 3 magic square with his students through questioning:

> **Wilson:** How can a 3 x 3 magic square be generated for the numbers 2, 3, 4, …10?
> **Student:** We have to find the sum for the row, column, and diagonal [for the grid].
> **Wilson:** How do we get the sum, as you have mentioned?
> **Student:** By adding the given numbers and divide the total by 3.
> **Wilson:** Why are we to divide the total by 3 to obtain the sum?
> **Students in chorus:** Because we are generating a 3 x 3 magic square.

Wilson went round the hall to monitor students as they worked to complete the 3 x 3 grid. After the students had been working for about 7 minutes, Wilson worked out the activity on the marker board and illustrated the grid (Table 6.1) for the students to compare with what they had. He added that those who got some of the entries wrong should make the necessary corrections.

Table 6.1: ***3 x 3 magic square***

5	4	9
10	6	2
3	8	7

Drawing on the previous knowledge, Wilson began the day's lesson on a 4 x 4 magic square. He worked out two examples on the board and also gave students some questions as a self-test of their understanding (for example, draw a 4 x 4 magic square with the numbers 5, 6, 7, 8, …, 20). Students worked for about 10 minutes, after which Wilson called on a student to record her answer on the board. She recorded the result as shown in Table 6.2

Table 6.2: ***4 x 4 magic square***

5	**18**	**19**	**8**
12	**10**	**11**	**9**
16	**14**	**15**	**13**
17	**6**	**7**	**20**

After the student presented her work on the board, Wilson called on the class to confirm whether her solution was right:

> **Wilson:** Is she correct?
>
> **Student:** Sir, her answer is wrong. She has missed the steps up the numbers.
>
> **Wilson:** Which part of her solution?
>
> **Another student:** I think almost all the entries. For example, column two has a total sum of 48, but if you check that of the first column, it is 50, which is not the same.

The explanation the student gave, hinted how his colleague and others who might have made a similar mistake could rectify their mistakes. Wilson therefore calls on the student to record his answer for the 4 x 4 grid on the marker board. After he was done with this, Wilson invited questions from the students, but none of them asked a question. After waiting for about 3 minutes with no questions, Wilson continued with the lecture, moving on to another concept, figurative numbers.

Wilson talks of figurative numbers as numbers that can be shown by dots or counters, and arranging them to form a geometric shape. He mentioned, among others, triangular numbers, square numbers, and pentagonal numbers as examples of figurative numbers. To show how dots

are arranged to form the various polygons, he began his activity with triangular numbers, using bottle tops. He used the bottle tops to illustrate the formation of the first three triangular numbers and modelled it on the marker board using dots (see Figure 6.7).

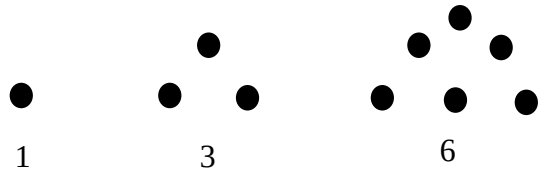


Figure 6.7: Wilson's modelling of triangular numbers.

After Wilson was done with the modelling of triangular numbers on the board, students started talking to each other, which led to noise in the lecture hall. As he tried to ask what the noise was all about, a student asked "Sir, how can one be considered as a triangle?" Another added that one gave us a dot, it did not form a triangle, so how can it be considered as a triangular number? Wilson answered: "Yes, one did not show a triangle, but you have to picture the one dot as a triangle in your mind."

He noticed that students were not satisfied with the answer that was given and therefore promised to show a video on the concept to illuminate the process and how one is considered as the first figurative number at his next meeting. Wilson asked his students to go into their groups and used think points to encourage them to think of an emerging pattern and generate the next four triangular numbers. The group activities ensured collaboration among students and facilitated learning. Students remained in their group for the rest of the lesson as the instruction process continued with square numbers and pentagonal numbers. Wilson ended the lesson by asking students questions to summarise the day's activity.

The researcher did not observe the follow-up lesson where Wilson promised to show the video; instead, the researcher was taken to a different group where the lesson on matrices was taught. The lesson started by recapping the previous work and providing feedback on previous topics. About 20 minutes was spent solving questions on how to find the sum to infinity of a given series or sequence; for example, given the series $2 + \frac{1}{2} + \frac{1}{8} + \cdots$ find the sum to infinity.

After students were done solving the question, Wilson said "I hope the groups are ready for the presentations", and the students replied "Yes, sir, we are ready" (chorus answer). The teacher asked "Which group is to present first?". "Group four", the students answered.

Wilson took his seat and called on group four members to start the presentation. The group began their presentation on the matrix by giving the definition and how the names of a matrix are derived. Members of the group took turns to explain an aspect of the concept through activities. Different groups followed one after the other to do their presentations on areas concerning the topic. After each group presentation Wilson required students to ask questions and comment on the presentation. He was always the last to comment before the next presentation.

In some situations, two groups presented on the same area, for example, how to solve simultaneous linear equations in matrix. One of the group discussions focused on writing the equation in matrix form and multiplying by the inverse to find the unknowns, while another group adopted Cramer's rule for solving systems of equations. There were six groups in all, with an average of six members each. In his closing remarks, Wilson asked his students to self-test themselves by solving more questions on their own, since the presentations brought to finality the discussion on the topic. He also asked them to read on binomial theorem, the topic for the week to come.

In his third observed lesson, Wilson was teaching binomial theorem, as he had mentioned in the closing remarks of his second observed lesson. Wilson used reflective questions to established students' knowledge on the topic. He then introduced his students to Pascal's triangle and led the students to generate it. Activities were used to enhance students' ability to recognise and use Pascal's triangle for solving binomial expansions (see example below).

Example

$$(3x-2)^5 = 1(3x)^5 + 5(3x)^4(-2) + 10(3x)^3(-2)^2 + 10(3x)^2(-2)^3 + 5(3x)(-2)^4 + 1(-2)^5$$

$$= 243x^5 - 810x^4 + 1080x^3 - 720x^2 + 240x - 32.$$

He followed this up with a series of examples. Self-test questions were used by Wilson to assess students' understanding of the concept. In addition, he explained and introduced the rule for the binomial theorem.

6.2.4 Description of Fordjour's instruction

In Fordjour's first lesson, there were 131 students registered for the module on trigonometry. As with Wilson's class, there was not enough space for all of the students and some were standing during lessons. Fordjour noted in an interview that an arrangement is being made to split the students into two groups. On the second occasion that Fordjour was observed, the class had been divided and there were 65 students in that group.

In the first observed lesson of Fordjour was teaching sine and cosine rules. He began the day's lesson by reviewing the previous lesson on radian measures. He wrote $\frac{5\pi}{4}$ on the board and asked his students to change it to degree measure. After the review session, Fordjour drew an equilateral triangle on the board and led his students to derive the sine rule as:

$$\frac{a}{Sin\ A} = \frac{b}{Sin\ B} = \frac{c}{Sinc} \quad \text{or} \quad \frac{Sin\ A}{a} = \frac{Sin\ B}{b} = \frac{SinC}{c}$$

After generating the formula for the sine rule, activities were used to apply the rules for finding sides or angles of a given triangle. He followed this up with other questions for the students to solve individually. As students worked on the task he went around to help those who were having difficulty. Fordjour's next activity required students to solve the triangle with sides 6, 14, and 16 units. He allowed his students to try it on their own. After they had worked for 10 minutes, he engaged his students to establish how they were going about the question, as per the transcribed excerpt below:

Fordjour: What is the question looking for specifically?

Student: I think we are to calculate the angles.

Fordjour: Good, then how do we go about it?

Student: Because we are to calculate the angles, we have first to draw a right-angle triangle then calculate the angles using the trigonometric ratio.

Fordjour asked the class whether the student was correct, and they responded "No Sir". Fordjour asked the students how this could be solved.

Another student: I think one needs to use the concept of Pythagoras triple to establish if the numbers 6, 14, and 16 form the sides of the right-angle triangle before the triangle can be considered as right-angle triangle.

He then asked the students to use the Pythagoras triple to check if 6, 14, and 16 form the sides of a right-angle triangle.

Fordjour recognised the contribution of his students, especially the one who talked about the Pythagoras triple, because his response gave his colleagues a clue as to how to go about solving the question. After applying the Pythagoras triple, students realised that the numbers 6, 14, and 16 do not form the sides of a right-angle triangle. On the basis of their result, Fordjour reminded his students to pay attention to details when answering questions. He added that there are other questions which the sine rule cannot be used to solve. Fordjour then introduced the students to cosine rule, noting that this rule could be said to be an expansion of the Pythagoras theorem. Fordjour explained that the reason why this is so, is that whenever any of the angles, i.e., angle A ($\angle A$) or angle B ($\angle B$) or angel C ($\angle C$) in the cosine rule is 90^0, the equation becomes $a^2 = b^2 + c^2$ which represents the Pythagoras theorem.

Activities were used to derive the cosine rule, and examples used to solve problems using the rules. For example, Fordjour worked out one of the interior angles of the triangle with sides 6, 14, and 16 using the cosine rule as follows:

$$a^2 = b^2 + c^2 - 2acCosA \implies 16^2 = 6^2 + 14^2 - 2(6)(14)Cos\ A \Rightarrow Cos\ A = -\frac{24}{168}$$

$$Cos\ A = -\frac{24}{168}$$

$$A = 98.2^0.$$

Realising that time was almost up, he tasked his students to try working out the angles for the other two sides on their own, and reminded them to read up on the application of trigonometry for the following week's lesson.

In the second observation, Fordjour was teaching longitudes and latitudes. He began the lesson by encouraging his students' contribution to the day's topic. After about 4 minutes of discussion, he explained longitudinal lines and latitudinal lines to his students. Fordjour went further by sketching a model globe (see Figure 6.8) on the board and used it in explaining the two concepts.

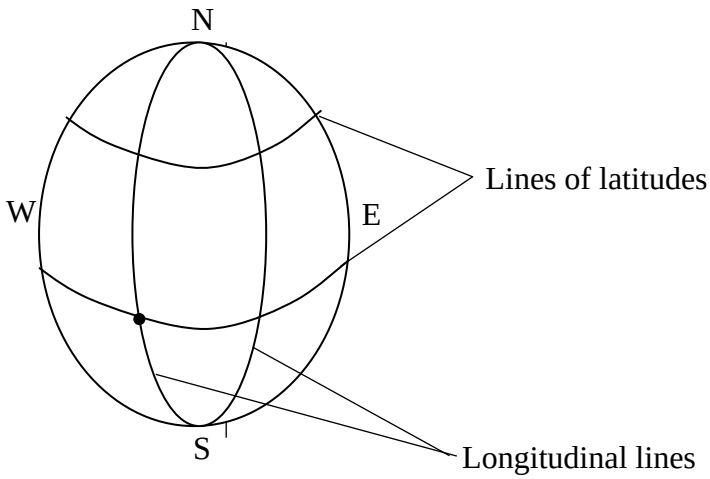


Figure 6.8: Fordjour's sketch of a model globe

With the help of the diagram, he explained to the students that the radius on the great circle is denoted by R= 6400, and led them to derive the radius on the small circle as $r = RCos\ \beta$.
Having derived the radius for a small circle, he worked out an example on the board with his students by finding the radius of latitude 60^0N, given that R = 6400. The students watched quietly as Fordjour solved the question. They then copied the example

$$r = RCos\beta \ \Rightarrow r = 6400Cos\ 60^0$$

$$r = 3200km$$

In another activity, he gave the students a question for self-testing and to check their understanding of the concept, asking his students to "Calculate the radius of latitude 35^0 N" and "Find the circumference of latitude $30^{0"}$.

The first part of the question was correctly answered by all, with few students struggling with question two. Activating students as resources of learning, Fordjour called on one of the students to present his answer to the class, as exemplified in the excerpt below:

> **Fordjour:** Explain how you had your answer.
> **Student:** To find the circumference, we need the radius of the small circle. After getting the answer for small r then you substitute the value into $2\pi r$, the formula for finding the circumference of a circle.

The lesson continued with other examples for practice, followed by how to find distance along the great circle. He worked out some examples with his students and also gave them a few questions to try. In his concluding remarks Fordjour asked his students to try solving questions on distance along the small circle, an aspect to be tackled in their next meeting.

I observed a similar pattern in his third observed lesson, which was a continuation of the second, so he was tackling distance along the small circle. He commenced the lesson by reviewing the students' previous knowledge on distance along the great circle. After the review of the previous lesson, Fordjour demonstrated to his students how to represent information on a small circle given on the globe by sketching. He later led the class in solving problems regarding distances along the small circle.

6.2.5 Description of Anani's instruction

In the first meeting with Anani for the observation, he led me to understand that a total of 420 students had registered for the module Methods of Teaching Basic School Mathematics. He explained that, due to the great number, the students had divided into eight groups of which he is handling three, with an average of 50 students in each. However, there was no single day where attendance of his students went up to the maximum number enrolled in each group.

Anani was observed for two of the three agreed lesson observations; unfortunately he was absent for the third observation, and efforts to reschedule the meeting did not come to fruition. However, his lesson presentation followed the same pattern on each of the days he was observed. Anani

began the lesson with questions and followed them up with explanations on how to design activities and the steps to follow when teaching Basic School Mathematics.

In his first observed lesson, Anani was teaching collecting and handling data (statistics). He used reflective questioning to ascertain the prior knowledge of his student on statistics, as shown by the excerpt below:

> **Anani:** What do we mean by statistics? What is statistics? [Repeating and rephrasing]. You said data, what is data in statistics? What is discrete and continuous data?

Students' responses served as a reference point for further explanation and discussion on the different aspects on the topic, such as data, organisation and interpretation of data, that emanated from the definition of statistics. After introducing the topic Anani elaborated on the lesson: "We are going to discuss how to plan an activity when teaching means, median and mode." He enumerated the procedure that needed to be followed when designing an activity to teach mean at the basic school level, as follows:

1. Guide learners to add or put the various item together.
2. Learners then count the number of items given.
3. Assist learners in finding the sum of the various items and dividing the result by the number of items.
4. Learners conclude, based on the result obtained.

To facilitate students' understanding, examples were used by Anani to illustrate the procedure required when designing activities to teach collecting and handling data (statistics) at the basic school level. For example, in one of the activities Anani wrote the numbers 120, 135, 125, 130, 120, 135, 140, 158, and 160 on the marker board and led his students in designing an activity to solve for the mean.

> **Anani:** Describe an activity you will use to guide Grade 8 learners to find the mean height of the numbers.
>
> **Student:** Guide learners to add or put together the various height, i.e. 120+135+125+130+120+135+140+158+160+160.
>
> **Another student:** Then lead learners to count the number of items given.

Anani: What will the learners do next?

Student: The teacher guides learners to find the sum of the various heights and divide the result by the number of items. That is $\frac{1383}{10}$. Learners then conclude that the mean height is 138.3.

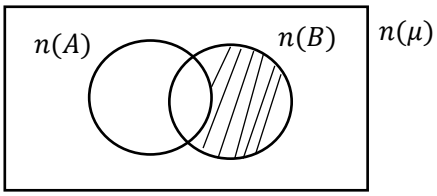
This activity was repeated, this time using the frequency distribution table approach. The lesson continued with other activities to illustrate steps or procedures that a teacher can follow to assist basic school learners in finding the median and mode of a given set of data. In a similar manner, I observed the same techniques and approaches during the second observation with Anani with the second group. Anani explained that this is to ensure that one group does not get ahead of the other, for equity and uniformity.

6.2.6 Description of Peprah's instruction

Peprah was teaching Algebra 1, a level 100 module with 74 registered students. She was observed three times, and in all the cases students' attendance record was 100%. The lecture hall was very spacious, but there were inadequate tables and chairs, so some students had to share tables with their colleagues. Visibility in the hall was not good due to a poor lighting system. I have reported these issues to the estate department for redress.

In the first observed lesson of Peprah, she was teaching a three-set problem under the applications of the concept set. She began the lesson by reviewing the previous lesson on two set problems, as illustrated below.

Peprah: How will you describe the shaded region in the Venn diagram shown?



Student: The shaded region is $A \cap B^1$.

Peprah: Do you agree with him?

Another student: No, it should be $A^1 \cap B$.

The review continued until the end, when the entire class came to agreement that the relationship between the sets and the universal set indicated by the shaded portion in the Venn diagram is described as $A^1 \cap B$. The review of the previous lesson was followed by the day's lesson*:* Three set problems. Peprah explained the relationship between the number of elements in each region of the three-set problem using DeMorgan's law, and quoted as follows:

$$n\ (A\ \cup B \cup C) = n(A) + n(B) + n(C) - n(A \cap B) - n(A \cap C) - n(B \cap C) + n(A \cap B \cap C)$$

She then worked out an example (see Example 1) on the board with her students, and followed it up with an example for the students to work out on their own. She went around while her students were working. She gave assistance to students having difficulties in solving the problem.

> **Example 1:** Given that, $n\ ((H\ \cup F \cup V)) = 87,\ \ n\ (H) = 43,\ \ n(F) = 42, and\ n\ (V) = 47$
>
> Find $n\ (H \cap F \cap V) = x$, if $n(H\ \cap F\ ) = 15\ and\ n\ (\ F\ \cap V\ ) = 21.$
>
> Peprah: Using the Law
>
> $$n\ (H\ \cup F \cup V) = n(H) + n\ (F) + n\ (V) - n\ (H \cap F) - n(F \cap V) + n\ (H \cap F \cap V)$$
>
> $$87 = 43 + 42 + 47 - 15 - 21 + x\ \Rightarrow\ n\ (H \cap F \cap V) = 87 - 79 = 8.$$

In addition, Peprah, together with her students, solved questions on three set problems. In her concluding remarks, she tasked her students to read on ratio and proportion for the next lesson.

In her second observed lesson, Peprah was teaching ratio, proportion, and percentages. The key learning outcome, which was to create contexts for ratio, proportion, rate, and percentages to enable students to gain an in-depth knowledge of the concepts and apply the knowledge of these concepts in solving real-life problems, was discussed by Peprah and her students. She began her lesson by gathering information on what the students knew or did not know, as per the transcript below:

> **Peprah:** What comes into mind when we talk of ratio?
>
> **Student:** Ratio is used to compare two or more quantities.
>
> **Peprah:** Quantities like what?
>
> **Students:** Like ages of two people.

On the basis of the knowledge that the students had, Peprah explained the concept of ratio and proportion further. The explanation was followed with examples to facilitate understanding. For example, Peprah read out the following question to her students: *A government worker shares his annual salary to his two children, Isaac and Rose, in the ratio 4: 5. If Isaac shares are Ghc 15,000, determine the amount shared, and also find how much Rose had as her share of the total amount.* Based on the notion that learning is an active process involving teachers and students, Peprah leads her students through the discussion and solving of the problem.

In pairs, students worked on additional examples. Peprah went round to give assistance as students worked with their peers. When she was about to end the lesson, she asked her students to pick up a sheet of paper and write one good thing and one bad thing they observed about the lesson and her teaching.

Her third observed lesson was on Relations and Function. Peprah started the lesson with a question and answer session. As observed in the other two lessons, she used questions to elicit students' understanding of the new topic. For instance, at the start of her third lesson she asked her students who their relations are. This question gave the students the opportunity to talk about their relations and aided her in presenting the day's lesson to them. After solving some questions with the students, she followed this up with questions to be tried by the students to test their understanding. Peprah went round to give a helping hand to students having difficulty as they worked on their own.

The classroom observation was used to generate information in response to the second critical research question: *How do mathematics teacher educators enact formative assessment in mathematics modules?* Using data from the observations and field notes for the case report of each teacher educator, the researcher developed within and cross-case data (Yin, 2014), which helped in identifying the assessment practices of the teacher educators. This cross-case analysis revealed similarities and differences in assessment techniques, which are presented and synthesised in Chapter 7 and used in answering the second critical question of the study.

6.3 Chapter Summary

In this chapter the researcher described and presented data on teacher educators' classroom lessons on mathematics and how they practice assessment in their mathematics modules. The next chapter will examine teacher educators' implementation of FA and reasons for adopting FA techniques in their instruction.

CHAPTER 7

ENACTMENT OF AND RATIONALE FOR USING FORMATIVE ASSESSMENT STRATEGIES

7.1 Introduction

The preceding chapter discussed data on teacher educators' lesson presentations, with the intention of ascertaining teacher educators' FA practice as it unfolded during classroom activities. This chapter discusses how teacher educators implement FA in the context of mathematics and the grounds for using FA techniques in their instructions. The chapter is made up of five sections, as follows: section 7.2 presents a discussion of the analysis of teacher educators' lesson observations and how categories were brought forth to answer the second research question. Section 7.3 focuses on teacher educators' implementation of FA strategies. Section 7.4 presents textual analysis of students' sample scripts with the aim of establishing the nature of feedback that teacher educators provide on students' written work. Section 7.5 discusses research question three, which is premised on teacher educators' reasons for using FA strategies in their modules. The last section, 7.6, present the factors which are in tension with teacher educators' implementation of FA. The sections conclude with a chapter summary of the study.

7.2 Analysis of lesson observations

Black and Wiliam (2009) indicated that FA is centred on five activities: sharing success criteria with learners, classroom questioning, comments-only marking, peer and self-assessment, and formative use of the summative test. These five activities form the basis for practices considered to be formative and can thus be considered as the way of enacting the five FA strategies outlined in Chapter 2 (section 2.7).

Teacher educators involved in this study were observed while teaching mathematics, and coding was done after lesson observation. Three mathematics lessons were observed in each College of Education. Except for Anani, who the researcher observed twice, the remaining participants were all observed on three occasions. Anani was observed only twice because he did not attend the last meeting that was planned. The lesson differed since they were conducted in different modules.

Observations are the essential data-generating instrument of qualitative inquiry, as they allow the researcher to gather 'live' data while actually being in the naturally occurring situation (Cohen, Manion, & Morrison, 2011). Lesson observation was executed to explore teacher educators' implementation of FA strategies during mathematics instruction. The aim was to capture the realities of classroom practices. The strategies used by each participant are presented in Table 7.1. This assisted the researcher in identifying common strategies that teacher educators used.

Table 7.1: Formative assessment instructional strategies used by teacher educators

Teacher educator	**College of teacher educator**	**Type of strategies used**
Emily	Roberkeyta College of Education	Marker board illustrations, questions and answers, demonstration, observation, group work individual activity, clarifying learning
Sekyi	Roberkeyta College of Education	Marker board illustrations, questions and answers, whole-class discussion, clarifying learning, demonstration, observation
Peprah	PhilNeri College of Education	Clarifying learning, marker board illustrations, questions and answers, observation, group work, individual activity
Anani	PhilNeri College of Education	Clarifying learning, marker board illustrations, observation, questions and answers
Wilson	Oswald College of Education	Questions and answers, marker board illustrations, observation, group presentation, paired activities, whole-class discussion, individual activity, clarifying learning
Fordjour	Oswald College of Education	Marker board illustrations, questions and answers, observation, clarifying learning, whole-class discussion, individual activity

From Table 7.1 it emerged that teacher educators are mostly utilising similar instructional strategies, with minor diversions. These will be discussed in detail in the sections below.

To answer the research question *How do teacher educators enact formative assessment in mathematics module*?, the researcher organised and analysed data gathered from lesson observation using Merriam's (2009) description of category construction. After coding the lesson observation, common categories of assessment strategies that teacher educators utilised were developed. Table 7.2 presents the categories or themes that emerged from the lesson observation.

Table 7.2: Categories that emerged during lesson observations

Categories	**Type of formative assessment strategy**
Category 1	Questioning as a formative assessment strategy
Category 2	Teacher educators' awareness of clarifying learning
Category 3	Involving students in assessment
Category 4	Observation of hands-on activity

For formative purposes of assessment, teacher educators are required to make use of assessment throughout their teaching to assess students, monitor and support learning, and evaluate their pedagogy to decide how to adjust their teaching methodology to facilitate students' learning. The sections that follow present how teacher educators in this study engaged in FA implementation as they assessed their students during teaching and learning in the context of mathematics, with reference to the categories developed and presented in Table 7.2.

7.3 Teacher educators' implementation of formative assessment

Chapter 5 captured teacher educators' understanding of FA and Chapter 6 presents the various lessons observed to see the alignment between teacher educators' understanding and their practices. This provides the basis for understanding how they enact FA. Black and Wiliam (2009, p. 9) conceived that

> practice in a classroom is formative to the extent that evidence about students' achievement is elicited, interpreted, and used by teachers, learners or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited.

Vingsle (2014) argues that the term “instruction” in Black and Wiliam's definition refers to any activity intended to create learning and denoting both teaching and learning. Therefore, activity theory within the sociocultural perspective of learning underpinned this analysis. The analysis draws on data collected from observation of six teacher educators and documents such as students’ assessment work. Data generated from this study revealed that teacher educators used a variety of informal and formal FA strategies in the process of assessing their students’ mathematics learning. The sections that follow present FA strategies as enacted by teacher educators.

7.3.1 Questioning as a formative assessment strategy

Black and Wiliam (1998a) observed that when teachers use assessment formatively, they should apply a questioning strategy as an opportunity to improve and enhance students' knowledge. During the interview, all participants acknowledged the importance of questioning in their instructions. Classroom observation revealed that questioning was the most dominant informal FA strategy teachers employed in their instruction. Although all teacher educators used questioning during their instruction, implementation of this strategy differed across the individual participants. Questions were used at various instruction stages: at the beginning of instruction, during instruction, and at times in the instruction's closing stage. Based on the lecture observations, teacher educators spent a few minutes at the beginning of each lesson giving a general review of the previous meeting. For example, at the start of his lectures, Sekyi reviewed the previous lesson by summarising the concept discussed in his previous encounter with the students. He followed this up with questions for the students to attempt to answer. This is exemplified in the excerpt quoted from his lesson below:

> *The last time we met, we discussed the various ways in which we can factorise or find the solution or the zeros of a quadratic equation. First, we discussed the factorisation method and as we went further one of us drew our attention to the fact that there is a limitation, especially with the factorisation approach. We observed that with the factorisation approach, we find the factors by multiplying the coefficient of x^2 [a] by the constant [c] in the equation to obtain [ac]. Then find two numbers, which are factors of ac and when multiply gives the product [ac], and when added, gives the coefficient of x [b]. But we saw that in some of the equations, it is not possible to factorise. Another approach that we consider very useful was the completing of squares, but unfortunately, we could not finish. I want us to*

go through with this approach. For instance: find the zeros for the equation $x^2 + 5x + 2 = 0$*, using the method of completing squares.*

In the extract above, Sekyi reminded students about the previous lessons instead of posing questions to elicit responses. Although he made an effort in checking students' understanding of the quadratic equation by giving them questions to try on their own, his method has some limitations as the focus was on the answer, not the explanation. In the last sentence he is instructing students to use a particular approach rather than allowing them to use their own approaches. The literature postulates that teachers' implementation of FA in the classroom should aim to enhance students' learning, and using questions and answers is one of the strategies to achieve that. While Sekyi claimed to be using questions and answers as an assessment strategy in the interviews presented in Chapter 5, the above extract seems to suggest that he is not – because instead of using questions and answers to elicit responses from students to inform the learning of the new lesson, he was recapping for the students.

The other five teacher educators did use questions and answers to elicit students' understanding. For example, Anani used questions and answers as a baseline assessment to understand students' existing knowledge or what students know about the yet to be discussed concepts. The following were questions he posed with the intention of finding out what the students know before introducing his lesson:

"What do we mean by statistics? What is statistics?" [Repeating and Rephrasing]
"What is data when we are doing statistics?"
"What is discrete and continuous data?"

In another example, Emily asked the following set of questions orally before introducing her students to the topic of integers:

"Who is owing someone money?"
"How much do you owe her?"
"How much were you having before she borrowed the 5. 00 cedis?"
"How are we going to write this 5.00 cedis she owes mathematically?"

Jiang (2014) argued that it would be inapposite to label questioning aimed at diagnosing learning as an FA strategy if follow-up actions are not taken to facilitate learning. Drawing from the preceding excerpts from the lesson observation transcripts, it is evident that Anani and Emily adopted questioning formatively, in line with the claim advanced by Jiang (2014). It can be argued that the follow-up questions posed by the two educators (Anani and Emily) were to enable them to find out what the students know about the topic, to identify gaps in the students' knowledge and understanding, and to scaffold the development of the students' understanding in order to close the gap between what the students know currently and the learning goals. Although these teacher educators utilised questions formatively, the questions asked were low-order questions that do not challenge students' thinking, but rather gather information needed to establish what students know. These kinds of questions, according to Feng (2014), require students to recall facts or definitions and can be situated under the knowledge, comprehension, and application levels of Bloom's taxonomy in accordance with Bloom's continuum for categorising questions.

In other scenarios teacher educators developed reasoning and structural questions to generate data on how students think. Reasoning and structural questions provide rich information to understand students' thinking, as evident in the following two classroom observation transcripts:

Fordjour asked the students to solve the triangle with sides 6, 14, and 16 units. He asked "What is the question looking for specifically?" One student answered that they thought they were to calculate the angles. Fordjour responded "How do we go about it?" and the student replied "Because we are to calculate the angles, we have to first draw a right-angle triangle, then calculate the angles using the trigonometric ratio." Fordjour asked the class whether the student was correct. The class responded "No, Sir", and Fordjour repeated the question by asking the students "How can this be solved?" Another student then replied "I think one needs to use the concept of Pythagoras triple to establish if the numbers 6, 14, and 16 form the sides of the right-angle triangle before the triangle can be considered as right-angle triangle." Fordjour then asked the students to use the Pythagoras triple to check if 6, 14, and 16 form the sides of a right-angle triangle.

Peprah asked her students to determine the amount that a government worker shared between his two children, Isaac and Rose, in the ratio 4: 5, if Isaac's share is Ghc 15 000. She then asked "What

is the total quantity shared?" and some students replied "9". Peprah confirmed that 9 represents the quantity or the total amount shared. She then walked around the lecture room and observed as the students worked on the activity. She went on to ask "The 4th part has been given as Ghc 15 000; what amount will determine the 5th part?" A female student replied "Rose's share, which is the 5th part, is Ghc 18 750". Peprah quizzed the student: "How did you get that?" The student replied "If Isaac's share is Ghc 15 000, then Rose's share is x. So, this in ratio gives $15\ 000 : x = 4:5$, then you solve for x, which is $x = (15\ 000\ \times 5) \div 4 = \text{Ghc}18\ 750$." Peprah then asked "What then is the total amount shared?". The students replied, "Total amount shared is Ghc 33 750". The students were actively involved in the process.

The preceding excerpts from the lesson observation transcripts delineate the FA practices of Fordjour and Peprah, and present evidence of teacher-student interaction in the teaching and learning process in which the teacher produces and acts on students' response. Bekoe, Eshun, and Bordoh (2013) remarked that interactive FA promotes learning outcomes through questioning in the form of dialogue. Unlike Anani and Emily's use of questions and answers, in Fordjour and Peprah lessons the students were empowered to argue and justify their ideas; based on that, teacher educators recognise and take into account a range of students' ideas to gain a clear picture of students' understanding (Ruiz-Primo, 2011).

In the same manner, Wilson elicited his students' knowledge and understanding of investigating number patterns, specifically generating a 4 x 4 magic square using the numbers 5, 6, 7,8 … 20, and made instructional moves to assist them in advancing their learning.

Furthermore, classroom observation revealed that students' questions played a critical role in the learning process and were envisioned as a resource for the teaching and learning of mathematics. That is, teacher educators recognised the students' questions in the assessment process during teacher-student interaction on mathematics content in the classroom. Students had the opportunity to ask questions to clarify concepts and for a deeper understanding, as evident in the excerpt below:

> *Sir, the other time you said with Cuisenaire rod, you can use two rods as a whole, but the explanation was not clear. You said you could use say yellow and red rods as a whole. Could you please explain further and give additional examples?*

The student's question was purposeful and indicates that they have been thinking about the ideas presented to them in the previous lesson. It also implies that the main idea or content on the Cuisenaire rod was not well understood; thus, putting forward a question for clarification was a step towards filling their knowledge gap for future learning.

Data generated from teacher educators' questions inform the direction of the ongoing learning process, whiles questions raised by students activated their prior knowledge and helped them to elaborate on their learning. It can therefore be concluded that some teacher educators' questions influence students' participation and help the students to explore the topic, and motivated them to think aloud. Students learn differently; therefore, it is necessary and important that teacher educators know the kind of knowledge students bring to class prior to instruction, in order to prepare a lesson and assessment that meets the learning needs of the students. Classroom observations showed that the majority of teacher educators tried to elicit information about students' knowledge on yet to be tackled subject matter (topics) through questions and answers.

7.3.2 Teacher educators' awareness of clarifying learning

Learning goals gives direction as to what a teacher wants his or her students to learn, know, or what they should be able to do. The literature indicates that learning goals enable teachers or students to answer the critical formative question: Where am I trying to go? (Chappuis, 2015). Teachers are therefore required to share and clarify what students are learning at the beginning of instruction (Clarke, 2001). During interviews teacher educators asserted that the learning goals they set for students are meant to enhance their learning, which means learning goals are used to answer critical formative questions. Classroom observation revealed that teacher educators do inform students about the learning goals, either before or after review of the previous lesson. For example, Emily shared the goals of her lesson after reviewing students' previous knowledge:

> *By the end of this lesson, you should demonstrate an in-depth knowledge and understanding on methods and materials for teaching number Bases. You should also be able to add and subtract numbers in other Bases apart from Base 10 numerals.*

On other occasions two participating teacher educators (Fordjour and Anani) began their lectures by stating the goals for the lesson, as evident in the following two excerpts from the lesson observation transcripts:

> *We are going to look at one of the applications of trigonometric ratio and it is on longitudes and latitudes. Under this, we will look at the great circles and the distance measured along the great circle as well as small circles and the distance along the small circles*. (Fordjour's lesson)

In the same manner, Anani began his lesson by stating the goal for it as follows:

> *Our lesson today is on Collecting and Handling Data. So, our objective for the lesson is that by the end of the lesson, you should be able to know what statistics is, how data are collected and analysed and how to draw statistical diagram for the data collected. We will also look at how to calculate the mean, the mode and the median.*

While the three teacher educators articulate the intended goal, Emily and Anani's goals are directed towards students' learning while Fordjour's goals are clarifying the teaching process. Clarification of the intended goals directs teaching and learning and thus informs the assessment process that should take place to enhance the process of teaching and learning.

Oduro (2015) argued that students are required to participate in the decision making about actions they need to take to ensure progress in their learning. Similarly, other FA researchers contributing to the discourse on how to implement this technique mentioned that teachers should provide students with the opportunity to discuss learning goals and criteria for success before the start of the lesson (Black & Wiliam, 2009; Ngwenya, 2012; Reddy & Andrade, 2010). Although teacher educators in this study clarify the intended goals, there was limited evidence of students' involvement in the development and clarification of learning goals and criteria for success. Students were informed about the learning goals, but were not given the opportunity to discuss and to know the action they need to take in order to progress in their learning. This shows an uneven implementation of this technique by teacher educators, as exemplified in the preceding excerpt.

While all six teachers asserted that they use learning goals to guide the new lessons and future learning for the students, two teacher educators (Sekyi and Wilson) did not clarify learning goals at all in their observed lessons. When probed as to why they do not set learning goals for students

at the beginning of their lessons, they argued that learning goals and criteria for success are captured in the course outline, of which every student has a copy; therefore, they see no need to repeat them during the lesson. The notion of learning goals captured in the course outline is evident in the extract below, drawn from Sekyi's comment:

> *... because of the course outline given to them in advance, the assumption is that they are aware of whatever that needs to be covered in each particular unit. But I think it is useful if we remind ourselves of what we want to do in the particular lesson, it will go a long way to shape the lesson.*

Peprah, exhibited a lack of clear understanding of the distinction between learning goals and subject matter. Peprah viewed the subject matter (topic) as synonymous with the learning goals of instruction. This is evident in what she said during debriefing, after failing to clarify learning goals with and for students during her observed lessons:

> *I did share the lesson objectives with my students. If you listen carefully, before I started my lesson I told them that our topic for today is Relations and Functions, so I did.*

Based on the comments of Sekyi and Peprah, it could be said that there is a discrepancy between what the teacher educators construed as the intention of setting learning goals and the implementation of it. While Sekyi believes that learning goals inform learning, failure to articulate each lesson's learning goals and confusing them with learning goals of the whole module suggest that while FA is meant to enhance learning, Sekyi's implementation is driven by summative assessment. Comments by Peprah are also an indication of her superficial knowledge of what the learning goals are.

7.3.3 Involving students in assessment

Facilitating students' involvement in FA can be achieved by providing them with the opportunity to regulate their own learning and be actively involved as resources for one another by giving them the chance to evaluate and judge the work of their peers. According to Du Plessis, Marais, Van Schalkwyk and Weeks (2011), the learning process is enhanced when students learn more about themselves and how to improve their performance through peer assessment and self-assessment. This theme therefore discusses how self- and peer assessment were enacted by teacher educators during their lessons.

7.3.3.1 Providing an opportunity for student self-assessment

In practice self-assessment goes beyond students simply checking answers on a multiple-choice test and grading themselves. It is a process where students monitor and evaluate their thinking when learning to identify strategies that improve understanding (McMillan & Hearn, 2008). According to Cauley and McMillan (2010), while teachers provide feedback they can promote self-assessment by asking questions that encourage self-monitoring. The notion of promoting self-assessment through teachers' feedback and questioning is exemplified in the excerpt below from Emily's observed lesson on number bases, when solving the sum $43_5 + 32_{5.}$

> Emily said to her students that they had 8 bundles of 5 sticks: "What should we do with it?" A student replied "You put them into 10s." Emily then asked "Why do you want to put them into 10s? Explain." The student replied "I wanted to convert it from Base 5 numeral to Base 10." Emily said "You do not have to convert into Base 10. We are working in Base 5, so count 5 of the 8 bundles of 5 sticks and put them together. What do you have now after counting?" After counting the student replied "One bundle of 5 bundles of 5 sticks and 3 bundles of 5 sticks".

Emily's questioning strategy aided in identifying her student's misconception. It was clear that the student was having difficulty in grasping the idea of an alternate number system, which was Base 5. This misconception might have occurred as a result of the student retrieving the wrong schema without recognising the error. The excerpt illustrates how Emily supported and set up students' self-assessment. For instance, she used the student response to explain the procedure to solve the question, thereby establishing a common understanding of how to solve the problem without necessarily providing the answer.

According to Ho (2015), teachers can implement self-assessment in their instruction through peer feedback. Thus, based on classroom observation, some teacher educators also adopted peer feedback as a strategy to implement self-assessment among students. The construct of peer feedback in this study refers to the degree to which students give reflective criticism (Falchikov, 2001) to others' work. For example, in Fordjour's lesson on distances along great and small circles, an application of trigonometry, he asked his students to compute the circumference of latitude 30^0 South. After the students had worked for about 5 minutes, he asked the class "How are you going to find the radius of the small circle?" A student responded "You have to divide the earth's radius

by two [6400 ÷ 2].” Fordjour asked “Which radius? Is he correct?”. “No”, another student replied, then commenting “Sir, we have to find the small circle radius using [the formula] $r = R\cos\alpha$.”

Fordjour then redirected the conversation to the whole class, and emphasised that a small circle's radius is always calculated using $r = Rcos\alpha$. The other student's reaction and comment on how to compute the radius of the small circle was corrective and informative, which gave his peer and others the opportunity to relook at their work and effect the needed changes. Fordjour’s action of asking his class whether the result from the first student was right or wrong can be viewed as passing the evaluative responsibilities to his students, by encouraging them to affirm an answer to a problem without having to directly mark each other’s responses.

Likewise, Peprah nurtured self-assessment among her students by using her own experience. In the closing stage of her lesson on ratio, proportion, and percentages she asked her students to take a sheet of paper and assess her lesson by writing down their impression of her performance in the lesson. She said:

> *Pick a sheet of paper and write some of the things you think I did right and what I did not do well so that I can improve next time. Do not write your name on the paper.*

Peprah's action was a good example for her students to self-assess their work and to improve from it. Students' assessment feedback was to assist her in making an instructional adjustment, with the aim of meeting the learning needs of her students. By telling her students not to write their names down it can be seen that she wanted her students to feel free to give honest feedback, without any fears.

Although data from the observed mathematics lessons revealed that students were actively engaged in the lecture activities, it was not clear from the researcher’s perspective as to how students actually self-assessed their own learning. Therefore, the researcher concludes that there is no evidence of how students employ their mathematical knowledge for making judgements about their own work.

7.3.3.2 Fostering peer assessment

Teacher educators recognised interaction as an effective way of stimulating mathematics learning by actively involving students as resources for one another. It was evident from the lesson observations that peer marking was one approach that teacher educators adopted in promoting peer assessment in this study. For example, Emily, one of the participating educators, integrated and activated students as resources for each other through peer marking. She made her students exchange their assessment workbook with their colleagues for marking, as evident in the following transcript excerpt:

> *Exchange your book with your neighbour and make sure you make meaning out of your neighbour's work. Check your neighbour's grammar, the concept and the steps used …*

Peer assessment was implemented in this case through peer marking. The criteria used in assessing their colleagues' work was based on language and steps required in teaching integers since the module she was teaching was Methods of Teaching Basic School Mathematics and the lesson was on teaching Grade 6 learners how to add two integers together using the number line model.

Peer assessment is not only about grading procedure, but forms part of the learning process where skills are developed (Dochy, Segers, & Sluijsmans, 1999). Oral presentations are recognised as a common and useful tool for peer assessment (Carless, 2013). Based on the classroom observation, it was evident that peer assessment was also implemented by teacher educators through paired activity or group projects during their pedagogical practices. For example, Wilson enacted peer assessment in his lesson through a group presentation by his students. Students' presentations were based on the topic matrices. Wilson divided his students into four groups, with each group presenting on a different aspect of the subject matter (matrices). Groups took turns to present on areas concerning the topic, and each group's presentation was assessed. The first group of students assessed the contributions of the following groups towards the project. Other students were given the opportunity to comments or ask questions based on the presentation. Comments from peers aided their colleagues in discovering for themselves different ways of presenting or solving a problem; peer assessment as an FA method can be observed as part of the self-assessment process, and serves to inform the self-assessment.

7.3.4 Observation of students' hands-on activities

According to Chan (2009) observation occurs during on-going activities of teaching and learning and the interaction between teacher and students. With direct observation, the teacher or assessor observes the students performing the assessment task, while he or she goes around to see if the students can perform the task that has been assigned to them properly. Classroom observation revealed that teacher educators frequently utilise direct observation as an effective means of gathering feedback about their teaching and students' understanding, as students work on assessment tasks individually or in groups. Data generated by teacher educators were used to fine-tune their pedagogy to cater for students' learning needs.

Classroom observation also showed that through observation, teacher educators could ask direct and purposeful questions of students who were inattentive. For example, Emily directed her students to solve the sum $43_5 + 32_5$ using bundles of sticks during her lesson on teaching Grade 6 learners number bases (methodology module). As students worked on the assessment task, she called on a student to tell the class her answer when she noticed that said student was not paying attention:

> **Emily calls on Joy (not actual name):** Tell the class what you had as an answer?
> **Student:** Seven bundles of 5 sticks and eeeee …
> **Emily:** Is that all? You see, I saw that you were not here; you were not paying attention.

Teacher educators adopted this strategy (observation) to gather information about the teaching and learning process, and on the basis of these data generated instructional modifications to address the learning needs of the students. However, there was no evidence of what the objectives of the observation assessment are, and assessment criteria were not made known to students. According to Chan (2009), to design a good direct observation assessment, the objectives of the observation assessment as well as assessment criteria should be made known to the students.

7.4 Analysis of students' scripts and educators' course outlines

According to Maree (2016), when textual or documents are used as data-gathering techniques the researcher focuses on printed communications that could potentially provide justification and explanations of the phenomenon being studied. This section therefore presents an analysis of

students' assessment scripts, with the aim of establishing the nature of feedback that teacher educators provide to students on their written work. Analysis of teacher educators' course outlines was in order to aid the researcher in exploring:

1. Whether or not learning intentions (goals) and criteria for success are explicitly stated in the outline.
2. Evidence of how students were going to be assessed as presented in course outline.

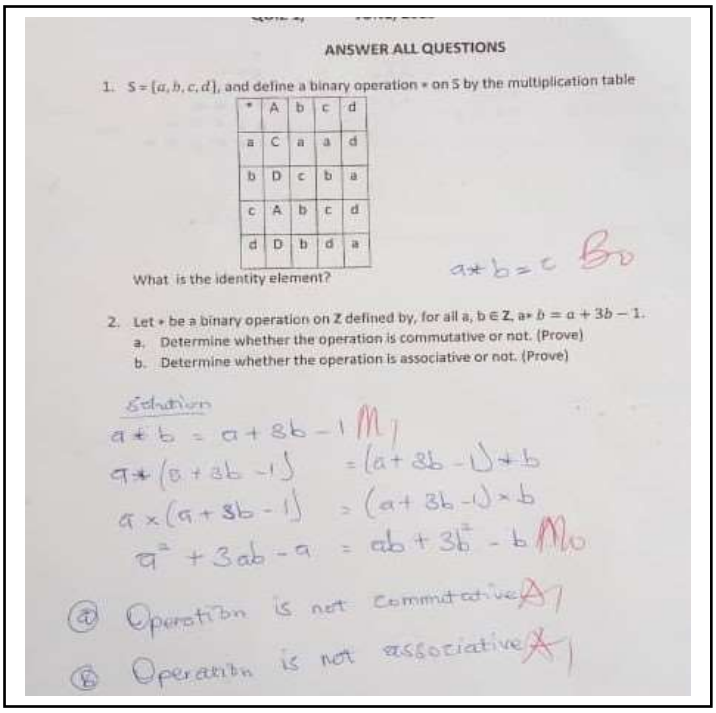
7.4.1 Nature of teacher educators' feedback on students' written work

When an assessment is formatively used, it provides feedback to students and teachers about students' learning and the teachers' pedagogy. From the students' point of view, the FA 'script' asks questions like: "What knowledge or skills do I aim to develop? How close am I now? and What do I need to do next?" (Brookhart, 2017, p. 1). This suggests that giving good feedback is one of the skills that teachers need to master in order to help students to find answers to these questions as part of a good FA. Therefore, teacher educators' feedback and the form it takes is useful in assessing whether they used assessment formatively. Analysis of students' work provided information about the quality and nature of feedback that MTEs give on the students' written work.

Eshun, Bordoh, Bassaw, and Mensah (2014) stated that the presence of mere feedback is insufficient for judging the direction of learning. This viewpoint is an indication that the quality and nature of feedback are decisive aspects of FA to enhance learning. Literature on feedback suggests that teachers' feedback on assessment tasks should focus on students' strengths and weaknesses and must highlight areas that require improvement by the students (Black & Wiliam, 1998a; Brookhart, 2017). Thus, documents were reviewed to analyse and identify the nature of feedback that the MTEs provide on students' quiz and assignment scripts. Analysis of students' quiz and assignment scripts showed consistency in terms of the nature of teacher educators' feedback on students' written work. Four of the participating educators' (Wilson, Sekyi, Peprah and Fordjour) feedback on students' scripts shows the use of annotations: M – method mark, A – accuracy mark, and B – mark for correct result independent of the method mark, with a numerical value attached to the annotation for scoring their students' work. In contrast, Emily and Anani's students' scripts revealed that these teacher educators also make use of the numbers 1 and 0 for scoring: 1 for a correct response and 0 for an incorrect or wrong response to a question. In all

cases, correct answers for the items (questions) are summed to produce the aggregate for the assessment task, which is then written in the top corner of the script. The analysis of the students scripts revealed that all the educators experienced difficulty in providing students with constructive feedback on their written work.

Samples of students' scripts showing the nature of teacher educators' feedback are presented Figure 7.1.



ANSWER ALL QUESTIONS

1. $S = \{a, b, c, d\}$, and define a binary operation $*$ on S by the multiplication table

*	A	b	c	d
a	C	a	a	d
b	D	c	b	a
c	A	b	c	d
d	D	b	d	a

What is the identity element?

a * b = c B0

2. Let $*$ be a binary operation on Z defined by, for all a, b ∈ Z, $a * b = a + 3b - 1$.
   a. Determine whether the operation is commutative or not. (Prove)
   b. Determine whether the operation is associative or not. (Prove)

Solution

$a * b = a + 3b - 1$ M1

$a * (a + 3b - 1) = (a + 3b - 1) * b$

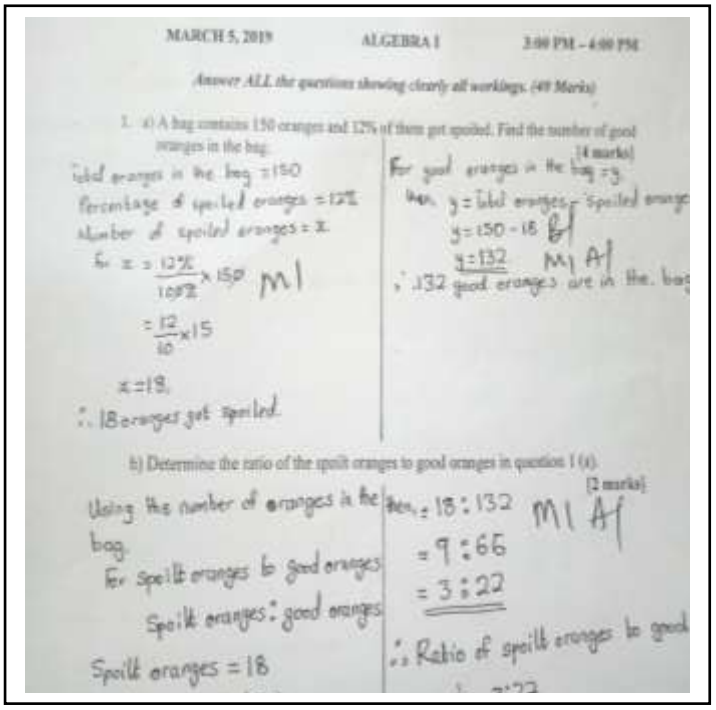
$a \times (a + 3b - 1) = (a + 3b - 1) \times b$

$a^2 + 3ab - a = ab + 3b^2 - b$ M0

(a) Operation is not commutative A1

(b) Operation is not associative A1

Wilson – Oswald College



MARCH 5, 2019 ALGEBRA I 3:00 PM – 4:00 PM

Answer ALL the questions showing clearly all workings. (40 Marks)

1. a) A bag contains 150 oranges and 12% of them got spoiled. Find the number of good oranges in the bag. [4 marks]

Total oranges in the bag = 150

Percentage of spoiled oranges = 12%

Number of spoiled oranges = x

$\therefore x = \frac{12\%}{100\%} \times 150$ M1

$= \frac{12}{10} \times 15$

$x = 18$

∴ 18 oranges got spoiled

For good oranges in the bag = y

Then, y = Total oranges − Spoiled oranges

y = 150 − 18 B1

y = 132 M1 A1

∴ 132 good oranges are in the bag

b) Determine the ratio of the spoilt oranges to good oranges in question 1 (a). [2 marks]

Using the number of oranges in the bag.

For spoilt oranges to good oranges

Spoilt oranges : good oranges

Spoilt oranges = 18

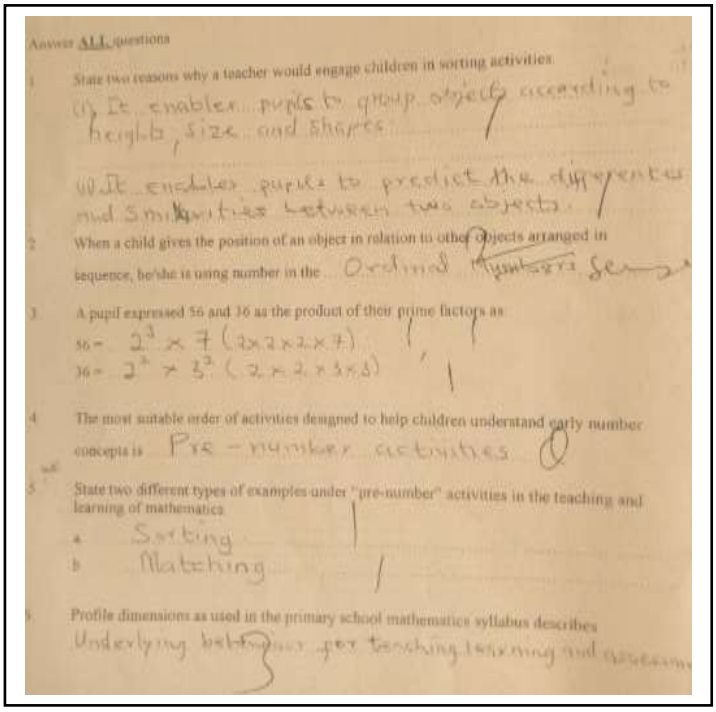
Then, = 18 : 132 M1 A1

= 9 : 66

= 3 : 22

∴ Ratio of spoilt oranges to good

Peprah – PhilNeri College



Answer ALL questions

1 State two reasons why a teacher would engage children in sorting activities

(i) It enables pupils to group objects according to height, size and shapes.

(ii) It enables pupils to predict the differences and similarities between two objects.

2 When a child gives the position of an object in relation to other objects arranged in sequence, he/she is using number in the Ordinal numbers sense

3 A pupil expressed 56 and 36 as the product of their prime factors as

56 = $2^3 \times 7$ (2x2x2x7)

36 = $2^2 \times 3^2$ (2x2x3x3)

4 The most suitable order of activities designed to help children understand early number concepts is Pre-number activities

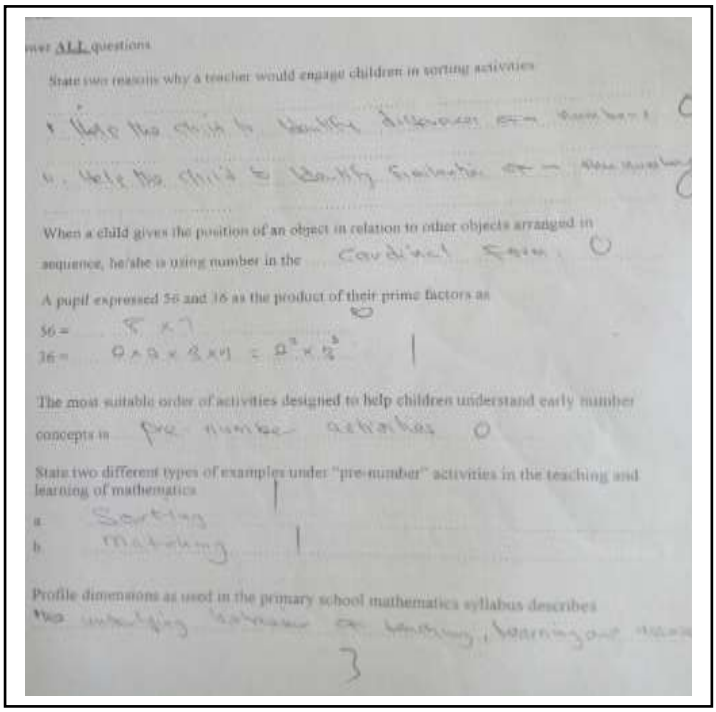
5 State two different types of examples under "pre-number" activities in the teaching and learning of mathematics

a Sorting

b Matching

6 Profile dimensions as used in the primary school mathematics syllabus describes Underlying behaviour for teaching, learning and assessm

Anani – PhilNeri College



Answer ALL questions

State two reasons why a teacher would engage children in sorting activities

When a child gives the position of an object in relation to other objects arranged in sequence, he/she is using number in the Cardinal Sense.

A pupil expressed 56 and 36 as the product of their prime factors as

56 = 7 x 7

36 = 2x2x3x3 = $2^2 \times 3^2$

The most suitable order of activities designed to help children understand early number concepts is pre number activities

State two different types of examples under "pre-number" activities in the teaching and learning of mathematics

a Sorting

b matching

Profile dimensions as used in the primary school mathematics syllabus describes

Emily – Roberkeyta College

Figure 7.1: Mathematics teacher educators' feedback type on students' assessment scripts.

This finding of the study is at variance with the literature. For example, the National Council of Curriculum and Assessment of Ghana (NaCCA, 2018) posits that feedback to students' work by teachers should be written (descriptive) and emphasise the students' strengths and weaknesses, as well as giving direction on the next steps to take in the learning process. In view of this, the researcher concludes that teacher educators' knowledge and skills about the feedback aspect of FA is superficial since their feedback does not provide any comments or information to the students on where they are in their learning and what they are expected to do next to help them improve their learning.

7.4.2 Assessment issues captured in teacher educators' course outlines

Table 7.3 shows a summary of assessment issues highlighted or stated on the teacher educators' course outlines which were made available to the researcher. The ticks (√) indicate where there

was evidence of such assessment principles captured on the teacher educators' outline, while a dash (-) is an indication that such key issues were not captured in the outline.

Table 7.3: Key concepts related to teacher educators' assessment practice

	Learning goals	Criteria for success	Assessment method for the module
Sekyi	√	√	√
Emily	√	-	-
Wilson	√	√	√
Fordjour	√	√	√
Anani	√	-	-
Peprah	√	√	√

Review of teacher educators' course outlines showed that all six educators recognise the importance of clarifying learning; therefore, goals for various learning were explicitly stated in their course outlines. It was also established that with the exception of two educators (Emily and Anani), criteria by which students' work will be evaluated were stated in the outlines. The assessment criteria in the outline makes learning visible and help students to focus their energy on what is to be evaluated. An assessment instrument that has received a lot of attention lately is the " scoring rubrics". Although scoring rubrics was not contained in the outline, there was evidence that students assessment tasks were marked using marking criteria or rubrics (see appendix I). Teacher educators posit that copies of the outline were made available to each student. The researcher therefore concluded that students are made aware in advance what they are aiming to learn, and the indicators are appropriate to measure their learning progress and inform future learning.

Review of teacher educators' course outlines also revealed that assessment of each module was in relation to the NTS, with a uniform weighting of 40% for FA, with 60% going into the summative end of semester examination. Four of the teacher educators (Sekyi, Peprah, Wilson and Fordjour) stated among the following as means by which their students were going to be assessed: group presentation, assignment, quizzes, and class exercises. Emily and Anani did not indicate a

summary of assessment methods for their module in their outline, but there was alignment with the others in terms of the content coverage.

7.5 Teacher educators' reasons for employing formative assessment techniques

An excellent mathematics programme ensures that assessment is an integral part of instruction, provides evidence of proficiency in important mathematics content and practices, with a variety of strategies and data sources, and gives feedback to students, including direction on instructional decisions and programme improvement (NCTM, 2014, p. 89). This pronouncement by the NCTM sets the context for exploring why teacher educators in the colleges of education make use of FA techniques in their teaching.

Teacher educators' reasons for implementing FA techniques in their teaching are discussed under this section, which used the question: Why are you using formative assessment techniques in the teaching and learning of mathematics? Responses generated during the FGD were attributed to the individual participants and not to the group, and where responses were repetitions of what had already been said, they were discarded.

In the FGD, Wilson stated:

> *We are using formative assessment techniques because we want to improve the performance of students and to do that, we have to use these techniques.*

Peprah stated that FA techniques offer teachers the opportunity to identify problems facing students during teaching and learning, to effect redress and enhance performance:

> *The informal technique helps the teacher to identify students' difficulties for remediation and this goes a long way to improve people's performance.*

In similar vein, Anani said:

> *You see, we based our teaching on these techniques to improve students' learning of mathematics. We are using these techniques just to address the falling standard of mathematics.*

Teacher educators mentioned that FA techniques serve as a useful tool in improving students' performance in mathematics. Teacher educators believes that a change in assessment practices from summative purposes towards the adaptation of formative techniques is the way to go in dealing with the declining performance of students in mathematics. FA researchers have acknowledged and documented in the literature that FA techniques are essential for enhancing learning (Black & Wiliam, 2009; McGatha, Bush, & Rakes, 2009; McMillan, 2007). According to McGatha et al. (2009), FA is a viable and effective process for improving mathematics.

Fordjour, a participating teacher educator, said:

> *… questioning is one of the tools we normally use in soliciting information from students. You question the students and when answers are given you know their understanding of the topic*.

Consistent with Fordjour's claim, classroom observation showed that teacher educators make use of questioning as an FA strategy to review students' previous knowledge, to check understanding and to elicit students' contribution towards the subject matter. The mathematics teacher educators believe that FA technique such as questioning provide feedback on how students are learning. This implies that questioning serves as a diagnostic tracker, which is used by teachers to gather evidence about students' thoughts on and understanding of subject matter. In support of this position, Juvrianto and Farda (2011, p. 5) stated that "Questioning as a diagnostic tool allows the instructor to look through the minds of students to find out not only what they know or do not know but also how they think about a topic." In order words, teachers elicit through questioning the ideas that students bring into the classroom prior to instruction, thereby making their thinking visible to themselves, their peers and the teacher.

Wilson said:

> *... when feedback is given, they make corrections on their work if they do not do well. They may also … find other ways of solving the same questions*.

The respondent's standpoint is that the purpose of providing feedback, which is a pivotal technique in FA, is to help students to identify their mistakes and inform them of what needs to be improved,

by providing the necessary information on how to make such improvements. Shute (2008) supports Wilson's view that the role of feedback is communicating information to a student, based on which the student can alter his/her work with the aim of improving learning.

Emily also remarked that feedback serves as an evaluating tool for the teacher to evaluate his or her teaching methodology:

> *… feedback informs you as to the level of understanding of your students. If you teach and maybe 75% of them are getting below half of the total marks for a quiz or exercise, then it means there is something wrong. So, as a teacher, I have to go back to restrategise – use a different strategy or method.*

Heritage **(**2011**)** concurs with Emily that feedback serves as an essential resource for teachers to shape new learning through adjustments in their instruction.

Anani, another of the participating teacher educators, also remarked that:

> *Sometimes I use group assignment and when they work in a group, those high achievers can help the lower achievers to come up.*

Anani's comment points to a sociocultural perspective of learning which emphasises the role of interaction and knowledge sharing in an individual's understanding and knowledge construction. It is worth noting from the outcome above that the sole reason for teacher educators' enactment of FA techniques in their module was to improve students' mathematics achievement and teachers' pedagogy, hence their adoption of FA techniques such as questioning. They employ questions to initiate classroom dialogue and identify learning gaps for appropriate remediation, an art that has been found to be the main purpose of FA and has been documented in the literature.

Heritage (2011) posits that interpreting the evidence from an FA is key to identifying the gap between students' current learning status and the goal of the current instruction. Teacher educators' comments also revealed a relationship between teachers' self-evaluation and their teaching methodology. Teacher educators mentioned that assessment results from students aid them in assessing themselves. When results are favourable, the teachers are happy and continue with their

method of instruction. However, when the contrary happens, they are forced to change their teaching method to address students' learning needs.

7.6 Factors' influencing teacher educators' practice of formative assessment

FA is held up as an assessment practice that can help teachers to adjust and improve their instructional practices to enhance the academic performance of students. However, certain contextual factors impeded teacher educators' practice of FA. Data from interviews and classroom observations revealed that class size, limited resources, lack of assessment transparency and college assessment policy are some of the factors which inhibit teacher educators from effectively incorporating FA strategies into their pedagogy and assessment practices. The next sections delineate these factors in detail.

7.6.1 Issues of internal and external summative assessment

Data generated revealed that existing policies in the College of Education, such as continuous assessment and the end of semester examination (external examination), are in tension with teacher educators' implementation of FA in the context of mathematics. Teacher educators mentioned during the semi-structured interview that they have to produce marks for continuous assessment. They said the continuous assessment contributes 40% towards the final module assessment marks. As Wilson commented:

> *… we produce continuous assessment of 40% which is used in addition to the 60% end of semester mark* [by affiliate university].

This was confirmed by Sekyi:

> *Students are graded based on the ratio 40 against 60. We produce 40% [of the] marks, which to me is more of formative because it is based on the quizzes and assignments, while the 60% is for the end of semester examination* [external by affiliate university].

The continuous assessment marks are combined with the marks from the external examination (end of semester examination) to arrive at the final score for the module. Therefore, all six of the teacher educators involved in this study were observed engaging in series of activities with the aim

of generating continuous assessment scores for their students. Classroom observation showed that teacher educators' interaction focuses more on the external examination, with the intention of maximising the grades of their students rather than assessing to inform learning. It appears that the high stakes nature of the end of semester examination distracts teacher educators' attentions from implementing some of the elements of FA in their classroom.

7.6.2 Formative assessment is time-consuming

Teacher educators mentioned that the use of FA can be very time-consuming for teachers and students. They said implementing FA techniques requires a lot of the time needed to be able to complete the curriculum content. For instance, Peprah of PhilNeri college of education remarked that:

> *Some of the techniques, they consume time. You have to allow time so that you will be able to exhaust some concept.*

Peprah mentioned peer assessment (group presentation) as a technique which requires time for implementation. This strategy might be seen as time-consuming, particularly when teachers in turn have to complete the course outline for their modules in under to enable their students to sit for the external examination.

Fordjour from Oswald College of Education remarked that students' delay in submitting assessment tasks affects the time by which feedback can be provided and delays instructional progress, since early concepts need to be understood before building on them:

> *In formative assessment teachers are able to find out whether what was taught had been understood by students, before other concepts can be introduced. Therefore, if students are not able to submit their exercise or assignment on time for necessary action to be taken, it affects the process.*

This response by Fordjour indicates that he believes that when students are able to submit their assessment tasks on time, this allows the teacher to provide feedback which can lead to identification of errors or gaps in learning at one stage of instruction, for correction before new concepts are introduced, in order not to compound them.

In addition, Wilson stated:

> *It is time-consuming as one tries to end the lesson without untying all knots, which may inhibit conception and formulating of higher-order questions on the spot to test understanding of concept. Sometimes it is very challenging.*

Wilson believes that FA becomes time-consuming when addressing misconceptions that students hold, and more challenging when the teacher is unable to correct all of the misconceptions of the students.

7.6.3 Lack of instructional resources and overfull classrooms

Meaningful learning of mathematics requires useful mathematical tools or manipulatives, such as algebra tiles, geoboards, counters, and so on (NCTM, 2014). This means that absence of or inadequate learning resources will have a detrimental effect on teachers' pedagogy and students' learning. During the FGD teacher educators expressed that there was a lack of teaching-learning materials. They said that the absence of instructional material hinders their implementation of various assessment strategies. For example, Anani expressed his concern as follows:

> *Lack of* [teaching] *materials makes it difficult to implement some of these assessment techniques.*

This was reaffirmed by Peprah:

> *Some mathematics concepts require teaching-learning materials (TLMs) to support the teaching. So, when a college or school lacks these materials, then it makes it difficult to teach, and creating arbitrary materials might not work to the expected standard.*

Teacher educators therefore felt that there is a need for authorities to provide teaching-learning materials to enable them to perform their duties to ensure improvement of students' mathematics performance. This was evident in Fordjour's comments:

> *Even though we have embraced formative assessment techniques to improve students' performance, but colleges lack teaching-learning materials, so management needs to provide teaching materials.*

The literature highlights the importance of instructional materials in the mathematics classroom (NCTM, 2014). It is worth noting that instructional materials aid in concept formation and supplement classroom interaction between teacher and student. Teacher educators' responses indicate that they recognise the importance of instructional materials in their pedagogical practices and therefore call on educational authorities to supply or provide colleges with teaching-learning materials to enable them to convey instructional information to students and to enhance learning. Therefore, lack of instructional materials limited most of the learning activities. For example, Emily has to teach the concept of fractions using the Cuisenaire rod in an abstract form, which does not help in bridging the gap between concept and facilitation of conception formation in mathematics. FA implementation may not always require complex technology to be effective (Black, Harrison, & Lee, 2003), but productive learning could be supported through equipment and conducive physical conditions (Ho, 2015).

In addition, classroom observation showed that teacher educators' implementation of FA strategies was impeded because of the overcrowded classroom. Enrolment of students into most of the modules observed were large, with large lecture areas. Packed lecture halls with limited tables and chairs made it impossible for teacher educators to implement some elements of FA techniques effectively in their modules. For example, Fordjour found it difficult to ensure students' collaboration during his lecture since most of the students had to stand during instruction, as a result of there being inadequate tables and chairs in the lecture hall. Likewise, it was difficult for Sekyi to move around during hands-on activity. The arrangement of desks was such that there was not enough space for him to move around; this therefore resulted in him observing only students sitting in the front row, with instructional adjustment or provision of feedback based on data gathered from those students only. Teacher–students' engagement was limited in these teachers' lessons as a result of the large class size. Teacher educators were observed focusing more on completion of the lesson tasks while paying less attention to individual students' needs.

7.6.4 Issue of transparency in constructing assessment criteria

For transparency, one needs to ensure that individuals who are involved in the assessment process clearly understand what is expected. Black and Wiliam (2009) argued that FA requires teachers to discuss learning intentions and share criteria for success with the students. The intention of involving students in determining the assessment criteria, according to Reddy and Andrade (2010),

is to facilitate the formative use of these criteria by students. This means that assessment criteria and standards need to be transparent for both students and the teacher.

However, classroom observation revealed that teacher educators made an attempt to inform students about the intentions or goals of assessment. Students did not have any input into the learning intentions. That is, teachers failed to discuss the learning intentions with the students. There was no evidence of teacher educators collaborating with students in developing the standards against which their learning will be assessed. Teacher educators assumed authoritative power by keeping the assessment criteria to themselves. This finding contradicts the position of Jonsson (2014), who argued that transparency in assessment is established when students become aware of the assessment intention and assessment criteria. Other studies revealed that collaborative assessment occurs when students and teachers co-create the criteria for assessment (Ngwenya, 2012).

7.7 Chapter summary

This chapter presented an analysis of how MTEs enacted FA during the lesson observations, and the grounds for their adoption of FA techniques in their instruction. Classroom observations of teacher educators' lessons revealed that they lack deep insight into the execution of some of the FA strategies. The study established that teacher educators frequently utilise some aspect of FA techniques with success. The study also established that teacher educators appear to be struggling to integrate some of the other techniques into their pedagogy. In addition, data analysis revealed factors which hinder teacher educators' effective implementation of FA. The study further revealed that the primary reason for teacher educators' use of FA techniques is to support students' learning and improve mathematics performance.

CHAPTER 8

SYNTHESIS, DISCUSSION, AND RECOMMENDATIONS

8.1 Introduction

This study sought to explore MTEs' understanding and practice of FA in the context of mathematics. The following questions directed the focus of the research:

1. What are mathematics teacher educators' understanding of formative assessment in mathematics?
2. How do mathematics teacher educators enact formative assessment in mathematics modules?
3. Why do mathematics teacher educators use the formative assessment techniques that they do?

The study was conducted within the interpretive paradigm. According to Creswell and Plano Clark (2011), the interpretive paradigm helps to understand human thoughts and actions and enables in-depth probing and deeper insight into the phenomenon under study. Underpinning the research was the concept of learning by gaining new insight, discovering new ideas, and increasing knowledge of an event (Grove, Burns, & Gray, 2012). Thus, a qualitative case study design was adopted since the aim was to gain an in-depth understanding of MTEs' knowledge and implementation of FA during the teaching of mathematics. Data generation was facilitated through the administration of semi-structured interviews, classroom observation of teacher educators' lessons, and analysis of documents such as teacher educators' course outlines, students' assessment scripts, and assessment policy documents. Teacher educators' data from interviews were triangulated with data from classroom observation and analysis of documents to situate their understanding and practice of FA in the context of mathematics.

In Chapters 5, 6 and 7 themes that were developed when analysing research questions one and two and three were discussed. The themes focused on teacher educators' understanding of FA and the implementation of FA techniques; in this concluding chapter, the researcher endeavours to address three critical issues. Firstly, the researcher synthesises teacher educators' understanding and

practice of FA in the context of mathematics to understand how teacher educators' knowledge of FA was translated into practice, by discussing and interpreting the findings against activity theory as well as literature on FA. Secondly, conclusions which highlight professional insights gained and policy implications are presented. Thirdly, the chapter ends with recommendations for directions for future research based on the findings.

8.2 Discussion and application of activity theory as a lens for analysing teacher educators' understanding and practice of formative assessment

Using activity theory, which is marked as an expansion of the sociocultural notion that all human learning and development occur in the form of activities, the study identified prominent characteristics and components for teacher educators' understanding and practice of FA. Findings are discussed and interpreted from the activity theory and sociocultural perspective, since FA is attributed to the social and cultural context of the learner (Pryor & Crossouard, 2008), and this is supported by reference to the literature. The work of Black and Wiliam (2009) is also used as an additional lens to analyse teacher educators' FA practices. In the next sections the researcher presents the findings as they relate to the three research questions shown above.

8.2.1 What are mathematics teacher educators' understanding of formative assessment?

Before proceeding to understand how MTEs implement FA in the teaching of mathematics, it is all-important to gain an understanding of how they interpreted FA, since teachers' beliefs regarding assessment are likely to affect classroom practices. This view is supported by Odoro-Okyireh, Akyina, Ansah-Hughes, and Torkornoo (2015), who stated that teachers' understanding of assessment determines effectual and sound assessment practice. MTEs' knowledge of FA is therefore discussed under the following themes:

- Teacher educators' meaning of formative assessment; and
- Teacher educators' understanding of formative assessment tools.

8.2.1.1 Teacher educators' meaning of formative assessment

Findings of the study established that teacher educators view FA as an ongoing process that forms part of teachers' pedagogical activity. This finding resonates with the claim advanced by Brink

(2017) that FA is a continuing process and an integral component of the teaching and learning process (Thomas, Deaudeline, Desjardins, & Dezutter, 2011). A key FA characteristic that emanated from the teacher educators' responses was the time of occurrence. Their responses portray that FA should be done in real-time, and mentioned the three stages of instruction: before teaching, during teaching, and after teaching.

The researcher was of the view that teacher educators' interpretation of FA would aid in eliciting information about teacher educators' conception of the role of FA for which they planned and designed during teaching and learning. Trumbull and Lash (2013) conceived that FA is determined by its purpose for assisting and shaping students' learning during the learning process. Of the six participating teacher educators, only two (Emily and Sekyi) gave responses giving a hint as to the role of FA. They mentioned that FA enables teachers to gather evidence about the teaching and learning processes. This finding is consistent with Prashanti and Ramnarayan's (2019) position that through FA, teachers recognise and respond to students' learning in order to enable and enhance it. However, probing further, two conceptions of FA were established, as outlined under the subthemes below.

8.2.1.1.1 Formative assessment supports teachers' practice and influences learning

The findings of the study indicate that four of the teacher educators (Sekyi, Wilson, Fordjour and Peprah) conceived FA as a process that supports teaching and learning. According to these teachers, FA should be employed by teachers and students mainly to assist in teaching and learning. Their conception implies that FA provides feedback relative to students' learning and teachers' instruction. In his response Sekyi demystifies the role of assessment data for the teacher, explaining that FA allows teachers to appraise their teaching and the method of instruction:

> *... to measure whether whatever you are teaching is going on well or also the method that you are applying in teaching them is also going on well ...*

For FA to guide and support instruction, teachers require information that is closely connected with the work of their students. Thus, Wilson, Peprah, and Fordjour focus on the role of FA in teaching and learning of mathematics as to help teachers evaluate the learning process, to know the strengths and weaknesses of the students and to select the appropriate strategy to remedy gaps

in the lesson. This finding of FA supporting teachers' practice and influencing students' learning affirms earlier works of Black and Wiliam (1998a) and Ruiz-Primo (2011) that FA supports teaching and learning.

To check for consistency and deviations, the researcher triangulated the interview responses with the classroom FA practices of the four teacher educators observed during the teaching of mathematics. The four teacher educators' conception of FA as a tool that supports teachers' practice and influence students' learning was consistent with their classroom practices. Through spontaneous (unplanned) FA techniques, teacher educators were able to gather information about their students' learning and about the lesson in real-time. For example, teacher educators employed the question and answer strategy to give feedback, facilitate mathematics discussion, and refer to students' responses to shape pedagogy. This is exemplified in the following excerpt from Peprah's lesson:

> Peprah quizzed her students "What comes into mind when we talk of ratio?". "Ratio is used to compare two or more quantities," one of the students replied. Peprah asked a follow-up question: "Quantities like what?". The students gave different responses, one being "Like ages of two people." Peprah then explained: "Yes, ratio is about comparing two or more quantities, but the quantities that you will compare must be of the same unit. If they are not, change one of the units to correspond with the other".

Questioning aided teacher educators to elicit students' understanding of concepts and to clarify students' difficulties during teaching and learning. According to Black and Wiliam (2009), classroom questioning is one way of implementing Wiliam and Thompson's (2008) second strategy of the FA process, which focuses on setting up useful discussion, questions, and tasks that elicit evidence of learning. This helped in answering the three underlying FA questions: what is working, what needs to be improved, and how can it be enhanced? (Dixson & Worrell, 2016; Wiliam & Thompson, 2008).

8.2.1.1.2 Formative assessment as a means of measuring students' learning

The findings of the study proved that two teacher educators (Anani and Emily) considered the role of FA as a means of measuring students' learning. FA is used on a daily and ongoing basis to evaluate students' learning in order to judge whether or not the assessment aligns directly with specific learning issues. Wiliam and Thompson (2008) argued in their framework for FA that one of the roles of teachers in the FA process is engineering effective discussion, questions, and tasks that elicit evidence of learning. Therefore, one can argue that this process can be explicitly linked to the attainment of standards.

The literature has established that methods of measuring students' learning are frequently characterised as a summative assessment or FA. It became evident that mid-semester quizzes measured students' learning; however, the mid-semester examination portrays a summative approach of assessment, but plays a formative functional role. This concurs with the work of Black and Wiliam (2009) that the summative test provides ways of extracting evidence of student accomplishment, and when utilised correctly can prompt feedback that moves learning forwards.

From the perspective of the students, test information provides them with the chance to help one another and apply the test as a guide in scheduling their own revision (Black & Wiliam, 2009; Chappuis, 2015). The researcher concludes, based on the findings, that teacher educators regard FA as any means of revealing students' relative performance during the teaching and learning process, thereby serving as a link towards students' achievement in the end of semester examination (summative assessment).

8.2.1.2 Teacher educators' understanding of formative assessment tools

When reviewed from an activity theory perspective, one can contend that teacher educators' recognition of a variety of assessment 'tools' for assessing students' understanding of a mathematical concept is significant for effective implementation of the assessment. It became evident in this study that the participating teacher educators have the tools and techniques to engage students in collaborative learning to achieve the learning goal during classroom interaction. Findings indicate that teacher educators have knowledge of both formal and informal assessment strategies that they employed during teaching and learning. For example, teacher educators cited,

among others, questioning as one of the FA strategies. It is important to note that questioning as an assessment strategy offers teacher educators the opportunity to determine the most effective point to start their lesson from, as well as the appropriate level at which to begin new instruction. Formative questioning can be said to be an informal FA strategy. Questioning as an everyday FA strategy is supported and discussed in the work of Ruiz-Primo and Furtak (2007), who posit that informal FA includes eliciting students' thinking via questions and classroom discussion that requires students to make predictions based on prior knowledge.

The core of an activity system is the relationship between the subjects (teacher educators) and the object (the thing being done), facilitated by tools (Hasan & Kazlauskas, 2014). Therefore, for consistency and to establish whether teacher educators' knowledge of FA tools translates into their practices, the researcher examined the community of the activity system within which the subjects (teacher educators) engage their students. Husain (2013) argued that teachers' lack of knowledge on the use of FA techniques might hinder the effective implementation of FA in the classroom. Data from the classroom observation revealed that during the teaching and learning of MTEs employ FA strategies as the main tools to engage students in collaborative learning. The researcher noted that the tools most frequently employed by teacher educators during mathematics lessons were informal, since they were not planned in advance but emerged spontaneously according to students' needs during an interaction between the subjects and the community. Ruiz-Primo and Furtak (2007) point out that informal assessment is improvisational and immediate, occurring during student-teacher interaction, and requires a teacher to elicit and recognise students' response then to use the information to ensure that the normal flow of classroom activity is not interrupted.

The researcher concludes that teacher educators' awareness of informal and formal pedagogical strategies is best for effective instructional practices. Thus, formal and informal FA techniques provide an opportunity for teachers to identify potential difficulties in students' learning, as well as gaps in lessons for students' conceptual development during instruction and to enhance their performance. The utilisation of the informal FA techniques offers teacher educators' recurrent opportunities to gather data about their students' progress towards the instructional goals in real-time.

8.2.2 How do mathematics teacher educators enact formative assessment in mathematics modules?

Colleges of Education in Ghana run a homogenous curriculum; therefore, although participants were teaching at different Colleges of Education, their assessment strategies in the context of the mathematics classroom were similar. The study established that teacher educators frequently used and enacted some aspects of FA strategies in a way that supports students' learning of mathematics, while other techniques were adopted in a disconnected manner, such that there was a lack of cohesion in implementation of their practice. For example, the study established that participating teacher educators showed greater strength and awareness in addressing and clarifying learning goals by linking current lessons to future learning. However, overall when it comes to the implementation of areas that requires more students' involvement, such as developing and sharing criteria for success with students, none of the six educators exhibited competency in the application during their pedagogical practices. That is to say, there was no evidence of teacher educators developing and sharing criteria for success with their students during the observation of their pedagogical practices by the researcher.

This finding resonates with the claims advanced by Reynek, Meyer, and Nel (2010) that assessment is not transparent. These authors indicated that 96.8% of the participants in their study never shared assessment criteria with their students. The researcher therefore observed that the patchy nature of teacher educators' implementation of FA is a step in the right direction to improve their FA practices, and therefore recommends that teacher educators need more practice and support to improve their competency and skills to enact FA strategies effectively, particularly in areas that require students' participation.

This section continues with discussions under the following themes:

- Promoting learning through questioning
- Teachers and students as partners in the assessment processes
- Learning mediated by informal observation
- Teacher educators not recognising the value of criteria for success
- Teacher educators' awareness and the nature of feedback to students.

8.2.2.1 Promoting learning through questioning

Questioning was the common strategy for teacher-student interaction and followed the IRF sequence where teacher educators initiate (I) a question, the students respond (R), and the teacher provides feedback (F) to the students' responses. Teacher educators' usage of the IRF strategy in eliciting evidence from students allows one or two students to respond during questioning. When teacher educators do not understand what all their students know and do not know, the decision on instructional adjustment is made based on the responses of the few students who answered the formative question. The study also established that teacher educator participants employed questioning to gauge students' mathematical understanding and to kindle students' involvement in the lesson and contributions from students about the subject matter. This finding is in agreement with that of Avdic, Wissa, and Hatakka (2016) that questioning plays an essential role in classroom interaction. The authors argued that teachers employ question and answer techniques to assess students' performance, promote learning, engage students to take part in the classroom activities, and as a fundamental tool to investigate how much students have understood (Lightbown & Spada, 2013).

Teachers play an essential role in the practice of FA, and one of their functions is to elicit data that can inform the direction of learning during ongoing instruction. Black and Wiliam (2009) argued that one means of obtaining evidence of students' understanding is through classroom questioning and other learning activities. That is, questioning can support student learning when used skilfully. Teachers adopt questioning for various purposes at different stages of instruction. The study showed that questioning was employed by teacher educators in determining where students were in terms of their knowledge and skills regarding mathematical concepts before teaching took place, so that an interactive learning environment between themselves and students and among students could be ensured.

Research conducted by Saeed et al. (2012) found that teachers dominate in the process of teaching and during assessment through questioning, with students having to respond to teachers' questions. Contrary to Saeed and his colleagues' position, this study revealed that despite teachers' dominance in posing most of the classroom questions, students were allowed to question and discover mathematical facts rather than just following teachers' processes, and to scaffold their

learning through feedback from the teacher. The researcher concludes that teacher educators gather essential information about the state of students' knowledge through classroom questions, thereby promoting students' learning. Consistent with activity theory is the notion that learning is a mediated activity with tools. Questioning as a mediated tool, as established in this study, is used by teacher educators in checking students' understanding of concepts and for creating an interactive classroom environment. This result gives credence to Heritage and Heritage's (2013) stance that questioning is a robust method for obtaining information on students' current learning position and for making decisions about the next steps in students' learning. Research conducted by Naidoo (2011) found that learning occurs as individuals interact with each other, and the interactions are mediated by tools. It can therefore be argued that questioning serves as one of the mediating tools employed by the participants (teacher educators) during interaction with students, at whom the activity is directed within the activity system.

8.2.2.2 Teacher educators and students as partners in the assessment processes

The kind of classroom induced by the sociocultural learning theory is one in which teachers and students share responsibility for learning (Heritage, 2010a). In trying to understand the role and responsibilities of teacher educators and students in the implementation of FA, the researcher looked at the division of labour from the perspective of the activity theory system. Within the context of the mathematics classroom, investigation of the division of labour was deemed necessary, as it specifies the power relationship between the actors of the activity system. The division of labour component suggests that each of the actors of the activity system has a role to play in ensuring effective enactment of the system and to mitigate the impact of any failure of the others (Black & Wiliam, 2009). In this study the division of labour became evident and manifested in teacher educators' role in establishing learning goals for students, marking students' assessment scripts, and providing students with feedback on their written work. This finding is consistent with that of Black and Wiliam (2009) that teachers are responsible for designing and implementing an effective learning environment. The obligation of learning rests with both the instructor and the students; hence it is necessary to take into consideration the role that students and their peers play in the pedagogical processes. The literature has shown that improving learning through FA also requires the active involvement of the students (Heritage, 2010b; Kollar & Fischer, 2010). During the semi-structured interviews, participating teacher educators expressed that students work

together in groups to maximise their own and each other's learning. Teachers believed that through group work, students are given the opportunity to work together by way of sharing ideas with their colleagues with the aim of promoting shared learning. This means that teacher educators consider collaborative learning as an important strategy for involving students in the assessment process. Classroom observation revealed that teacher educators adopt different strategies, such as group presentation, paired marking and paired activities, in an attempt to foster peer and self-assessment.

To my surprise, students were made to work in pairs or groups without any agreed set of criteria to evaluate their colleagues' contribution/s, thereby limiting the whole criteria for discussion on whether the answer is right or wrong. McKay (2006) mentioned that students could assess their work and that of their peers based on some agreed criteria. This suggests that students' involvement in the assessment procedure goes beyond working in groups, marking of scripts, and accumulation of marks. Students' performance is assessed against an agreed set of criteria, which means that for students to play a crucial role in making a judgement about their performance and that of their peers, there should be criteria to evaluate what is considered relevant in the students' work. These criteria should be made available to students to ensure uniformity in the assessment process, thereby avoiding any doubt in the students' minds. Tillema, Leenknecht, and Segers (2011) aver that students' trust in the assessment is an influence when criteria for assessment are determined and made known to them. However, there was limited evidence on teachers setting criteria for the assessment task. I therefore conclude that students' involvement in the assessment process was tokenistic in nature. This piecemeal implementation of students' involvement in the assessment process could be attributed to a range of variables identified during the teaching and learning process as tensions and flaws within the classroom activity system.

8.2.2.3 Learning mediated by informal observation

Another important finding from the study concerns teacher educators' usage of an informal observation strategy in mediating learning. If teacher educators are to implement FA, they need to collaborate with others within the activity system (Mkhwanazi, 2014). Classroom observation revealed a constant collaboration between the teacher and students, as well as among students during teachers' pedagogical practices, which could be explained as 'community' from the perspective of activity theory. Data from this study showed that within the community of the activity system, observation was one of the daily routine assessment techniques of teacher

educators during an ongoing classroom activity. Teacher educators closely observed their students as they worked on classroom assessment tasks to gauge the effectiveness of their teaching methodology as well as students' attitude to learning. In the context of classroom activities, this unplanned opportunity emerges, and teachers observe individual students learning (Chan, 2009). This finding is in line with Ho (2015), who argued that observation as an assessment strategy allows teachers to gain authentic, comprehensive and contextualised information about students' learning

Observation manifested as a mediating tool during classroom activities and supported teacher educators in gathering evidence of students' learning to inform instructional planning. Naidoo (2011) notes that the most widely accepted tools are those that closely fit within the social and conceptual structure of the classroom. The notion of learning as a mediated process is understood as the interaction between the actors, their mediational means, and the environment. This means that informal observation as FA artifacts mediate between the subject (teacher educators) and the object (all learning activities within the mathematics classroom) within the community of learning.

8.2.2.4 Teacher educators not recognising the value of criteria for success

Ramsey and Duffy (2016) argued that successful practice of FA begins with the establishment of clear, quality learning goals, transparent criteria for success and alignment of past and future learning to ensure students' understanding of what they should know already, what they are about to learn, and how that learning ties together. Literature indicates that teachers should develop and share criteria for success at the beginning of learning. Black and Wiliam (2009) argued that students should be well informed about the assessment criteria to be implemented before they start working on the assessment task. The study established that teacher educators do not communicate assessment criteria to and with their students, but analysis of documents revealed that they use criteria (a marking scheme) to mark students' assessment scripts. Based on the findings, the researcher concludes that teacher educators' inability to communicate criteria for success might be attributed to lack of knowledge on relaying assessment criteria to students. Not involving students in the development of the assessment criteria or not displaying the criteria for success might impede their performance, because they will not be able to self-regulate their learning according to the assessment criteria. Ngwenya (2012, p. 66) argued that the provision of "clear

and explicit instruction and criteria for success is a fundamental feature of successful assessment." It is worth noting that when criteria for success are established by both teacher and students, it provides direction and guidance to students to understand the standard against which their work will be assessed.

The setting of learning goals before learning is essential for teachers and students because it provides guidance on the direction of learning by answering the FA question: Where are we going? The study established that the FA practice of learning goals showed teacher educators' awareness of clarifying the knowledge and skills expected to be learned by students by the end of the lesson. Implementation of this strategy was enacted in terms of information provided to students. Teacher educators' informed students about the content that they will be learning, without any discussion between teacher educators and students about the learning goals:

> *We are going to look at one of the applications of trigonometric ratio and it is on longitudes and latitudes. Under this, we will look at the great circles and the distance measured along the great circle as well as small circles and the distance along the small circles.* (Fordjour)

Trends in the literature on FA require teachers to discuss learning goals with their students to encourage them and give them a greater sense of ownership in the instructional activities (Cauley & McMillan, 2010). However, the study established that teacher educators did not negotiate learning goals with their students.

Situating this within the perspective of the activity theory framework are 'rules' which regulate the social interaction between teacher educators (subject) and the community. The rules provide guidance for acceptable interaction between the subject and the community to accomplish the aim of the activity system (Ryder & Yamagata-Lynch, 2014). Rules mediate teacher educators' and student engagement in the classroom activity. Adapting the notion of rules within the context of FA is that teacher educators are required to negotiate learning goals and criteria for success with students at the beginning of instruction, to ensure effective implementation of FA. Nevertheless, this work revealed that teacher educators enact the part of this strategy in a disconnected way, rather than ensuring cohesion to improve learning. In view of this, the researcher concludes that

teacher educators lack knowledge and skills in negotiating learning goals and criteria for success with students.

8.2.2.5 Teacher educators' awareness and operationalisation of feedback

Another significant finding which emerged strongly in the study is participating teacher educators' awareness of feedback and the nature of the feedback that they provide to students. The value and forms of feedback were discussed in Chapter 2, section 2.7.3, which highlighted the importance of feedback to teachers and students as well as the form that feedback should take concerning FA to move learning forward. This study established that participating teacher educators have limited understanding of feedback in the teaching and learning of mathematics. This finding therefore gives credence to the finding of Lema and Maro (2016) that mathematics teachers have limited knowledge on the feedback aspect of FA. Three of the participating teacher educators (Wilson, Emily and Fordjour) conceived that feedback shapes their instructional practices, while the other three indicated that feedback helps students to be aware of any gaps between their desired learning goals and their understanding of the subject matter. Extant literature has shown that feedback is a two-way conversation. That is: 1) feedback from students serves as an essential resource for teachers to shape new learning through instructional modification; and 2) teachers' feedback to students enables them to assume the responsibilities of their own learning and to use it to develop their learning (Black & Wiliam, 1998; Bansilal, James & Naidoo, 2010; Heritage, 2011). The researcher concludes that teacher educators' knowledge of the feedback aspect of FA is a one-way transmission – either as a resource to students or resources to the teacher – instead of a two-way conversation. However, it was evident that teacher educators' comments have reference to the dual purpose of the feedback aspect of FA as expressed in literature (Black & Wiliam, 1989; Heritage, 2011).

Research evidence showed that feedback is a central aspect of FA in the instruction and learning process, and when implemented effectively in the classroom substantial learning gains are achieved (Black & Wiliam, 1998a). Feedback plays a significant role in supporting students' learning when incorporated with suggestions for improvement (Bansilal et al., 2010; Kitta & Tilya, 2010). Black and Wiliam (1998a) indicated that some types of feedback are more efficacious than others. Therefore, the researcher draws upon the work of Lee (2008), as noted in Chapter 2, who

provided six procedures for effective classroom implementation of feedback: 1) students should be told about their strengths and weakness and what needs to be done; 2) information should be clearly communicated to students about what they have learned; 3) feedback should clarify good performance and promote a close link between teaching, learning, and assessment; 4) feedback should provide students with opportunities to act on teachers' feedback and improve their work; 5) feedback is effective if it encourages learners to play an active role in managing their learning; and 6) feedback is effective if it is used to improve teaching. These principles resonate with Chappuis' (2015) seven strategies of assessment.

It was established in this study that even though teacher educators have a limited conception of feedback, they utilise feedback during pedagogy to inform the teaching and learning of mathematics. Based on classroom observations, teacher educators were seen providing oral feedback to students. For example, in Sekyi's lesson on fractions he provided oral feedback to his students which helped them to go through the assessment task, as evident below.

> Sekyi asked his students to solve the fraction $\frac{4}{5} - \frac{1}{5}$ using the Cuisenaire rod. A student asked "Sir, in finding the unit whole, let's say the 5 which is yellow, can you also use two reds and a white as a unit whole?". Sekyi replied "Please, get this clear, the unit whole could be a combination of two or more rods, but the subdivision should be the same rod", giving further explanation of how unit whole rods are selected.

Teacher educators' feedback sometimes gives directions to students to change their incorrect answers to correct ones, while at other times it helps them to develop a conceptual understanding of mathematics and identify steps for completing assessment tasks. Previous research by Lee (2008) and Bansilal et al. (2010) found that students expect teachers to provide written comments and more explicit feedback on errors. Teachers can advance students' learning through comments-only feedback (Black & Wiliam, 2009). This study also found that teacher educators' knowledge about the type of feedback was grounded on marks, in establishing how much a student has achieved regarding a specific mathematics concept. Teacher educators' feedback practices on students' written work reports took the form of marks only, instead of providing students with suggestions for improving their performance by stressing strengths and weaknesses. It is worth noting that grades and marks are not enough feedback to help students improve their learning, as students search for ways of obtaining good grades against how to improve their learning when

classroom activities focus on grades or rank (Black & Wiliam, 1998b). In this study it was evident that while in the lesson the teacher educators attempt to give verbal feedback, document analysis revealed that the focus is only on giving marks. In this respect, the researcher concludes that teacher educators lack skill in providing feedback that gives direction to students on where they are in their learning and what they are expected to do next, which would aid them to improve. While students can hear the oral feedback given during the lecture, the written feedback would be more meaningful as students could refer back to it in the future.

The teacher educators' feedback type (marks) on students' work can be considered as a contradiction that emerged from the activity system. This tension or contradiction is aptly delineated by West and Thorn (2001), who argued that the form or type of feedback selected by the classroom teacher for implementation depends largely on timing, right or wrong answers, level of cognitive skills, course content, and age of the students. Alquraan, Bsharah, and Al-Bustanji (2010) also argued that written feedback which helps students to compare their performance is time-consuming and takes effort. It is for this reason that Lee (2011) explained that teachers experienced feedback as one of the most challenging areas in FA and teaching in general.

The study has shown that although the teacher educators have a limited conception of feedback, they do recognise the importance of feedback in the teaching and learning of mathematics and employ feedback during mathematics pedagogy; however, their practices in terms of the forms and quality of the feedback are superficial. Teacher educators therefore need to balance their feedback practice by providing students with feedback in the form of comments instead of marks, remarking on where they are in their learning and what they are expected to do next in order to maximise its effectiveness on their performance. The researcher also believes that teacher educators' feedback on students' written work should not be a combination of comments and marks. This position is in accordance with Black and Wiliam (1998a), who reasoned that students tend to ignore feedback comments when marks are applied.

8.2.3 Why do mathematics teacher educators' use the formative assessment techniques that they do?

During the interview section of the study the participant teacher educators pointed out that they utilise FA techniques with the intention of improving students' mathematics achievement. Teacher educators articulated in their responses that students' performance in mathematics over the years has not been encouraging. The achievement of students in mathematics has been declining, a situation which is of concern to teachers and stakeholders. They therefore believe that FA techniques assist them in pulling together information from students and using the information to improve learning. This finding resonates with the claim advanced by Cauley and McMillan (2010) that teachers and administrators recognise FA as one of the powerful strategies for enhancing student achievement. To increase standards and improve student learning, there is a need for a fuller understanding of classroom assessment (Black & Wiliam, 1998a).

Another important finding that emerged from teacher educators is how valuable the FA technique is to the teacher. Teacher educators explained that assessment evidence elicited from students by FA strategies such as questioning is used by the teacher for an instructional adjustment that can help improve student learning. The finding is supported by Black and Wiliam (1998a), who argued that teachers must not interpret and make meaning of the assessment data only, but must also adjust their teaching to meet the needs of their students by employing the assessment information. It can therefore be argued that FA is at the heart of effective teaching, and its techniques are central tenets of sound teaching methodology. This study showed that FA techniques provide teacher educators with the opportunity to engage students in collaborative learning.

8.3 Factors that affect teacher educators' adoption of formative assessment

Teachers are less confident to implement FA strategies (Leahy, Lyon, Thompson, & Wiliam, 2005) because of some constraints of educational reform, learning culture, curriculum changes, collaborative environment, accountability, stakeholders' perceptions as well as the context of the school environment, all of which influence teachers' adoption and implementation of assessment strategies (Adamson, 2011; Hui, Brown, & Chan, 2017). It became evident in the study that there is a myriad of factors that affect teacher educators' adoption of FA in their classroom assessment practices. The challenges encountered by teacher educators have a place in the activity system in

relation to the activity theory framework and are viewed as contradictions or tensions which influence teacher educators' assessment practices. Factors that hinder FA practice by teacher educators of the Colleges of Education revealed by this study are grouped into two major themes, resource-related factors and contextual factors, which are further discussed in the next two sections.

8.3.1 Resource-related factors

It emerged from the study that one of the barriers which inhibit teacher educators' adoption and effective implementation of FA was resource-related. The study demonstrated that resource-related factors, which are related to resources such as instructional materials, time and class size, affect teacher educators' adoption of FA. This finding concurs with the results of Black and Wiliam (1998a, 2009) showing that resources such as information, materials, funding, and time impede teachers' adoption of FA. This notion of resource-related factors as a barrier to teacher educators' adoption of FA is exemplified by the FGD excerpt below:

> **Anani:** Lack of [teaching] materials makes it difficult to implement some of these assessment techniques.

Black and Wiliam (1998a) posit that the availability of assessment materials and funding may affect teachers' use of FA. This means that teacher educators require various types of FA strategies and instructional materials for effective teaching and learning in the mathematics classroom. This result corroborates the finding of Kellaghan and Greaney (2005) that poor-quality classroom assessment can be attributed to the shortage of teaching and learning materials. Another resource-related factor found to be inhibiting teacher educators' adoption of FA strategies was class size. Izci (2016) and Jones and Webb (2007) recognised class size and number of lessons taught as factors that affect teachers' adoption of FA. Classroom observation revealed that teacher educators whose classes were congested as a result of the number of students registered for the modules find it challenging to attend to the learning needs of individual students. For example, the large classes made giving of individual feedback difficult. Sutton (2010) reported that it is hard for teachers to employ FA in large classes (more than 39 students) because classroom management, giving effective feedback, and paying attention to individual students' learning would be exceedingly hard in these circumstances.

8.3.2 Contextual factors

Izci (2016) contends that contextual factors are directly related to teaching contexts, such as the school's environment and realities. He further argued that contextual factors are not associated with teachers' internal ideas. Another significant finding which impeded teacher educators from adopting FA in their module was college assessment policy, which is considered a contextual factor. Teacher educators' classroom assessment practices were affected by the college continuous assessment policy. Educators were to generate assessment marks (continuous assessment) to be submitted to the affiliate university by management:

> **Wilson:** We produce continuous assessment of 40% which is used in addition to the 60% end of semester mark [by affiliate university].

This causes teacher educators to focus their assessment on test-driven activities in order to maintain high scores rather than meeting the learning needs of students. Teacher educators tend to pay attention more to the college assessment policy than the needs of the students. Bichi and Musa (2015) stress that the present continuous assessment system does not serve formative evaluative purposes, because it is characterised by frequent test-taking. The pressure of frequent summative tests makes teachers adopt transmission and employ activities which are driven by testing (Izci, 2016).

Sociocultural theorists argue that learning is co-constructed and therefore requires all participants to have a shared understanding of the assessment goals and standards according to which classroom activities would be assessed (Black & Wiliam, 2009; Heritage, 2011). In other words, there should be transparency in the assessment process for lecturers and students in order to enhance students' performance (Ho, 2015). Another notable result that emerged from the study as a challenge for teacher educators' adoption of FA is the issue of transparency of the assessment criteria, which is grounded in the context of practice. In this study, despite teacher educators' efforts in explaining the assessment processes and the goal of assessment to students, success criteria or standards by which students' works are assessed were not articulated and shared with students. It can be derived that teacher educators continue to hold onto their authoritative role in assessment by keeping the assessment criteria to themselves. This affects teacher educators' facilitation and adoption of FA practices in the classroom.

8.4 Summary of main findings

This section provides a summary of the findings as established and discussed in this report and in line with the findings in the literature discussed in Chapter 2.

8.4.1 Teacher educators' conception of formative assessment

Research question one aimed at exploring teacher educators' knowledge of FA within the context of mathematics. The conception and perceptions of teachers affect their teaching, the process of assessment and the nature of students' learning. It emerged from this research that most teacher educators conceived FA as an ongoing process which forms part of teachers' everyday instructional activities. Views expressed by the teacher educators revealed that assessment form (formative or summative) is based on when it occurs or is administered with respect to the purpose of the assessment. The majority of teacher educators (participants in this study) observed that the function of FA is to gather data about teachers' teaching and about students' learning in order to enhance it. The study further revealed that teacher educators were knowledgeable about some formal and informal FA techniques. Assessment techniques which teacher educators exhibited knowledge on and cited include questions and answers, quizzes, assignments, observation where the teacher monitors what happens during classroom learning activities, and small group discussion. It can therefore be inferred that the teacher educators have the requisite knowledge and understanding of FA.

8.4.2 Teacher educators' practices of formative assessment

The second critical research question assessed how teacher educators implement FA in their teaching. The study demonstrated that teacher educators were able to enact some FA techniques with success, while other techniques were implemented in a disjointed manner. Transition from feedback to self-monitoring can be fostered in FA if students come to know what constitutes quality. This means that assessment standards or criteria for assessing students' work need to be communicated to the students. However, this study revealed that standards and criteria for success were not articulated to the students by the teacher educators. Questioning was found to be the principal technique teacher educators employ in gathering data about students' learning and for checking their instructional methodology. Questioning together with other cooperative learning

strategies such as discussion helped students to consolidate knowledge during classroom instructional delivery. Teacher educators lacked skill in providing feedback comments that move mathematics learning onwards but had adequate knowledge on feedback. The study further established that factors like insufficient assessment materials, class size, and college assessment policy influences teacher educators' implementation of FA in their assessment practices.

8.4.3 Reasons for teacher educators' adoption of formative assessment techniques

Research question three was meant to look into the reason behind teacher educators' adoption of FA techniques. The study findings revealed that FA techniques play a crucial role in the teaching and learning of mathematics. The study established that teacher educators unanimously acknowledged that the ultimate reason informing their decision to adopt FA strategies is to improve and enhance students' mathematics performance, and to prevent it from further deteriorating. The study also showed that effective usage of informal FA techniques like questioning in the mathematics classroom aid teacher educators to gather evidence in determining where the students are in their learning, and to find out if students are working towards the desired learning goal. There could be no FA without feedback. The findings further revealed that teacher educators' usage of FA techniques provide an opportunity to give feedback to students. Effective usage of feedback techniques also encourages students to share and receive feedback among themselves.

8.5 Implications and contributions of the study

This study revealed that teacher educators have the requisite knowledge regarding FA but lack the skill and competency to implement some aspects of FA strategies. Thus, seeing this issue of inadequate skills and how teacher educators involved in this study struggled in adopting some FA strategies effectively in their teaching, there is a need to give serious consideration to the gaps in their knowledge and practices. The implications of this study are considered in relation to FA practices.

Sadler (1989), in his study of FA and the design of instructional systems, as cited in Ho (2015), contends that teachers have inadequate knowledge and conceptualisation of FA with regard to criteria and closing learning gaps. This study provided evidence to suggest that teacher educators have inadequate skills in developing learning goals and sharing criteria for success with their

students, thereby limiting students' involvement in the process of making assessment decisions. This finding indicates that there is a need to address this gap in teacher educators. FA techniques that enhance teaching and learning place more attention on the students. With the many aspects of the learning process, FA requires teachers to develop and share learning goals with and for the students, as opposed to the former practice where teachers assume the exclusive obligation and lead students on an unknown journey. This means that teacher educators are required to have good knowledge and skill in areas that provide a more focused application for students to enhance teaching and learning. Furthermore, this study demonstrated that teacher educators' feedback made in relation to students' work does not point out to the students how they can improve their learning and achievement. Therefore students would not be aware of what they could improve upon, what was good about their work, or the aspects that they made mistakes on. This means that students would repeatedly make the same mistakes, since they would not know the kind of error that they had made, meaning that they were unable to address them.

This study makes a valuable contribution to the literature, specifically to the field of FA, with respect to the gaps identified in Chapters 1 and 2. The issue of FA among teachers in the literature explored either teachers' understanding of FA only or teachers' practices of FA, and mostly focused on in-service teachers. This study is perhaps the first to provide evidence by exploring together both teacher educators' understanding and their practices of FA, since there is the need to know how one's knowledge translates into practice. Also, the practices of in-service teachers may be influenced by their learning while in training; therefore, it was important that teacher educators' understanding and practices were explored, as this has the potential to influence teaching and learning practices in schools.

Another contribution this study provides is related to its methodological approach in addressing the research objectives. Oduro (2015) indicates that most Ghanaian academics are familiar with and prefer to employ a quantitative approach and procedures in their research, regardless of their subject area, due to the relative ease, speed, clarity, precision and standardisation which characterizes this method. The use of a qualitative design in this study allowed for elicitation of information from the lived experiences of participants, and focuses on understanding the meaning which an individual or a group ascribes to a social or human problem, and generates words for data analysis rather than numbers. In addition, while FA research in higher education in Ghana

(Ankomah & Oduro, 2004; Bekoe et al., 2013) employs interview and observation schedules for data generation, this research expanded the method of data production by including textual materials.

8.6 Recommendations of the study

Based on the findings established in the study, recommendations are made in response to the objectives.

Related to the first objective, to explore MTEs' understanding and practice of FA in mathematics, the following recommendation was arrived at:

- Teacher educators need to marry their understanding of FA gained from the literature with their practices, in order to harvest the full potential of FA in enhancing students' performance.

In respect of objective two, which was to determine how MTEs enact FA in mathematics modules, the following recommendations were made:

- In planning classroom instruction, teacher educators must involve students in reaching decisions about the learning goals and how their work would be assessed. Once a forum for discussion and communication is established, the issue of lack of transparency in the assessment process could be addressed.
- Instructional resources such as assessment materials should be provided for teacher educators by stakeholders to complement them with FA techniques to facilitate effective instructional delivery, learning and assessment.
- Teacher educators' assessment practices cannot be achieved individually, or independently or changed overnight. Thus, teacher colleges need to provide support to teacher educators by organising regular professional development programmes which build on teacher educators' existing knowledge and FA practices. It is further recommended that teacher educators should be trained to develop their skills in providing feedback which can aid students to navigate their way onto the next step of their learning process.

Based on the third objective, to establish the reasons why teacher educators adopt FA techniques, the following recommendations are made:

- Teacher educators should adapt their instructional methodology and consider multiple FA techniques and the various learning styles of their students in order to meet their learning needs.
- FA techniques should be considered by teacher educators as instructional strategies that ensure classroom dialogue between teacher and students and regulate the pace of instructional delivery.
- Teacher educators' ongoing classroom assessment of students and their progress is central to real learning. Thus, it is further recommended that FA techniques should be adopted and employed in real-time before teaching, during teaching and after teaching, for the purposes of gathering evidence about the instructional delivery and student learning to aid the provision of effective and timely feedback that is within the grasp of students.

8.7 Directions for future research

Aside from the recommendations which have been stated clearly in this report, the following suggested areas can be considered for future research:

- Research can be conducted to explore the alignment between teacher educators' and pre-service teachers' understanding of FA in mathematics modules.
- Furthermore, future research can look at the effect of scoring as a way of providing feedback on enhancement of students' learning.

References

Abell, S. K., & Siegel, M. A. (2011). Assessment literacy: What science teachers need to know and be able to do. In D. Corrigan, J. Dillon, & R. Gunstone (Eds.) *The Professional Knowledge Base of Science Teaching* (pp. 205-221). Dordrecht, The Netherlands: Springer.

Adamson, B. (2011). Embedding assessment for learning. In R. Berry, & B. Adamson, *Assessment Reform in Education* (pp. 197-203). Dordrecht: Springer.

Ahmed, J. U. (2010). Documentary research method: New dimensions. *Indus Journal of Management & Social Sciences, 4*(1), 1-14.

Aikenhead, G. S. (1997). Towards a first Nation cross- cultural science and technology curriculum.*Science Education, 81*(2), 217 - 238.

Almeida, P. A. (2012). Can I ask a question? The importance of classroom questioning. *Procedia-Social and Behavioral Sciences, 31*, 634-638.

Alotaibi, K. A. (2019). Teachers' perceptions on factors influence adoption of formative assessment. *Journal of Education and Learning, 8*(1), 74-86.

Alquraan, M. F., Bsharah, M. S., & Al-Bustanji, M. A. (2010). Oral and Written Feedback and Their Relationship with Using Different Assessment Methods in Higher Education. *International Journal of Applied Educational Studies, 7*(1).

Amankwaa, L. (2016). Creating protocols for trustworthiness in qualitative research. *Journal of Cultural Diversity, 23*(3).

Anastasakis, M. (2018). *An activity theory investigation of tool-use in undergraduate mathematics.* (Doctoral dissertation), Loughborough University, England.

Amoako, I., Asamoah, D., & Bortey, J. (2019). Knowledge of formative assessment practices among Senior high school mathematics teachers in Ghana. *American Journal of Humanities and Social Sciences Research, 3,* 8 -13.

Andrade, H. L., Wang, X., Du, Y., & Akawi, R. L. (2009). Rubric-referenced self-assessment and self-efficacy for writing. *The Journal of Educational Research, 102*(4), 287-302.

Ankomah, Y., & Oduro, G. (2004). Improving learning through formative assessment: The lecturer's dilemma. *Makerere Journal of Higher Education, 1*(1), 134-142.

Anney, V. N. (2014). Ensuring the quality of the findings of qualitative research: Looking at trustworthiness criteria. *Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS), 5*(2), 272-281.

Arrafii, M. A., & Sumarni, B. (2018). Teachers' understanding of formative assessment. *Lingua Cultura, 12*(1), 45-52.

Artefact, M. (2015). Two interacting activity systems as minimal model for third generation of activity theory.--Engestrom 1999. Retrived from http://www.bath.ac.uk/research/liw/resources/Models%20and%20principles%20of20Activity%20Theory.pdf

Arumugham, K. S., Abdullah, S. S., & Mahmud, N. (2017). Conceptions of formative assessment among Malaysian secondary school teachers. *International Journal of Multidisciplinary Education and Research, 2*(2), 27-30.

Ary, D., Jacobs, L. C., Razavieh, A., & Sorensen, C. (2010). Introduction to research in education: Cengage Learning. Journal of Correctional Education, 9 -22.

Asan, O., & Montague, E. (2014). Using video-based observation research methods in primary care health encounters to evaluate complex interactions. *Informatics in Primary Care, 21*(4), 161.

Asare-Danso, S. (2014). *Effects of Educational Policies on Teacher Education in Ghana: A Historical Study* of the Presbyterian College of Education *International Journal of Humanities and Social Science, 4*(6), 57 -65.

Ashlock, R. B. (2001). *Error patterns in computation: Using error patterns to improve instruction.* Boston: Prentice Hall.

Astin, F., & Long, A. (2014). Characteristics of qualitative research and its application. *British Journal of Cardiac Nursing, 9*(2), 93-98.

Avdic, A., Wissa, U. A., & Hatakka, M. (2016). *Socratic Flipped Classroom: What Types of Questions and Tasks Promote Learning?* Paper presented at the European Conference on e-Learning.

Babbie, E. (2001). Qualitative filed research. *The practice of social research, 9,* 298 - 300.

Babu, R. (2015). *Nature of questioning in english classroom using communicative language teaching approach at junior secondary level.* (Master's Dissertation), University of Dhaka, Bangladesh.

Bailey, K. (2008). *Methods of social research.* New York: Simon and Schuster.

Balan, A. (2012). Assessment for learning: A case study in mathematics education.(PhD thesis), Malmö University, Malmö.

Bansilal, S., James, A., & Naidoo, M. (2010). Whose voice matters? Learners. *South African Journal of Education, 30*(1).

Barab, S., Kling, R., & Gray, J. H. (2004). Introduction: Designing for virtual communities in the service of learning. In S. A. Barab, R. Kling & J. H . Gray(Eds.), *Designing for virtual communities in the service of learning* (pp. 3-15). Cambridge: Cambridge University Press.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report, 13*(4), 544-559.

Bekoe, S. O., Eshun, I., & Bordoh, A. (2013). Formative assessment techniques tutors use to assess teacher-trainees' learning in Social Studies in Colleges of Education in Ghana. *Research on Humanities and Social Sciences, 3*(4), 20-30.

Bell, B., & Cowie, B. (2001). The characteristics of formative assessment in science education. *Science Education, 85*(5), 536-553.

Beni, S. (2014). *Foundation phase teachers' interpretation and implementation of the natural science curriculum in the life skills learning programme: a case study.*(PhD theses), University of KwaZulu - Natal, Durban.

Bennett, R. E. (2011). Formative assessment: A critical review. *Assessment in Education: Principles, Policy & Practice, 18*(1), 5-25.

Bezuk, N . S., Cathcart, W. G., Vance, J. H., & Pothier, Y. M. (2001). Learning mathematics in elementary and middle schools. Columbus:Merrill prentice Hall.

Bichi, A. A., & Musa, A. (2015). Assessing the correlation between continuous assessment and examination scores of education courses. *American International Journal of Research in Humanities, Arts and Social Sciences*, 290-294.

Biggs, J. (1999). What the student does: Teaching for enhanced learning. *Higher Education Research & Development, 18*(1), 57-75.

Birgin, O. (2011). Pre-service mathematics teachers' views on the use of portfolios in their education as an alternative assessment method. *Educational Research and Reviews, 6*(11), 710-721.

Bitsch, V. (2005). Qualitative research: A grounded theory example and evaluation criteria. *Journal of Agribusiness, 23*(345-2016-15096), 75-91.

Black, P. (2013). Pedagogy in theory and in practice: Formative and summative assessments in classrooms and in systems. In D. Corrigan, R. Gunstone, & A. Jones (Eds.), *Valuing assessment in science education: Pedagogy, curriculum, policy* (pp. 207-229). Dordrecht, The Netherlands: Springer.

Black, P., Harrison, C., Hodgen, J., Marshall, B., & Serret, N. (2011). Can teachers' summative assessments produce dependable results and also enhance classroom learning? *Assessment in Education: Principles, Policy & Practice, 18*(4), 451-469.

Black, P., Harrison, C., & Lee, C. (2003). *Assessment for learning: Putting it into practice.* London: McGraw-Hill Education.

Black, P., & Wiliam, D. (1998a). Assessment and classroom learning. *Assessment in Education: principles, policy & practice, 5*(1), 7-74.

Black, P., & Wiliam, D. (1998b). Inside the black box: Raising standards through classroom assessment. *Phi delta kappan, 80*(2), 139-148.

Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability (formerly: Journal of Personnel Evaluation in Education), 21*(1), 5.

Blaikie, N. (2010). *Designing Social Research* (2nd ed.). Cambridge: Polity Press.

Blome, C., & Schoenherr, T. (2011). Supply chain risk management in financial crises—A multiple case-study approach. *International Journal of Production Economics, 134*(1), 43-57.

Bloom, B. S. (1956). *Taxonomy of educational objectives: The classification of educational goals.* Essex, England: Harlow

Boaler, J., & Brodie, K. (2004). *The importance, nature, and impact of teacher questions.* Paper presented at the Proceedings of the 26th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.

Boote, D. N., & Beile, P. (2005). Scholars before researchers: On the centrality of the dissertation literature review in research preparation. *Educational Researcher, 34*(6), 3-15.

Bordoh, A., Bassaw, T. K., & Eshun, I. (2013). Social Studies tutors' cognition in formative assessment in Colleges of Education in Ghana. *Development Country Studies, 3*(11), 1-11.

Boud, D. (1991). *Implementing student self-assessment.* Sydney: Higher Education Research abd Development Society of Australasia (HERDSA).

Boud, D. (2000). Sustainable assessment: rethinking assessment for the learning society. *Studies in Continuing Education, 22*(2), 151-167.

Boud, D. (2013). *Enhancing learning through self-assessment.* London: Routledge.

Boulet, J. R. (2008). Summative assessment in medicine: the promise of simulation for high-stakes evaluation. *Academic Emergency Medicine, 15*(11), 1017-1024.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal, 9*(2), 27-40.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101.

Briggs, D. C., Ruiz-Primo, M. A., Furtak, E., Shepard, L., & Yin, Y. (2012). Meta-Analytic Methodology and Conclusions about the Efficacy of Formative Assessment. *Educational Measurement: Issues and practice, 31 (4),* 13 -17.

Brindley, G. (2003). Classroom-based assessment.In D. Nunan (ed.), Practical English language teaching (pp. 309 - 328). New York: McGraw Hill.

Brink, M. K. (2017). *Teachers' Perceived Understanding of Formative Assessment and How This Understanding Impacts their Own Classroom Instruction* (dissertation). Southern Illinois University at Carbondale.

Broadfoot, P. (2012). *Assessment, schools and society* (Vol.35). Oxon, England: Routledge.

Brookhart, S. M. (2011). Educational assessment knowledge and skills for teachers. *Educational Measurement: Issues and Practice, 30*(1), 3-12.

Brookhart, S. M. (2017). *How to give effective feedback to your students.* Alexandria, VA: ASCD.

Brookhart, S. M., Moss, C. M., & Long, B. A. (2010). Teacher inquiry into formative assessment practices in remedial reading classrooms. *Assessment in Education: Principles, Policy & Practice, 17*(1), 41-58.

Brown, G. T. L. (2004). Teachers' conceptions of assessment: Implications for policy and professional development. *Assessment in Education, 15 (3),* 301 - 318.

Brown, G., Bull, J., & Pendlebury, M. (1997). *Peer and self-assessment. Assessing student learning in higher education* (pp. 170-184). London: Routledge.

Bryman, A. (2016). *Social research methods.* Oxford, England: Oxford University Press.

Buchanan, T. (2000). The efficacy of a World-Wide Web mediated formative assessment. *Journal of Computer Assisted Learning, 16*(3), 193-200.

Budden, R. (2016). *Exploration of factors that inform curriculum studies students to use e-resources in conducting Masters of Education dissertations at a South African university.* (Doctoral dissertation), University of KwaZulu - Natal, Durban.

Burke, J. R., & Larry, C.(2017). Educational research: Quantitative, qualitative and mixed approach. Thousand Oaks, CA: Sega.

Burkhardt, H., & Swan, M. (2012). Designing assessment of performance in mathematics. *Educational Designer: Journal of the International Society for Design and Development in Education, 1*, 1 - 24.

Calitz, M. (2009). *A cultural sensitive therapeutic approach to enhance emotional intelligence in primary school children*. (Doctoral dissertation), University of South Africa, Pretoria.

Carless, D. (2013). Trust and its role in facilitating dialogic feedback. In D. Bound & L. Molloy (Eds.), *Feedback in higher and professional education* (pp.90 -103). London: Routledge

Carrillo-de-la-Peña, M. T., Bailles, E., Caseras, X., Martínez, À., Ortet, G., & Pérez, J. (2009). Formative assessment and academic achievement in pre-graduate students of health sciences. *Advances in Health Sciences Education, 14*(1), 61-67.

Carter, N., Bryant-Lukosius, D., DiCenso, A., Blythe, J., & Neville, A. J. (2014). The use of triangulation in qualitative research. *Oncology Nursing Forum,41* (1), 545 - 547.

Cauley, K. M., & McMillan, J. H. (2010). Formative assessment techniques to support student motivation and achievement. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 83*(1), 1-6.

Chafi, M. E., & Elkhouzai, E. (2014). Classroom interaction: Investigating the forms and functions of teacher questions in Moroccan primary school. *International Journal of Innovation and Applied Studies, 6*(3), 352.

Chan, C. (2009). Assessment: Direct observation, assessment resources @HKU, University of Hong Kong. Retrived from http://ar. Cetl. hku.hk.

Chappuis, J. (2015). *Seven strategies of assessment for learning*: New York, NY: Pearson.

Chappuis, S., & Stiggins, R. J. (2002). Classroom assessment for learning. *Educational Leadership, 60*(1), 40-44.

Chin, C. (2007). Teacher questioning in science classrooms: Approaches that stimulate productive thinking. *Journal of Research in Science Teaching*, *44*(6), 815-843.

Chin, C., & Chia, L. G. (2004). Problem-based learning: Using students' questions to drive knowledge construction. *Science Education, 88*(5), 707-727.

Chin, C., & Osborne, J. (2008). Students' questions: a potential resource for teaching and learning science. *Studies in Science Education, 44*(1), 1-39.

Clark, I. (2012). Formative assessment: Assessment is for self-regulated learning. *Educational Psychology Review, 24*(2), 205-249.

Clarke, S. (2001). *Unlocking formative assessment: Practical strategies for enhancing pupils' learning in the primary classroom.* London: Hodder & Stoughton Educational.

Clarke, V., & Braun, V. (2013). Teaching thematic analysis: Overcoming challenges and developing strategies for effective learning. *The Psychologist, 26*(2), 120-123.

Coffey, J. E., Hammer, D., Levin, D. M., & Grant, T. (2011). The missing disciplinary substance of formative assessment. *Journal of Research in Science Teaching, 48*(10), 1109-1136.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research Methods in Education.* London: Routledge.

Cope, D. G. (2014). Methods and meanings: credibility and trustworthiness of qualitative research.*Oncology Nursing Forum, 41* (1), 89 - 91

Cotton, K. (1988). Classroom questioning. *School Improvement Research Series, 5*, 1-22.

Cowie, B., & Bell, B. (1999). A model of formative assessment in science education. *Assessment in Education: Principles, Policy & Practice, 6*(1), 101-116.

Cresswell, J., & Plano Clark, V. (2011). *Designing and conducting mixed method research* (2nd ed.). Thousand Oaks, CA: SAGE Publications.

Creswell , J., & Poth, C. (2018). *Qualitative Inquiry and Research Desain: Choosing Among Five Approaches.* Thousand Oaks, CA: SAGE Publications.

Crooks, T. (2001). *The validity of formative assessments.* Paper presented at the British Educational Research Association Annual Conference, University of Leeds.

Cross, K. P. (1996). Improving teaching and learning through classroom assessment and classroom research. In G. Gibbs (Ed.), Improving student learning:using research to improve student learning (pp. 3 -10). Oxford: Oxford centre for staff development.

Crossouard, B., & Pryor, J. (2012). How theory matters: Formative assessment theory and practices and their different relations to education. *Studies in Philosophy and Education, 31*(3), 251-263.

Cuccio-Schirripa, S., & Steiner, H. E. (2000). Enhancement and analysis of science question level for middle school students. *Journal of Research in Science Teaching, 37*(2), 210-224.

Curtin University (2011). Using evaluate to improve students learning: *Providing feedback for students learning.* Retrived from http://evaluate.curtin.edu.au/info/index.cfm [accessed December 11, 2018).

Dandis, M. A. (2013). The assessment methods that are used in a secondary mathematics class. *Journal for Educators, Teachers and Trainers, 4*.

Davidson, C. (2009). Transcription: Imperatives for qualitative research. *International Journal of Qualitative Methods, 8*(2), 35-52.

Davies, A., & Hill, M. (2009). *Making classroom assessment work*. Wellington: NZCER Press.

Denzin, N. K., & Lincoln, Y. S. (2011). Introduction: The discipline and practice of qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), The Sage handbook of qualitative research (4 th ed., pp. 1 -21). Thousand Oaks, Calif.; London: Sage Publications.

Dixson, D. D., & Worrell, F. C. (2016). Formative and summative assessment in the classroom. *Theory into practice, 55*(2), 153-159.

Dochy, F., Segers, M., & Sluijsmans, D. (1999). The use of self-, peer and co-assessment in higher education: A review. *Studies in Higher Education, 24*(3), 331-350.

Du Plessis, E . C., Marais, P., Van Schalkwyk, A., & Weeks, F. (2011). Adapt or die: The views of Unisa student teachers on teaching practice at schools. *Africa Education Review, 7* (2), 323 - 341.

Earl, L. M. (2012). *Assessment as learning: Using classroom assessment to maximize student learning* (2nd ed.) Thousand Oaks, CA: Corwin.

Earl, L., & Katz, S. (2006). Rethinking classroom assessment with purpose in mind. Winnipeg, Manitoba: Western Norther Canadian protocol.

Elder, L., & Paul, R. (1998). The role of Socratic questioning in thinking, teaching, and learning. *The Clearing House, 71*(5), 297-301.

El - Sherif, M. H. (2017). Qualitative research approach in LIS education: Comparative methodology study. *IOSR Journal of Research and Method in Education, 7* (1), 83 - 89.

Engeström, Y. (2001). Expansive learning at work: Toward an activity theoretical reconceptualization. *Journal of Education and Work, 14*(1), 133-156.

Engeström, Y., & Kerosuo, H. (2007). From workplace learning to inter-organizational learning and back: the contribution of activity theory. *Journal of Workplace Learning, 19*(6), 336-342.

Engeström, Y., Miettinen, R., & Punamäki, R.-L. (1999). *Perspectives on activity theory*: Cambridge: Cambridge University Press.

Engeström, Y., & Sannino, A. (2011). Discursive manifestations of contradictions in organizational change efforts: A methodological framework. *Journal of Organizational Change Management, 24*(3), 368-387.

Erbilgin, E. (2019). Two mathematics teacher educators' efforts to improve teaching and learning processes: An action research study. *Teaching and Teacher Education, 78,* 28 -38.

Eshun, I., Bordoh, A., Bassaw, T. K., & Mensah, F. (2014). Evaluation of social studies students' learning using formative assessment in selected colleges of education in Ghana. *British Journal of Education, 2*(1), 39-48.

Educational Testing Service (2010). About the KLT program. Princeton, NJ: Author.

Etsey, Y. K. A., & Gyamfi, A. (2017). Improving assessment of learning in mathematics through assessment as learning. *Journal of Educational Assessment in Africa, 12* , 11 - 20.

Etsey, Y. K. A. (2016). *Assessment as learning: A metacognition approach to teaching, learning and assessment.*A paper presented at WAEC monthly seminar, WAEC: Accra.

Fairbrother, J. T. (2010). *Fundamentals of motor behavior.* Champaign, IL: Human Kinetics.

Falchikov, N. (2001). *Learning together: Peer tutoring in higher education.* Hove, East Sussex: Psychology Press.

Falchikov, N. (2013). *Improving assessment through student involvement: Practical solutions for aiding learning in higher and further education.* London: Routledge.

Feng, Z. (2014). Using teacher questions to enhance EFL students' critical thinking ability. *Journal of Curriculum and Teaching, 2*(2), 147.

Filsecker, M., & Kerres, M. (2012). Repositioning formative assessment from an educational assessment perspective: A response to Dunn & Mulvenon (2009). *Practical Assessment, Research & Evaluation, 17*.

Finfgeld-Connett, D. (2010). Generalizability and transferability of meta-synthesis research findings. *Journal of Advanced Nursing, 66*(2), 246-254.

Fitzgerald, T. (2012). Documents and documentary analysis. *Research Methods in Educational Leadership and Management*, 296-308.

Foot, K. A. (2014). Cultural-historical activity theory: Exploring a theory to inform practice and research. *Journal of Human Behavior in the Social Environment, 24*(3), 329-347.

Fraile, J., Panadero, E., & Pardo, R. (2017). Co-creating rubrics: The effects on self-regulated learning, self-efficacy and performance of establishing assessment criteria with students. *Studies in Educational Evaluation, 53*, 69-76.

Frambach, J. M., Driessen, E. W., & van der Vleuten, C. P. (2014). Using activity theory to study cultural complexity in medical education. *Perspectives on Medical Education, 3*(3), 190-203.

Furtak, E. M. (2012). Linking a learning progression for natural selection to teachers' enactment of formative assessment. *Journal of Research in Science Teaching, 49* (9). 1181 - 1210.

Gardner, J., Harlen, W., & Hayward, L. (2010). *Developing teacher assessment*. Maidenhead: McGraw-Hill Education (UK).

Ghana Statistical Service. (2016). Projected population growth by sex 2010-2016. Accra, Ghana: Author.

Gibbs, G., & Simpson, C. (2004). Does your assessment support your students' learning. *Journal of Teaching and learning in Higher Education, 1*(1), 1-30.

Gibson, W., & Brown, A. (2009). *Working with qualitative data.* London: SAGE Publications.

Glendon, I. A., & Clarke, S. G., & McKenna, E.F. (2006). *Human Safety and Risk Management.* London: Taylor & Francis.

Glover, C., & Brown, E. (2006). Written feedback for students: too much, too detailed or too incomprehensible to be effective? *Bioscience Education, 7*(1), 1-16.

Graesser, A. C., & Person, N. K. (1994). Question asking during tutoring. *American Educational Research Journal, 31*(1), 104-137.

Greeno, J., & Engestrom, Y. (2006). Learning in activity. In K. Sawyer (Ed.), *Cambridge handbook of the learning sciences*(pp. 79 - 96). New York: Cambridge University press.

Gregory, R. J. (2000). Psychological Testing, History, Principles, and Application (3rd ed.). Boston: Allyn and Bacon

Grove, S. K., Burns, N., & Gray, J. (2012). *The practice of nursing research: Appraisal, synthesis, and generation of evidence.* St Louis, MO: Elsevier Health Sciences.

Guest, G., MacQueen, K. M., & Namey, E. E. (2011). *Applied thematic analysis.* Thousand Oaks, CA: SAGE Publications.

Gullo, D. F. (2005). *Understanding assessment and evaluation in early childhood education* (Vol. 95). New York: Teachers College Press.

Hamidi, E. (2010). Fundamental issues in L2 classroom assessment practices. *Academic Leadership, 8*(2), 21.

Hanna, G. S., & Dettmer, P. (2004). *Assessment for effective teaching: Using context-adaptive planning.* Boston: Allyn & Bacon.

Hanover Research (2014). The impact of formative assessment and learning intentions on student achievement. Washington, DC: Hanover Research

Hargreaves, E. (2007). The validity of collaborative assessment for learning. *Assessment in Education, 14*(2), 185-199.

Hariparsad, S. D. (2004). *In search of deep change: A study of the implementation of assessment policy in South African schools.* (PhD thesis), University of Pretoria.

Harlen, W. (2007). *Assessment of learning.* London: SAGE Publications.

Harlen, W., & James, M. (1996). Creating a Positive Impact of Assessment on Learning. New York: AERA.

Harris, S. E. (2016). *Teachers' Understanding and Use of Formative Assessments in the Elementary Mathematics Classroom.* (Doctoral dissertation), Harvard Graduate School of Education.

Harris, L. R., Irving, S. E., & Peterson, E. (2008). Secondary teachers' conceptions of the purpose of assessment and feedback. Paper presented to the Annual Conference of the Australian Association for Research in Education (AARE), December 4, Brisbane, Australia.

Hasan, H., & Kazlauskas, A. (2014). *Activity Theory: who is doing what, why and how*. Faculty of Business, Univerity of Wollongong Papers (Archive). 403. Retrived from

https://ro.uow.edu.au/buspapers/403 [accessed 19th May, 2019]

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81-112.

Havnes, A., Smith, K., Dysthe, O., & Ludvigsen, K. (2012). Formative assessment and feedback: Making learning visible. *Studies in Educational Evaluation, 38*(1), 21-27.

Hove, M. L., & Hlastshwayo, A. (2015). ' I am asking the scope of the paper' : Negative washback and examination (under) preparedness in South Africa. *Journal of Education and Practice, 6* (24), 30 -37.

Healy, M., &Perry, C. (2000). Comprehensive criteria to judge validity and reliability of qualitative research within realism paradigm. *Qualitative Market Research, 3*(3), 118-126.

Heinze, A. (2005). Mistake-handling activities in the mathematics classroom. *International Group for the Psychology of Mathematics Education, 3*, 105-112.

Hemje, K. (2014). Student perspectives of classroom assessment.(Maters dissertation), Mid Sweden University.

Hennink, M., Hutter, I., & Bailey, A. (2020). *Qualitative research methods*. London: SAGE Publications.

Hennink, M. M. (2013). *Focus group discussions.* Oxford: Oxford University Press.

Heritage, M. (2010a). *Formative Assessment and Next-Generation Assessment Systems: Are We Losing an Opportunity?* Paper prepared for the Council of Chief State School Officers, Wsahington, DC.

Heritage, M. (2010b). *Formative assessment: Making it happen in the classroom.* Thousand Oaks, CA: Corwin Press.

Heritage, M. (2011). Formative assessment: An enabler of learning. *Evidence-Based Education*, 18-19.

Heritage, M., & Heritage, J. (2013). Teacher questioning: The epicenter of instruction and assessment. *Applied Measurement in Education, 26*(3), 176-190.

Hernández, R. (2012). Does continuous assessment in higher education support student learning? *Higher Education, 64*(4), 489-502.

Ho, T. N. (2015). *An exploratory investigation of the practice of assessment for learning in Vietnamese higher education: Three case studies of lecturers' practice* (PhD dissertation). Queensland University of Technology, Brisbane.

Hubley, A. M., & Zumbo, B. D. (2011). Validity and the consequences of test interpretation and use. *Social Indicators Research, 103*(2), 219.

Hui, S. K. F., Brown, G. T., & Chan, S. W. M. (2017). Assessment for learning and for accountability in classrooms: The experience of four Hong Kong primary school curriculum leaders. *Asia Pacific Education Review, 18*(1), 41-51.

Husain, N. (2013). *ESL Teachers' Perceptions and Practices on Formative Assessments in Classroom.* Johor, Malaysia: Universiti Teknologi Malaysia,

Islam, F. (2012). Understanding pre-service teacher education discourses in communities of practice: A reflection from an intervention in rural South Africa. *Perspectives in Education, 30*(1), 19-29.

Izci, K. (2016). Internal and external factors affecting teachers' adoption of formative assessment to support learning. *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering, 10*(8), 2541-2548.

Jacob, S. A., & Furgerson, S. P. (2012). Writing interview protocols and conducting interviews: Tips for students new to the field of qualitative research. *The Qualitative Report, 17*(42), 1-10.

Jiang, Y. (2014). Exploring teacher questioning as a formative assessment strategy. *RELC Journal, 45*(3), 287-304.

Jones, J., & Webb, M. (2007). *Assessment for learning (AfL) across the school: A case study in whole school capacity building.* Paper presented at the British Educational Research Association Annual Conference, University of Warwick, 6-9 September 2006.

Jonsson, A. (2014). Rubrics as a way of providing transparency in assessment. *Assessment & Evaluation in Higher Education, 39*(7), 840-852.

Juvrianto, C. J., & Farda, C. (2011). *Analysis of teachers questioning in EFL classroom interaction*. Retrived from www. academia. edu. [accessed on 18 January, 2019].

Kang, H., Thompson, J., & Windschitl, M. (2014). Creating opportunities for students to show what they know: The role of scaffolding in assessment tasks. *Science Education, 98*(4), 674-704.

Kanjee, A. (2009). Teacher assessment practices in South African schools? *Education as Change, 13*(1), 67-83.

Kanjee, A., & Mthembu, J. (2015). Assessment literacy of foundation phase teachers: An exploratory study. *South African Journal of Childhood Education, 5*(1), 142-168.

Kaptelinin, V., & Nardi, B. (2012a). Activity theory in HCI: Fundamentals and reflections. *Synthesis Lectures Human-Centered Informatics, 5*(1), 1-105.

Kaptelinin, V., & Nardi, B. (2012b). *Affordances in HCI: toward a mediated action perspective.* Paper presented at the SIGCHI Conference on Human Factors in Computing Systems.

Karanasios, S., Riisla, K., & Simeonova, B. (2017). Exploring the use of contradictions in activity theory studies: An interdisciplinary review.Presented at 33rd EGOS Colloquium: The Good Organisation, Copenhagen, July 6- 8. Retrived from https://dspace.lboro.ac.uk/dspacejspui/bitstream/2134/26026/1/PDF.pdf [accessed on 2nd June 2019]

Kawalkar, A., & Vijapurkar, J. (2013). Scaffolding Science Talk: The role of teachers' questions in the inquiry classroom. *International Journal of Science Education, 35*(12), 2004-2027.

Kawanaka, T., & Stigler, J. W. (1999). Teachers' use of questions in eighth-grade mathematics classrooms in Germany, Japan, and the United States. *Mathematical Thinking and Learning, 1*(4), 255-278.

Kellaghan, T., & Greaney, V. (2005). *Monitoring performance: Assessments and examinations in Africa* (pp. 271-292). Paris: Association for the Development of Education in Africa.

Kenyon, B. J. (2019). Teachers' Formative Assessment Use to Check for Understanding and to Adjust Instruction.(Doctoral thesis), Walden University.

Khoza, S. B. (2012). Who helps an online facilitator to learn with students in a day. *Mevlana International Journal of Education, 2*(2), 75-84.

Kilpatrick, J. (1993). The chain and the arrow: From the history of mathematics assessment. In M. Niss(ed.). *Investigations into assessment in mathematics education* (pp. 31-46). Springer, Dordrecht: Kluwer Academic Publishers.

King, N., Horrocks, C., & Brooks, J. (2018). *Interviews in Qualitative Research.* London: SAGE Publications.

Kingston, N., & Nash, B. (2011). Formative assessment: A meta -analysis and a call for research. *Educational measurement: Issues and practice, 30* (4), 28 -37.

Kitta, S., & Tilya, F. (2010). The status of learner-centred learning and assessment in Tanzania in the context of the competence-based curriculum. *Papers in Education and Development, 29*, 77-91.

Klein, H. K., & Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS Quarterly, 23* (1), 67-93.

Klenowski, V. (1996). *Connecting assessment and learning.* Paper presented at the British Educational Research Association annual conference, Lancaster University.

Kollar, I., & Fischer, F. (2010). Peer assessment as collaborative learning: A cognitive perspective. *Learning and Instruction, 20*(4), 344-348.

Koster, B. (2002). *Lerarenopleiders onder de loep: De ontwikkeling van een beroepsprofiel voor lerarenopleiders en het effect van het kennisnemen daarvan op hun zelfdiagnose*. (Doctoral thesis),WCC, Utrecht University, Utrecht.

Krueger, R., & Casey, M. (2015). Participants in a focus group. In R. A. *Krueger & M.* A. Casey (Eds), *Focus Groups A Practical Guide for Applied Research* (pp. 63 -84). Thousand Oaks, CA: SAGE Publications.

Kumarapeli, P., & De Lusignan, S. (2012). Using the computer in the clinical consultation; setting the stage, reviewing, recording, and taking actions: Multi-channel video study. *Journal of the American Medical Informatics Association, 20*(e1), e67-e75.

Kumator, H. (2017). *Classroom assessment primary teachers' perceptions and practices in the AnyakoAfiadenyigba Circuit of the Keta Municipal Assembly (KEMA).* Winneba: University of Education, Winneba.

Kunnan, A. J. (2000). *Fairness and Validation in Language Assessment, Selected Papers from the 19th Language Testing Research Colloquium, Orlando, Florida*. Cambridge: Cambridge University Press.

Kunnan, A. J. (2005). *Towards a model of test evaluation: Using the test fairness and test context frameworks.* In L. Taylor & C. J. Weir (Eds), *Multilingualism and assessment: Achieving transparency, assuring quality, sustaining diversity* (pp. 229-251) Proceedings of the ALTE Berlin Conference. Cambridge: Cambridge University Press.

Kuutti, K. (1996). Activity theory as a potential framework for human-computer interaction research. In *Context and consciousness: Activity theory and human-computer interaction*

(p. 1744) Retireived from https://www.ics.uci.edu/~corps/phaseii/nardi-ch2.pdf [accessed on 20th June, 2019]

Kvalve, S., & Brinkmann, S. (2015). Interviews: *Learning the craft of qualitative research interviewing (Vol 3)*. Thousand Oaks, CA: Sage

Lambert, D., & Lines, D. (2013). *Understanding assessment: Purposes, perceptions, practice*. London: Routledge.

Leahy, S., Lyon, C., Thompson, M., & Wiliam, D. (2005). Classrom assessment: Minute, Minute and Day, *Educational Leadership, 63*(3), 18-24.

Lee, I. (2008). Student reactions to teacher feedback in two Hong Kong secondary classrooms. *Journal of second language writing, 17*(3), 144-164.

Lee, I. (2011). Feedback revolution: What gets in the way? *ELT Journal, 65*(1), 1-12.

Lee, I. (2013). Research into practice: Written corrective feedback. *Language Teaching, 46*(1), 108-119.

Lema, G., & Maro, W. (2016). Secondary School Teachers' Utilization of Feedback in the Teaching and Learning of Mathematics in Tanzania. *Papers in Education and Development, 36*, 104 -117.

Leontiev, A. N. (1981). Problems of development of mind. Moscow: Progress Press.

Li, J. (2015). Exploring teacher ltutor cognition with activity theory: a cose study of feedback given on the written assignments of undergraduate students in a New Zealand university. *Graduate and Postgraduate E- Journal, 4*(2), 1- 14.

Lian, L. H., Yew, W. T., & Meng, C. C. (2014). Enhancing Malaysian Teachers' Assessment Literacy. *International Education Studies, 7*(10), 74-81.

Lightbown, P. M., & Spada, N. (2013). How languages are learned (4th ed.). Oxford: Oxford University Press.

Lines, P. M. (2000). Homeschooling comes of age. *Public Internet, 140*, 74.

Lissitz, R. W., & Schafer, W. D. (2002). *Assessment in Educational Reform: Both Means and Ends*. ERIC.

Loh, J. (2013). Inquiry into issues of trustworthiness and quality in narrative studies: A perspective. *The Qualitative Report, 18*(33), 1-15.

Lopez, R., & Kossack, S. (2007). Effects of recurring use of self-assessment in university courses. *International Journal of Learning, 14*(4).

Low, J. (2013). Unstructured and semi-structured interviews in health research. *Researching health: Qualitative, quantitative and mixed methods, 2*, 87-105.

Lynch, B. K. (2001). Rethinking assessment from a critical perspective. *Language Testing, 18*(4), 351-372.

Magno, C., & Lizada, G. S. (2015). Features of classroom formative assessment. *Educational Measurement and Evaluation Review, 6*.

Maree, K. (2016). *First Steps in Research.* Pretoria: Van Schaik.

Marsh, C. J. (2007). A critical analysis of the use of formative assessment in schools. *Educational Research for Policy and Practice, 6*(1), 25-29.

Marshal, C., & Rossman, G. B. (2006). Designing qualitative research (4th ed.). London: Sage

Martino, A. M., & Maher, C. A. (1999). Teacher questioning to promote justification and generalization in mathematics: What research practice has taught us. *The Journal of Mathematical Behavior, 18*(1), 53-78.

Maxwell, J. A. (2012). *Qualitative research design: An interactive approach* (Vol. 41). London: SAGE Publications.

McCarthy, P., Sithole, A., McCarthy, P., Cho, J.-P., & Gyan, E. (2016). Teacher questioning strategies in mathematical classroom discourse: A case study of two Grade Eight teachers in Tennessee, USA. *Journal of Education and Practice, 7*(21), 80-89.

McClure, J. R., Sonak, B., & Suen, H. K. (1999). Concept map assessment of classroom learning: Reliability, validity, and logistical practicality. *Journal of Research in Science Teaching, 36*(4), 475-492.

McGatha, M. B., Bush, W. S., & Rakes, C. (2009). The effects of professional development in formative assessment on mathematics teaching performance and student achievement. *Journal of Multidisciplinary Evaluation, 6*(12), 32-43.

McKay, P. (2006). *Assessing young language learners.* Stuttgart: Ernst Klett Sprachen.

McMillan, J. H. (1997). *Classroom Assessment. Principles and Practices for Effective Instruction.* ERIC.

McMillan, J. H. (2003). Understanding and improving teachers' classroom assessment decision making: Implications for theory and practice. *Educational Measurement: Issues and Practice, 22*(4), 34-43.

McMillan, J. H. (2007). *Formative classroom assessment: Theory into practice.* New York, NY: Teachers College Press.

McMillan, J. H. (2007a). Formative classroom assessment: The key to improving student achievement. In *Formative classroom assessment: Theory into practice* (pp. 1-7). New York, NY: Teachers College Press.

McMillan, J. H. (2007b). *Formative classroom assessment: Theory into practice.* New York, NY: Teachers College Press.

McMillan, J. H. (2011). *Classroom Assessment. Principles and Practices for Effective Instruction*. Boston: Pearson.

McMillan, J. H. (2013). Why we need research on classroom assessment. In *SAGE Handbook of Research on Classroom Assessment* (pp. 3-16). Thousand Oaks, CA: SAGE Publications.

McMillan, J. H., & Hearn, J. (2008). Student self-assessment: The key to stronger student motivation and higher achievement. *Educational Horizons, 87*(1), 40-49.

McTighe, J., & O'Connor, K. (2005). Assessment to promote learning. Educational Leadership, 63(3), 10 -17.

Mellati, M., & Khademi, M. (2018). Exploring Teachers' Assessment Literacy: Impact on Learners' Writing Achievements and Implications for Teacher Development. *Australian Journal of Teacher Education, 43*(6), 1.

McMillan, J., & Schumacher, S. (2001). Research in education: Evidence - based inquiry. A Conceptual Introduction. New York: Person

Mercy, K. (2012). *Assessment problems in Zimbabwe's primary schools with special reference to Gweru district schools.*(PhD thesis), Zimbabwe Open University, Zimbabwe.

Merriam, S. (2009). *Qualitative research: A guide to design and implementation.* San Fransisco, CA: John Wiley & Sons.

Merriam, S. B.,& Tisdell, E. J. (2015). Qualitative research: A guide to design and implementation. San Francisco: John Wiley & Sons.

Messick, S. (1994). The interplay of evidence and consequences in the validation of performance assessment. *Educational researcher, 23*(2), 13 -23.

Mkhabela, N. D. (2016). *Exploring foundation phase teachers' use of instructional strategies to teach data handling.* (PhD thesis), Univerity of KwaZulu - Natal, Durban.

Mkhwanazi, H. N. (2014). *Teachers' use of formative assessment in the teaching of reading comprehension in Grade 3. Mediterranean Journal of Social Sciences, 5*(7), 468-475.

Mkhwanazi, H. N., Joubert, I., Phatudi, N. C., & Fraser, W. J. (2014). Teachers' use of formative assessment for the teaching of Reading Comprehension in Grade 3. *Mediterranean Journal of Social Sciences, 5*(7), 468.

Moskal, B. M., & Leydens, J. A. (2000). Scoring rubric development: Validity and reliability. *Practical Assessment, Research & Evaluation, 7*(10), 71-81.

Moss, C. M. (2013). Research on classroom summative assessment. In *SAGE Handbook of Research on Classroom Assessment* (pp. 235-255). Loss Angeles: SAGE Publications.

Moss, C. M., Brookhart, S. M., & Long, B. A. (2011). Knowing your learning target. *Educational Leadership, 68*(6), 66-69.

Moutong, E. B., & Prozesky, P. V. B. (2001). The Practice of Social Research. Oxford: University Press.

Moyer, P. S., & Milewicz, E. (2002). Learning to question: Categories of questioning used by preservice teachers during diagnostic mathematics interviews. *Journal of Mathematics Teacher Education, 5*(4), 293-315.

Muijs, D. (2011). Introduction to quantitative research. In D. Muijis (Ed.), Doing quantitative research in education with SPSS (2nd ed., pp. 1 -10). Thousand Oaks, CA: SAGE

Murphy, E., & Rodriguez-Manzanares, M. A. (2008). Using activity theory and its principle of contradictions to guide research in educational technology. *Australasian Journal of Educational Technology, 24*(4), 442-457.

Murphy, F., & Yielder, J. (2010). Establishing rigour in qualitative radiography research. *Radiography, 16*(1), 62-67.

Myhill, D., & Dunkin, F. (2002). What is a good question? *Literacy Today, 33*(8).

Naidoo, J. (2011). *Exploring master teachers' use of visuals as tools in mathematical classrooms.* (Doctoral thesis), University of KwaZulu-Natal, Durban.

National Council for Curriculum and Assessment. (2017). *National Teacher Education Curriculum Framework.* Ghana: Ministry of Education..

National Council for Curriculum and Assessment. (2018). *National Pre-tertiary Education Curriculum Framework for developing subject curricula.* Ghana: Ministry of Education.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics (2014). *Principles to Actions: Ensuring Mathematics Success for all*. Reston, VA: Author.

National Teaching Council. (2017). *National Teachers' Standard for Ghana Guidelines*. Ghana: Ministry of Education

Neibling, J. (2014). Teachers' conceptions towards type of assessment: Grade level and State tested content area. (Masters dissertation), University of Kansa, Kanas city.

Newby, P. (2010). *Research Methods for Education.* Harlow: Pearson Education.

Ngwenya, J. C. (2012). *Formative assessment in accounting: exploring teachers' understanding and practices* (PhD thesis). University of KwaZulu-Natal, Durban.

Nind, M., & Todd, L. (2011). Prospects for Educational Research. *International Journal of Research and Methods in Education, 1*(34), 1 -2.

Niss, M. (2013). *Cases of assessment in mathematics education: An ICMI study* (Vol. 1). Kluwer: Dordrecht.

Njie, B., & Asimiran, S. (2014). Case study as a choice in qualitative methodology. *Journal of Research & Method in Education, 4*(3), 35-40.

Noori, A., Shafie, N. H., Mashwani, H. U., & Tareen, H. (2017). Afghan EFL Lecturers' Assessment Practices in the Classroom. *Imperial Journal of Interdisciplinary Resources, 3* (10), 130 - 143.

Odoro-Okyireh, G., Akyina, K. O., Ansah-Hughes, W., & Torkornoo, P. (2015). Formative assessment practices of senior high school teachers in the Ashanti Mampong Municipality of Ghana. *International Journal of Academic Research and Reflection, 3*(7), 55-66.

Oduro, E. O. (2015). *Assessment in mathematics classrooms in Ghana: A study of teachers' practices.* Brighton: University of Sussex.

Onwuegbuzie, A. J., & Leech, N. L. (2007). Validity and qualitative research: An oxymoron? *Quality & Quantity, 41*(2), 233-249.

Ord, K., Mane, J., Smorti, S., Carroll-Lind, J., Robinson, L., Armstrong-Read, A., . . . Jalal, J. (2013). Developing pedagogical leadership in early childhood education. Wellington: NZ Childcare Association.

Ortenzi, J. (2002). *Probing questions paper*. Retrived from

http://www.personal.psu.edu/users/j/x/jxo151/SCIEDweb458/probing_questions.htm (accessed on August 7, 2018).

Osanloo, A., & Grant, C. (2016). Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your "house". *Administrative issues journal: connecting education, practice, and research*, *4*(2), 7.

Panadero, E., & Jonsson, A. (2013). The use of scoring rubrics for formative assessment purposes revisited: A review. *Educational Research Review, 9*, 129-144.

Parson, R., & Brown, K. (2002). *Teacher as reflective practitioner and action researcher*. Belmont, CA: Wadsworth.

Patton, M. (2015). Purposeful sampling and case selections: Overview of strategies and options, In. *Qualitative research & evaluation methods: Integrating theory and practice* (p. 265). Thousand Oaks, CA: SAGE Publications.

Perumanathan, P. S. (2014). Formative assessment and feedback in the primary classroom: An interplay between teachers belief and practice. (Doctoral thesis), Victoria University of Wellington, New Zealand.

Polit, D. F., & Beck, C. T. (2014). Essentials of nursing research: Appraising evidence for nursing practice (8 th ed.). Philadelphia. PA: Wolters Kluwer.

Polly, D., Allman, B., Casto, A., & Norwood, J. (2017). Sociocultural Perspectives of Learning. In R. E. West, *Foundations of Learning and Instructional Design Technology* (Chapter 12). EdTech Books. Retrieved from https://edtechbooks.org/. (accessed on July 10, 2019)

Popham, J. (2008). *Transformative Assessment*. Alexandria, VA: Association for Supervision and Curriculum Development (ACSD).

Popham, W. J. (2009). Assessment literacy for teachers: Faddish or fundamental? *Theory into Practice*, *48*(1), 4-11.

Prashanti, E., & Ramnarayan, K. (2019). *Ten maxims of formative assessment*. Bethesda, MD: American Physiological Society.

Pryor, J., & Crossouard, B. (2008). A socio-cultural theorisation of formative assessment. *Oxford Review of Education, 34*(1), 1-20.

Quansah, K. B. (2005). Continous assessment handbook: BECAS project document (pp. 2-3).: Accra: Ghana Education Service Publication.

Radatz, H. (1980). Students' errors in the mathematical learning process: a survey. *For the Learning of Mathematics, 1*(1), 16-20.

Ramsey, B., & Duffy, A. (2016). Formative assessment in the classroom: Findings from three districts. West Lake Hills, TX: Michael and Susan Dell Foundation and Education First.

Rao, N., & Sun, J. (2010). *Early childhood care and education in the Asia-Pacific region: Moving towards Goal 1(p.97).* Hong Kong: CERC, the University of Hong Kong/UNESCO.

Raveaud, M. (2004). Assessment in French and English infant schools: Assessing the work, the child or the culture? *Assessment in Education: Principles, Policy & Practice, 11*(2), 193-211.

Reddy, Y. M., & Andrade, H. (2010). A review of rubric use in higher education. *Assessment & Evaluation in Higher Education, 35*(4), 435-448.

Rehman, A. A., & Alharthi, K. (2016). An introduction to research paradigms. *International Journal of Educational Investigations, 3*(8), 51-59.

Resnick, L. B., & Resnick, D. P. (1992). Assessing the thinking curriculum: New tools for educational reform. In B. G. Gifford & M. C. O'Conner (Eds.), Changing assessments:Alternative views of aptitude, achievement and instruction (pp. 37 - 75). Boston: Kluwer Academic Publishers.

Reynek, M., Meyer, L., & Nel, C. (2010). School-based assessment: the leash needed to keep the poetic 'unruly pack of hounds' effectively in the hunt for learning outcomes. *South African Journal of Education, 30*(2).

Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: a systematic review and meta-analysis. *Psychological Bulletin, 138*(2), 353 - 387.

Rogoff, B. (2008). Observing sociocultural activity on three planes: Participatory appropriation, guided participation, and apprenticeship. *Pedagogy and Practice: Culture and Identities*, 58-74.

Rolheiser, C., & Ross, J. A. (2001). Student self-evaluation: What research says and what practice shows. *Plain Talk About Kids, 43*, 57.

Rossman, G. B., & Rallis, S. F. (2016). *An introduction to qualitative research: Learning in the field.* Los Angeles: Sage Publications.

Rowland, T., & Ruthven, K. (2011). Introduction: Mathematical knowledge in teaching. In *Mathematical knowledge in teaching* (pp. 1-5). Dordrecht: Springer.

Rowntree, D. (2015). *Assessing students: How shall we know them?* London: Routledge.

Rubin, H. J., Rubin, I. S. (2013).Qualitative interviewing: The art of hearing data (3th ed.). Thousand Oaks, CA: Sage Publications.

Ruiz-Primo, M. A. (2011). Informal formative assessment: The role of instructional dialogues in assessing students' learning. *Studies in Educational Evaluation, 37*(1), 15-24.

Ruiz-Primo, M. A., & Furtak, E. M. (2007). Exploring teachers' informal formative assessment practices and students' understanding in the context of scientific inquiry. *Journal of Research In Science Teaching, 44*(1), 57-84.

Rule, P., & John, V. (2011). *Your guide to case study research.* Pretoria: Van Schaik.

Ryder, L., & Yamagata-Lynch, L. (2014). Understanding tensions: Activity systems analysis of transpacific collaboration. *CALICO Journal, 31*(2), 201-220.

Sadler, D. R. (1989). Formative assessment and the design of instructional systems. *Instructional Science, 18*(2), 119-144.

Saeed, T., Khan, S., Ahmed, A., Gul, R., Cassum, S., & Parpio, Y. (2012). Development of students' critical thinking: The educators' ability to use questioning skills in the baccalaureate programmes in nursing in Pakistan. *Journal of the Pakistan Medical Association, 62*(3), 200.

Sahin, A. (2007). Teachers' classroom questions. *School Science and Mathematics, 107*(1), 369-371.

Sahin, A., & Kulm, G. (2008). Sixth grade mathematics teachers' intentions and use of probing, guiding, and factual questions. *Journal of Mathematics Teacher Education, 11*(3), 221-241.

Salvia, J., Ysseldyke, J., & Witmer, S. (2012). *Assessment: In special and inclusive education.* Boston: Cengage Learning.

Sardareh, S. A., & Saad, M. R. M. (2012). A sociocultural perspective on assessment for learning: The case of a Malaysian primary school ESL context. *Procedia-Social and Behavioral Sciences, 66*, 343-353.

Santiago, N. (2009). Interview Types: Structured, Semi - Structured and Unstructured. Retrived from www. examiner.com / article/ interview -types -structured-semi-structured- and

unstructured. (accessed on Februrary, 2019)

Sato, M., Wei, R. C., & Darling-Hammond, L. (2008). Improving teachers' assessment practices through professional development: The case of National Board Certification. *American Educational Research Journal, 45*(3), 669-700.

Schartel, S. A. (2012). Giving feedback–An integral part of education. *Best Practice & Research Clinical Anaesthesiology, 26*(1), 77-87.

Seifried, J., & Wuttke, E. (2010). Student errors: how teachers diagnose and respond to them. *Empirical Research in Vocational Education And Training, 2*(2), 147-162.

Senk, S. L., Beckmann, C. E., & Thompson, D. R. (1997). Assessment and grading in high school mathematics classrooms. *Journal for Research in Mathematics Education*, 187-215.

Sethusha, M. J. (2012). *An investigation of the challenges affecting teachers' classroom assessment practices.* (Doctoral dissertation), University of South Africa, Pretoria.

Shavelson, R. J. (2003). *On the integration of formative assessment in teaching and learning with implications for teacher education.* Paper presented at the Biannual Meeting of the European Association for Research on Learning and Instruction, Padova, Italy, 2003.

Shepard, L. (2001). The role of classroom assessment in teaching and learning. In Handbook of Research on Teaching, ed. V. Richardson (4th ed.). Washington D.C: American Educational Research Association.

Shepard , L. A. (2005). Linking formative assessment to scaffolding. *Educational Leadership, 63*(3), 66-70.

Shermis, M. D., & DiVesta, F. J. (2011). *Classroom assessment in action.* Lanham, MD: Rowman & Littlefield Publishers.

Shrivasta, S. R., Shrivasta, P. S., & Ramasamy, J. (2014). Effective feedback: An indispensable tool for improvement in quality of medical education. *Journal of Pedagogic Development, 4*(1), 12 -20.

Shute, V. J. (2008). Focus on formative feedback. *Review of Educational Research, 78*(1), 153-189.

Siegel, M. A., & Wissehr, C. (2011). Preparing for the plunge: Preservice teachers' assessment literacy. *Journal of Science Teacher Education, 22*(4), 371-391.

Silver, E. A. (1992). Assessment and mathematics education reforms in the United States. *International Journal of Educational Research, 17*(5), 489 -502.

Simons, H. (2009). *Case study research in practice.* London: SAGE Publications.

Singh, D. (2016). *Exploring mathematics lecturers reflections on assessing ESL students.*(Honours dissertation), University of KwaZulu - Natal, Durban.

Sinkovics, R. R., & Alfoldi, E. A. (2012). Progressive focusing and trustworthiness in qualitative research. *Management International Review, 52*(6), 817-845.

Smith, E., & Gorard, S. (2005). 'They don't give us our marks': the role of formative feedback in student progress. *Assessment in Education: Principles, Policy & Practice, 12*(1), 21-38.

Stake, R. E. (2013). *Multiple case study analysis.* New York: Guilford Press.

Stobart, G. (2005). Fairness in multicultural assessment systems. *Assessment in Education: Principles, Policy & Practice, 12*(3), 275-287.

Stolk, K. (2013). Types of Questions that Comprise a Teacher's Questioning Discourse in a Conceptually-Oriented Classroom.(Master's dissertation), Brigham Young University, Utah.

Strauss, J., & Myburgh, C. (2001). *Research Methodology* (Study Guide 81416). Johannesburg: University of Johannesburg.

Supovitz, J. (2012). Getting at student understanding--the key to teachers' use of test data. *Teachers College Record, 114*(11), n11.

Susuwele-Banda, W. J. (2005). *Classroom Assessment in Malawi: Teachersâ Perceptions and Practices in Mathematics.*(Doctoral dissertation), Virginia Polytechnic Institute and Stae University, Virginia.

Sutton, R. (2010). Making formative assessment the way the school does business: The impact and implications of formative assessment for teachers, students and school leaders. In *Second international handbook of educational change* (pp. 883-899). New York: Springer.

Swaffield, S. (2011). Getting to the heart of authentic assessment for learning. *Assessment in Education: Principles, Policy & Practice, 18*(4), 433-449.

Taras, M. (2009). Summative assessment: The missing link for formative assessment. *Journal of Further and Higher Education, 33*(1), 57-69.

Taras, M. (2010). Assessment for learning: assessing the theory and evidence. *Procedia-Social and Behavioral Sciences, 2*(2), 3015-3022.

Tessier, S. (2012). From field notes, to transcripts, to tape recordings: Evolution or combination? *International Journal of Qualitative Methods, 11*(4), 446-460.

Thacker, W. D. (2016). A phenomenological study of middle school teachers' implementation of formative assessment practices in a semi-rural Northwest Georgia District. Master's Dissertation, Liberty University.

Thanh, N. C., & Thanh, T. (2015). The interconnection between interpretivist paradigm and qualitative methods in education. *American Journal of Educational Science, 1*(2), 24-27.

Thomas, E., & Magilvy, J. K. (2011). Qualitative rigor or research validity in qualitative research. *Journal for Specialists in Pediatric Nursing, 16*(2), 151-155.

Thomas, G. (2010). *How to do your case study*. London: Sage.

Thomas, J. D., & Arnold, R. M. (2011). Giving feedback. *Journal of Palliative Medicine, 14*(2), 233-239.

Thomas, L., Deaudelin, C., Desjardins, J., & Dezutter, O. (2011). Elementary teachers' formative evaluation practices in an era of curricular reform in Quebec, Canada. *Assessment in Education: Principles, Policy & Practice, 18*(4), 381-398.

Thompson, N. A. (2013). Reliability & Validity. *Journal of Language Teaching & Research, 3*(3), 30-32.

Thorgeirsdottir, H. (2015). Investigating the use of action research and activity theory to promote the professional development of teachers in Iceland. (Doctoral thesis), University of Iceland and University of Exeter.

Threlfall, J. (2005). The formative use of assessment information in planning–the notion of contingent planning. *British Journal of Educational Studies, 53*(1), 54-65.

Tiekstra, M., Minnaert, A., & Hessels, M. G. (2016). A review scrutinising the consequential validity of dynamic assessment. *Educational Psychology, 36*(1), 112-137.

Tighe-Mooney, S., Bracken, M., & Dignam, B. (2016). Peer Assessment as a teaching and learning process: The observations and reflections of three facilitators on a first-year undergraduate critical skills module. *AISHE-J: The All Ireland Journal of Teaching and Learning in Higher Education, 8*(2).

Tillema, H., Leenknecht, M., & Segers, M. (2011). Assessing assessment quality: Criteria for quality assurance in design of (peer) assessment for learning–a review of research studies. *Studies in Educational Evaluation, 37*(1), 25-34.

Tobin, G. A., & Begley, C. M. (2004). Methodological rigour within a qualitative framework. *Journal of Advanced Nursing, 48*(4), 388-396.

Tofade, T., Elsner, J., & Haines, S. T. (2013). Best practice strategies for effective use of questions as a teaching tool. *American journal of pharmaceutical education*, *77*(7), 1 -8.

Topping, K. J. (2009). Peer assessment. *Theory into practice, 48*(1), 20 -27.

Topping, K. J. (1998). Peer assessment between students in colleges and universities. *Review of Educational Research, 68*(3), 249-276.

Torrance, H., & Pryor, J. (1998). *Investigating formative assessment: Teaching, learning and assessment in the classroom.* Buckingham: McGraw-Hill Education (UK).

Tracy, S. J. (2019). *Qualitative research methods: Collecting evidence, crafting analysis, communicating impact.* Malden, MA: John Wiley & Sons.

Trumbull, E., & Lash, A. (2013). *Understanding formative assessment. Insights from learning theory and measurement theory.* San Francisco, CA: WestEd.

Tsui, A. B., Edwards, G., Lopez-Real, F., Kwan, T., Law, D., Stimpson, P., . . . Wong, A. (2008). *Learning in school-university partnership: Sociocultural perspectives*. New York: Routledge.

Uden, L. (2007). Activity theory for designing mobile learning. *IJMLO, 1*(1), 81-102.

Van de Walle, J. A. (2001). Teaching through problem solving. *In Elementary and Middle School Mathematics* (pp. 40-61). New York: Longman.

Van der Walle, J. A. (2007). Elementary and middle school mathematics: *Teaching developmentally.* Boston: Allyn and Bacon.

Van Gennip, N. A., Segers, M. S., & Tillema, H. H. (2010). Peer assessment as a collaborative learning activity: The role of interpersonal variables and conceptions. *Learning and Instruction, 20*(4), 280-290.

Van Teijlingen, E., & Hundley, V. (2002). The importance of pilot studies. *Nursing Standard, 16*(40).

Vandeyar, S., & Killen, R. (2007). Educators' conceptions and practice of classroom assessments in post-apartheid South Africa. *South African Journal of Education, 27*(1), 101-115.

Velan, G. M., Kumar, R. K., Dziegielewski, M., & Wakefield, D. (2002). Web-based self-assessments in pathology with Questionmark Perception. *Pathology, 34*(3), 282-284.

Vingsle, C. (2014). *Formative assessment: Teacher knowledge and skills to make it happen.* Umeå, Sweden: Umeå Universitet.

Vygotsky, L. S. (1980). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Wahyuni, D. (2012). The research design maze: Understanding paradigms, cases, methods and methodologies. *Journal of Applied Management Accounting Research*, *10*(1), 69-80.

Walker, M. (2013). Feedback and feedforward: Student respnses and their implications. In S. Merry., M. Price., D. Carless., & M. Taras (eds.), *Reconceptualising feedback in higher education: Developing dialogue with students* (pp. 103-112).New York: Routledge.

Wang, L., Bruce, C., & Hughes, H. (2011). Sociocultural theories and their application in information literacy research and education. *Australian Academic & Research Libraries, 42*(4), 296-308.

Wang, T.-H. (2007). What strategies are effective for formative assessment in an e-learning environment? *Journal of Computer Assisted Learning, 23*(3), 171-186.

Warren, C. A., & Karner, T. X. (2015). *Discovering qualitative methods: Ethnography, interviews, documents, and images.* Oxford: Oxford University Press.

Wass, R., & Golding, C. (2014). Sharpening a tool for teaching: The zone of proximal development. *Teaching in Higher Education, 19*(6), 671-684.

Wass, R., Harland, T., & Mercer, A. (2011). Scaffolding critical thinking in the zone of proximal development. *Higher Education Research & Development, 30*(3), 317-328.

Ward, M., Gruppen, L., & Regehr, G. (2002). Measuring self-assessment: current state of the art. *Advances in health sciences education, 7*(1), 63-80.

Watson, A. (2006). Some difficulties in informal assessment in mathematics. *Assessment in Education, 13*(3), 289 - 303.

Wears, R. L. (2000). Beyond error. *Academic Emergency Medicine, 7*(11), 1175-1176.

Weaver, M. R. (2006). Do students value feedback? Student perceptions of tutors' written responses. *Assessment & Evaluation in Higher Education, 31*(3), 379-394.

Webb, N. M. (1991). Task-related verbal interaction and mathematics learning in small groups. *Journal for Research in Mathematics Education*, 366-389.

Weiss, I. R., & Pasley, J. D. (2004). What is high-quality instruction? *Educational Leadership, 61*(5), 24.

Wen, M. L., & Tsai, C.-C. (2006). University students' perceptions of and attitudes toward (online) peer assessment. *Higher Education, 51*(1), 27-44.

West, L., & Thorn, R. (2001). Goal-setting, self-efficacy, and memory performance in older and younger adults. *Experimental Aging Research, 27*(1), 41-65.

Westberry, N. C. (2009). *An activity theory analysis of social epistemologies within tertiary-level elearning environments.*(Doctoral thesis), University of Waikato.

Widodo, H. P. (2014). Methodological considerations in interview data transcription. *International Journal of Innovation in English Language Teaching and Research, 3*(1), 101-107.

Wiliam, D. (2007a). Changing classroom practice. *Educational Leadership, 65*(4), 36.

Wiliam, D. (2007b). Keeping learning on track: *Classroom assessment and regulation of learning*. In F. K. Lester Jr. (Ed.), *Second handbook of research on mathematics teaching and learning (pp.* 1053-1098). Greenwich, CT: Information Age P.

Wiliam, D. (2009). *Content then process: Teacher learning communities in the service of formative assessment.* Bloomington: Solution Tree Press.

Wiliam, D. (2011). *Embedded formative assessment.* Bloomington: Solution Tree Press.

Wiliam, D., Lee, C., Harrison, C., & Black, P. (2004). Teachers developing assessment for learning: Impact on student achievement. *Assessment in Education: Principles, Policy & Practice, 11*(1), 49-65.

Wiliam, D., & Thompson, M. (2008). *Integrating assessment with learning: What will it take to make it work?* New York: Lawrence Erlbaum Associates.

Willis, J. (2009). Assessment for learning: a sociocultural approach. *Proceedings of Changing climates: Education for sustainable futures:* Australian Association for Research in Education (AARE) Conference, Kelvin Grove, Queensland, Australia, 30 November 2008, 1–10. (accessed 15 August 2018).

Willis, J. W., Jost, M., & Nilakanta, R. (2007). *Foundations of qualitative research: Interpretive and critical approaches.* London: SAGE Publications.

Wilson, M. (2018). Classroom Assessment: Continuing the Discussion. *Educational Measurement: Issues and Practice, 37*(1), 49 -51

Wilson, V. (2014). Examining teacher education through cultural-historical activity theory. *Teacher Education Advancement Network Journal (TEAN), 6*(1), 20-29.

Wininger, S. R. (2005). Using your tests to teach: Formative summative assessment. *Teaching of Psychology*, *32*(3), 164-166.

Wojtas, O. (1998). Feedback? No, just give us the answers. *Times Higher Education Supplement*, *25*(7).

Wragg, E. C. (2003). *Assessment and learning in the primary school.* London: Routledge.

Yamagata-Lynch, L. C. (2010). *Activity systems analysis methods: Understanding complex learning environments.* London: Springer Science & Business Media.

Yamauchi, L. A., Ponte, E., Ratliffe, K. T., & Traynor, K. (2017). Theoretical and conceptual frameworks used in research on family-school partnerships. *School Community Journal, 27*(2), 9-34.

Yang, M., Badger, R., & Yu, Z. (2006). A comparative study of peer and teacher feedback in a Chinese EFL writing class. *Journal of second language writing*, *15*(3), 179-200.

Yao, Y. (2015). Teacher perceptions of classroom assessment: A focus group interview. *SRATE Journal, 24*(2), 51-58.

Yin, R. K. (2011). *Applications of case study research.* London: SAGE Publications.

Yin, R. K. (2014). *Case study research: Design and methods* (5th ed.). London: SAGE Publications.

Yorke, M. (2003). Formative assessment in higher education: Moves towards theory and the enhancement of pedagogic practice. *Higher Education, 45*(4), 477-501.

Young, J. E., & Jackman, M. G.-A. (2014). Formative assessment in the Grenadian lower secondary school: Teachers' perceptions, attitudes and practices. *Assessment in Education: Principles, Policy & Practice, 21*(4), 398-411.

Zaslavsky, O. (2009). Mathematics educators' knowledge and development. In R. Even, & D.L.Ball (Eds.), the professional education and development of teachers of mathematics (pp. 105 -111). Springer, Boston, MA.

Zepeda, S. J. (2014). *The instructional leader's guide to informal classroom observations.* Larchmont, NY: Routledge.

Appendices

Appendix A: Ethical Clearance Certificate from UKZN

27 November 2018

Mr Justice Enu 218081769
School of Education
Edgewood Campus

Dear Mr Enu

Protocol reference number: HSS/1981/018D
Project Title: Exploration of mathematics teacher educators' understanding and practices of formative assessment in Ghana.

Full Approval – Expedited Application

In response to your application dated 25 October 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application 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.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

.....
Prof S Singh

/px

cc Supervisor: Dr AZ Ndlovu
cc Academic Leader Research: Dr SB Khoza
cc School Administrator: Mr SN Mthembu, Ms M Ngcobo and Ms S Jeenarain

Humanities & Social Sciences Research Ethics Committee
Professor Shenuka Singh (Chair)/Dr Shamila Naidoo (Deputy Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
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Website: www.ukzn.ac.z

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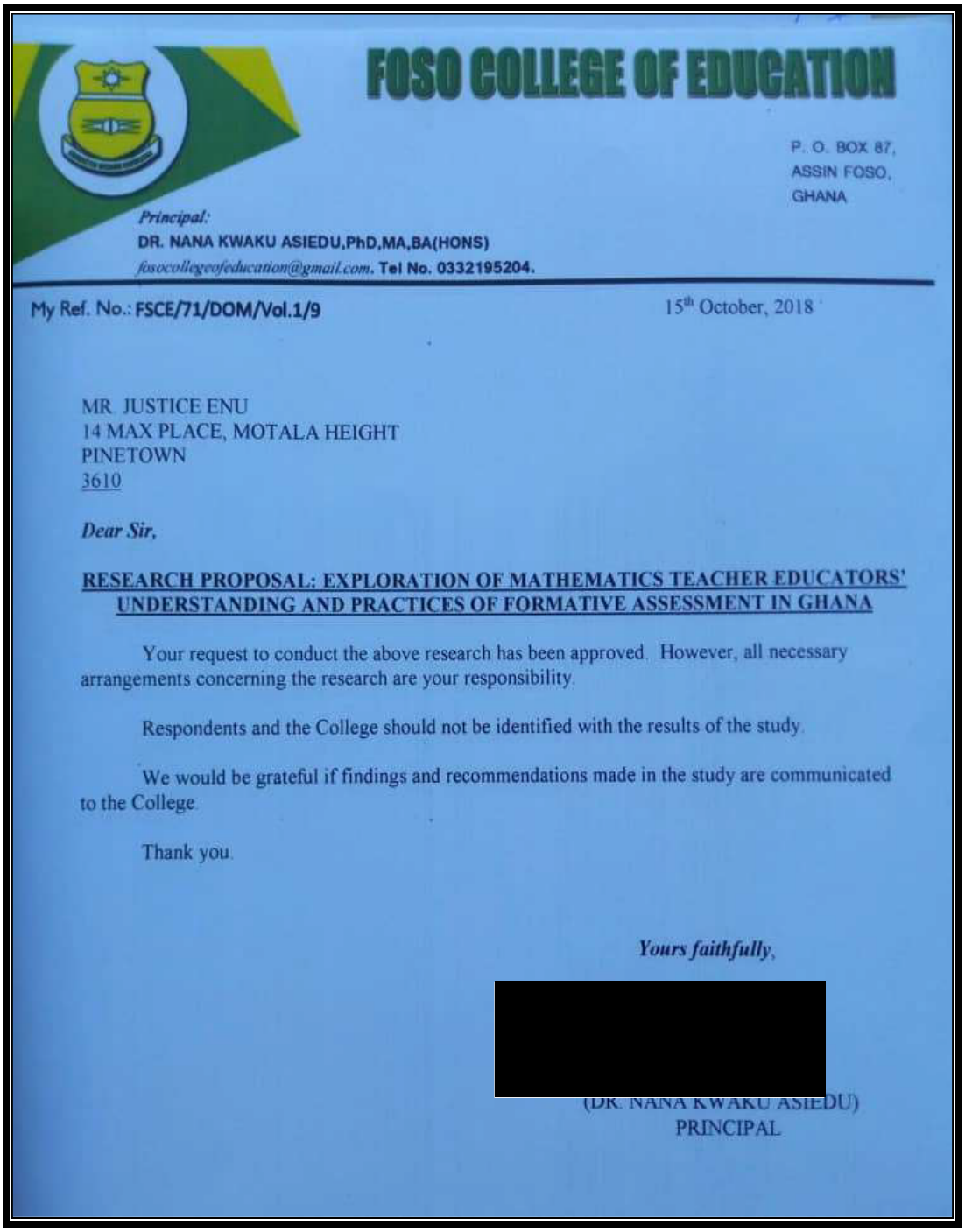
Appendix B1: Approval from Colleges

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATAL



FOSO COLLEGE OF EDUCATION

P. O. BOX 87,
ASSIN FOSO,
GHANA

Principal:
DR. NANA KWAKU ASIEDU,PhD,MA,BA(HONS)
fosocollegeofeducation@gmail.com. Tel No. 0332195204.

My Ref. No.: FSCE/71/DOM/Vol.1/9

15th October, 2018

MR. JUSTICE ENU
14 MAX PLACE, MOTALA HEIGHT
PINETOWN
3610

Dear Sir,

RESEARCH PROPOSAL: EXPLORATION OF MATHEMATICS TEACHER EDUCATORS' UNDERSTANDING AND PRACTICES OF FORMATIVE ASSESSMENT IN GHANA

Your request to conduct the above research has been approved. However, all necessary arrangements concerning the research are your responsibility.

Respondents and the College should not be identified with the results of the study.

We would be grateful if findings and recommendations made in the study are communicated to the College.

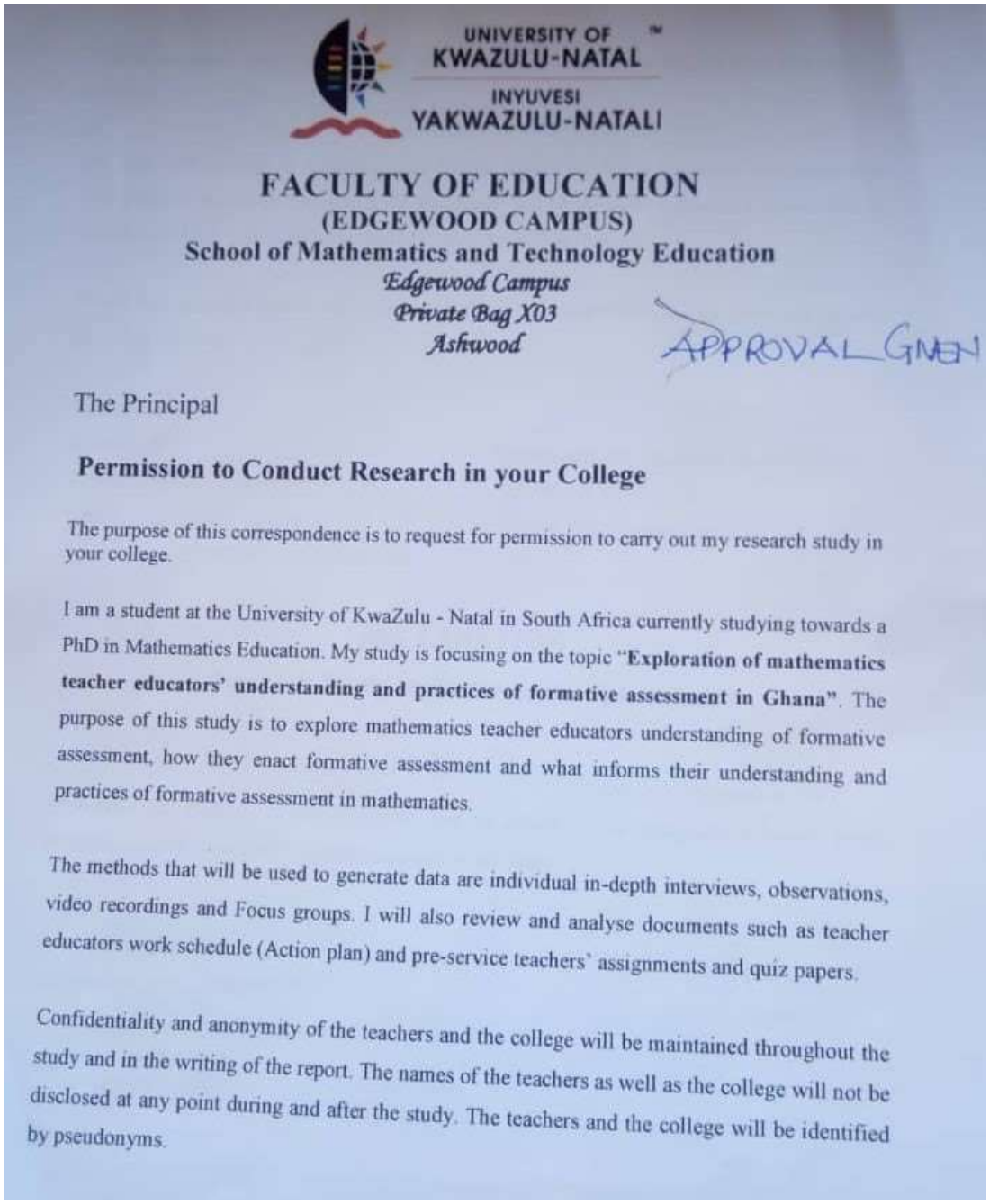
Thank you.

Yours faithfully,

[redacted]

(DR. NANA KWAKU ASIEDU)
PRINCIPAL

Appendix B2



UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

FACULTY OF EDUCATION
(EDGEWOOD CAMPUS)
School of Mathematics and Technology Education
Edgewood Campus
Private Bag X03
Ashwood

APPROVAL GMEN

The Principal

Permission to Conduct Research in your College

The purpose of this correspondence is to request for permission to carry out my research study in your college.

I am a student at the University of KwaZulu - Natal in South Africa currently studying towards a PhD in Mathematics Education. My study is focusing on the topic "**Exploration of mathematics teacher educators' understanding and practices of formative assessment in Ghana**". The purpose of this study is to explore mathematics teacher educators understanding of formative assessment, how they enact formative assessment and what informs their understanding and practices of formative assessment in mathematics.

The methods that will be used to generate data are individual in-depth interviews, observations, video recordings and Focus groups. I will also review and analyse documents such as teacher educators work schedule (Action plan) and pre-service teachers' assignments and quiz papers.

Confidentiality and anonymity of the teachers and the college will be maintained throughout the study and in the writing of the report. The names of the teachers as well as the college will not be disclosed at any point during and after the study. The teachers and the college will be identified by pseudonyms.

Teacher educators' participation in the study is voluntary and can withdraw from this study at any time.

The data will be kept in a secure place by the University for a period of five years after submission of the thesis, after which the documents will be shredded and video cassettes will be incinerated. All the electronic copies in my computer will be deleted.

Please find enclosed herein my contact and that of my supervisor if you have any queries regarding the study.

Yours sincerely,

Justice Enu
Students Number: 218081769
E-mail: enukj28@gmail.com
Tel. No. +27638709134 / +233268012256

Supervisor: Dr. Annatoria Zanele Ndlovu
Tel. No. +27724011275
E-mail: Ndlovuz3@ukzn.ac.za

DECLARATION

Research Study in Mathematics Education

I REV. SISTER ELIZABETH AMOAKO (full name) hereby confirm that I understand the contents of this document and the nature of the study and I hereby grant permission to the researcher to conduct research in my school.

[redacted]
.....Signature of Principal

PRINCIPAL
OLA COLLEGE OF EDUCATION
P. O. BOX 175
CAPE COAST

22/10/18
Date

Appendix B3

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

KOMENDA
COLLEGE OF EDUCATION

P. O. Box CK 5
Komenda, Ghana

Our Ref. KMCE/CR/NTS/Vol./014

Your Ref.

12th October, 2018
Tel. office (03321) 91768
Residence (03321) 91769

Mr. Justice Enu
14 Max Place, Motala Height
Pinetown
3610

Research Proposal: Exploration of Mathematics Teacher Educators' Understanding and Practices of Formative Assessment in Ghana.

Your application to conduct the above research in this college has been approved subject to the observation of following conditions:

1. Make all the necessary arrangements concerning the investigation.
2. Educators and the college should not be identifiable in any way from the results of the investigation.
3. Ensure that educators' programmes are not interrupted.
4. Interviews are not conducted during the time of examination.
5. Upon completion of the research, a brief summary of interview content, findings and recommendation should be provided to the Principal.

Yours Sincerely,

[redacted]

Mrs. Comfort Sarpong Akosa
Principal

cc:
Head of Department
Mathematics and ICT

Appendix C: Letter seeking permission from Colleges

FACULTY OF EDUCATION
(EDGEWOOD CAMPUS)
School of Mathematics and Technology Education
Edgewood Campus
Private Bag X03
Ashwood

The Principal
X College of Education
Central Region – Ghana.

Sir / Madam,

Permission to Conduct Research in your College

The purpose of this correspondence is to request for permission to carry out my research study in your college. I am a student at the University of KwaZulu - Natal in South Africa currently studying towards a PhD in Mathematics Education. My study is focusing on the topic "**Exploration of mathematics teacher educators' understanding and practices of formative assessment in Ghana"**. The purpose of this study is to explore mathematics teacher educators understanding of formative assessment, how they enact formative assessment and what informs their understanding and practices of formative assessment in mathematics.

The methods that will be used to generate data are individual in-depth interviews, observations and Focus group discussion. I will also review and analyze documents such as teacher educators work schedule (Action plan) and pre-service teachers' assignments and quiz papers.

Confidentiality and anonymity of the teachers and the college will be maintained throughout the study and in the writing of the report. The names of the teachers as well as the college will not be

disclosed at any point during and after the study. The teachers and the college will be identified by pseudonyms.

Teacher educators' participation in the study is voluntary and can withdraw from this study at any time. The data will be kept in a secure place by the University for a period of five years after submission of the thesis, after which the documents will be shredded and video cassettes will be incinerated. All the electronic copies in my computer will be deleted.

Please find enclosed herein my contact and that of my supervisor if you have any queries regarding the study.

Yours sincerely,

Justice Enu
Students Number: 218081769
E-mail: enukj28@gmail.com
Tel. No. +27638709134 / +233268012256

Supervisor: Dr. Annatoria Zanele Ndlovu
Tel. No. +27724011275
E-mail: Ndlovuz3@ukzn.ac.za

DECLARATION

Research Study in Mathematics Education

I …… (full name) hereby confirm that I

understand the contents of this document and the nature of the study and I hereby grant permission to the researcher to conduct research in my college.

…… ……

Signature of Principal Date

Appendix D: Letter seeking permission from participants

FACULTY OF EDUCATION
(EDGEWOOD CAMPUS)
School of Mathematics and Technology Education
Edgewood Campus
Private Bag X03
Ashwood

Dear Colleague in education

Letter of Informed Consent to Participate in Research

My name is Justice Enu, I am a PhD student at the University of KwaZulu – Natal, Edgewood campus, South Africa. I am interested in learning about mathematics teacher educators understanding of formative assessment. You are therefore being invited to participate in this study. The purpose of this study is to find out Mathematics teacher educators understanding and practices of formative assessment in mathematics modules. In all a total of six (6) mathematics teacher educators from three teacher Colleges are expected to be involved in the study. Two teachers' educators' from each College.

In order to get information for this study, I will be conducting semi-structured interviews and the questions will be open ended through interview schedule. The questions will be focused on formative assessment. This will be followed with lesson observation during scheduled times to allow for an in-depth contextual study of the selected teacher educators classroom practices. The duration of your participation if you choose to enroll and remain in the study is expected to be one month.

Your participation in this research is voluntary and you have the right to withdraw without any negative consequences. However, your participation will be valuable in that the findings may

proposes a theoretical construction of teacher development that will inform policy and decisions regarding the teaching of mathematics in the teacher colleges.

Please, upon the completion of the study, a brief summary of the findings as well as recommendation made will be sent to you through your head of department.

The information you shall provide will be treated as confidential as possible. Your name and that of your college will not be shown in any manner in the report of this study and you have the right to review any information being used in this study. Data generated will be stored in secured and destroyed after 5 years.

In the event of any problem (s) or concerns /questions you may contact the researcher at +233268012256 or enukj28@gmail.com or my supervisor Dr. Annatoria Zanele Ndlovu at the University of KwaZulu – Natal on

+27312603784.

You may also contact UKZN Humanities & Social Sciences Research Ethics Committee; contact details as follows:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus

Govan Mbeki Building

Private Bag X 54001
Durban
4000

KwaZulu-Natal, SOUTH AFRICA

Tel: 27 31 2604557- Fax: 27 31 2604609

Email: HSSREC@ukzn.ac.za

Thank you for your contribution to this research

…….. ……

Justice Enu Date

DECLARATION

I …… (**Full name of participant**) have been informed about the study entitled Exploration of Mathematics teacher educators understanding and practices of formative assessment in Ghana by Mr. Justice Enu. I understand the purpose and procedures of the study and have also been given an opportunity to answer questions about the study and have had answers to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any of the benefits that I usually am entitled to. If I have any further questions/concerns or queries related to the study I understand that I may contact the researcher at enukj28@gmail.com or +233268012256.

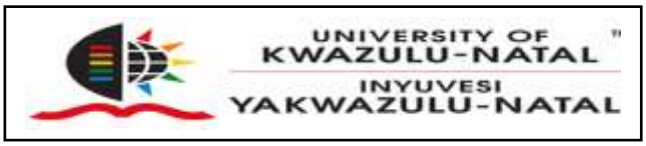
If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact the Research Office through Tel: + 27 31 2604557

Fax: 27 31 2604609 or Email: HSSREC@ukzn.ac.za.

I hereby provide consent to (**by ticking as applicable**) whether or not you are willing to allow the interview and classroom observation to be recorded by the following instruments:

	Yes	**No**
Audio record my interview		
Video record my lesson		
Video record focus group discussion		

Appendix E: Semi -Structured Interview Protocol



Critical question

1. **What are mathematics teacher educators' understanding and practices of formative assessment in mathematics**?

Please, as mentioned early the aim of this study is to gather data about your understanding and practices of formative assessments and therefore your identity and responses provided will be confidential and been used for the purposes of this study only.

Sir / Madam,

1. Tell me your experience of teaching as mathematics teacher educator.
2. Why do you assess students in mathematics?
3. What is your understanding of assessment in mathematics?
4. What does formative assessment mean to you?

   Prompt: How different is it from summative assessment?
5. What is the role of formative assessment in the teaching and learning of mathematic
6. What influence your assessment practices?
7. Do you know some of the formative assessment tools / techniques?

   Prompt: Can you mention some of these tools / techniques?
8. Do you use any of this formative assessment tools in your teaching?

   Prompt: why is it that you use or do not use this tool?
9. What kinds of difficulties do you experience in applying formative assessment and why?
10. Why do you think feedback is important in the teaching and learning process?
11. What form of feedback do you give to your students?

    Prompts:

    a) What do you think you achieve for providing feedback to your students?

    b) Do you think your students make use of the feedback you provide them?

    c) How do you ensure that they use it?

Appendix F: Lesson - observation Protocol

Critical question

2. **How do mathematics teacher educators enact formative assessment in mathematics modules**?

Observer	
Name of College	
Time of observation	
Level	
Topic	
MTE observed	

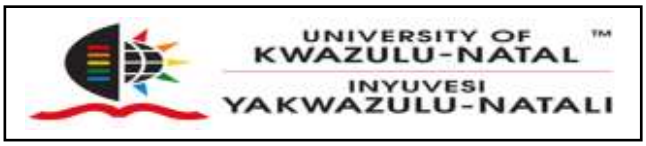
1. Context for formative assessment practice – The context for enacting FA will be observed under the following:
   a) Classroom context
      - How were the students arranged in the classroom?
   b) Teaching, learning and assessment process
      - How was teaching done?
      - What Strategies were employed by the teacher?
      - How were the students assessed?
2. Did teacher educator share learning goals for lesson with students?
3. How did teacher gather evidence of his or her lesson?
4. Did teacher educator use formative assessment techniques?
5. Which are those?
6. How did he/she use them?
7. When are they being used?

- Are they used to introduce/ during the course of lesson/consolidate lesson/throughout the lesson?

Feedback

8. Teacher provided feedbacks to students (e.g. individual / whole class)
9. Who is assessing during classroom interaction?
    a) Teacher
    b) Self
    c) Peer

Appendix G: Focus group discussion protocol



Critical question

1. **Why do Mathematics teacher educators use formative assessment techniques**?

Over the years learning of mathematics has remained problematic for students at all levels of education in the country. Students' performance in the subject has always been in declining and this has been attributed to many reasons; examples: lack of learning materials, methods of instruction, school factors etc. Therefore, the bid to reform teacher education in the country has seen the introduction of both formal and informal ways of assessing students.

1. How have you embraced this assessment technique?

   ……
   ……
   ……

2. How do you assess your students?

   ……
   ……
   ……

3. Do you think the kind of assessment technique you used enable your students to learn mathematics and how?

   ……
   ……
   ……

4. How have you been monitoring students' progress during lesson delivery?

   ……
   ……
   ……

5. Don’t you think assessment for learning can be used to enable students’ learning of mathematics?

   ……

   ……

   ……

6. Have you ever used assessment for learning to enable your students’ learning of mathematics?

   ……

   ……

   ……

   Prompt:

   If yes

   a) What makes you use it or implement it?

      ……

      ……

      ……

   b) How does it (FA) assist you in teaching of mathematics?

      ……

      ……

      ……

      ……

   If No

a) Can you give details as to why you are not using it?

   ……

   ……

   ……

   ……

b) What do you think needs to be done to enable you to make use of FA?

Appendix H: Sample of MTE formative assessment task

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

FIRST SEMESTER QUIZ 1, MARCH 2019

MARCH 5, 2019 ALGRBRA I

Answer ALL the questions showing clearly all workings in the space provided. (40 marks)

1. a) A bag contains 150 oranges and 12% of them got spoiled. Find the number of good oranges in the bag. [**4marks**]

   c) Determine the ratio of the spoilt oranges to good oranges in question 1(a).

2. Given that $\log_{10} 2 = 0.3010$ and $\log_{10} 3 = 0.4771$, evaluate $\log_{10} \sqrt{60}$ and leave your answer correct to four significant figures. [**8 marks**]

3. Find the value of x that satisfies the equation : $2^{9x-3} = 8^{3-x}$. [**6 marks**]

4. Simplify: $\log_5 9 + \log_5 21 - \log_5 7$ [**5 marks**]

5. Andrews had 2246_{eight} Algebra books. He sold 1024_{eight} books and gave out 665_{eight} of the books

   i. How many books were left for Andrews? Leave your answer in base eight [**4 marks**]

   ii. Convert the number of books left as a number in base ten [**4 marks**]

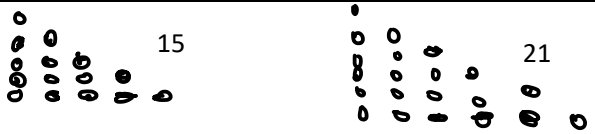
6. The marked price of a wristwatch in a shop was Ghs 75.00. The shopkeeper allowed a discount of 10% off the marked price and still made a profit of 15% on the cost price. Calculate, correct to the nearest cedi, the cost price [**7marks**]

Appendix I: Sample of MTE's Marking Criteria

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

DEPARTMENT OF MATHEMATICS AND ICT
FDC 222: FURTHER ALGEBRA
MARKING SCHEME FOR QUIZ 1

Marks are subdivided into method (M) marks, accuracy (A) and independent accuracy marks not preceded by method mark (B). Total marks according to the scheme is 20

QUESTION 1 [2 MARKS]		
Ques	**solution**	**Explanation**
1.	From the table, the identity element defined on S by the operation $*$ is C ✓✓ B	**2B :** For obtaining C as the identity
QUESTION 2 [8 MARKS]		
2. a	For commutative $a * b = b * a$ LHS: $a * b = a + 3b - 1$✓M RHS: $a * b = b + 3a - 1$✓M $LHS \neq RHS$: Therefore the operation is not commutative ✓A	**1M**: For finding $a * b$ **1M:** For finding b$* a$ **1A**: For correct conclusion made
2. b	For associativity $a * (b * c) = (a * b) * c$ LHS: $b * c = b + 3c - 1$ $a * (b * c) = a + 3b + 9c - 4$ ✓✓MA RHS: a $* b = a + 3b - 1$ $(a * b) * c = a + 3b + 3c - 2$ ✓✓ MA RHS $\neq LHS$. Hence the operation is not associative ✓A	**2MA**: For obtaining any one of the equations on the LHS correct. **2MA**: For obtaining any one of the equations of the RHS correct. **1A**: Correct conclusion made
QUESTION 3 [4 MARKS]		
Ques	**solution**	**Explanation**
3	$T_1 = (1)^2 - 1 = 0$ ✓ M $T_2 = (2)^2 - 1 = 3$ $T_3 = (3)^2 - 1 = 8$ $T_4 = (4)^2 - 1 = 15$ ✓✓ MA First four terms : 0 , 3 , 8 , 15 ✓ A	**1M:** Correct approach **2MA**: Obtaining the other terms **1A** : Finding the first four terms
QUESTION 4 [2 MARKS]		
4	 ✓✓B	**2B**: Obtaining the next triangular numbers using dots

QUESTION 5 [4MARKS]		
5	$S_{20} = (20)^2 = 400$ $T_{12} = \frac{12}{2}(12+1) = 6 \times 13 = 78$ ✓✓MA $T_5 = = 15$. Now $S_{20} - T_{12} + T_5 = 400 - 78 + 15 = 337$✓✓MA	**2MA**: Finding T_{12} **2MA**: Correct answer

Appendix J: Turnitin report

UNIVERSITY OF KWAZULU-NATAL ™
INYUVESI YAKWAZULU-NATALI

Exploring teacher educators understanding of formative assessment

ORIGINALITY REPORT

8%	%	8%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Paul Black, Dylan Wiliam. "Developing the theory of formative assessment", Educational Assessment, Evaluation and Accountability, 2009 Publication	<1%
2	"Leadership of Assessment, Inclusion, and Learning", Springer Science and Business Media LLC, 2016 Publication	<1%
3	"Assessment for Learning: Meeting the Challenge of Implementation", Springer Science and Business Media LLC, 2016 Publication	<1%
4	"Encyclopedia of Education and Information Technologies", Springer Science and Business Media LLC, 2020 Publication	<1%
5	Kathleen M. Cauley, James H. McMillan. "Formative Assessment Techniques to Support	<1%

Appendix K: Letter from editor

L. Gething, M.Phil. (cum laude)

WHIZZ@WORDS

PO Box 1155, Milnerton 7441, South Africa; cell 072 212 5417

4 November 2020

Declaration of editing of Dissertation:

Exploration of mathematics teacher educators' understanding and practices of formative assessment: A case of three Colleges in Ghana

I hereby declare that I carried out language editing of the above thesis on behalf of the author, Justice Enu.

I am a professional writer and editor with many years of experience (e.g. 5 years on *SA Medical Journal*, 10 years heading the corporate communication division at the SA Medical Research Council), who specialises in Science and Technology editing - but am adept at editing in many different subject areas. I have edited a great deal of work for various academic journals and universities, including many theses.

I am a full member of the South African Freelancers' Association as well as of the Professional Editors' Association.

Yours sincerely

LEVERNE GETHING leverne@eject.co.za